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H. SANTAPAU, S.J., D. E. REUBEN,
ZAFAR FUTEHALLY, & J. C. DANIEL

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Amphiesma platyceps (Blyth) and *Amphiesma sieboldii* (Guenther): sibling species (Reptilia : Serpentes)

BY

EDMOND V. MALNATE

Department of Ichthyology and Herpetology,
Academy of Natural Sciences of Philadelphia

(*With* 3 *figures*)

The Himalayan natricine snake *Amphiesma platyceps* (Blyth) has long been believed to be an extremely variable species. Ninety-six years ago Stoliczka (1870 : 191) suggested that variation in the degree of carination of the dorsal scales and in colour pattern were correlated with sexual dimorphism. Boulenger (1890 : 344) made a similar suggestion but, perhaps significantly, made no further reference to the possibility in his CATALOGUE OF SNAKES (1893 : 248). Later authors apparently could find no constancy in such a correlation and were content to describe the variations they found in the species. A study of 55 specimens of *Amphiesma platyceps* from stations throughout the known range of the species has provided data which show that *Amphiesma platyceps* (auct.) is a composite of two very similar, but distinct, sympatric species: *Tropidonotus platyceps* Blyth 1854, and *Tropidonotus sieboldii* Guenther 1860.

DISCUSSION

Amphiesma platyceps and *A. sieboldii* are distinguishable on the basis of two primary characters : (1) the extent and degree of the carination of

the dorsal scales; and (2) the number of ventrals. Differences of lesser degree have been observed in several other characters: (3) number of subcaudals; (4) number of infralabials; and, (5) colour pattern; and are suggested in (6) dimensions and proportions; and, (7) distribution.

1. *Carination of the dorsal scales.* The extent and degree of keeling present on the dorsal scales is a strong dichotomous character. Keels are present but weakly developed (sometimes extremely faint) only on five to seven mid-dorsal scale rows in *A. platyceps.* The scales of all dorsal rows are keeled in *A. sieboldii*; the keels are not strongly developed and the first scale row may be smooth (43·8% of the specimens examined). No intermediate condition has been observed; all specimens examined showed either one type of keeling or the other. The characteristic carination of each species is similarly produced in both males and females [ruling out Stoliczka's (loc. cit.) suggestion] and in specimens of varying ages. Geographic variation either in the extent or the degree of carination cannot be demonstrated.

2. *Number of ventrals.* The observed variation in the number of ventrals in *A. platyceps* and *A. sieboldii* is shown in Table I. Among

TABLE I

VARIATION IN THE NUMBER OF VENTRALS IN *Amphiesma platyceps* AND *Amphiesma sieboldii*

	Sex	N	Range of variation	Mean
platyceps	♂	8	205-234	220·8
	♀	13	191-216	202·1
sieboldii	♂	13	191-207	199·2
	♀	13	168-190	182·7

the specimens studied only 7% (4 specimens) could not be assigned to either species on the basis of ventral counts alone; examination of additional specimens very probably will alter this figure. Of special interest is that the sexes of both species are strongly differentiated in the number of ventrals, and that it is the males of each which show the higher counts, a condition contrary to a general tendency among colubrid snakes to produce a greater number of ventrals in females. The geographical distribution of ventral counts, by sex, is shown in

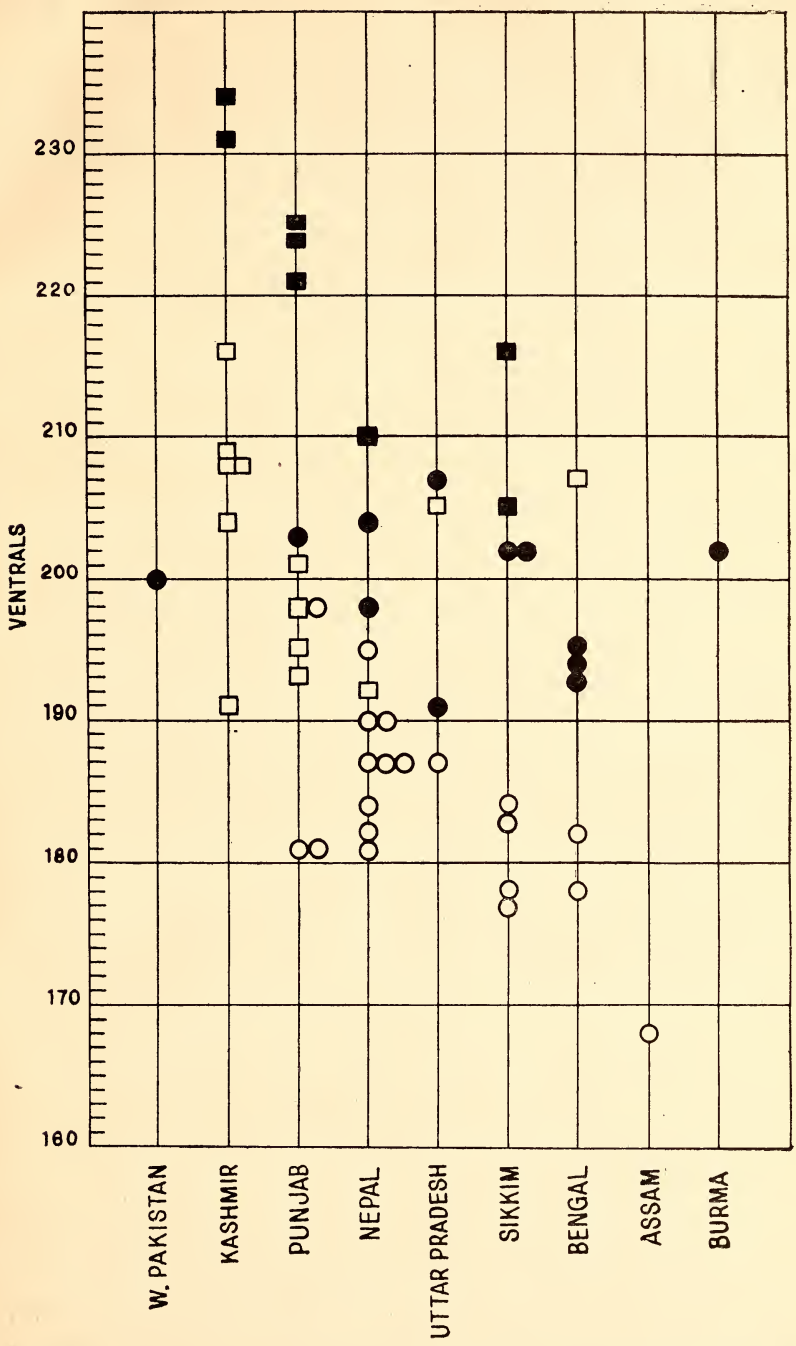

FIG. 1. Geographical distribution of ventral counts of *Amphiesma platyceps* (squares) and *A. sieboldii* (circles). Open symbols represent female counts, solid symbols are male. Specimens from Himachal Pradesh and Punjab are recorded over "Punjab".

Fig. 1. Limited data prevent analysis but variation through the ranges of both species appears, broadly, to be parallel.

The character of the keeling of the dorsal scales and the number of ventrals appear to be correlated and strongly differentiate *platyceps* and *sieboldii*. The characters next noted are not diagnostic but they contribute to the differences between the species.

3. *Number of subcaudals.* Variation in this character in *platyceps* and *sieboldii* is summarized in Table II. Differentiation between the

TABLE II

VARIATION IN THE NUMBER OF SUBCAUDALS IN *Amphiesma platyceps* AND *Amphiesma sieboldii*

	Sex	N	Range of variation	Mean
platyceps	♂	6	88-98	92·2
	♀	11	78-96	86·1
sieboldii	♂	9	97-111	103·7
	♀	14	81-110	95·9

two species in the number of subcaudals, especially in females, is not strong (42% of the specimens with whole tails could not be separated on the basis of this character); the difference is most clearly indicated by the means. Whereas the higher number of ventrals occurs in *platyceps*, it is *sieboldii* which produces the higher number of subcaudals. Male snakes tend to possess a greater number of subcaudals than do females in both species (the anticipated condition). The geographical distribution of subcaudal counts is shown in Fig. 2; analysis is not possible but parallel trends appear in both species. It may be noted that, whereas there is indicated a general east to west increase in the number of ventrals, the number of subcaudals tends to decrease east to west.

The fact that *platyceps* possesses a greater number of ventrals but fewer subcaudals and the reverse condition in *sieboldii* suggest the possibility that a simple shift in the position of the anus is responsible. This may well be true, at least in part, but the data presented in Table III show that *platyceps*, especially the males, tends to develop a greater total number of ventral scutes (ventrals plus subcaudals) than does *sieboldii*.

4. *Number of infralabials.* Analysis of the variation in these scales is presented in Table IV. Because the number of infralabials

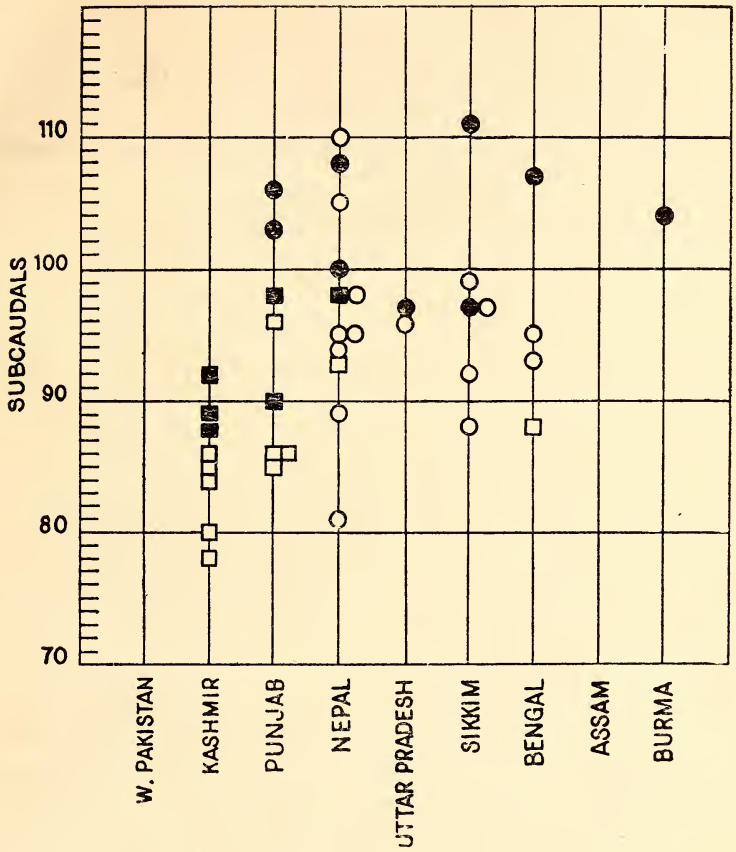

FIG. 2. Geographical distribution of subcaudal counts of *Amphiesma platyceps* and *A. sieboldii.* Symbols as in Fig. 1. Specimens from Himachal Pradesh and Punjab are recorded over "Punjab ".

TABLE III

VARIATION IN THE SUM OF VENTRALS PLUS SUBCAUDALS IN *Amphiesma platyceps* AND *Amphiesma sieboldii*

	Sex	N	Range of variation	Mean
platyceps	♂	6	308-326	316·7
	♀	11	271-302	287·3
sieboldii	♂	9	299-313	305·0
	♀	14	266-300	278·3

may differ on each side of the head, counts of each individual series are used (normally two per specimen). A tendency to develop a higher

TABLE IV

VARIATION IN THE NUMBER OF INFRALABIALS IN *Amphiesma platyceps* AND *Amphiesma sieboldii*

No. of infralabials	*platyceps*		*sieboldii*	
	No. of counts	% of total counts	No. of counts	% of total counts
8	5	12·8	(mean = 9·8)	
9	22	56·4	12	21·4
10	12	30·8	43	76·8
11	(mean = 9·2)		1	1·8

number of infralabials is evident in *platyceps*, 30·8% of the counts being 10. In *sieboldii*, however, 10 or more infralabials are common, occurring in 78·6% of the counts. Geographic variation in this character is not evident in the data at hand.

5. *Colour pattern.*

HEAD. The nuchal crescent (a pattern element produced from the last supralabial and extending upwards and backwards over the nape) of *platyceps* commonly is a simple, dorsoposterior extension of the dark postocular streak which borders the upper edge of the supralabials; the light colour of the supralabials and the dark of the lip edge are rarely included. The nuchal pattern of *sieboldii*, on the other hand, may be fully developed as a light, dark-bordered crescent extending from the last supralabial up and back over the nape and, sometimes, produced posteriorly on the neck for a short distance as parallel stripes. Occasionally, the crescent is broken into 3 or 4 light, dark-edged spots.

DORSUM. The dorsum of both species is more or less uniform; *platyceps*, however, is more frequently marked with small dark spots than is *sieboldii*. A dorsolateral series of small light spots is rarely evident on *platyceps*, and when present the spots are weakly defined. These spots are commonly present on *sieboldii*, obscure posteriorly on the body but more prominent anteriorly.

VENTRUM. It is on the ventrum that the major pattern difference between the species appears. The ventral surface of *platyceps* usually is

immaculate; a lateral series of dark streaks may be present, these either obscure or sharply defined. The subcaudal surface, usually immaculate, occasionally is darkened with grey or, rarely, shows dark stippling along the common, median sutures of the plates.

In *sieboldii* the ventrum rarely is immaculate; often it is darkened posteriorly with a greyish suffusion of variable intensity, and occasional, discrete, dark spotting also may be present. A lateral series of dark streaks usually is present, more prominent posteriorly on the belly. The subcaudal surface is rarely light or immaculate. Commonly, a lateral series of dark spots (a continuation of the ventral series) is present and the median, common sutures of the subcaudals are darkened. Occasionally the entire subcaudal surface is dark. Among the specimens of *sieboldii* examined 50% have the chin and throat darkened with a tone which varies from grey to dark brown or black. The darkened area may be confined to the scales of the chin or extend posteriorly to the level of the 20th ventral.

6. *Dimensions and proportions.* The tail of *sieboldii* is proportionately somewhat longer than that of *platyceps*, perhaps in association with the greater number of subcaudals in that species; this is shown in Table V.

TABLE V

TAIL/TOTAL LENGTH RATIO IN *Amphiesma platyceps* AND *Amphiesma sieboldii*

	Sex	N	Range of variation	Mean
platyceps	♂	5	0·243-0·267	0·2520
	♀	10	0·232-0·273	0·2478
sieboldii	♂	8	0·261-0·295	0·2769
	♀	14	0·242-0·300	0·2759

Reduction in the number of dorsal scale rows from 19 to 17 is, in both species, accomplished by the loss of the fourth scale row. This scale row is present for a greater percentage of the head and body length in *sieboldii* (Table VI).

7. *Distribution.* *Amphiesma platyceps* is known, on the basis of the specimens examined, to be distributed from Darjeeling, Bengal, west to Kashmir, at altitudes ranging from 6000 to 10,000 feet (Fig. 3). *A. sieboldii* is known from Taung-gyi, Burma (see p. 15 below), to

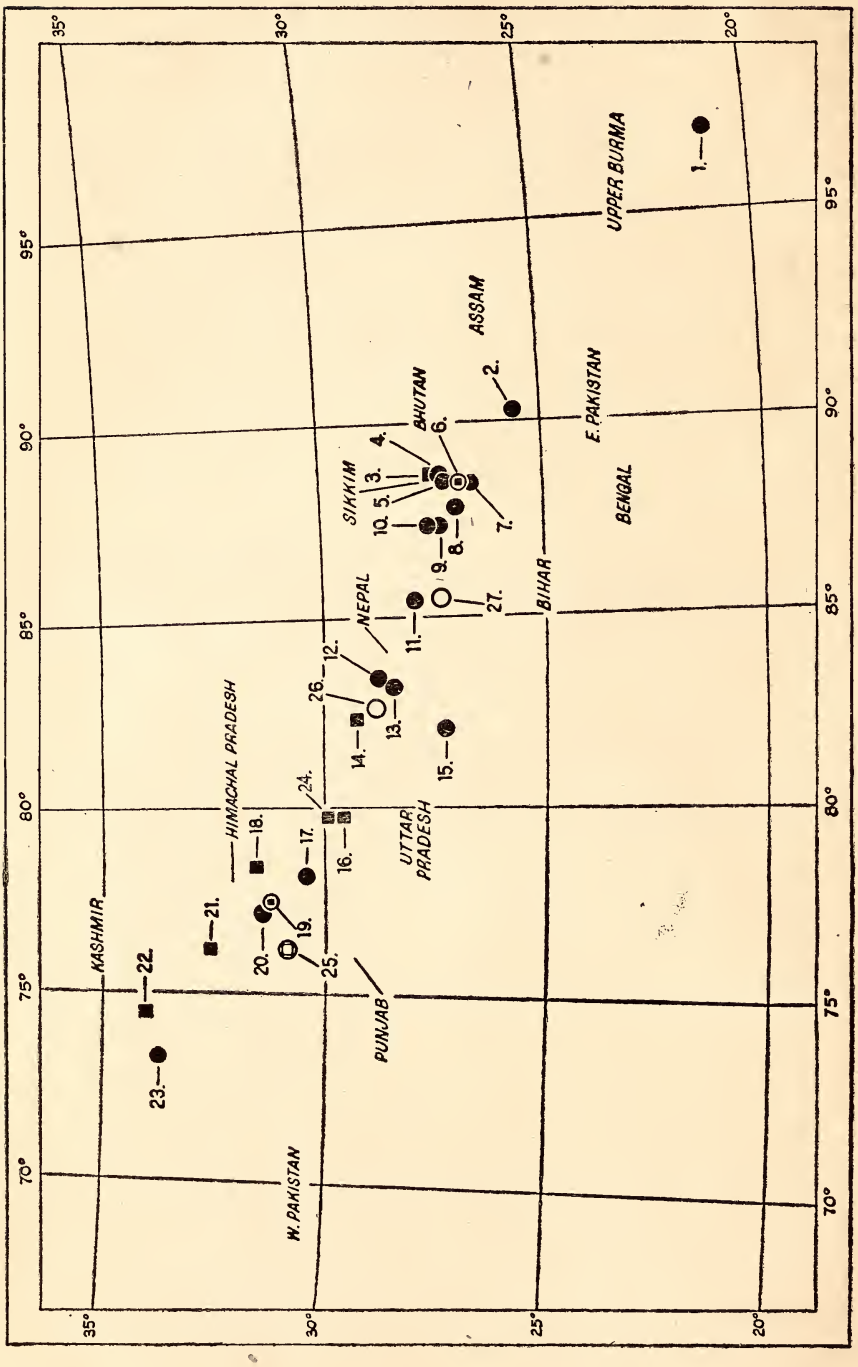

FIG. 3. The distribution of *Amphiesma platyceps*, squares, and *A. sieboldii*, circles. Numerals refer to localities cited in the text (specimens examined). Thundiani (25), Punjab, and Amp pipal (27), Nepal, cannot be located with certainty.

Ghora Galli, West Pakistan; thus, it is sympatric with *platyceps* through most of its range but shows an eastward extension. The known altitudinal distribution of *sieboldii*, 4000 to 12,000 feet, is broader than that

TABLE VI

LENGTH OF 4TH SCALE ROW, AS A PERCENTAGE OF THE HEAD AND BODY LENGTH IN *Amphiesma platyceps* AND *Amphiesma sieboldii*

	Sex	N	Range of variation	Mean
platyceps	♂	4	56·5%-59·5%	57·83%
	♀	7	55·3%-64·8%	58·87%
sieboldii	♂	6	56·5%-61·2%	59·07%
	♀	9	52·8%-64·0%	60·18%

of *platyceps*. Both species have been taken at three stations: Darjeeling, Bengal, Simla, Himachal Pradesh, and Thundiani, Punjab.

The differentiation of *Amphiesma platyceps* and *A. sieboldii*, as observed in the present study, may be summarized thus: (1) in *platyceps* only the scales of the mid-dorsal rows are keeled, and these faintly so; in *sieboldii* all scale rows except, occasionally, the outer row are keeled; (2) *platyceps* has a greater number of ventrals; but, (3) fewer subcaudals; (4) the number of infralabials is most frequently 9 in *platyceps*, 10 in *sieboldii*; (5) slight pattern differences between the species appear on the head and dorsum; the ventral pattern, of the two species, however, is more strongly differentiated, that of *platyceps* normally being immaculate whereas the ventrum of *sieboldii* is rarely so; (6) *platyceps* appears to have a proportionately shorter tail, and a reduction in the length of the fourth scale row; (7) *platyceps* is not known further east than Sikkim, *sieboldii* ranges into Assam and eastern Burma.

The two species are notably similar or identical in the following variable characters:

a. Oculars (1 pre–, and 3, often 2, postoculars)
b. Temporals (usually a single anterior temporal, sometimes 2; posterior temporals commonly single, frequently 2, very rarely increased to 3 in *platyceps*)
c. Supralabials (8, the 3rd to 5th border the orbit)
d. Apical scale pits (not observed on most specimens examined; they may be faintly evident, however, on the scales of the neck)
e. Head length/width ratio (1·7 to 2·6, mean 2·0, 43 specimens)

f. Length of snout (28% to 35% of the head length, mean 31·8%, 18 males; 26% to 35%, mean 28·2%, 25 females)

g. Eye diameter (14% to 21% of the head length, mean 18·2%, 18 males; 14% to 21%, mean 16·1%, 26 females)

h. Maxillary dentition (teeth usually in continuous series in *platyceps*, the posterior two, enlarged teeth sometimes separated from the anterior series; posterior enlarged teeth commonly separated from anterior series in *sieboldii*)

i. Hemipenes (organ simple in both species but usually is bilobate at the tip in *sieboldii*; the single, enlarged basal spine present in both species is, in *sieboldii*, commonly followed distally by a cluster of stout spines; both characteristics are rarely present in *platyceps*)

j. Secondary sexual characters [among males of both species greater than 528 mm. in total length, the scales of the cloacal region are more strongly keeled and the keels are knobbed (tuberculate); females of both species, 490 mm. and larger in total length, may possess tubercles on the dorsal head shields].

It is evident that two forms have, indeed, been confused under the name *Amphiesma platyceps* (auct.). In spite of the great similarity of the two forms the correlation of carination of the dorsal scales and the number of ventrals readily separate them. The differentiation in these characters plus the lesser differences observed are believed to indicate the presence of two distinct species and not a single, dimorphic species in which one form possesses keels on all scale rows, the other having the keeling confined to the vertebral rows. Both forms are sympatric over most of their ranges and are not presently known to have ecological separation (future field work may show ecological divergence), yet none of the specimens examined could be determined to be intermediate; reproductive isolation is, therefore, assumed.

Mayr (1963 : 34) defines sibling species as 'morphologically similar or identical natural populations that are reproductively isolated'. Such a definition applies to *Amphiesma platyceps* and *sieboldii*. Mayr further states (op. cit. : 57) that 'geographic speciation is the normal process by which sibling species originate'. It is impossible, within the present limits of our knowledge, to determine previous geographic isolation for *platyceps* and *sieboldii*. Three factors observed in the study, however, may have some relevance : (1) the eastward extension of *sieboldii* into Assam and Upper Burma to the exclusion of *platyceps*; (2) the broader altitudinal range of *sieboldii* (4000 to 12,000 feet; 6000 to 10,000 feet for *platyceps*); and, (3) the apparently parallel clinal trends in the numbers of ventrals and subcaudals in both species. Differentiation in geographic isolation is not necessarily supported by these data but they may be

interpreted as indicating the possibility of two, separate, dispersals from an eastern centre. Both species appear to be related to a complex of species of *Amphiesma* (*modesta*, *et al.*), centred in the region at the eastern end of the Himalayas. The interrelationships of the species of this complex are, unfortunately, confused and confusing. A discussion of the possible derivation of *platyceps* and *sieboldii* from one or more of the species associated with *modesta* must be deferred until such time as the group is more clearly understood.

Redescription of the species

It is believed pertinent here to briefly redescribe *Amphiesma platyceps* and *A. sieboldii*; data presented in Tables I-VI are not repeated in the descriptions. The disposition of the specimens examined in the course of the study is included under each species.

Amphiesma platyceps (Blyth)

Tropidonotus platyceps Blyth, 1854, Journ. Asiatic Soc. Bengal **23** (3): 297 [type: Indian Museum (Calcutta), ZSI Reg. No. 7482; type locality: Darjeeling, Bengal]

Zamenis himalayanus Steindachner, 1867, Verh. Zool.-bot. Gesell. Wien **17**: 513, pl. 13 (types Natur. Mus. Wien, Nos. 18569, 18570: 1-2; type locality: Simla and Kulu, Himachal Pradesh, India)

It is impossible to give a complete synonymy inasmuch as both *platyceps* and *sieboldii* are included in the comments of most authors. For the same reason distribution records in the literature are not considered.

Blyth's original description (loc. cit.) mentions five specimens. Two from Assam, one with '155 scutae only' and a 'small young example', appear to be representative of *Amphiesma parallela*. A third specimen 'remarkable for having the chin and throat quite black' evidently represents *sieboldii*. Thus, Blyth's description is a complex characterization of three species. Dr. B. Biswas, Superintending Zoologist, Zoological Survey of India, informs me (*in litt.*) that only one specimen of the original series, ZSI 7482, remains. This individual agrees best with the largest example Blyth had before him and upon which his description is essentially based. To this specimen may be applied Blyth's name *platyceps*. The specimen is described as having only the 3 or 4 vertebral rows weakly keeled, the lateral rows being smooth; the ventrals number 183 (a lower count than any personally observed), the subcaudals 93 (?), the tip of the tail being broken; the total length is 692+ mm., the tail 195+ mm.; the belly is white and no pattern is

visible on the chin (Dr. Biswas, *in litt.*). Blyth describes traces of greenish-dusky on the throat ; these marks evidently have faded.

Steindachner's (loc. cit.) nominal form *himalayanus* almost certainly belongs here. Through the courtesy of J. Eiselt, Natur. Mus., Wien, I have been permitted to examine Stoliczka's specimens, upon which Steindachner based his name. The three specimens (NMW 18569, 18570:1-2) are all females with faint keels present on the vertebral 5 to 7 scale rows only. Ventral and subcaudal counts are 200+63, 201+83, and 205+92, respectively. These data leave no doubt that *himalayanus* is a synonym of *platyceps*.

Description of the species. Rostral wider than high, narrowly visible from above. Internasals as wide as long, internasorostral contact 1 or slightly less than 1. Prefrontals wider than long, longer than the internasals. Frontal longer than its distance from the tip of the snout, equal in length to the interparietal suture. Parietals shorter than their combined width. Nasal divided completely or below the nostril only. Loreal longer than high. Preoculars single ; postoculars 3, often 2. Anterior temporals single, occasionally paired ; posterior temporals usually single, very often 2 (one count of 3). Supralabials 8 (one count of 7), 3rd to 5th border the orbit. Posterior chin-shields the longer pair, separated $\frac{1}{2}$ to their entire length by small scales.

Dorsal scales in 19-19-17 rows, the 3 to 7 vertebral rows only are faintly keeled, all other rows being smooth ; apical scale pits not usually evident but they may be present, obscurely, on the neck.

Head light brown above, sometimes mottled or marbled with dark brown, especially on the parietals ; paired, light occipital spots and a postparietal light streak may be present. Supralabials light, bordered above with a dark brown or black stripe from the rostral to the eye (sometimes lacking) and from the eye to the commissure of the mouth (may be greatly reduced but usually is present). Nuchal crescent often reduced to a single dark streak from the angle of the jaw up and back across the nape ; rarely includes a light stripe or light spots. Dorsum brown or olive-brown (olive-green in life, auct.) ; small, dark brown spots commonly present, these most prominent and regularly arranged in a vertebral series with a dorsolateral series less evident and irregular ; both series usually are more prominent anteriorly on the body ; a dorsolateral series of light spots is rarely evident. Ventrum usually immaculate, a lateral series of dark streaks may be present, especially posteriorly but are weakly defined ; a speckling of tiny dark spots may occur posteriorly (over the entire ventral surface, except the anal plate, on one specimen) ; lateral edges of the ventrals are red in life (auct.) ; subcaudal surface usually immaculate, sometimes more or less peppered with dark spots, rarely the median sutures of the subcaudals are

darkened; chin greyish on one specimen, the gular scales finally edged dark on another.

Maximum observed total length: male, 676+ mm.; female, 927 mm. Head length/width ratio: 1·7 to 2·4, mean 2·1, 18 specimens. Snout (as a percentage of the head length): 29% to 33%, mean 31·3%, 7 males; 29% to 35%, mean 31.0%, 9 females. Diameter of eye (as a percentage of the head length): 15% to 21%, mean 18.8%, 7 males; 14% to 19%, mean 16·0%, 11 females.

Maxillary teeth 18 to 22; the anterior series of 16 to 20 gradually increase in size posteriorly and are followed by two strongly and abruptly enlarged teeth which sometimes are separated from the anterior series by a slight interspace (15 maxilla examined).

Hemipenes extend to the level of the 8th to 10th subcaudals; the organs are simple, rarely bilobate, spinous throughout, the spines small; one enlarged basal spine present, rarely followed by a cluster of stout spines. Sulcus spermaticus single, extending to the organ tip. (Description based on the hemipenes of 6 males.)

Distribution. Darjeeling, Bengal, in the east, to Gulmarg, Kashmir, in the west, at recorded altitudes of 6000 feet (Dalhousie, Himachal Pradesh) to 10,000 feet (unspecified locality in Kashmir).

Natural history. The stomachs of specimens examined contained only *Leiolepisma himalayanum.* Curiously, three of the four snakes having fed on this lizard had swallowed their prey tail first! One *A. platyceps* contained eight adult and four juvenile specimens of *L. himalayanum.* An ingested *L. himalayanum* contained three well-developed embryos. A female *A. platyceps*, 717 mm. in total length, contained two large (25×8 mm.) eggs.

Specimens examined: (Numerals in parentheses following each locality refer to locations on map.) NEPAL: Jumla (14), 7600 feet (BM 1953. 1. 1. 63), no specific locality (BM 45. 1. 12. 570); INDIA: Sikkim, Mangpu (3), (CNHM 15827), no specific locality (BM 60.3.19.1354); Bengal, Turjun tea estate, Darjeeling (6), (BNHS 80-11); Uttar Pradesh, Almora (16), (BNHS 80-3), Binsar (24), (BM 1911.9.8.2); Punjab, Thundiani (25), (BNHS 580); Himachal Pradesh, Dalhousie (21), 6000 feet (BNHS 80-2), Simla (19), (BNHS 80-5 (b), 80-7), Upper Sutlej Valley (18), 7000 feet (BM 1911.5.9.1); Kashmir, Gulmarg (22), (BM 96.11.20.5-6), no specific locality (BM 70.11.30.36A-D, 10,000 feet; BM 1903.6.22.23; USNM 48469-70).

Amphiesma sieboldii (Guenther)

Herpetoreas sieboldii Guenther, 1860, Proc. Zool. Soc. London: 156 (type : British Museum, 1946.1.13.16; type locality: Sikkim, 7500 feet); 1864, Reptiles British India: 257)

Tropidonotus chrysargus Wall, 1907, Rec. Ind. Mus. 1 (2): 156 (*non* Schlegel; this is Wall's first recording of the two specimens later described as *firthi*).

Tropidonotus firthi Wall, 1914, Journ. Bombay nat. Hist. Soc. 23 (1): 166 (types: Indian Museum (Calcutta), ZSI Reg. No. 15817-18; type locality: Chitlang, Nepal).

Natrix firthi Shaw, *et al.*, 1939, Journ. Darjeeling nat. Hist. Soc. 13 (4): 150.

Guenther's original description of *sieboldii* (loc. cit.), upon which species Guenther based the monotypic genus *Herpetoreas*, was prepared from a single specimen. Guenther variously describes the dorsal scales as 'keeled', or 'those of the back slightly keeled'. Miss Alice G. C. Grandison, after examination of the type, informs me (*in litt.*) that all but the outer row of scales bear faint but distinct keels. Miss Grandison further describes the type as a male, with 211 ventrals (a slightly higher number than any personally observed) and 89 subcaudals. There seems to be little doubt that Guenther had before him a specimen of the species here reported as distinct from *platyceps* and that the name proposed by Guenther, *sieboldii*, must be assigned to it.

Wall's original description of *firthi* (loc. cit.) clearly associates his species with that of Guenther. Dr. Biswas (*in litt.*) has verified the salient characteristics upon examination of the cotypes in the Indian Museum. Dr. Biswas also informs me that the disposition of a third specimen (from Takdah, Darjeeling District, Bengal), included by Wall in his original description, is unknown.

Description of the species. Rostral wider than high, narrowly visible from above. Internasals longer than wide, internasorostral contact 1 or slightly less than 1. Prefrontals wider than long, longer than the internasals. Frontal slightly longer than its distance from the tip of the snout, equal to the length of the interparietal suture. Parietals shorter than their combined width. Nasal completely divided (sometimes below the nostril only). Loreal longer than high. Preoculars single, rarely divided; postoculars 3, occasionally 2. Anterior temporals most commonly single, often paired; posterior temporals usually single, often 2. Supralabials invariably 8; 3rd to 5th border the orbit. Posterior chin-shields the longer pair, separated from ½ to their entire length by small scales.

Dorsal scales in 19-19-17 rows, lightly keeled, outer row often smooth; apical scale pits not usually evident but may be present, obscurely, on the neck; to approximately mid-body on the type (A.G.C. Grandison, *in litt.*).

Head brown above, lighter laterally; paired, light occipital spots and a postparietal light streak usually present. Supralabials light, bordered above with a dark brown or black stripe, from the rostral to the eye, and from the eye to the commissure of the mouth; lid edge also may be dark, especially posterior to the eye. The pattern of the supralabials continues up and back over the nape as a nuchal crescent, and, in an occasional specimen, continues posteriorly on the neck for a short distance; the nuchal crescent may be reduced (or absent) or broken into a series of 3 or 4 light, dark-edged spots. Dorsum more or less uniform (olive-green in life, auct.), lighter laterally; scales frequently dark-edged; a vertebral series of irregular, transverse, blackish crossbars sometimes is present; a dorsolateral series of small, light spots may be present, these generally obscure but sometimes are more prominent posteriorly on the body. Ventrum light, a lateral series of dark, elongate spots is usually present; rarely an overall suffusion of grey appears; area lateral to the series of black spots is reddish in life (auct.); scattered black stippling sometimes present or the stippling is concentrated medially on the posterior portion of the venter; chin and throat often darkened with a greyish to black pigmentation which may extend posteriorly as far as the 20th ventral; subcaudal surface with lateral dark spots and a dark edging to the common, median sutures of the plates, or sometimes the undertail is totally suffused with dark grey.

Maximum observed total length: male, 729 mm.; female, 943 mm. Head length/width ratio: 1·7 to 2·6, mean 2·0, 25 specimens. Snout as a percentage of the head length): 28% to 35%, mean 32·1%, 11 males; 26% to 33%, mean 30·5%, 14 females. Diameter of eye (as a percentage of the head length): 14% to 21%, mean 17·9%, 11 males; 14% to 21%, mean 16·2%, 15 females.

Maxillary teeth 17 to 21 + 2; the teeth of the anterior series gradually increase in size posteriorly, and are separated by a slight diastema from the two, strongly enlarged posterior teeth (17 maxilla examined).

Hemipenes extend to the level of the 7th to 10th subcaudals; the organs are simple, usually bilobate at the tip, spinous throughout, the spines small; a single enlarged basal hook is followed immediately distad by a group of 3 or 4 stout spines (these rarely absent). Sulcus spermaticus single, extending to the tip of the organs. (Description based on the hemipenes of 9 males.)

Distribution. Taung-gyi, Upper Burma, in the east, to Ghora Galli, West Pakistan, in the west, at known altitudes varying from 4000 feet (Amp pipal, Gorkha district, Nepal) to 12,000 feet (Balangra Pass, Nepal). Wall (1923:604), without comment, states that the record from Taung-gyi is 'untrustworthy'. The specimen (BNHS 80.4) is unques-

tionably *sieboldii*. Taung-gyi, approximately 500 miles south-east of the Garo Hills, Assam, is on the Shan Plateau of eastern Burma; surrounding altitudes vary from 5000 to 8000 feet. The Shan Plateau is associated with the complex of low mountains radiating from the eastern end of the Himalayas (including the Garo and Khasi hills). The penetration of the Shan Plateau by *sieboldii* may have some association with the broader altitudinal range recorded for the species. Although the appearance of *A. sieboldii* on the Shan Plateau is believed valid it seems best to retain Wall's question until the record is verified.

Natural history. Stomach contents of specimens examined included unidentified frogs, tadpoles, frog eggs, and partially digested *Lygosoma indicum indicum.* A female *A. sieboldii*, 435 mm. in total length, contained five, small, undeveloped eggs.

Specimens examined. (Numerals in parentheses following each locality refer to locations on map.) BURMA: Shan States, Taung-gyi (1), (BNHS 80.4); NEPAL: Amp pipal (27), 4000 feet (CNHM 109762), Balangra Pass (26), 12,000 feet (BM 1953.1.1.64), Hatia (10), Arun River, 6500 feet (BM 1962.1047), Lumsum (13), 22 m. NW. Beni, 6500 feet (BM 1955. 1. 13. 71), Maikola Valley (8), 7000-10,000 feet (BM 1913. 5. 22. 1), Maewa khola, Sangwe (9), 6500 feet (BM 1962.1048), Taglung (12), 5 m. S. Tukucha, 9500 feet (BM 1955. 1. 13. 69-70), Thangjet (11), 5000 feet (BM 1950. 1. 5. 59-60), no specific locality (BM 45. 1. 12. 572); SIKKIM: Gangtok (4), (BNHS 80-10); INDIA: Assam, Garo Hills, Tura (2), (BNHS 80–8); Bengal, Darjeeling (6), (BM 70.11.30.37M-N), Lebong (5), (BNHS 1835), no specific locality (BNHS 80-15, BM 53. 8. 12. 30K-L, BM 60. 3. 19. 1352); Takdah (7), (MCZ 58238-40); Uttar Pradesh, Gonda (15), (BNHS 80-9), Mussoorie (17), 6000-7000 feet (BM 1905. 10. 27. 1, UMMZ 77237); Punjab, Thundiani (25), (BNHS 581); Himachal Pradesh, Simla (19), (BNHS 582, 80-5a), Taradevi hill (20), near Simla (BNHS 80-6); WEST PAKISTAN: Rawalpindi, Ghora Galli (23), (BNHS 80-14).

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Rhododendrons in Nepal

BY

M. L. Banerji

Superintendent, Botanical Survey, Nepal

The genus *Rhododendron*, also known as Rose Bay, gets its name from the Greek words 'rhodos' and 'dendron', which mean a rose and a tree respectively; and truly the flowers are like roses. This enormous genus belongs to the family Ericaceae, a name conserved over Rhodoraceae, and includes some 700-725 species which are concentrated in the mountains of east and south-east Asia, and are found in many other parts of the world, mostly in temperate climates.

The rhododendrons possess but few economic properties. The wood of the arborescent species which is hard and close-grained is used for fuel, for construction, and also for turnery work. The leaves of some species are used medicinally and as incense; and the flowers of various species are sometimes made into a subacid jelly, but the honey obtained from the flowers is poisonous.

It was about 1850 that a large number of Sikkim rhododendrons were introduced into England. The beautiful species are cultivated in gardens of Europe and many hybrids have been raised which are now more extensively cultivated than the original parent species. In the Himalayas, the largest number of species are to be found in Bhutan and Sikkim, and the number gradually declines towards the west. In the Nepal Himalayas there are on record some 29 species, most of which are in the eastern part of the country. In this context, Stainton (1963) writes: 'We had hoped to see at least one or two species such as *Rh. falconeri*, *thomsonii*, *cinnabarinum* var. *roylei*, *campylocarpum*, or others which are common in the country at the head of the Arun, but if any of them grow on Ganesh Himal, they successfully eluded our search. It would be interesting to know whether these rhododendrons and various other ericaceous plants which are so prominent a feature in the forests of east Nepal are to be found in the intervening Jugal and Rolwaling Himalaya.' Banerji (1954) observed a gradual reduction in the number of species as one moves from the easternmost parts of east Nepal to the west. So also has been Stainton's (loc. cit.) observation when he writes: 'and in particular I was struck by the absence of so many of the species of rhododendrons which grow in eastern Nepal'. It may be

added that out of 29, the total number of species so far on record, some have been collected and are known from the central part of the country only.

The purpose of this paper is to provide useful information, gathered from different sources, about rhododendrons in Nepal. Stainton (loc. cit.) writes: 'if anyone asked me where to go in Nepal in the spring to see the country at its best, I would without hesitation recommend the rhododendron-conifer woods which lie between 10,000 ft. and the tree-line. Later in the year they are rather sombre places, but in late April and early May they are superb.' This raises the question about the flowering season of the different species. There are some species that begin to flower in March and continue up to May, while other species begin late, say in May, and continue up to June. I am inclined to hold that from late April to early May one may reasonably expect to find most of the species in flower. One may even find flowers of some species as late as October, or as early as mid-January. I have found *Rh. arboreum* in flower in mid-January, and *Rh. lepidotum* and *setosum* bearing flowers in October. The fruiting season for the different species varies accordingly.

The characters deemed important in the identification of the species are: the habit of the plant, shape of the leaf, presence or absence of 'lepidote' scales, occurrence of hairs which form the indumentum, presence of the glands and their shape, the number of parts in the calyx and the corolla, shape and colour of the corolla, number of the stamens and their position, shape of the ovary, and appearance of the fruit. It may be added that there are some species having different colour forms, which are often treated as varieties, e.g. *Rh. arboreum* and *cinnabarinum*.

Before enumerating the different species so far reported to occur in Nepal, I would very much like to add that the national flower of Nepal is the Rhododendron and for the botanists it works out as *Rh. arboreum* Sm.; also that the rhododendron has featured prominently in Indian poetry as well as in modern Nepali poetry. The largest number of species that I have found in one area is between Dongen and Tapkegola (27°37′ N., 87°35′ E.), and the biggest area under one particular species is at Lamjuree (27°35′ N., 86°30′ E.), where the belt is some 150 metres broad and about 2·5 km. long.

In the following enumeration, the species have been arranged alphabetically.

Rh. anthopogon D.Don in Mem. Wern. Soc. 3: 409, 1821; Hook. f. Fl. Brit. Ind. 3: 472,1882; Stev. Spec. Rhod. 4, 1947; Kitamura in Fauna & Fl. Nep. Himal. 192, 1955; Stainton, Notes, 1964 (mimeograph). Nepali name—*dhupi*

Small shrub, 30 cm. high; branchlets short, scaly when young; winter bud-scales deciduous; leaves obovate-elliptic, sub-obtuse at both

ends, mucronate apex, 2·5-4·0 cm. long, 1·3-2·5 cm. broad, upper surface slightly scaly, lower surface densely scaly; petiole 7 mm. long. Inflorescence several-flowered, subumbellate, and terminal; flowers pink; calyx deeply lobed, lobes elliptic-obtuse, 7 mm. long, ciliate along the margin; corolla narrowly tubular, throat hairy, 2 cm. long, lobes 5, obtuse, entire; stamens 6-8, included; ovary 4- to 5-celled, scaly, style very short and thick, glabrous; capsule 4 mm. long, ovoid, enclosed by the persistent calyx.

Common in the Himalayas and southern Tibet at 3700-5300 m. Flowering in June; fruiting in October and November both in the eastern and the western Himalayas.

Rh. arboreum Sm. Exot. Bot. 1 : 9 1804; Hook. f. Fl. Brit. Ind. 3: 465, 1882; Stev. Spec. Rhod. 4, 1947; Kitamura in Fauna & Fl. Nep. Himal. 192, 1955; Bonner in Candollea, 17: 63, 1959; Stainton, Notes, 1964 (mimeograph). Nepali name—*gurans*

Tree, 7-14 m. high, branched from the base; leaves oblong-lanceolate to oblong-oblanceolate, leathery, 10-20 cm. long, 3-6 cm. broad, lamina base cuneate, apex acute, upper surface green, glabrous; mid-rib grooved, veins deeply impressed, under surface indumentum varying in consistency from thin film to a thicker, woolly felt (a character used for the varietal differences). Inflorescence of about 20 flowers crowded on a compact head-like corymb, 10-15 cm. across; pedicel 6-8 mm. long, hairy; bracts densely hairy. Calyx small, 3 mm. long, forming a rim with 5 lobes; corolla campanulate, 4-5 cm. across, deep scarlet typically, tube fleshy, 5 prominent black nectar pouches at the base, tube marked all over with deep-coloured dots; lobes 5, 1·5 cm. long, 2-3 cm. broad, apex notched, margin somewhat wavy; stamens 10, unequal, 4-5 cm. long, filaments glabrous; ovary conoid, 4·5 cm. long, tomentose, tomentum white, 7- to 10-chambered, style slightly curved at the tip; capsule ribbed and roughened due to the vestiges of the hairs.

Common in the temperate Himalaya—Kashmir to Bhutan at 1700-3300 m. Flowering from March to June; fruiting October to December in eastern Himalaya; in western Himalaya flowering in May.

var. **arboreum**. Indumentum on the lower surface of the leaf white; corolla pink, 4 cm. long, 3·5-4 cm. diameter.

var. **album** (Hamilt. ex Don) Wall. Pl. Asiat. Rar. 2:23, 1832. *Rh. album* Hamilt. ex D.Don, Prodr. Fl. Nep. 154, 1825. Leaf indumentum white or cinnamon to pale brown; corolla white with purple spots, 4 cm. long, 4 cm. diameter.

var. **limbatum** Hook. f. in Bot. Mag. t. 5311, 1862; Bonner in Candollea 17: 64, 1959. Corolla rose, 6 cm. long, 5 cm. diameter.

var. **cinnamomeum** (Wall.) Hook. f. in Bot. Mag. t. 3825, 1840; Bonner in Candollea 17: 64, 1959.

Leaf indumentum loose tomentum, leaves relatively small. Flowers campanulate, white or pale rose with purple spots, 6 cm. long.

Rh. barbatum Wall. ex G.Don, Gen. Syst. 3: 844, 1834; Hook. f. Fl. Brit. Ind. 3: 468, 1882; Stev. Spec. Rhod. 129, 1947; Kitamura in Fauna & Fl. Nep. Himal. 192, 1955; Bonner in Candollea 17: 65, 1959; Stainton, Notes, 1964 (mimeograph). Nepali name—*lal chimal*

Tree, 10-15 m., bark purple-red, smooth, peeling off in large flakes. Leaves elliptic-lanceolate, 10-20 cm. long, 4-7 cm. broad, lamina base obtuse to semi-rounded, apex acute, margins reflexed and roughened, upper surface glabrous, under surface at first tomentose, tomentum loose woolly but mature leaves with under surface glabrous, petiole 1-1·5 cm. covered with bristles. Inflorescence compact, rounded, many-flowered; bud-scales and bracts persistent, sticky; pedicels 1-1·5 cm. long; calyx 1-1·5 cm. long, thickened at the base, calyx-lobes irregular, crenulate; corolla campanulate, fleshy, deep crimson or deep red, 3 cm. long, lobes broad, rounded; stamens 10, clustered around the style, anthers purple-black; ovary conoid, 5- to 9-celled, covered with stalked glands, style white, stigma slightly broader than style, pink; capsule oblong-cylindric.

Kumaon to Bhutan, common in Nepal and Sikkim Himalaya at 3000-4000 m. Flowering from March to June and fruiting in October in eastern Himalaya. In western Himalaya flowering in May.

Rh. camelliaeflorum Hook. f. Rhod. Sikkim Himal. t. 28, 1851, et Fl. Brit. Ind. 3: 470, 1882; Stev. Spec. Rhod. 173, 1947; Stainton, Notes, 1964 (mimeograph).

A shrub growing up to 2 m., often epiphytic, branches densely scaly; leaves oblong or elliptic or even narrowly oblong-lanceolate, 5-8 cm. long, 2-3 cm. broad, apex obtusely mucronate, base obtuse, under surface densely scaly, petiole 8 mm. long, densely scaly. Inflorescence terminal, usually two-flowered (sometimes four-), pedicel 4-6 mm. long, densely scaly; calyx deeply 5-lobed, glabrous with a few scales at the base; corolla fleshy, broadly tubular, limbs wide-spreading, throat villous, outside scaly, white tinged with pink; stamens 12 to 16, exserted, filaments pubescent at the base; ovary 10-celled, densely scaly, style stout, stigma rounded; capsule about 1·5 cm. long, ovoid or ellipsoid, densely scaly.

Eastern Nepal to Bhutan at 3000-3700 m.

Rh. campanulatum D. Don in Mem. Wern. Soc. 3:410, 1821; Hook. f. Fl. Brit. Ind. 3: 466, 1882; Stev. Spec. Rhod. 177, 1947; Kitamura in Fauna & Fl. Nep. Himal. 193, 1955; Bonner in Candollea 17: 65, 1959; Stainton, Notes, 1964 (mimeograph).

Nepali name—*nilo chimal*

A large shrub, 4-6 m.; leaves elliptic or oval, 7-15 cm. long, 3-6 cm. broad, apex obtuse often mucronate, lamina base rounded or semi-cordate, upper surface glabrous, bark green, mid-rib grooved, under surface with rusty brown tomentum. Inflorescence of about 8 flowers in a racemose corymb; rachis 2-2·5 cm. long, pedicel 2-2·5 cm. long; calyx small, 1-2 cm.; 5 minute lobes, broadly triangular; corolla campanulate, 4 cm. long, lobes 5, rounded and notched, white, various shades of rosy purple to purple, spotted within; stamens 10, unequal, filaments glabrous but puberulous at the base; ovary 5- to 8-chambered, conoid, glabrous; capsule cylindric more or less curved.

Common in the Himalayas from Kashmir to Bhutan at 3300-4500 m., abundant at about 3700 m. Flowering from May to June, and fruiting in November. This is a very variable species.

var. **wallichii** Hook. f. Leaves elliptic or oblong, tomentum beneath lax, petiole densely woolly.

Rh. campylocarpum Hook. f. Rhod. Sikkim Himal. 30, 1851, et Fl. Brit. Ind. 3: 467, 1882; Stev. Spec. Rhod. 702, 1947; Bonner in Candollea 17: 65, 1959; Stainton, Notes, 1964 (mimeograph).

A small rounded shrub, 1·5-3 m. tall, young branches covered with stalked glands; leaves ovate to shortly elliptic, 5-8 cm. long, 3-5 cm. broad, apex rounded, base cordate to truncate, under surface minutely punctate, leathery. Inflorescence of lax racemose umbels of 6-8 flowers, pedicels 2-3 cm. long, glandular, glands stalked; calyx cupulate, lobes 5, unequal, glandular; corolla campanulate, 4 cm. long, lobes 5, 1·5-2 cm. long, 2-2·5 cm. broad, rounded or emarginate, yellow or bright yellow with faint crimson blotches; stamens 10, unequal, filaments glabrous, puberulous at the base, anther-lobes reddish; ovary 5-celled, conoid, 5 mm. long, densely glandular, style curved, also glandular at the base, stigma broad and lobulate. (Fruit not studied.)

Eastern Nepal and Sikkim at 3250-4500 m. in usually open situations. Flowering in May and fruiting in October.

Rh. ciliatum Hook. f. Rhod. Sikkim Himal. t. 24, 1851, et Fl. Brit. Ind. 3: 470, 1882; Stev. Spec. Rhod. 455, 1947; Bonner in Candollea 17: 65, 1959; Stainton, Notes, 1964 (mimeograph).

Shrub, 2-3 m. high, procumbent on rocks; leaves elliptic, lamina-base rounded, 4-7 cm. long, 2-3·5 cm. broad, upper surface setose, under surface laxly scaly, mid-rib with scattered bristles; petiole

7 mm. long with long hairs. Inflorescence shortly racemose with 2-4 flowers, pedicels densely bristly and scaly; flowers white to rose tinge; calyx 5-lobed, lobes deep, broadly ovate, densely fringed with stiff hairs; corolla broadly funnel-shaped, 3·7-5 cm. long, lobes 5, emarginate; stamens 10, equalling the corolla-lobes, densely pubescent towards the base; ovary 5-celled, scaly, style as long as the corolla, not scaly; capsule about 2 cm. long with persistent calyx.

Eastern Nepal and Sikkim at 3000-4000 m. Flowering in June. No record of fruiting time, probably in October. This species is of rare occurrence in eastern Nepal.

Rh. cinnabarinum Hook. f. Rhod. Sikkim Himal. t. 8, 1849, et Fl. Brit. Ind. 3: 474, 1882; Stev. Spec. Rhod. 222, 1947; Stainton, Notes, 1964 (mimeograph). Nepali name—*sanu chimal*

Shrub 2 m. high, branches purple; leaves ovate-elliptic to broadly oblanceolate, apex rounded or mucronate, 7·5 cm. long, 4 cm. broad, under surface densely scaly, scales small, petiole about 1·5 cm. long, scaly. Inflorescence 5-flowered, terminal, sub-umbellate, pedicels scaly, flowers cinnabar-red or brick-red; calyx 5-lobed, one lobe often longer than the rest; corolla tubular, 5-lobed, 3·5-5 cm. long; stamens 10, slightly exserted, filaments pubescent towards the base; ovary 5-celled, scaly, style slightly longer than the stamens; capsule densely scaly, about 1·5 cm. long.

Eastern Nepal, Sikkim, and Bhutan, at 3300-4000 m. flowering from April to June; fruiting in August to November.

var. **blandfordiaeflorum** (Hook. f.) Millais. Flowers red outside, yellow or greenish yellow within; calyx rim-like. This variety has not been so far reported from Nepal.

var. **roylei** Hook. f. Flowers intense red; corolla more or less open than the other, about 3 cm. long; calyx lobes distinct and nearly equal.

This variety occurs widely in East Nepal.

Rh. cowanianum Dav. in Notes Roy. Bot. Gard. Edin. 21: 99, 1952; Stainton, Notes, 1964 (mimeograph).

Shrub, 1·5 m. high with twigs either sparsely bristled or smooth; leaves obovate or oblong-obovate, apex rounded and pointed, base obtuse or cuneate, 2·3-5·2 cm. long, 1·2-2·4 cm. broad, upper surface densely covered with scales, smooth or with sparse hairs, under surface covered with yellowish green scales, margin with long hairs, petioles 3-4 mm. long with scales and bristles. Inflorescence an umbel or short raceme, 2- to 4-flowered, rachis up to 4 mm. in length, pedicels 1-1·6 cm. long, flowers reddish purple; calyx 5-8 mm. long, lobes rounded or oblong-ovate, scaly on the outside; corolla bell-shaped, about 1·5-1·8 cm. long, lobes 5, smooth or with sparse

scales on the outside; stamens 10, filaments 1-1·4 cm. long, unequal, hairy at the base; ovary 4 mm. long, densely covered with scales, style short; capsule 6-8 mm. long, scaly with persistent calyx.

This species is of very limited distribution and is regarded as an endemic element in Nepal, for so far it is known from Khumbu and Langtang in eastern Nepal at 3150 m. Flowering in March or April?

Rh. dalhousiae Hook. f. Rhod. Sikkim Himal. t. 2, 1849, et Fl. Brit. Ind. 3: 469, 1882; Stev. Spec. Rhod. 492, 1947; Bonner in Candollea 17: 66, 1959; Stainton, Notes, 1964 (mimeograph).

Nepali name—*lahara chimal*

Epiphytic, laxly branched or a shrub, 2-3 m. high; leaves obovate to oblanceolate, apex obtuse, base cuneate, 6-15 cm. long, 2·5-6 cm. broad, under surface rather densely scaly. Inflorescence about 5-flowered, pedicels softly pubescent, flowers white tinged with rose outside, fragrant; calyx deeply 5-lobed, lobes oblong not ciliate along the margin; corolla funnel-shaped, about 8·5 cm. long, lobes 5, broad, tube glabrous on the outside except for a few scales; stamens 10, filaments pubescent, anthers large and massive, about 1·5 cm. long; ovary 5-celled, densely scaly, style scaly for its lower two-thirds; capsule 3·5 cm. long with persistent calyx.

Eastern Nepal, Sikkim, and Bhutan, at 2000-2700 m. Flowering in May and June; fruiting in October and November.

Rh. falconeri Hook. f. Rhod. Sikkim Himal. t. 10, 1849, et Fl. Brit. Ind. 3: 465, 1882; Stev. Spec. Rhod. 244, 1947. Nepali name—*korlinga*

A large shrub or tree, 14-16 m. high, old branches with flaking bark, young shoots with grey tomentum, leaves oblong-oval to elliptic or broadly obovate, 20-30 cm. long, 5-15 cm. broad, apex obtuse-rounded, base subcordate, upper surface rugulose, under surface with dense rusty tomentum, petioles 4-6 cm. long, slightly grooved, covered with thin grey tomentum. Inflorescence a compact corymb of 20 or more flowers, pedicels 4-5 cm. long, tomentose, flowers creamy white, yellow with purple spots on the throat; calyx small, 8-lobed, lobes small, tomentose; corolla oblique-campanulate, lower surface ventricose, lobes 8-10, usually 8; stamens 12-16, about 4·5 cm. long, filaments slightly puberulous at the base; ovary 16- to 18-celled, 8-10 mm. long, covered with glands and branched hairs, style stout, glabrous, exserted in fully open flower, stigma discoid; capsule large, woody, obliquely set, 4-6 cm., ridged and warted.

From eastern Nepal to Bhutan, at 3300-4300 m. Flowering from April to June, fruiting in October to December.

Rh. fulgens Hook. f. Rhod. Sikkim Himal. t.27, 1851, et Fl. Brit. Ind. 3:466, 1882; Stev. Spec. Rhod. 178, 1947; Stainton, Notes, 1964 (mimeograph). Nepali name—*chimal*

A rounded shrub, 2-3 m. high, branched, leaves oblong-oval to broadly obovate, 6-11 cm. long, 5-7 cm. broad, apex rounded, base rounded or slightly cordate, upper surface glossy, under surface covered with dense tawny woolly tomentum, petiole 1·5-2·5 cm. long, bright green. Inflorescence of 10-12 flowers in a compact rounded truss, pedicels 1 cm. long; flowers deep red or scarlet; calyx small with 5 broadly rounded lobes; corolla tubular-campanulate, fleshy, about 3 cm. long, 4·5 cm. across, 5 black-red nectaries in basal pouches, lobes 5, slightly notched; stamens 10, unequal, turned at the tips, filament white, anther chocolate-brown; ovary 8-celled, 5 mm. long, glabrous, stigma black, truncate; capsule slightly curved, 3 cm. long, 1 cm. broad at base.

Eastern Nepal and Sikkim, at 4000-4700 m. Flowering in May.

Rh. glaucophyllum Rehder in Journ. Arn. Arb. 26: 73, 1945; Stainton, Notes, 1964 (mimeograph). *Rh. glaucum* Hook. f. Rhod. Sikkim Himal. t. 17, 1851, et Fl. Brit. Ind. 3: 471, 1882; Stev. Spec. Rhod. 300, 1947.

Small shrub with scaly branchlets, leaves lanceolate to oblanceolate, 3·7-8·5 cm. long, 1-2·5 cm. broad, apex pointed and mucronate, upper surface dull, lower surface glaucous and scaly, petioles 6-10 mm. long, scaly. Inflorescence 5- to 6-flowered, flowers pink; calyx large, 5 ovate-lanceolate lobes, apex pointed; corolla 5-lobed, 1-1·4 cm. long; stamens 10, exserted; ovary 5-celled, scaly, becoming gradually thicker towards the apex, stigma large and lobulate; capsule short, ovoid, 8 mm. long, covered with persistent calyx.

Previously known from Sikkim only at 3045-3650 m. Stainton's report is the first record from Nepal.

Rh. grande Wight in Calcut. Journ. nat. Hist. 8: 176, 1847; Hook. f. Fl. Brit. Ind. 3: 464, 1882; Stev. Spec. Rhod. 310, 1947.

A tree, 10 m. tall, branched and spreading, bark reddish brown, peeling off in small scales, leaves oblong-lanceolate to oblanceolate or oblong-elliptic, 14-30 cm. long, 8-13 cm. broad, apex obtuse to acuminate, base narrowed, obtuse to cuneate, primary veins deeply impressed, under surface silvery white, with a thin indumentum, petiole 4-5 cm. long, slightly grooved above, with a thin whitish indumentum. Inflorescence a large rounded corymb of 20-25 flowers, rachis 4-5 cm. long, becoming lengthened in fruit, pedicels 2-3 cm. long; calyx short, 8 undulate lobes, 1-2 mm. long; corolla ventricose-campanulate, pale rose in bud but later white or creamy white with basal purple blotches, 5- to 8-lobed, 5-7 cm. long; stamens 16, unequal, 3·5-5 cm. long,

filaments white, pilose or glabrous; ovary oblong, densely glandular, 16-chambered, style stout, stigma large and discoid; capsule 3 cm. long, curved.

Temperate regions of east Nepal, Sikkim, and Bhutan, at 2700-3300 m., forming forests. Flowering from February to May; fruiting in December and January.

Rh. hodgsonii Hook. f. Rhod. Sikkim Himal. 16, t. 15, 1851, et Fl. Brit. Ind. 3 : 464, 1882; Stev. Spec. Rhod. 247, 1947; Bonner in Candollea 17 : 66, 1959; Stainton, Notes, 1964 (mimeograph).

Nepali name—*korlinga*

A small tree, 4-6 m. tall, branches arising from the base, leaves oblong-elliptic to broadly oblong-oblanceolate, 18-30 cm. long, 7-12 cm. broad, apex obtuse to rounded, base obtuse to rounded, under surface clothed with grey indumentum; petiole 5 cm. long, covered with thin indumentum. Inflorescence of 15 to 20 flowers in a compact rounded umbel; flowers dark magenta-purple fading to magenta-lilac; pedicels 3-4 cm. long, densely tomentose; calyx a short cup with 7 teeth; corolla tubular campanulate fleshy, 3-4 cm. long, lobes 7-8; stamens 16 (15-18); ovary 9- to 12-celled, oblong-conoid, 7 mm. long, tomentose, style glabrous; capsule 4 cm. long.

Eastern Nepal to Bhutan, at 3300-4000 m. altitude. Flowering May to June, fruiting in October to January.

Rh. hypenanthum Balf. f. in Notes Roy. Bot. Gard. Edin. 9 : 291, 1916; Stev. Spec. Rhod. 8, 1947; Bonner in Candollea 17 : 66, 1959.

Shrub, branchlets short and twiggy, leaves narrowly obovate-elliptic, 2·5-4 cm. long, 1·3-2·5 cm. broad, apex obtusely mucronate, base rounded to slightly cuneate, under surface densely scaly. Inflorescence terminal as in *Rh. anthopogon*, flowers yellow; calyx as in *Rh. anthopogon* but lobes more densely hairy; other characters as of *Rh. anthopogon*.

Along the Himalayas from 3700 to 5300 m. altitude. Flowering June, fruiting in October to November.

Rh. lepidotum Wall. ex Royle, Ill. Bot. Himal. 260, t. 64, 1835; Hook. f. Fl. Brit. Ind. 3 : 471, 1882; Stev. Spec. Rhod. 442, 1947; Kitamura in Fauna & Fl. Nep. Himal. 193, 1955; Bonner in Candollea 17 : 66, 1959; Stainton, Notes, 1964 (mimeograph).

Nepali name—*bahle sunpati* or *saluma*

Small shrub, 1-1·5 m. tall, branches warty, leaves narrowly oblanceolate, 2·5-4 cm. long, under surface densely covered with more or less fleshy scales. Inflorescence terminal, 3- to 4-flowered, pedicels slender about 2 cm. long, densely glandular, flowers pale or greenish yellow or pink or purple; calyx deeply 5-lobed, lobes scaly on

the outside; corolla shortly tubular, broad, about 2·5 cm. in diam., 5-lobed, densely scaly-glandular outside; stamens 8 rarely 10, exserted, filaments hairy below; ovary 5-celled, scaly, style short and thick; capsule 1 cm. long, densely scaly, covered by the persistent calyx.

Along the Himalayas—Kashmir to Bhutan, at 3100-5000 m. Flowering in June, fruiting in October and November.

Rh. lindleyi T. Moore in Gard. Chron. 364, 1864; Stev. Spec. Rhod. 494, 1947; Stainton, Notes, 1964 (mimeograph).

Nepali name—*lahara chimal*

Epiphytic, leaves elliptic to elongate-oblong, 6-15 cm. long, 1·8-3 cm. broad, rounded at both the ends, under surface glaucous and laxly lepidote, petioles 8-12 mm. long. Inflorescence of 4 to 6 flowers, flowers white to pale yellow and slightly scented, very large; calyx 5-lobed, 1·6 cm. long, lobes broadly oblong-elliptic, densely fringed with soft hairs; corolla 7·5 cm. long, widely tubular, lobes 5, rounded; stamens 10; ovary 5-celled, densely scaly; capsule 5 cm. long, lepidote and covered by the persistent calyx.

Eastern Nepal, Sikkim, and Bhutan, at 1825 to 3045 m. Flowering from April to June, fruiting in December and January. This species is often confused with *Rh. dalhousiae*.

Rh. lowndesii Dav. in Notes Roy. Bot. Gard. Edin. 21 : 99, 1952; Kitamura in Fauna. & Fl. Nep. Himal. 193, 1955.

Nepali name—*barjhum mendo*

A low creeping shrub, 10 cm. high, twigs slender, hairy, sparsely or moderately covered with scales, leaves obovate or oblanceolate, 1·3-2 cm. long, 5-11 mm. broad, apex rounded and pointed, base obtuse or cuneate, upper surface with or without scales, under surface sparsely covered with hairs and yellowish-green scales, margin hairy. Inflorescence 1- to 2-flowered, flowers pale yellow or yellow, pedicel slender, 2·5-4·3 cm. long with hairs and scales; calyx 5-lobed, 2-5 mm. long, lobes rounded, ovate or oblong-ovate, scaly on the outside, hairy along the margins, dark red; corolla 1·4-1·7 cm. long, rounded and bell-shaped, red-spotted towards the base, scaly on the outside; stamens 10-11, unequal, 7-10 mm. long, exserted, filaments downy; ovary cone-shaped, 2-3 mm. long, densely scaly, style short and much curved.

This also is an endemic species in Nepal and is known from central Nepal at 2500-3650 m., growing under the shade of boulders. Flowering in June.

Rh. nivale Hook. f. Rhod. Sikkim Himal. 29, t. 26B, 1851, et Fl. Brit. Ind. 3: 472, 1882; Stev. Spec. Rhod. 416, 1947; Bonner in Candollea 17: 66, 1959; Stainton, Notes, 1964 (mimeograph).

Low prostrate shrub, forming cushions, branchlets densely scaly,

leaves elliptic, very small, less than 6 mm. long, both surfaces densely scaly. Inflorescence 1-flowered, terminal; pedicels very short, scaly, flowers bright magenta; calyx 3 mm. long, lobes slightly unequal; corolla open, tube very short, deeply lobed, lobes slightly scaly on the outside, tube villous within; stamens 10, exserted, filaments pubescent towards the base; ovary 5-celled, scaly, style curved, exceeding the stamens; capsule ovoid, 4 mm. long, scaly.

Eastern Nepal, extending westwards as far as Langtang; also Sikkim and southern Tibet, at 4700-5400 m.

Rh. pendulum Hook. f. Rhod. Sikkim Himal. t. 13, 1849, et Fl. Brit. Ind. 3: 469, 1882; Stev. Spec. Rhod. 232, 1947; Stainton, Notes, 1964 (mimeograph).

Epiphytic shrub with pendulous branches, young branches densely woolly, leaves elliptic to oblong-elliptic, 3-5 cm. long, 2-3 cm. broad, apex mucronate, base obtuse, under surface woolly tomentose and glandular-punctate. Inflorescence 2- to 3-flowered, terminal, flowers white, slightly yellow inside, pedicels densely woolly; calyx deeply lobed, lobes reddish, densely fringed with hairs; corolla shortly tubular, lobes 5, spreading, loosely scaly on the outside; stamens 10, slightly exserted; ovary 5-celled, bristly hairy, style reddish; capsule 1·5 cm. long, scaly.

Eastern Nepal and Sikkim, at 3300-4000 m. Flowering in May, fruiting in November?

Rh. pumilum Hook. f. Rhod. Sikkim Himal. t. 14, 1849, et Fl. Brit. Ind. 3: 471, 1882; Stev. Spec. Rhod. 444, 1947; Stainton, Notes, 1964 (mimeograph).

A small shrub, 8-20 cm. high, branchlets semi-prostrate, leaves subsessile, small, obovate-elliptic, 1-1·8 cm. long, 4-8 mm. broad, apex mucronate, base rhomboid, upper surface glabrous, under surface with scattered scales. Inflorescence usually 3-flowered, flowers rose-coloured or pink, pedicels 2·5-3 cm. long; calyx deeply lobed, lobes 5, ovate-oblong, obtuse, purplish, sometimes scaly, persistent; corolla widely funnel-shaped, 1·2-1·8 cm. long, shortly 5-lobed, pink or rose-coloured; stamens 10, filaments hairy below; ovary 5-celled, densely scaly abruptly contracted into the style; capsule ovate-oblong, erect, 1 cm. long.

Eastern Nepal, Sikkim, and southern Tibet, at 3600-2470 m. Stainton's report of the species is the first from Nepal. No data available on flowering and fruiting times.

Rh. setosum D. Don in Mem. Wern. Soc. 3: 408, 1821, et Prodr. Fl. Nep. 152, 1825; Hook. f. Fl. Brit. Ind. 3: 472, 1882; Stev. Spec. Rhod. 428, 1947; Kitamura in Fau. & Fl. Nep. Himal. 194,1955;

Bonner in Candollea 17: 67, 1959; Stainton, Notes, 1964 (mimeograph).

A small shrub 30 cm. high, branches densely setose, leaves oblong-elliptic, 8-15 mm. long, 6 mm. broad, glandular-scaly on the upper surface, under surface densely scaly and setose, petioles bristly. Inflorescence 3-flowered, terminal, flower bud-scales deciduous, flowers bright purple or pink; calyx 6 mm., lobes scaly, reddish; corolla funnel-shaped, lobes not scaly; stamens 10, exserted, filaments pubescent towards the base; ovary 5-celled, densely scaly, style reddish; capsule ovoid, hardly exceeding the persistent calyx.

Eastern Nepal, Sikkim, and southern Tibet at 3700-5300 m. Flowering in April to June, fruiting October to November.

Rh. thomsonii Hook. f. Rhod. Sikkim Himal. 13,t.12,1851, et Fl. Brit. Ind. 3: 468, 1882; Stev. Spec. Rhod. 745, 1947; Stainton, Notes, 1964 (mimeograph).

A large shrub, 3-5 m. tall, usually bushy, leaves broadly elliptic (orbicular), 4-8 cm. long, 3-6·5 cm. broad, apex rounded or bluntly mucronate, base round, mid-rib slightly grooved, upper surface glaucous but later glabrous, under surface with prominent mid-rib, whitish to pale green, petiole 1-2 cm. long. Inflorescence a loose corymb of 6 to 8 flowers, flowers deep blood-red; calyx 1-2 cm. long, cupulate, lobes rounded or truncate, obscurely unequal; corolla campanulate, 5-6 cm. long, fleshy, spotted on the posterior side, lobes 5, broad, emarginate; stamens 10, filaments unequal, glabrous; ovary 6- to 10-celled, conoid-cylindric, furrowed, 7 mm. long, style glabrous; capsule truncate, encased in the enlarged and persistent calyx.

Eastern Nepal and Sikkim, at 3700-4400 m. In Fl. Brit. Ind. two varieties are mentioned, but the differentiating characters are not very clearly marked out. No reliable data on flowering and fruiting times, but it is presumed that flowers appear in April to June and accordingly fruiting in November to January.

Rh. trichocladum Franch in Bull. Soc. Bot. Fr. 33: 234, 1886; Stev. Spec. Rhod. 757, 1947; Stainton, Notes, 1964 (mimeograph).

A shrub, 1 m. high, branches covered with long hairs, leaves oblong, 3·5-4 cm. long, 8-10 mm. broad, apex mucronate, upper surface pubescent, under surface minutely scaly, margin hairy, petiole 4 mm. long. Inflorescence terminal, 3- to 5-flowered, flowers greenish yellow, spotted with dark green, pedicels 8 mm. long, densely scaly; calyx lobes 5, oblong-lanceolate, densely fringed with long hairs; corolla funnel-shaped, 2·5 cm. long, lobes 5; stamens 10, shortly exserted; ovary conoid, scaly, style bent; capsule 6 mm. long, scaly.

This species is present in western Yunnan at 2300-3045 m. but Stainton reports the occurrence of this species in Nepal—upper Arun (27° 45′ N., 87° 15′ E.); thus its occurrence in Nepal is of great interest.

Rh. triflorum Hook. f. Rhod. Sikkim Himal. 20, t. 19, 1851, et Fl. Brit. Ind. 3: 474, 1882; Stev. Spec. Rhod. 791, 1947; Bonner in Candollea 17: 67, 1959; Stainton, Notes, 1964 (mimeograph).

Nepali name—*phenla chimal*

Shrub, 2·5 m. high, branches with black glands, leaves lanceolate or oblong-lanceolate, 3-8 cm. long, 1·5-3 cm. broad, apex acute, base obtuse or rounded, upper surface glabrous, under surface densely scaly-glandular, petioles 6 mm. long, scaly. Inflorescence 3-flowered, terminal, flowers light yellow, green spotted, fragrant, pedicels 8-10 mm. long, scaly; calyx small, 5-lobed, lobes scaly outside, fringed with a few short hairs; corolla short, campanulate, corolla tube densely scaly on the outside; stamens 10, exserted, filaments densely woolly towards the base; ovary 5-celled, densely scaly; capsule 1·8 cm. long, covered with scales.

Eastern Nepal, Sikkim, and Bhutan, at 2700-3100 m. Flowering May to July and fruiting in November to January.

Rh. vaccinioides Hook. f. Rhod. Sikkim Himal. 3, 1851, et Fl. Brit. Ind. 3: 464, 1882; Stev. Spec. Rhod. 825, 1947; Stainton, Notes, 1964 (mimeograph).

A shrub, 0·3-1 m. high, epiphytic and on rocks, branches densely rugose with wart-like glands, leaves small, scattered, spathulate-oblanceolate, 1·6 cm. long, 6 mm. broad, apex emarginate and mucronate, base attenuated, under surface glandular-scaly, petiole, very short. Inflorescence 1- to 2-flowered, pedicels 1.2 cm. long, glandular, flowers lilac-pink; calyx lobes ovate-oblong, 3 mm. long; corolla 5-lobed, 8 mm. long, lobes wide-spreading, round or obovate, white or lilac-pink; stamens 10, filaments densely hairy; ovary 5-celled, ovoid, scaly not hairy, gradually passing into the thick style, stigma clavate; capsule 2·5 cm. long, valves recurved to their bases, seed with a tail at each end.

Previously known from Sikkim at 1830-2200 m. and south-east Tibet at 2435-3650 m. Stainton's report from east Nepal is the first for the area. Flowering in June and July, fruiting in November and December.

Rh. virgatum Hook. f. Rhod. Sikkim Himal. t. 26, 1851, et Fl. Brit. Ind. 3: 474, 1882; Stev. Spec. Rhod. 831, 1947; Stainton, Notes, 1964 (mimeograph).

A shrub, 1-1·3 m. high, branchlets scaly, leaves scattered, narrowly oblong or broadly lanceolate, 5·5 cm. long 1·5 cm. broad, apex acute,

base broadly obtuse, upper surface glabrous or glandular-punctate, under surface glandular-scaly, petioles 6 mm. long. Inflorescence of solitary axillary flowers, pedicels 6-8 mm. long, several large caducous bracts, flowers purple or pale purple; calyx 5-lobed, small, ovate; corolla lobes 5, spreading, 8 mm. long, purple or pale purple; stamens 10-8, exserted; ovary 5-celled, densely scaly; capsule oblong, 1-1·2 cm. long.

Known from Sikkim and Bhutan, at about 2750 m., but Stainton's report from upper Arun is the first for Nepal. Exact flowering and fruiting time not known.

Rh. wightii Hook. f. Rhod. Sikkim Himal. t. 27, 1851, et Fl. Brit. Ind. 3: 467, 1882; Stev. Spec. Rhod. 386, 1947; Kitamura in Fauna & Fl. Nep. Himal. 194, 1955. Nepali name—*radu*

A small tree, 2-3·5 m. tall, young branches grey-floccose, older branches glabrous, leaves leathery, oblong-elliptic to oblong-obovate or oblanceolate, 12-18 cm. long, 5-7 cm. broad, apex obtuse or acute, base rhomboid or semi-rounded, upper surface bright green, under surface cinnamon or rufous or even greyish, petioles 1·5-2·5 cm. long. Inflorescence a rounded umbel of 12-18 flowers, flowers pale-yellow, heavily blotched crimson, bud-scales hard and viscid, persistent, pedicels 3-4 cm. long; calyx very small, 5-lobed; corolla campanulate, broad at the base, lobes 5, 1·5 cm. long, 2 cm. broad, deeply notched; stamens 10, filaments 2-3 cm. long; ovary 10-celled, conoid, densely tomentose, style glabrous, stigma discoid; capsule cylindric and slightly curved.

Nepal, Sikkim, and Bhutan, at 3100-4700 m. Flowering in May and June, fruiting time presumed to be in October and November.

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The Indian Wild Buffalo, *Bubalus bubalis* (Linn.), in peninsular India: a preliminary survey

BY

J. C. DANIEL
Curator

AND

B. R. GRUBH
Research Assistant
Bombay Natural History Society

(*With four maps and two plates*)

CONTENTS

INTRODUCTION

The former princely State of Bastar in eastern peninsular India (now a district of Madhya Pradesh State) and the adjoining areas of Orissa and Maharashtra, by their remoteness and inaccessibility, form the last stronghold of the Indian Wild Buffalo in peninsular India. However, conditions are deteriorating even in these remote regions and the Government of Madhya Pradesh concerned at the yearly decline in the number of the Buffaloes through disease and poaching consulted the Bombay Natural History Society about the possibility of shifting, for better protection, the remaining herds in Bastar to the Kanha National Park in

Mandla District to which area Buffaloes were monsoon migrants in earlier days.

The Society, after consulting its knowledgeable members and Dr. George Schaller, the American Ecologist, who was working on a project in the Kanha Sanctuary, advised that moving the population would not be practicable considering the difficulties involved in capture and transport and the fact that the animals in their new environment would not be free from the causes of their decline in the present habitat. It was suggested to the State Government that what was required immediately was an assessment of the ecological factors of the present environment which permit continued existence in the area and the measures required to preserve these environmental conditions.

On the State Government's approval of this suggestion and offer of financial and other assistance, it was decided to survey the area in April-May 1965 when the Wild Buffalo would be restricted to areas with perennial sources of water in its habitat. Dr. Schaller, who had very kindly offered to accompany the party, was able to join us in the first fortnight of April, and the Survey was conducted in the first three weeks of April in Bastar, and in adjoining tracts of Orissa in the last week of April.

General Account of the Survey

The Secretary to the Government of Madhya Pradesh in the Department of Agriculture and Forests had sent to the Society a list of localities in Bastar where Buffaloes are known to occur and it was arranged by the Forest Department to have us commence the survey in the Bhairamgarh Range of West Bastar Forest Division, the area believed to hold the largest concentration.

Bastar is one of the few areas in India where the railway has not penetrated, and Jagdalpur, the district headquarters and former state capital, is 180 miles by road from Raipur, the most convenient rail-head.

We reached Raipur on the evening of 1 April 1965 and after staying overnight left by road for Jagdalpur the next morning, reaching Jagdalpur in the evening of 2 April. After discussions with Dr. Schaller we met Mr. Bhil, Divisional Forest Officer, West Bastar Forest Division, where the first camp was scheduled. We left early on 3rd April for Kutru our camp for the next eight days.

Camp Kutru, April 3-11

Kutru, the headquarters of a former zamindari is a small forest village situated on the border of the Toinar and Bhairamgarh Forest Ranges of West Bastar Forest Division. These two contiguous ranges hold the major part of the population of the Buffaloes in Bastar and have

the characteristic habitat of the species in peninsular India which though river-orientated is quite different from the purely riverain and grass land habitat of the animal in eastern India (Assam), being Sal or Deciduous Forest of mixed species (in Kutru, it is only the latter) with grass undergrowth interspersed with nullahs and fairly open grounds—the maidans—with tall grass.

The main geographical feature is the beautiful Indravati River which flows through these Ranges from east to west and forms, at the western limits of Toinar Range, the north boundary of the Range before looping to the south to form the western boundary of the Range and the district.

The river is perennial and is studded with forest-covered islands and occasional patches of sparkling white sand. The Bhairamgarh Range is divided into nearly equal halves by the river. The northern half is a part of the Abujhmar Hills, the home of the hill Marias and is not a normally suitable habitat for Buffalo except along the banks of the Indravati and perhaps along the banks of the numerous tributaries which drain the hills ; similarly the part of the Toinar Range on the north bank of the river. South of the river, the tract is comparatively flat with occasional hill formations and numerous nullahs and is covered with good quality mixed forests. The main road from Jagdalpur to Bhopalpatnam, the easternmost town of some importance in the district, runs parallel to the river up to Matwada in Bhairamgarh Range before turning south. From Matwada a forest road continues parallel to the river to the border of Toinar Range and, turning south at Pasewada, continues parallel to the river before turning east to rejoin the west road at Kutru. The west road from Matwada to Pasewada forms the south boundary of the summer range of the buffalo. The distance between the road and the river varies from approximately four to ten miles.

The camp at Kutru was located in an ancient grove of mango trees facing a large pond covered with water lilies, among which Bronzewinged Jaçanas (*Metopidius indicus*) and a large flock of Lesser Whistling Teal (*Dendrocygna javanica*) scrambled for food during the day. The location of the camp in the middle of the summer range, a survey area of approximately 400 square miles of forest between the river and the road, was advantageous. From discussions with the Forest staff we gathered that the Buffaloes, though now confined to the river, would not be as easy to locate as they are when they occupy less remote localities in the monsoon and in the winter. In view of the short time available to us it was decided to transect areas which, according to local information, Buffaloes frequent and where they had been seen recently. Seven such transects were made between 4 to 11 April covering the whole strip of forest north of the road between Matwada and Pasewada. South of the road, Tekametta Reserve Forest on the east bank of the river in Toinar Range and Gudma Reserve Forest south of Kutru were also visited.

Comments on the Transects

During the seven transects that we made in the area (see Table I) we were able to sample a substantial portion of the Buffalo habitat (Map I) and could form an opinion on the status of the Buffalo in the area. It was evident that very little was known of the distribution of the animal in summer[1]. Some of the areas visited by us were selected on the

TABLE I

TRANSECT DATA OF THE THREE WILD BUFFALO AREAS SURVEYED

Transect No.	Date	Route	Approximate distance walked (miles)	Buffalo tracks seen: solitary	approximate herd strength	total	Buffaloes seen
WEST BASTAR							
I	4 April	Pathakutru-Berabasti-Kutru	10-12	2	—	2	10
II	5 April	Jegur-Indwada-Dodum-Jegur	12-14	2	12	14	—
III	6 April	Matwada-Ider-Matwada	12-14	3	16 (10, 6)	19	—
IV	7 April	Gudma Reserve Forest	5-6	1	—	1	—
V	8 April	Museli-Bitre-Karkeli-Karpe-Madhpur-Dudapalli	12-14	2	12 (4, 8)	14	—
VI	9 April	Karkewada-Nelkakler-Pengonda-Pasewada	10-12	5	5	10	—
VII	10 April	Tekametta-Jarguda-Tekametta	4-5	—	—	—	16
				15	45	60	26
SOUTH BASTAR							
I	15 April	Pamed-Koragatta border	10-12	1	10	11	—
II	16 April	Rampuram-Pusgupa-Dharamvaram-Rampuram	12-14	—	—	—	—
ORISSA							
I	26 April	Chitrakonta-Kondakamberu-Bandamamidi-Chitrakonta	5-6	—	3	3	3

NOTE. Tracks probably did not exceed 24 hrs. in age.

[1] The seasons as described in this report are Summer—(March to May); Monsoon—(June to October); Winter—(November to February).

strength of local information based on sightings during the rains and in winter when the animals are found in a large area as water and food are easily available. In summer the Buffalo is restricted to the narrow strip between the river and the road from Matwada to Pasewada, frequenting areas undisturbed by man, with good cover and water, out of which it ventures at night to feed on the tender new grass and bamboo shoots growing in burnt areas. During the seven days we walked through the forest we saw only two herds. In the same period we saw 30 Chital, 2 Nilgai, and 7 Fourhorned Antelopes and, from our observations of the herds we saw, it did not appear to us that Buffalo is in any way shyer than these species. However large mammals are scarce in West Bastar, and apart from those listed above we twice saw fresh tracks of gaur and tiger.

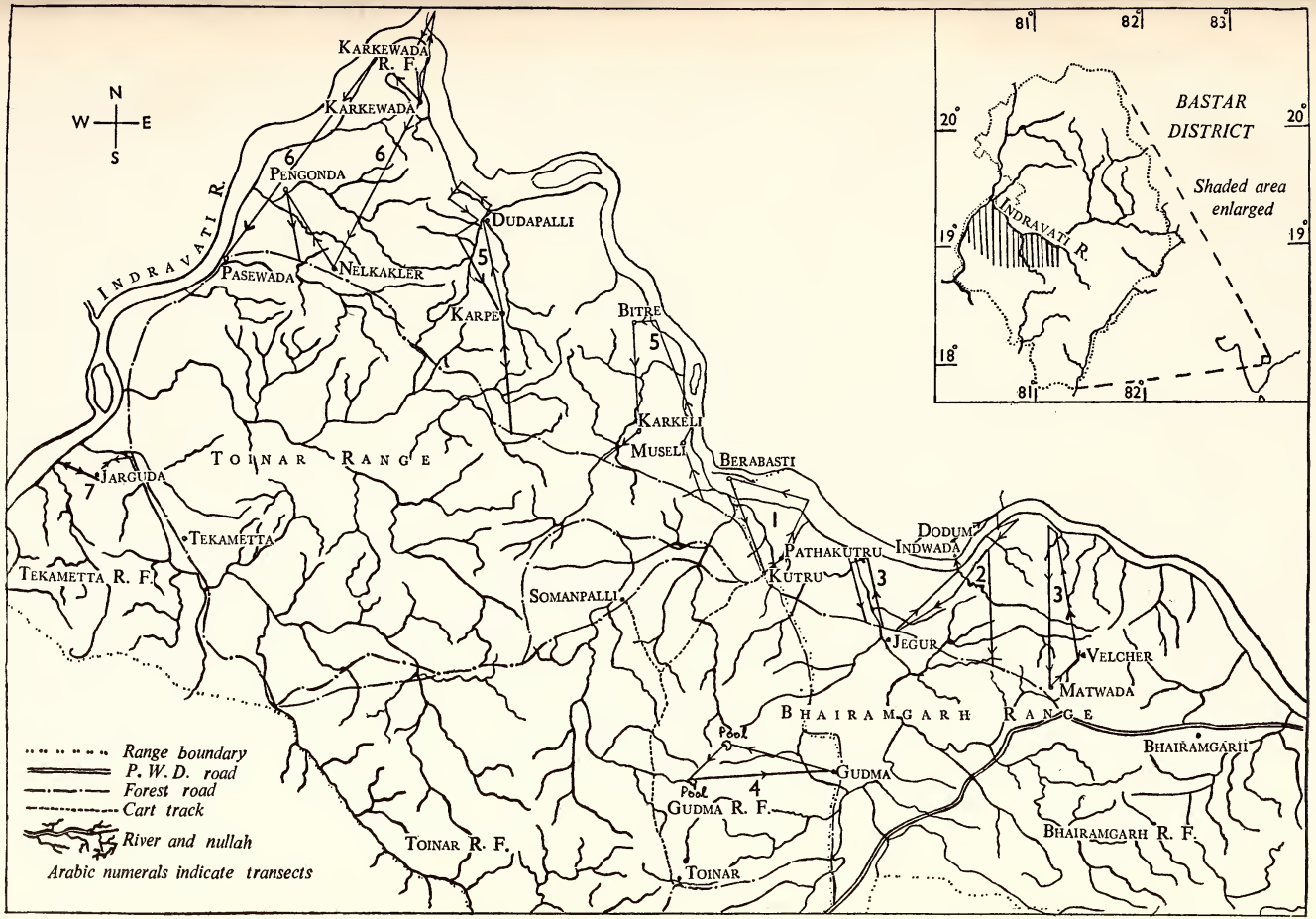
April 11 *to April* 14

After breaking camp at Kutru on April 11 we reached Pujarikaker in Awapalli Range in the south of West Bastar Forest Division on the evening of 14 April.

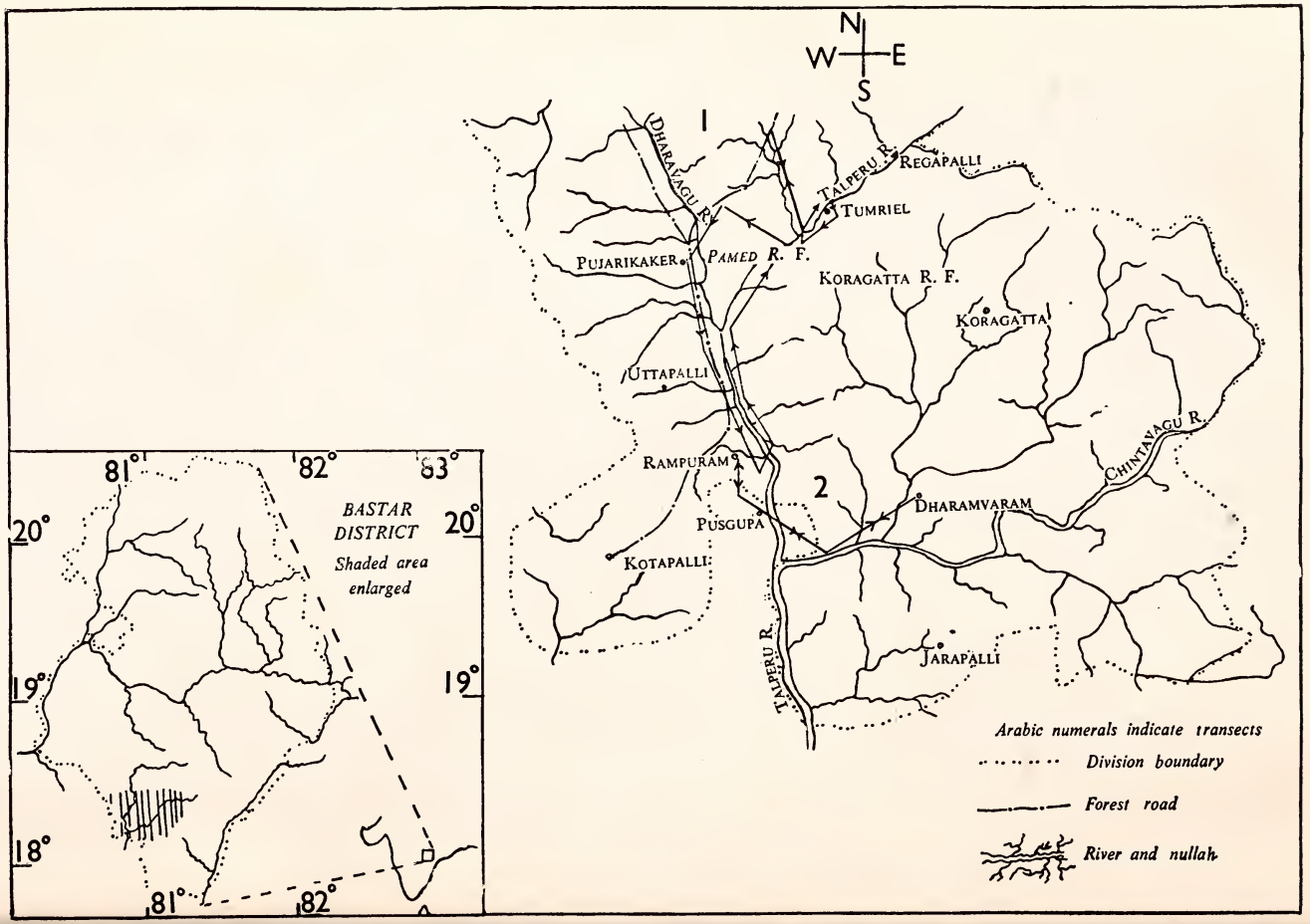
Awapalli Range, West Bastar Forest Division, April 14-17

The Pamed and Koragatta Reserve Forests of Awapalli Range and the adjoining Konta and Kistaram Range Forests of South Bastar Forest Division hold the southern population of the Buffalo in Bastar. The Awapalli Range lies in the riverain tract of South Bastar, separated in the east from the Warangal District of Andhra Pradesh by the Albaka Hills. The main river is the Talperu, a perennial stream arising at nearly 4000 ft. on the Bailadila Ridge and draining the west face of Bailadila Hills, the east face of Albaka Hills, and Golapalli Hills in the south-east by its tributaries before joining the Godavari River near Cherla in Andhra. The Talperu forms the south and west boundaries of Pamed and its tributaries Dharavagu and Kongavagu a part of its east and west boundaries. The larger Koragatta Reserve has the Talperu as its east and north boundaries and a main tributary, the Chintavagu, as a part of its south boundary. In the west the Reserve has a common boundary with the Konta and Kistaram Ranges of South Bastar Forest Division. The Koragatta Reserve is uninhabited except along its borders and is not usually visited by Forest personnel as the forest is not worked. The forests in both reserves are drier than the habitat in the west and the whole area is deficient in water. The Talperu River remains the main source of water in summer and the Buffaloes remain mainly in Koragatta during the season.

We made two transects (Table I and Map II) in the area, one covering Pamed and the Pamed-Koragatta border and the second the south border of Koragatta Reserve. We were unable to penetrate Koragatta Reserve owing to lack of roads and persons with knowledge of trails in the area.



Map 1. Transects in west Bastar



Map 2. Transects in south Bastar

Comments on Transects

The two transects we made gave us an indication of the conditions in the habitat in the south. In the Pamed Reserve the grass undergrowth was either burnt or grazed to the roots by large itinerant herds of Banjara[1] cattle, several herds of which were passing through the Pamed area at the time of our visit and in the disturbance from their movement wild life had shifted to the west bank of the Talperu into the Koragatta Reserve. The local villagers believed that there were only a herd of 10 to 11 animals and 2 to 3 solitaries in their area, an opinion which agrees more or less with the track counts we made (see Table I). The Koragatta Reserve, particularly to its north, appears to be the summer sanctuary of the herds but no one appears to have personal information. South of Koragatta and Pamed, the country towards Andhra Pradesh is more populous and dry and is overgrazed so that it is most unlikely that Buffaloes now occur in Andhra Pradesh.

South Bastar, April 17-22

On completing the survey of the Awapalli Range we had planned to shift camp by the shortest route through Cherla and Dumagudem in Andhra Pradesh to Golapalli in South Bastar Division. Unfortunately the car developed engine trouble and it was not considered wise to take it over the road to Cherla which was in poor condition. Another two days were lost in the return to Jagdalpur, in arranging for another vehicle, and in the journey to Konta in south Bastar on 19 April. The road to the south runs through beautiful sal forests at the beginning but turns to dry deciduous further south, becoming very dry near Konta. We saw two large parties of Gonds on *Parad*, their communal hunt, during the journey. We stayed overnight at Konta and a pleasant hour's drive the next morning over low forest-covered hills brought us to the village of Golapalli, the headquarters of the Golapalli and Kistaram Ranges of the South Bastar Forest Division. In discussions with the Range Officers of Kistaram and Golapalli we learnt that Buffaloes are not seen in their Ranges in summer, when there is considerable difficulty for water and large herds of cattle from Andhra are permitted to graze in the forests. In their opinion Buffaloes do not occur south of Potakpalli village 15 miles north of Kistaram village even in the rains but frequent the extreme north of Kistaram Range in the vicinity of Elmagonda and Kolaiguda villages adjoining Koragatta Reserve of Awapalli Range, W. Bastar. The Range Officer, Kistaram, had seen a herd of 15 to 17 animals between Elmagonda and Kolaiguda villages in 1963, and in March 1965 a solitary bull was seen on the road from Elmagonda to Potakpalli. A visit to

[1] Banjaras, once indispensable as carriers and used as such by all the armies which campaigned in the Deccan and central India, are now mainly cattle traders.

Elmagonda area 25 miles north of Golapalli proved fruitless. We started back for Jagdalpur from Golapalli on 22 April, reaching Jagdalpur the same evening. Transport was not available to visit the Paralkote and Makdi areas in north Bastar which had been listed by the State Government as holding Buffaloes. It was a great disappointment to us that we were unable to survey these areas.

Orissa, April 24-27

On 23 April, while we were still uncertain whether transport would be available to us to visit north Bastar, we received a letter from Mr. Ahmedulla, Conservator, Jeypore Circle, inviting us to visit Buffalo habitats in his Circle.

We reached Jeypore on the 24th morning and arrived the same evening at Chitrakonta in the valley of Kondakamberu, the main habitat of the Buffalo.

Kondakamberu used to be a forsaken little Police Outpost with a few attendant huts in a high and narrow valley of the Jeypore Hills in the Koraput District of Orissa. Through the valley, surrounded on all sides by hills covered with dense forest, flows River Sileru towards its junction with Sabri River below Konta. A remote, wild, and inaccessible valley, scantily populated by tribal people related to the Gonds of Bastar, it is the last sanctuary of the remnants of herds of Buffalo which once inhabited the riverain tracts of the Sileru and the Sabri. Where the Buffaloes once roamed freely giant machines rip up the earth shattering the silence and hordes of people roam the jungles. Across the valley an earthen dam is rising in all its raw-earth ugliness to hold the waters of the Sileru to feed the turbines of a hydro-electric project being constructed jointly by the Governments of Orissa and Andhra with Russian technical assistance. Once the dam is completed the present Buffalo habitat in the valley will be under hundreds of feet of water and the Buffaloes driven to the hill slopes or to the few smaller valleys protected by dykes.

In the very short time available to us it was possible to obtain some information (Table I) on Buffaloes and to visit Buffalo habitats. The whole area was considerably disturbed and according to local information most of the Buffaloes had moved to the secluded and undisturbed areas of the valley. We returned to Jagdalpur on 27 April and after assuring ourselves that no transport was available for north Bastar terminated the survey.

The Wild Buffalo in Bastar and Orissa

The literature on the Buffalo is limited to occasional observations on habits published by hunters in the records of their hunts and notes on the species, mainly based on these observations, published in standard

Above : Indravati River, West Bastar. *Below :* Wild Buffalo wallow in mixed forest, West Bastar

(*Photos : George Schaller*)

Above : Wild Buffalo in Kaziranga Sanctuary, Assam. *Below :* Solitary Wild Buffalo bull in Kaziranga Sanctuary, Assam

Note difference between the habitats—Bastar (Plate I) and Assam (Plate II)

(*Photos : E. P. Gee*)

works on Indian fauna. Where relevant these have been correlated with our observations. We have also included information on the distribution and status of the Buffalo in eastern India to present as complete an account as possible of the present position of the animal.

The Animal

The Wild Buffalo is a magnificent large and streamlined version of the domestic animal, attaining a height of 5 ft. 4 in. at the shoulder and a weight of over 2000 lb. The horns are massive and average over 3 ft. in length. None of the domestic breeds equals the wild animal in size and weight except perhaps the Hissar, but there is no comparison with the lithe alertness that freedom has bred into the wild animal.

Distribution and Status

HISTORICAL

The distribution of the Wild Buffalo was associated with the large rivers and their tributaries in the Gangetic Plain and eastern and eastern-peninsular India, extending from the riverain grass jungles of the Rohilkhand Terai to Assam in the east and the Godavari in the south-east, within historic times (Map III).

In the first and second quarters of the nineteenth century, the Wild Buffalo was abundant and reportedly seen in hundreds along the great rivers of eastern India, particularly in the marshes, jheels, and extensive riverain coverts which occurred at that period in the districts of Purnea (Bihar), Malda, Dinajpur, Jalpaiguri, Dacca, Fareedpur, Noakhali, and the maritime tracts of Midnapore of undivided Bengal, and the churs of the Brahmaputra and the plains of Assam.

In peninsular India they were equally abundant in the maritime tracts of Balasore and Cuttack in Orissa and the plains of south-eastern Madhya Pradesh in the districts of Mandla, Raipur, Sambalpur, and Bastar with a west boundary approximately coinciding with the 80° longitude and the Pranhitta River and as the south boundary the north bank of the Godavari River.

The settlement of these areas and consequent clearing of the habitat for cultivation, combined with large scale hunting and loss through disease, have wiped out the population over a large area of its general distribution and restricted the animal to the protection of sanctuaries or the inaccessibility of the habitat.

Present Distribution

EASTERN INDIA AND NEPAL

The Wild Buffalo is now extinct in the Terai of U.P., Bihar and Bengal, and the maritime tracts of Midnapore (Bengal) and Balasore and Cuttack

(Orissa). In Assam it is seen only in the sanctuaries of Manas, Kaziranga, Pabha, Laokhowa ; in the Sankos-Manas riverain tract, and in Lakhimpur. A few herds are also found in the Kosi River area of Nepal, in the most inaccessible portions of the flood plains east and west of the river some 20 to 30 miles upstream from the Kosi River Barrage near the International border (Willan : pers. communication).

PENINSULAR INDIA

In the range of the species in eastern peninsular India, mentioned earlier, we have personal knowledge of their occurrence only in west and south Bastar and the Koraput District of Orissa. They are reported to occur also in north Bastar and south Raipur districts in Madhya Pradesh, and east Chanda in Chanda District, Maharashtra. There are possibly a few animals in the upper reaches of the Jonk River in Orissa, where they used to be abundant in earlier days. As suggested by Mooney (1930), these animals are perhaps shared with south Raipur. We are also informed that a few buffalo may still persist on Gamdhamardhan Hill between Patnagarh and Nawapata in Orissa.

One of the specific questions that we planned to study during the survey was the distributional limits of the different populations. We were able to obtain a fairly comprehensive idea of the distribution in west and south Bastar.

Bastar (Map IV)

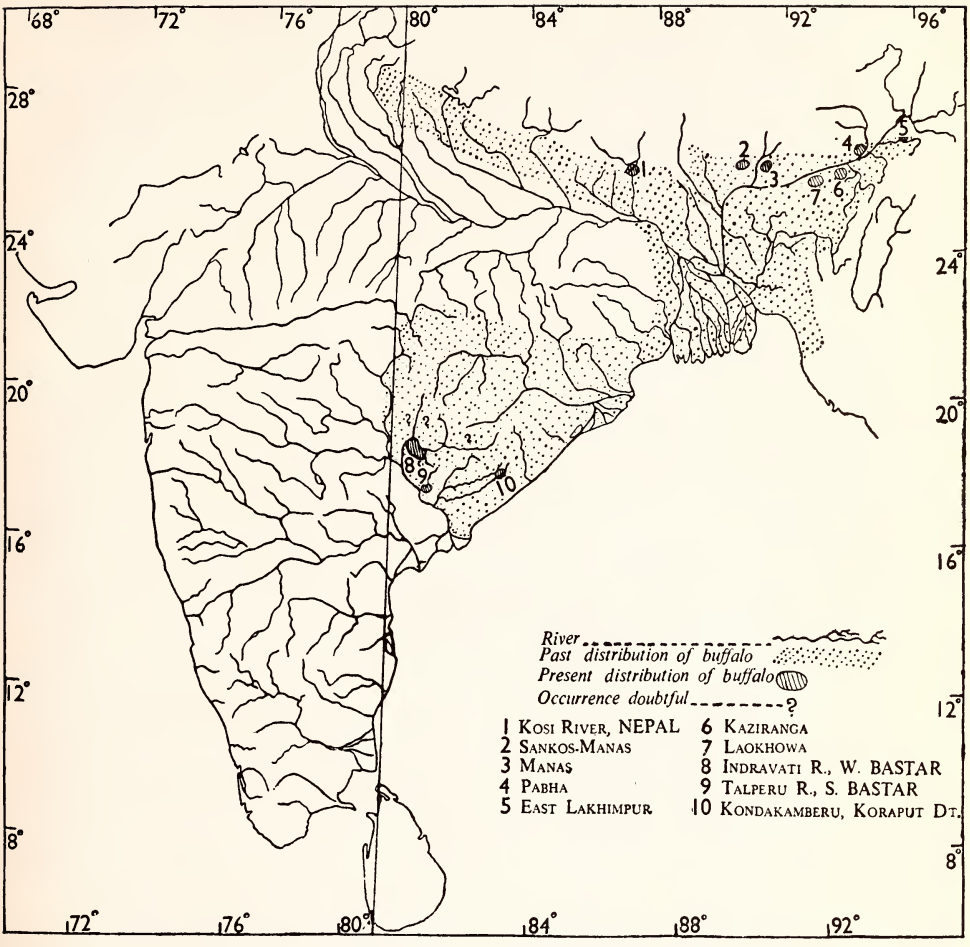
The range of the species is so dependent on the availability of water at different times of the year that it is not difficult to define the larger monsoon and winter range, associated with easy availability of water, and the restricted summer range, limited to areas with perennial water.

West Bastar

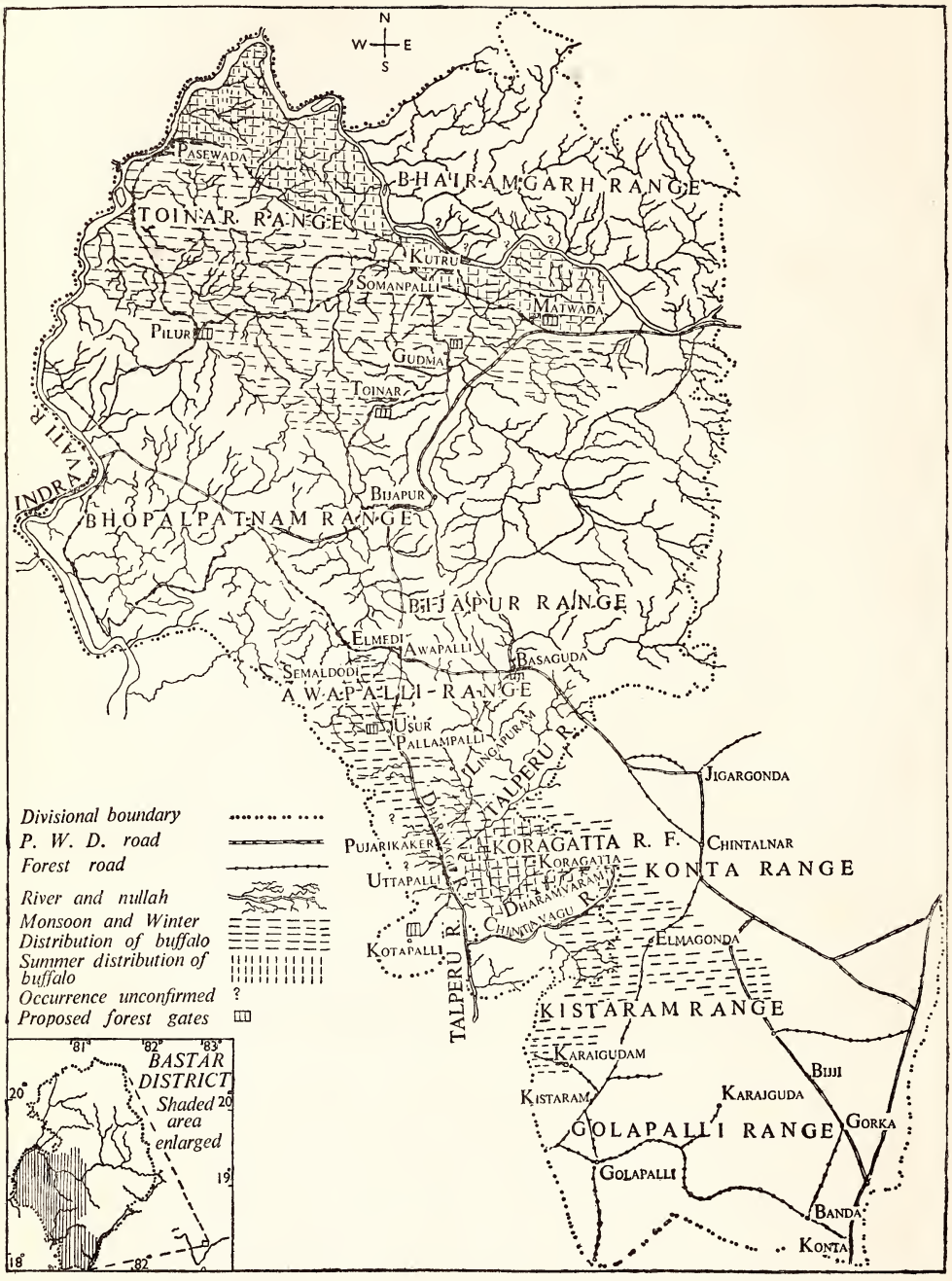
We refer here only to the Toinar and Bhairamgarh Ranges of West Bastar Forest Division. The Awapalli Range of the same Division adjoins Buffalo areas in south Bastar and is considered along with them in the distribution of the Buffalo in south Bastar.

Monsoon and Winter. In the Toinar Range, from the south bank of the Indravati River to Toinar Forest in the south-east and Mingachel (Berudi River) in the west. It is likely that they are seen throughout the Bhairamgarh Reserve Forest south of the Indravati in these seasons. The marginal limits are tentative and perhaps animals wander further south in forest areas. Solitary animals have a larger range.

Summer. In summer the Buffalo is restricted to the banks of the Indravati River and to the forests on its south bank bounded on the



Map 3. Past and present distribution of the Wild Buffalo in the Indian Region



Map 4. Distribution of the Wild Buffalo in west and south Bastar

south by the forest road running from Matwada in the east to Pasewada in the west. Along the river they occur up to Tekametta and perhaps further south where suitable cover is available. Solitaries may wander to areas south of the road.

South Bastar

Monsoon and Winter. In the Awapalli Range of West Bastar Forest Division, they range from the Koragatta Reserve Forest in the south to Usur Reserve Forest and Semaldodi in the north moving north along the Dharavagu River from their summer range. In the Kistaram Range of South Bastar Forest Division they occur up to Kolaiguda in the east and Potakpalli in the south. Solitaries are said to reach up to Bijji village in Konta Range, South Bastar Forest Division.

Summer. Koragatta Reserve Forest in Awapalli Range, solitaries occasionally in Pamed Reserve and north Kistaram.

The two populations in west and south Bastar are now isolated, though there is the possibility of intermingling through solitaries during the maximum distribution in the monsoon and early winter. This is perhaps uncommon in view of the extensive cultivated areas between the ranges of the two populations.

Orissa

Buffalo occur in only a very restricted area in the Koraput District in the upper reaches of Sileru River. Our stay in the area was too short for us to get an idea of the range. The valley they inhabit will be submerged. We were informed of some herds in the Maheswarpur area near Balimela at the foot of the hills adjoining the Kondakamberu valley. Buffaloes are said to have been found near Orkel on the Potteru River west of the Sileru.

Habitat

Bastar

We have information only on the habitat in west and south Bastar. The Sal forest in the north, where also they are said to occur, was not visited. In the west and south they inhabit tropical dry deciduous forests associated with the two major rivers of the region, the Indravati in the west and the Talperu in the south. The forests, classified as mixed forests, have several species of trees of almost equal importance. The forest canopy is 40 to 60 ft. high and the growth is spaced and not so dense, the canopy being 40-50% when in leaf. Most of the dominant species are deciduous, some of the important constituents being *Diospyros melanoxylon, Terminalia tomentosa, Anogeissus latifolia, Lagerstroemia*

parviflora, *Buchanania latifolia*, *Madhuca indica*, *Stereospermum suaveolens*, *Tectona grandis*, *Pterocarpus* sp., *Gmelina arborea*, and *Butea monosperma*, near villages. Bamboo (*Dendrocalamus strictus*) occurs on hill slopes and river banks. Grass is the dominant undergrowth and grows luxuriantly in forests ungrazed by domestic stock, and in clear-felled areas the sites of abandoned cultivation, which are a common feature in the forests near the Indravati River. Dominant species of grass are *Imperata cylindrica*, *Eulaliopsis binata*, *Heteropogon contortus*. Almost pure stands of the *Chind* palm *Phoenix acaulis* form the undergrowth in rocky areas. Saplings and shrubs are found as undergrowth only in hill features.

The grass cover is a good 3 feet in height in areas not grazed by domestic stock, but progressively deteriorates in quantity and quality in settled areas with large domestic stock. Around villages it is close-cropped and lawn-like with only Mohwa trees (*Madhuca indica*) left of the original forest cover, giving an indication of how the country will appear with increased human population, and the clearing of forests.

A similar type of forest occurs in the south but it is drier, particularly south of Talperu. It is heavily grazed by cattle and is subject to other human interference.

In the summer when we visited the area almost all the deciduous trees were leafless and the undergrowth of grass had been fired by the villagers to facilitate the collection of mohwa flowers. If some of the forest fires we saw are an indication, uncontrolled forest fires must be doing considerable damage. In April summer showers were commencing and new grass had started to grow on burnt areas. The river in its shallow sections had a good growth of sedge and a grass-like tuberous plant said to be favoured by Buffalo. Most of the nullahs were dry or had water only near their junction with the river. Wallows within the forest had dried. Food and water resources were thus at a minimum.

Orissa

The only habitat seen in Orissa was the Kondakamberu valley. The forest here also is of mixed species but growth is denser and the canopy higher than in Bastar. The river bed held sedges similar to those in Bastar and the undergrowth was predominantly grass.

Population

Very large herds, estimated at 75 to 100 animals, were noted formerly throughout the then distributional range of the Buffalo. It seems unlikely that these estimates are based on actual counts but it is evident that the Buffalo was extremely abundant.

The present population, in keeping with the reduced distribution, is

but a fraction of its earlier abundance. During the surveys we had track counts and actual sightings as listed below :

	Solitary	Herd	Total
West Bastar ..	15	71	86
South Bastar ..	1	10	11
Orissa ..	—	8	8
			105

West Bastar

Considering the fact that in west Bastar we have the largest and best Buffalo habitat now available in peninsular India, an area of about 400 sq. miles, the population is astonishingly low. We do not believe that there are more than 200 to 250 animals in the area, and some among these are shared with the adjoining Chanda District of Maharashtra. The actual count is about half the lower estimate but we are taking into account herds we were told of and did not see and areas which we did not have the opportunity or the time to visit. Information gathered from Forest Department personnel and villagers independently more or less tallies with our figure. The population was estimated at 75 to 100 and 50 to 100 respectively in South Bhairamgarh Range which area is said to have the largest concentration.

We often heard in Bastar of the numbers seen during the rains and in winter, but it must be noted that at these seasons the Buffalo wanders considerably and there is every possibility that a herd may be reported from two or three places.

South Bastar

We hesitate to give an estimate of the population as the Koragatta Reserve was not surveyed but, from the evidence we have, an estimate of 50 may be excessive.

Orissa

Our period of stay was not of sufficient length to make an assessment of the population, but Mr. Ahmedulla, the Conservator of Forests, Jeypore Circle, thinks there are about 100 animals in his Circle mainly concentrated in the Kondakamberu valley and Maheswarpur near Balimela.

General

We do not think that the total population throughout the present distributional range in peninsular India would exceed 400 to 500 animals.

Mr. E. P. Gee very kindly gave us the figures of his estimate of the population in eastern India and Nepal and these are quoted below to give an idea of the total population of the species :

ASSAM		
Manas Sanctuary	..	400
Kaziranga Sanctuary	..	700
Pabha Sanctuary	..	100
Laokhowa	..	50
Sankos-Manas	..	75
East Lakhimpur	..	100
	Total ..	1425
NEPAL		
Kosi River	..	15-20*

*Approximately 100 (Willan : pers. comm.).

Dr. Schaller who spent six days in the first week of May in Kaziranga Sanctuary has sent us data gathered during his stay. In his visits to a major portion of the Sanctuary he counted herds of 3, 7, 8, 18, 18, 17, and 20 and 4 solitary bulls. He received the impression that Mr. Gee's estimate of the population in Kaziranga Sanctuary is rather high.

It should be noted that the total population of the species throughout its range does not exceed 2000. This fact needs the serious consideration of conservationists.

Breeding

The 15 calves of less than six months of age seen in Bastar and at Kaziranga (see Table II on Herd Composition) suggest that the main

TABLE II

HERD COMPOSITION

Date	Location	Adult bulls	Adult cows	Sub-adult and yearling bulls	Sub-adult and yearling cows	Young: 0-6 months	Young: 6-12 months	Total	Source
10 April	Indravati River, west Bastar	—	6	1	2	5	2	16	Daniel and Schaller
26 April	Kondakamberu, Koraput Dt., Orissa	—	3	—	2	—	—	5	Daniel
May	Kaziranga Sanctuary, Assam	1	4	1	—	1	1	8	Schaller
	do.	—	7	—	2	5	—	14	do.
	do.	—	8	2	4	2	—	16	do.
	do.	—	10	2	4	2	—	18	do.

period of rut is apparently not confined to the autumn as stated in literature but is spread over a period of at least five months, and perhaps longer, with a peak of conceptions occurring during the first half of the year.

Solitary Bulls

Several opinions have been expressed in literature regarding the reasons which make many bulls lead a solitary existence. It has been suggested that solitary bulls are dispossessed master bulls of herds and also that solitary animals become so of their own accord. In the opinion of Dr. Schaller, based on his observations on the Gaur (*Bos gaurus*) in Kanha and the Buffalo in Bastar and Kaziranga, it is apparent that mature bulls are solitary and associate with a herd only periodically. Fights may occur when two bulls happen on a herd holding a cow in season, the stronger bull keeping with the herd and driving off later arrivals. It is significant that of the six herds of which we have composition data only one had an adult bull. In summer at least bulls are seldom seen with herds. Bulls wander considerably and at times remain in summer in areas in which herds are now seldom or never seen.

Daily activity and food

We could obtain very little information on the daily activity of the animal and there is little published information. In undisturbed areas they are said to feed in the open at dusk and dawn, retreating into cover or to their wallows during the intervening period. In Bastar they are said to frequent forests near cultivation where crops, particularly rice, are grown. In the herd we saw in the early morning at Bastar some were feeding on the sedge *Cyperus corymbosus* growing on the river bed and some lying in the water. Some of the animals were rather thin.

The Buffalo is considered a selective feeder, wandering long distances in the course of grazing. The only grass that has been so far identified as a food of the species is the Dub, *Cynodon dactylon*, a perennial creeping grass found throughout India—one of the commonest and most useful species and about the only species that remains green in hot weather. Among the grasses collected by us the following species *Themeda quadrivalvis* and *Coix* sp. were identified by local villagers as eaten by Buffalo.

Predators

Other than man the tiger is the only predator capable of killing adult animals and instances of kills relate mainly to calves and sub-adults. Inverarity (1895) records seeing the remains of a calf of about 18 months and also seeing an old bull with teeth and claw marks on the rump.

The only evidence we had in Bastar of death through natural predators was the remains we saw of a calf during the fifth transect in West Bastar. The kill, probably a tiger's, was some 3 to 4 months old and bones, teeth, and hair were collected. In Orissa we had reliable information on the killing of a sub-adult female by a tiger near Kondakamberu. This animal had an infection on its head and was living in the forest near a village. Schaller was informed that tigers occasionally kill adults in Kaziranga.

Relation to Man

In its relation to man lie the reasons for the decline of the Buffalo, as the ideal Buffalo habitats in the riverain regions of the Gangetic Plain and eastern and peninsular India have been mostly reclaimed for cultivation. Curiously enough, in Bastar, though man's activities have been in the main inimical, his methods of cultivation have partly contributed to the utilization of its habitat by the Buffalo. Bastar has remained as one of the few regions in Madhya Pradesh where the original Gond inhabitants have retained their tribal organization and practices. In the Indravati area of Bhairamgarh and Toinar Ranges settled by Hill and Dorla Marias respectively shifting cultivation is still practised. Flat land covered with forest is clear-felled and fired for cultivation and after two to three years of use is abandoned for twelve to fourteen years. There are several such abandoned clearings and their adjoining villages in the two Ranges in various stages of forest regeneration. These sites, because of the forage available, are much frequented by buffaloes.

These indirect benefits are offset by other human activities, particularly the killing of animals in the large scale communal hunts (*Parads*) and in the protection of crops.

Domestic Stock and the Buffalo

In west Bastar the forest villages in the summer range of the species in the Bhairamgarh and Toinar Forest Ranges have very few cattle and the forest, except in the vicinity of the villages, shows little effect of grazing. The village of Karkewada had the largest number of cattle, approximately 200 to 300 head.

In south Bastar very large herds are grazed in the monsoon and winter range, and in part of the summer range in the summer months when the availability of food is at a minimum. Most of these cattle are brought into Bastar from Andhra Pradesh. In addition, large herds of Banjara cattle move through the area. The conditions within the Koragatta Reserve are not known to us, but outside this fresh grass is hard to come

by. There is, thus considerable pressure on food resources which would affect the chances of survival of the few animals still existing in the south.

Domestic buffaloes are uncommon in the forest villages of the Indravati tract, though seen quite often in the settled area to the east and south. The horns of the domestic buffalo in Bastar often showed a distinctive resemblance in shape to those of the wild animal. In the more populated south, domestic buffaloes are kept by villagers living near the Buffalo habitat.

The wild and tame animals being so little differentiated, interbreeding occurs through solitary wild bulls appropriating domestic herds. The result of a crossing with a wild bull is not usually successful. The wild cross calf being large often causes the death of the mother at delivery and 75% of the calves also die at birth or within 8 days, owing, it is believed, to insufficiency of milk. Chances of survival however increase with the second generation (Gee 1953, Lall 1953). These reports refer to the situation in Assam, where owners of domestic stock strongly dislike for these reasons the mating of their animals with wild stock.

We did not receive similar reports in Bastar where apparently crossing with wild bulls is not disliked. According to Noronha (1954) the buffaloes of the village of Bijji in Konta Range, south Bastar, are three-quarters wild and mating with wild bulls is encouraged. In the one case investigated by us in Dharamvaram village in south Bastar, we were informed that a solitary bull had visited the village from August to December for three consecutive years, spending the night with the herd and leaving in the morning. Three cow buffaloes had conceived but all had aborted after four months. The suggestion that the animals had been deliberately aborted in view of the belief that cows mated to wild bulls die at delivery was vigorously denied.

Disease

Contagious diseases spread by domestic animals have been one of the main reasons for the disappearance of the Wild Buffalo in peninsular India. In the 1920's, Stewart (1927) and Stockley (1928) noted that Rinderpest had almost wiped out the Buffalo in the Central Provinces (Madhya Pradesh).

We were informed by the Range Officer, Kistaram Range, that there was a severe attack of Rinderpest in the Golapalli Reserve Forest in the cold weather of 1963-64, when several sambar and chital were found dead. He had no information on the situation among the Buffaloes which occur further north in areas rarely visited by Forest personnel. Sporadic attacks of Rinderpest are not uncommon in Bastar, a main cause being the large herds of Banjara cattle driven through the district

from the end of the rainy season. These cattle use roads which run close to or through buffalo habitats in west Bastar and are grazed in Buffalo habitats in South Bastar. Contagious diseases thus remain a constant danger.

Hunting and Poaching

The Buffalo has been statutorily protected in Bastar since 1908 and shooting was prohibited up to 1955, when shooting of bulls was allowed on permits issued by the Government at a fee of Rs. 200.00 to Indians and Rs. 500.00 to foreigners. Shooting was again completey prohibited for a period of five years from 1957. Since 1955, 7 bulls have been shot under licence, 3 in 1955 (Toinar and Bhairamgarh Ranges), 2 in 1956 (Bhairamgarh Range), 1 in 1962 and 1 in 1965 (Toinar Range). Except one animal in 1955, all the others were shot by American tourists on shoots arranged by a shikar firm of Nagpur.

It is possible that a number of animals of both sexes and of different age groups are destroyed by poachers every year. The remoteness of the tract and the difficulty of policing the whole area with the few local Forest staff makes it almost impossible to check poaching when it is done by villagers, as is evident from the number of poacher's pits and machans that we saw in our transects in west Bastar.

Conservation

A sanctuary is to be shortly established in Bhairamgarh Range, in the portion of the Bhairamgarh Reserve Forest bounded on the north by Indravati River and in the south by the Forest Road from Matwada to Pasewada. All working of the forest except for removal of teak and valuable miscellaneous species, shooting, and grazing are to be prohibited, fire protection strictly enforced, and tanks constructed within the sanctuary. Fair weather roads are to be laid for use by visitors and two bungalows are to be built for their accommodation.

Future of the Wild Buffalo in peninsular India

The restricted range of the species and the small population has now made the Buffalo extremely vulnerable and we doubt whether Buffalo will continue to exist in peninsular India unless immediate and effective measures are undertaken for their conservation.

Some of the points which need careful consideration are Habitat Destruction and its corollaries, Predation, and Disease.

Habitat Destruction

The remoteness and inaccessibility of the Buffalo habitats in Bastar and Orissa protected the animals to the present day. The tribal inhabitants, comparatively few in number, were sufficient in their tribal economy and had little interest in money or inclination to work for it. Communications were so poor in these areas that development of the resources and colonization were inhibited and the region retained its wildness. All this is going to be changed shortly. In Bastar, with the commencement of the Bailadila Iron Ore Project, a railway line is being laid from the port of Vishakapatnam to the Project Area close to the habitat in west Bastar and another connecting the area to Bhadrachalam, Andhra Pradesh, in the south is being surveyed. When these lines go into operation the area is going to lose its isolation, and there will be severe pressure on arable land not only from new settlers but also the original Gond inhabitants, who are now losing their tribal fidelities and communal life and set more value on permanent private ownership of land. The cry is already heard in Bastar that the Buffalo population should be thinned as they damage standing crops.

The forests which are classified as good quality mixed forests have not been commercially exploited on a large scale in west Bastar by the Forest Department as extraction of timber is not economical. This position will change with the advent of the railway. More Forest plantations of commercially valuable species will appear and grazing by Buffaloes in them may lead to herds in particular areas being proscribed. One of the recent developments we noticed in the area is the establishment of the ecologically useless eucalyptus plantations.

While it may be possible to protect the summer range of the species, it seems very likely that the extensive monsoon and winter range now available will be severely reduced and there will be more pressure from domestic stock on the available grazing. The Buffalo does cause damage to standing crops, and conflict with human interests will increase and political pressure in all its short-sightedness will presently assert itself in an area which has so far shown little signs of this blight.

Hunting and Poaching

The hunting of bulls under licence should be stopped, as it will give the impression to the villagers that Government extends protection to the animal only to have them killed by people who can pay for the privilege. Information is also required on the effect the removal of bulls would have on the population.

Increase in the area under cultivation will mean an increase in crop-protection guns and increased poaching which cannot be controlled under existing rules, not due to defects in the rules but owing to the impossibility of enforcing them with the Forest personnel available for the purpose.

The *Parads* or communal hunts which are organized by the tribal people during the summer completely clear large areas of their animal life and are one of the reasons for the scarcity of wild life of all types in remote areas of Bastar which cannot be policed.

Disease

The occurrence of disease in virulent form would be disastrous to the small population now existing in Bastar. This is always a possibility and its probability will increase as more and more domestic stock is brought into the area with the increasing population.

Recommendations

I. It is very necessary that a complete field study of the Wild Buffalo should be made to collect detailed information on its ecology. However, this will have to wait till the State or Central Government or some other agency has trained personnel who can undertake such a study.

The immediate requirement is a biannual or annual census by the Forest Department which would at least give a rough indication of the animal's status and would also draw the attention of the forest villagers to Government's interest in the protection of the animal. The census should be under the personal field supervision of the Divisional Forest Officer concerned.

II. The protected forest in the area of the Bhairamgarh and Toinar Ranges between Matwada and Pasewada, bounded on the north by the Indravati and on the south by Matwada-Pasewada Road (Map IV) should be converted into Reserve Forest and closed completely for shooting and further colonization by man. This area is the summer range in west Bastar, and protection of the forest is essential as denial of access to the river, in the absence of necessary cover and water outside the area, will lead to the extinction of the species.

The summer range in the south is within Reserved Forests but grazing should be prohibited in Pamed Reserve Forest.

III. It is evident that the Forest Department does not have enough personnel for simultaneous Forest and Game management. This is a point which has often been stressed in similar contexts elsewhere, and when protection of a species threatened with extinction is considered full time staff are a necessity. We feel that for the enforcement of protective measures Game Guards should be appointed from local men who have knowledge of the area and the animal. They should not be liable to transfer unless for misdemeanour. Headmen of the forest villages

should be held responsible for any poaching near their villages and in the forests visited by their people for collection of forest produce. It is most unlikely that any poaching can be done in an area without the knowledge, if not the active co-operation, of the local villagers.

It appears that poaching by outsiders can be easily controlled if gates are erected at the following points on the forest roads of W. Bastar, namely Matwada, Pilur, Toinar, Gudma, and in south Bastar at Basaguda, Usur, and Kotapalli, (Map IV). This is not likely to cause hardship as the gates will cover roads lying in an area in which only Forest Officers will have any legitimate business at night. Licence numbers of cars passing through the gates during day should be recorded.

Deterrent punishment should be meted out to poachers, particularly to officials who have this unsavoury habit. More co-operation between the Forest and Police Departments is necessary if *Parads* are to be effectively suppressed.

IV. There is every likelihood of infections reaching the Buffalo unless domestic stock belonging to villages in the Buffalo habitat is inoculated and new additions similarly protected. This ideal answer is most unlikely and also cattle cannot be inoculated against all transmittable diseases. The number of cattle should be limited. Movement of cattle through the Buffalo habitat can be prevented if the Banjara herds are allowed to use only the main road from Jagdalpur to Konta.

V. Indravati Wild Life Sanctuary. The proposal to start this sanctuary reflects the serious concern of the Madhya Pradesh Government for the protection of the Buffalo. However, we feel that the area proposed to be set apart for the sanctuary is not sufficiently large to ensure the preservation of the Buffalo. It should be extended westwards as much as possible to protect most of the summer range.

We feel that the recreational facilities offered by the beautiful Indravati River should be fully utilized to enhance the value of the sanctuary. Visitors' Bungalows should be situated on the bank of the river; several sites are available which overlook magnificent stretches of the river. The river has many sandy ' beaches ' and pools and rapids well stocked with fish, and angling could be an added attraction to visitors. We emphasize these points, for it may not be sufficiently attractive if the sanctuary is to be advertised to the public as a Buffalo Sanctuary only. The Buffalo can be more easily and conveniently seen in established sanctuaries like the Kaziranga and Manas in Assam. With the opening of the railways the area will be easily accessible to visitors and if adequate publicity is given the sanctuary should become popular.

There is a proposal to construct tanks within the sanctuary. This is unnecessary in view of the access to the Indravati. It would be useful if existing wallows are not permitted to run dry in the hot weather;

they would be points at which Buffaloes can be shown to visitors without difficulty. The existing salt-lick can also be developed. It may be necessary to have controlled burning of the grass in cleared areas to ensure fresh growth, the burning to be limited to clear-felled areas and done after adequate protection of adjoining forests. The Game Warden should be required to supervise the firings personally.

Separate staff should be appointed for the sanctuary, and those of and above the rank of Forester trained to at least identify the animal life of the area. A permanent Game Warden of the rank of Assistant Conservator of Forests should be required to stay in the sanctuary and promotion should be as far as possible from personnel of the sanctuary to ensure continuity of management.

The sanctuary, if maintained with due care to the preservation of the habitat and strict enforcement of the rules, should be of value in the conservation of the Buffalo in Bastar.

VI. Orissa. We visited only one Buffalo habitat in Orissa, the Kondakamberu Valley and the areas in the valley frequented by Buffaloes will be under water when the Balimela Dam is completed. However, this destruction of the present habitat can itself be used with advantage for the conservation of the Buffalo. The gradual rise of water behind the dam will move the Buffaloes up the several creeks flowing into the valley and to the slopes of the surrounding hills. We presume that the forests on these hills will be kept inviolate to protect the slopes from erosion and the silting of the reservoir. If the valley is declared a completely protected area, a fine sanctuary can be developed as the area contains most of the larger game animals, and, if clear-felled areas two to three acres in extent are made above high water mark at suitable sites on secluded portions of the shore, it should be possible to see Buffaloes and other animals from the lake. We strongly recommend that a sanctuary be immediately established for the conservation of the Buffalo. The organization should be on the lines suggested for the Indravati Game Sanctuary.

We draw the attention of the Government of Orissa to Resolution 2(c) of the Indian Board for Wild Life passed at the 2nd Session held at Calcutta in January 1955, which recommended declaring River Valley Project areas as Protected Areas for Wild Life.

Acknowledgements

We are very grateful to the Secretary, Forest Department, Government of Madhya Pradesh, for extending financial and other assistance which made the survey possible ; the Chief Conservator of Forests, M. P., and Mr. T. C. Sur, Conservator of Forests, Bastar Circle, who took an active interest in our programme of work ; Mr. N. S. Bhil, D.F.O.,

West Bastar, whose personal interest assisted us greatly in our survey of W. Bastar ; Mr. A. A. Ansari, D.F.O., South Bastar, who looked after our tour arrangements in the absence of the Conservator ; Mr. Kalia, D.F.O., West Bastar, for allowing us the use of his Division's Land Rover ; Mr. S. V. Rao, Range Officer, Bhairamgarh and Mr. Sharma, Range Officer, Awapalli, for help in many ways ; Mr. Okhade, A.C.F., who was deputed to accompany us and whose assistance during his stay with us was invaluable. Finally, we would like to express our appreciation of our driver Mattia, who was helpful at all times and kept alive his good humour under the most trying conditions.

We are grateful to the Chief Conservator of Forests, Orissa, for arranging for our visit to Orissa ; to Mr. Ahmedulla, Conservator of Forests, Jeypore Circle, for giving us transport and other assistance ; Mr. Ahmed, Divisional Manager, Orissa Forest Corporation, and his officers, who made possible our work in the Kondakamberu Valley.

We record our thanks to Mr. E. P. Gee for giving us information on sanctuaries in Assam and Mr. R. C. N. Willan, Chief Conservator of Forests, Nepal, for information regarding Nepal. Thanks are due to Mr. P. B. Shekar of the Bombay Natural History Society who accompanied the party and assisted in the survey.

Finally we would record our indebtedness to Dr. G. B. Schaller, whose interest, personal participation in the field, and advice in the preparation of this report were invaluable.

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Oberonia sulcata Jos. et Chowd.: A New Orchid from Kameng Frontier District, NEFA, Assam

BY

J. JOSEPH AND S. CHOWDHURY

Botanical Survey of India, Eastern Circle, Shillong

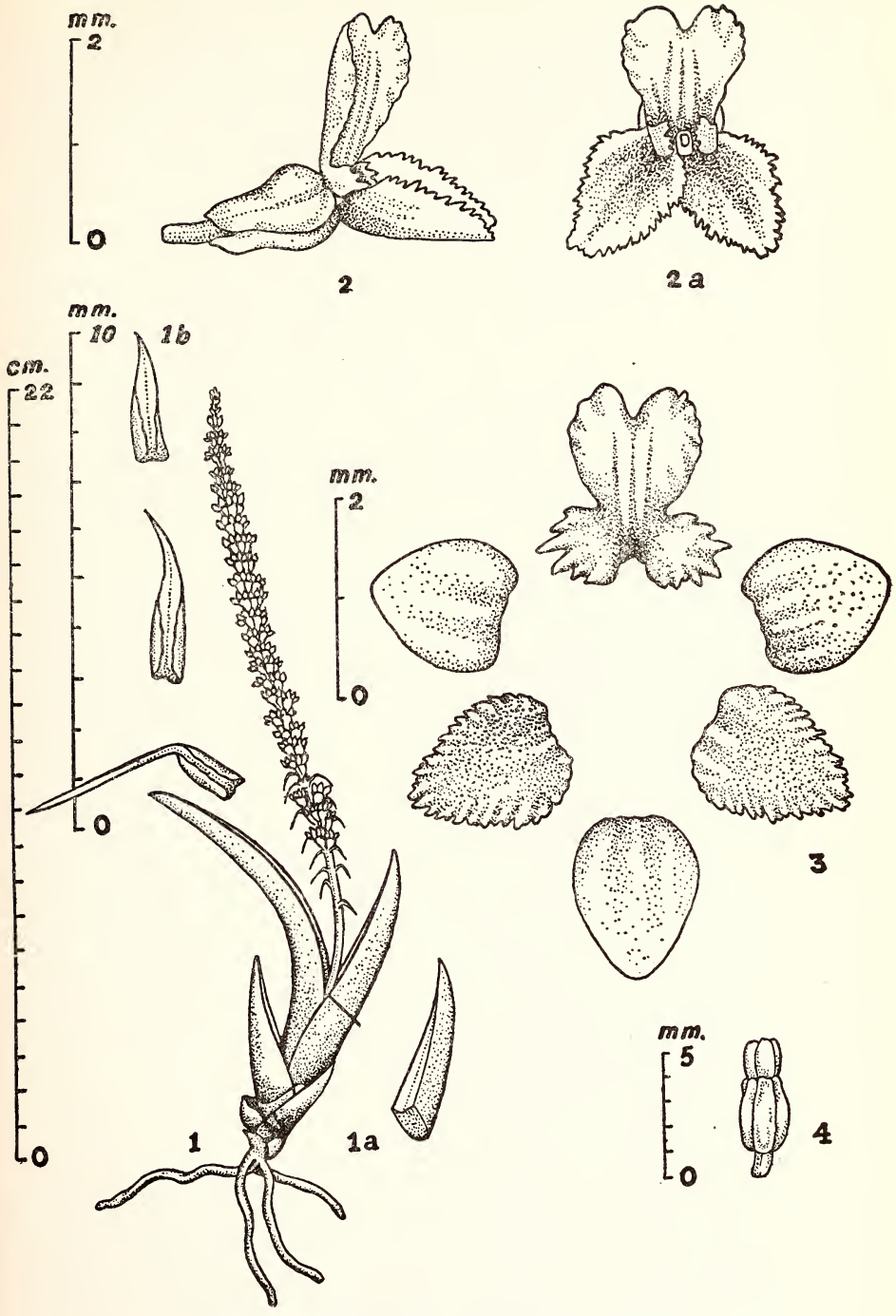
(*With a plate*)

This paper describes a new species of orchid, *Oberonia sulcata* Jos. et Chowd., collected during a botanical exploration from Selari Forest, 9 km. north-east of Bomdi La, Kameng Frontier District, NEFA, in the month of September 1964.

Oberonia sulcata Joseph et Chowdhury, sp. nov.

Pertinet ad Orchidaceas, affinisque est *Oberoniae roseae* Hook. f., a qua tamen differt foliis distincte ad basin articulatis, marginibus adaxialibus canaliculatis; inflorescentia multo longiore foliis, bracteis heteromorphis; petalis aeque latis ac sepalis, marginibus breviter dentatis vel serratis; lobulo medio labelli alte obcordato.

Erecta, caespitosa, epiphytica vulgo in *Quercu*, inflorescentia tenui, longa, arcuata florum parvorum luteolo-brunneorum. *Folia* 1·5-12 cm. × 0·7 cm., circa 6 numero, basalia quidem multo minora, equitantia, disticha, carnosa, anguste ensiformia, distincte articulata ad basin, marginibus adaxialibus paulum canaliculatis per totam longitudinem, marginibus integris, apice acuto. *Inflorescentia* 15-17 cm. longa, subspicata, folio longissimo multo longior; axis teres, ad basin nudus, supra vero bracteis sterilibus longe aristatis, floribus verticillatis densius ad medium quam alibi in apicem nudum desinens; *bracteae* heteromorphae, amplexicaules, marginibus subintegris, longiores ovario; basales quidem singulae ±5×1 mm. apice longo rigido geniculato subulato ornatae; superiores vero gradatim breviores 3·5-2 mm. apicibus acuminatis vel acutis. *Flores* circa 3·5 mm. longi ex stipite ad apicem petalorum lateralium, luteo-brunnei, non-resupinati, subsessiles; *sepala* ±1·25× 1·25 mm., sub-aequalia, anterius paulo longius ovatum obtusum reflexum hyalinum marginibus integris; *lateralia petala* aeque lata et paulo longiora sepalis, parallele patentia, luteolo-brunnea, crassa, minute



Oberonia sulcata Jos. et Chowd., sp. nov.

1. Habit ; 1a. Leaf partly in cross section ; 1b. Bracts : top, middle, and basal ; 2. Flower in side view, 2a. flower in front view ; 3. Outer 3 sepals, inner 2 petals, and the lip spread out ; 4. Fruit. (Drawn from *Joseph* 40358)

papillata, ovato-lanceolata, paulum concava, anguste fissa ad apicem, marginibus irregulariter serratis vel dentatis; *labellum* ±2 mm. longum, distincte trilobatum, ±2 mm. latum ad basin loborum lateralium, erectum leniter 3-nervium; lobi laterales multo minores medio, incurvi et includentes columnam, irregulariter dentati; lobo medio ±1·25 mm. longo erecto alte obcordato marginibus subintegris. *Capsula* ±4× 2 mm. ellipsoidea breviter stipitata 6-rugata coronata perianthio marcescente.

Holotypus *Joseph* 40358 lectus in silva Selari ad Bomdi La in Kameng Frontier District, NEFA, ad 2700 m. die 28 septembris anni 1964 et positus in Herbario Nationali Centrali (CAL.); isotypi, *Joseph* 40358 A-D, positi in herbario Assamico ad Shillong (ASSAM).

Oberonia sulcata Joseph et Chowdhury, sp. nov.

Oberonia sulcata Joseph et Chowdhury, Orchidaceae, is allied to *O. rosea* Hk. f. but differs in its leaves distinctly jointed at the base, channelled adaxial margins; inflorescence much longer than the leaves, bracts heteromorphous; petals as broad as the sepals and margins shortly dentate or serrate; mid-lobe of lip deeply obcordate.

Erect, caespitose, epiphyte on trunks and branches generally of *Quercus*, with slender, long, arched, inflorescence of small, yellowish brown flowers. *Leaves* 1·5-12 cm. × 0·7 cm., about 6 in number, basal ones much smaller, equitant, distichous, fleshy, ensiform, distinctly articulate at the base, with adaxial margins shallowly grooved all along and edges entire; apex acute. *Inflorescences* 15-17 cm. long, subspicate, much longer than the longest leaf; axis terete, bare at base but with long-awned sterile bracts higher up, with flowers in whorls more dense at the middle than in other parts, and ending in a naked tip; *bracts* heteromorphous, clasping, margins subentire, longer than the ovary; basal ones each ±5×1 mm. with long, stiff, geniculate subulate apex; upper ones progressively shorter ranging from 3·5 to 2 mm. and with apices acuminate to acute. *Flowers* ±3·5 mm. long from stalk to the tip of the lateral petals, yellowish brown, non-resupinate, subsessile; *sepals* ±1·25 × ±1·25 mm., subequal, anterior sepal slightly longer, ovate, obtuse, reflexed, hyaline, margins entire; *lateral petals* as broad as and slightly longer than the sepals, parallelly outstretched, yellowish brown, thick, minutely papillose, ovate-lanceolate, slightly concave, narrowly cleft at the apex, margins irregularly serrate or dentate; *lip* ±2 mm. long, distinctly trilobed, 2 mm. broad across the lateral lobes at the base, erect, faintly three-nerved; side-lobes much smaller than the mid-lobe, bent over enclosing the column, irregularly toothed; mid-lobe 1·25 mm. long, erect, deeply obcordate, margins subentire. *Capsule* 4 × 2 mm., ellipsoid, very shortly stalked, 6-ridged, crowned with the marcescent perianth. (See Plate)

Joseph 40358 collected in Selari forest 9 km. NE. of Bomdi La, Kameng Frontier District, NEFA, at an altitude of ±2700 m. (about Lat. N. 27° 19′ and Long. E. 92° 25′) on 28th September 1964 is the holotype and is deposited at the Central National Herbarium, Calcutta (CAL.). The isotypes, *Joseph* 40358 A-D, are in the Herbarium of the Botanical Survey of India, Eastern Circle, Shillong, Assam.

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Halictus latisignatus Cameron : a polymorphic Indian halictine bee with caste differentiation (Hymenoptera, Halictidae)[1]

BY

Sh. F. Sakagami

Zoological Institute, Hokkaido University, Sapporo, Japan

AND

F. L. Wain, s.s.j.e.

Panch Howd, Poona 2

(*With twenty-two text-figures*)

Recently we discovered an interesting cephalic polymorphism in the females of an Indian halictine bee, *Halictus latisignatus* Cameron, apparently linked with an incipient differentiation between queen and worker. The original description of this species being poorly given, Blüthgen (1931) made additional comments ; both sexes are re-described in the present paper. The biological data are still meagre. This paper gives the first biological data from the Oriental Region about halictine bees, which are remarkable for the occurrence of diverse types of social organization.

Description

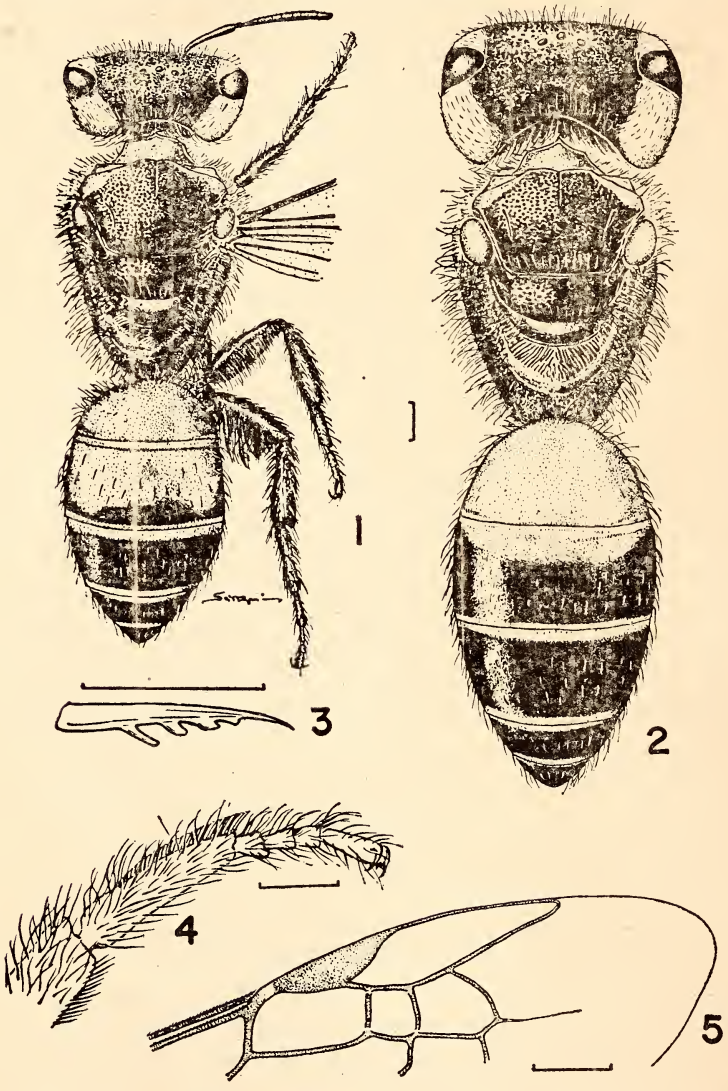
Halictus (Halictus) latisignatus Cameron

Cameron, 1908, *J. Bombay nat. Hist. Soc.* **18**:310; Blüthgen, 1931, *Zool. Jb. Syst.* **61** : 320, 324; Cockerell, 1937, *Amer. Mus. Nov.* No. 950 : 9.

SMALL FEMALE. Similar to *Apis florea* in size and blac-red colour pattern (Fig. 1). Metasomal marginal pubescence conspicuous. Head partly appears greyish because of dense appressed pubescence. Head swollen behind and above eyes. Body length 7-8·5 mm., length of forewing 5·5-6·5 mm.

[1] Contribution No. 686 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan. In particular, the authors thank Dr. Ch. D. Michener, University of Kansas, for his kind suggestions.

Coloration. Black. Tergum I, T II basally, and sterna I-IV reddish brown, T III basally also reddish brown but often invisible. Antennal flagella tending to blackish brown, frontally often paler. Mandibles apically, tegulae, articulations of legs, coxae to femora below, and tarsal segments more or less brownish. Wings hyaline, veins pale brown to brown, veins *C* and *Rs* 3+4 darker, *Sc* and pterostigma dark brown.



Figs. 1-5. *Halictus latisignatus* Cameron : Females (All scales given, 0·5 mm.). 1 & 2. Small and Large Females; 3. Inner spur of left hind tibia; 4. Left fore tarsus; 5. Right forewing partly

Pilosity. Hairs white, those on sterna V-VI and hypopygium, tibiae, and tarsi mostly golden brown, those on black areas of terga darker,

Tempora, genae, and paraocular areas below with short appressed hairs, so dense and, especially on genae, tomentum-like that they completely cover surface. Supraclypeus, and face laterally, with similar but sparse and less appressed hairs. Vertex and face above medially rather sparsely haired, with sparse erect hairs intermixed on vertex. Clypeus with sparse but long stouter, downward-directed hairs. Eyes naked.

Pronotum above including posterior lobes, mesoscutum anteriorly, and metanotum anteriorly with dense tomentum-like hairs covering surface. Mesoscutum with sparse, rather erect hairs, slightly denser anteriorly, and with finer but denser, rather appressed hairs, denser laterally, both types sparser medially. Mesoscutellum and metanotum with erect hairs, longer than on mesonotum, especially posteriorly. Pleura with dense tomentum-like hairs, denser above and on metepisternum, and also with moderately dense longer hairs. Propodeum naked on horizontal area, with long erect hairs and relatively sparse, somewhat tomentum-like hairs on sides and on median area of declivity, on the former longer laterally. Posterior margin of forebasitarsi with differentiated, short but stout, dense hairs forming comb (Fig. 4). Legs otherwise normally haired.

Tergum I on anterior vertical area with sparse tomentum-like hairs and moderately dense, long, erect hairs, as on all terga laterally. T V with similar but denser and more appressed hairs. Marginal pubescence limited on T I to lateral corners, consisting of rather short and inconspicuous hairs; on T II fascia more conspicuous but still broadly interrupted medially; wider and complete on T III-IV. T II-IV basally with similar hair bands, though often concealed. Other areas of terga silky with dense, appressed hairs, so fine that T I-II appear nude medially seen from some directions, mixed with scattered stouter, longer, moderately appressed hairs of darker tint on T III-IV. Plumose hairs on sterna I-III medially fine but long.

Sculpture. Head (Fig. 20) with very dense, uniform, and small punctures, interspaces smooth and shining but seldom exceeding diameter of punctures even on vertex, so that surface appears as if dull coriaceous, especially on paraocular areas above, where punctation is densest. Area surrounding ocelli narrowly smooth and shining. Supraclypeus above similarly but more sparsely punctured, with interspaces irregularly sculptured, below more sparsely punctured, interspaces, larger than diameter of punctures. Clypeus above like supraclypeus, or punctures slightly sparser, below very sparsely and rather coarsely punctured, interspaces 2-3 times as large as diameter of punctures and smooth and shining. Hypostomata inconspicuously reticulate and shining, not striated, with scattered coarse and ill-defined punctures.

Mesoscutum uniformly punctured like head, more sparsely posteriorly where smooth shining interspaces are as large as diameter of punctures.

Mesoscutellum like mesoscutum but punctures sparser and interspaces larger than diameter of punctures. Metanotum finely and densely punctured, interspaces irregular, giving reticulo-coriaceous appearance. Pleura striated; interspaces coriaceous and dully shining. Propodeal enclosure with distinct transverse or oblique striation, varying in individuals, interspaces coriaceous and dully shining; medially striation a little irregular. Other parts of propodeum very finely punctured, appearing coriaceous except latero-anterior parts, which are striated like pleura.

Terga with very fine but distinct punctures, dense and uniform, as fine, but not so dense, as on face; though interspaces less than diameters of punctures.

Structure. Head (Figs. 1, 20, 21) about as wide as, or slightly wider than, distance between outer margins of tegulae. Seen dorsally, distinctly extending behind eyes, with roundly and gently convergent lateral contour; distinctly curved post-marginally; occiput not carinate. Seen oblique-dorsally, ocellocular distance slightly less than ocelloccipital distance, than twice the interocellar distance, and than four times the diameter of anterior ocellus (80 : 90 : 55 : 22). Seen frontally, approximately as long as wide, with round-cubic contour, upper margin gently convex. Supraorbital line passing through middle of anterior ocellus. Upper third of inner orbits slightly divergent below, remainder nearly parallel. Ratios of eye length to upper, middle, and lower interorbital distances about as 22 : 23 : 25 : 24·5. Vertex and frons medially gently raised, frontal line not keeled. Supraclypeus gently convex above, lateral margins slightly convex. Clypeus transverse and flat; upper margin laterally gently concave, without specific emargination; lower interorbital line passing at or slightly above middle of clypeus; lower margin of clypeus transverse, slightly pointed at lateral angles, medially with blunt rounded process. Seen laterally, genae distinctly enlarged, about 1·5 times as wide as maximum eye width seen laterally, not angulate below. Hypostoma flat and simple. Labrum normally bituberculate. Mandibles stout, bidentate. Scape a trifle longer than ocellalveolar distance (14 : 12), apex not exceeding posterior ocelli, about half as long as pedicel and flagellum combined. Pedicel knot-like, distinctly longer than wide (25 : 20). Seen frontally, flagellum I distinctly longer than F II, slightly longer than F III, slightly shorter than F IV, and longer than apical width (25 : 20 : 23 : 27 : 23).

Pronotum laterally not strongly projected anteriorly: anterior margin approximately straight, ending in distinct lateral angulation; lateral margin gently concave. Mesoscutum anteromedially slightly bilobed, with differentiated shining vertical area separated from rest by distinct carina. Mesoscutellum gently convex, without median furrow, distinctly longer than metanotum and nearly as long as horizontal area of propodeum. Horizontal area of propodeum posteriorly not carinate;

separated from vertical declivity by rounded angle; posterior margin of horizontal area gently curved, not triangular nor squared; enclosure demarcated by fine suture. Posterior declivity with lateral carinae only in lower half.

Legs normal, inner hind tibial spur (Fig. 3) with four (occasionally five) spines. Three basal spines slender, round-headed; apical one knot-like. Hind basitibial plate normal. Ratios of hind tibia to hind basitarsus and to other tarsal segments combined 26 : 18 : 14. Radial cell about 4 times as long as wide (22 : 5·5), apex rounded, not on wing margin. Pterostigma slightly shorter than three times its width (12 : 3·5). Submarginal cell I slightly shorter than II+III (11 : 4·5 :8), Cell II receiving 1 m-cu subapically, and III receiving 2 m-cu at apical $\frac{1}{3}$. Veins 1 and 2 r-m not weakened. Hamuli usually 8, occasionally 9 (Fig. 5).

Metasoma elongate oval. Tergum I not elongate. T II and III basally distinctly depressed. Submarginal lateral convexities mild, marginal areas only slightly depressed, not particularly depigmented.

LARGE FEMALE (Figs. 2, 18, 19). Like small female but distinctly larger (body length 11 to 15 mm., length of forewing 7·5-9 mm.), and conspicuously macrocephalic. Seen dorsally, head distinctly wider than distance between outer margins of tegulae, behind eyes distinctly projecting posteriorly, posterior margin semicircular. Seen oblique-dorsally, ocelloccipital distance distinctly longer. Seen frontally, head distinctly cubic, greatly enlarged above eyes. Upper margin straight or occasionally even gently concave. Inner orbits distinctly divergent below. Clypeus distinctly wider. Scape distinctly surpassing postocellar line. Seen laterally, genae enormously developed. Hypostoma with strong triangular process. Mandibles stouter. Punctation on head distinctly sparser, especially on paraocular areas and vertex, where interspaces are often 2 or even 3 times as large as diameter of punctures, correspondingly smoother and more shining in general appearance. Smooth area surrounding ocelli very conspicuous. Punctation of mesoscutum and mesoscutellum also slightly sparser, though not so conspicuously so as on head. Hamuli 9-10.

MALE. Similar to female in general appearance. No pale markings on legs and head. Antennae reaching middle of mesosoma. Metasoma not particularly slender nor curved. Terga weakly convex. Body length 7·5-9 mm., length of forewing 6-7 mm.

Pilosity. Differing from female: (1) White hairs often having slight tint of yellow ochre, particularly on lower paraocular areas along inner orbits; (2) Tomental hairs far less developed on paraocular areas below, genae, pronotum above, and mesoscutellum changing to mere slightly dense undergrowth, not completely covering surface except on limited parts of lower paraocular areas and pronotum: mesoscutum and tergum

I practically without appressed hairs; (3) Clypeus more sparsely haired: hairs on paraocular areas above dense but sparser than in female, rather erect; (4) tergal marginal pubescence less developed, reduced to inconspicuous side patches on T I, still uninterrupted but narrower on T II-IV, often not completely covering surface.

Legs as in males of *Halictus* s. str., but foretarsi with long posterior hairs, nearly 3 times as long as width of segment (Fig. 7), postmarginal hairs of forefemora moderately developed, as long as width of segment, but not so long as in many species of *Lasioglossum*. Sterna I-III with fine, dense golden-tinted hairs, postmarginally denser and more whitish, forming inconspicuous bands. Sterna IV-VI with stouter, darker, and denser hairs, showing differentiation as described below.

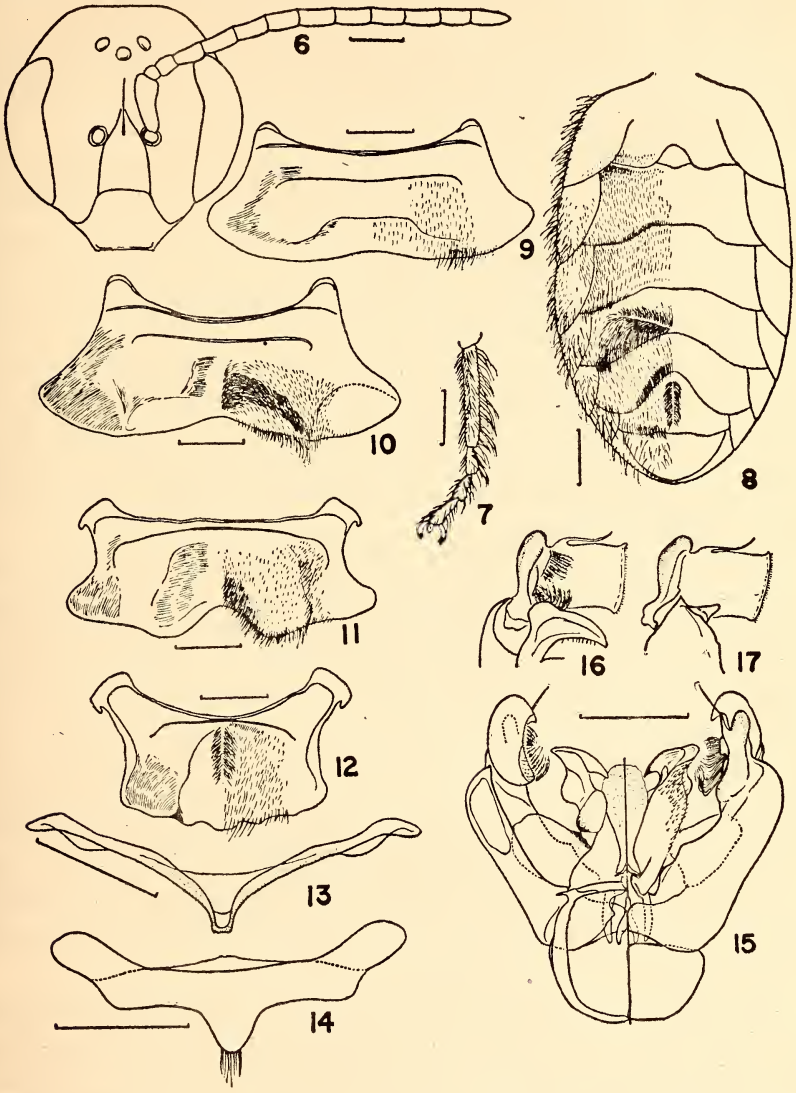
Sculpture. As in female but generally coarser, especially on mesoscutum, mesoscutellum, and T I anteriorly. Striation on propodeal enclosure also a little coarser.

Structure. General structure as in female. Head (Fig. 6) slightly narrower than distance between outer margins of tegulae (35 : 37), slightly longer than wide (40 : 38), not so conspicuously swollen as in female. Ratios of ocellocular, ocelloccipital, interocellar distances, and diameter of anterior ocellus, 8 : 9 : 6 : 3. Outer orbits more convex, inner orbits more convergent below. Ratios of eye length to upper, middle, and lower interorbital distances 24 : 24·5 : 26 : 23. Clypeus projecting below, lower orbital line distinctly above its middle, lower margin straight and simple. Scape about $\frac{1}{6}$th as long as pedicel and flagellum combined. Pedicel slightly longer than double the width. Ratios of lengths of flagellum I-IV and width of F I and IV, 35 : 50 : 54 : 55 : 36 : 28. Flagellum I distinctly convex below basally, apical flagellamere slightly over twice as long as broad, gently concave above and convex below.

Basal depressions and submarginal convexities of terga mild, corresponding to those in *Halictus tumulorum*. Marginal areas very weakly depressed, without anterior demarcation. Tergum VII apically rounded, medially narrowly smooth and shining; ventral flexion narrow, not separated by ridge from dorsal part, Sterna II-III (Figs. 8-9) posteriorly gently concave. S IV posteriorly more concave, medially with dense, stout hairs radiately arranged (Fig. 10). S V (Fig. 11) posteriorly with deep semicircular emargination, marginal hairs simpler than on S IV, longer medially. S VI (Fig. 12) posteriorly irregularly lobed, marginal hairs simple but anterior half of postgradular area with dense paired longitudinal hair tufts, consisting of stout hairs directed obliquely-posteriorly. S VII (Fig. 13) slender, median projection narrow but conspicuous, truncate apically. S VIII (Fig. 14) posteriorly straight with distinct round-headed triangular projection medially, with conspicuous hair tuft.

Genitalia (Fig. 15) resemble those of *H. tumulorum*. Gonobase

between $\frac{1}{3}$ and $\frac{1}{2}$ as long as gonocoxite, anterior dorsal margin rather straight, ventrapical dechitinized window elongate and conspicuous.



Figs. 6-17. *Halictus latisignatus* Cameron : Males (All scales given, 0·5 mm.). 6. Head seen frontally ; 7. Left foretarsus; 8. Ventral side of metasoma ; 9-14. Metasomal sterna III-VIII ; 15. Genitalia (left ventral, right dorsal view) ; 16. Lateral inner view of left gonostylus ; 17. Lateral outer view of right gonostylus

Gonostyli (Fig. 15, 16) issuing from inner sides of apices of gonocoxites, not petiolate ; dorsally projection with round apex ; ventral lobe broad and quadrate, inner hair tufts conspicuous, consisting of curled plumose hairs, basodorsally with conspicuous flagellar process, apex of which does not exceed apical margin of ventral lobe, apical margin of ventral lobe truncate and broad, with very fine setae ; basal external projection

simple and small. Penis valves not extending much beyond gonocoxites, dorsally simple with conspicuous, dense, bristle-like hairs.

DISTRIBUTION. Previous records : Deesa and Matheran, India.

Specimens examined. Lonavla, Western Ghats, India (650 m.): many specimens as given later; Sinhagad, W. Ghats, India (1320 m.): 2 small females, 7 Jan. 1964. All collected by F. L. Wain.

VARIABILITY. The coloration of female tergum II is variable. In the most melanic individuals (Fig. 2), only the basal third is reddish at the middle and the black area reaches to the base laterally. In the opposite extreme (Fig. 1), only apical third or fourth is black, with or without lateral extension, and the tint becomes very pale. In more than half of specimens examined (18/30), however, the black area occupies the apical $\frac{2}{3}$ of the sclerite and extends forward laterally but not to the base. The male shows similar but wider variation, but only six specimens were examined. In the melanic extreme, T II is completely black, leaving a dim transverse trace of reddish at the base medially. In the opposite case, the whole sclerite is reddish with a similar dim, slightly darker band apico-medially.

The antennae are nearly black with a slight brownish tint anteriorly in the melanic extreme; dark brown, anteriorly paler, the apical segments anteriorly yellowish brown in paler specimens. The mandibles vary from only apically reddish brown to cases in which the apical $\frac{2}{3}$ and basal articulations are reddish brown, and tegulae from nearly yellowish to dark brownish. Similar variation is also seen in the legs.

Striation of the propodeal enclosure varies among individuals. In some individuals several transverse striae run parallel to the anterior margin of the sclerite before the oblique striation (Fig. 1). In an extreme case the latter was nearly absent. In other individuals, such transverse striation is reduced and the oblique striations start directly from the anterior margin (Fig. 2). The median portion of the enclosure also varies as to degree of irregularity in sculpture.

AFFINITY. The specimens examined agree with the original description by Cameron, including wing venation and the presence of metasomal anal rima. The specimens also agree with the comments of Blüthgen (1931). This clearly shows that they belong to *H. tetrazonius* group (=*Halictus* s. str. in the sense of Michener 1944), though the male apical sterna have a peculiar arrangement of hairs.

Compared with typical species of *Halictus* s. str. (and also of the subgenus *Seladonia*), this species is peculiar in the possession of long hairs on male foretarsi. The anteriorly carinate mesoscutum and differentiated comb-like hairs on the female foretarsi are also remarkable, but both are found in lesser degrees in some other species of *Halictus* s. str. For instance, *H. quadricinctus* (Fabricius) approaches *latisignatus*

in both, especially in the latter character. The differentiation of male sterna V and VI, especially the latter, gives good distinctive characters. As to the male genitalia, the relatively large gonobase with straight dorsal anterior margin, and the non-petiolate gonostyli rather resemble those of *H.* (*Seladonia*) *tumulorum* than those of some species of *Halictus* s. str. At any rate, there is no reason to consider this species other than an Oriental offshoot of *Halictus* s. str., a primarily Holarctic group.

This species further resembles *Halictus acrocephalus* Blüthgen (1926) from Pusa (Bihar), India. He did not discuss this similarity in his paper in 1931, but the species runs straight to *H. acrocephalus* in his key of ' more or less reddish coloured (Oriental) species ' (1926, p. 604) by

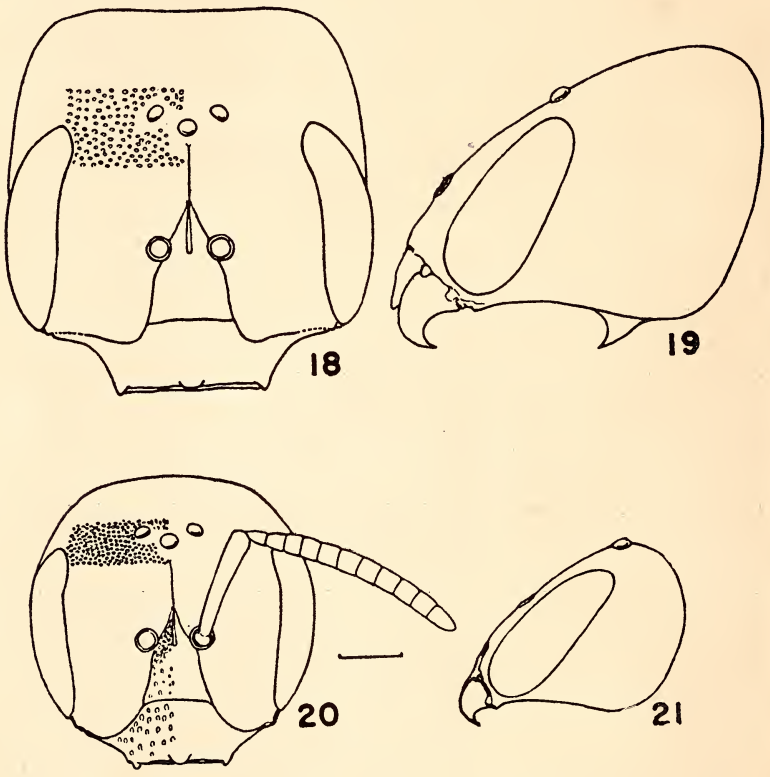
TABLE 1

DIFFERENCES BETWEEN *Halictus acrocephalus* AND *H. latisignatus*

	acrocephalus	*latisignatus* (small female)
1. Body size	5-5·5 mm.	7-8·5 mm.
2. Dark metasomal area	Schwarzbraun [Blackish brown]	Black
3. Coloration on tergum I	Gewölbte Mittelpartie und Beulengegend geschwärzt [Convex centre and lateral elevation black]	Totally reddish
4. Tergal marginal area	Durchsichtig horngelb [Transparent horny-yellow]	Not particularly depigmented
5. Supraclypeus and clypeus	Wie Stirn, aber viel flacher und deshalb ganz obsolet punktiert, Kopfschild unten etwas stärker (aber auch noch äusserst feiner) punktiert [As the vertex, but much smoother, and therefore with the punctures quite obsolescent, clypeus below somewhat strongly (but extremely finely) punctured]	Distinctly and rather coarsely punctured
6. Sculpture of propodeal enclosure	Mikroskopisch feiner, äusserst dichter welliger Längsrunzelung [Microscopically fine, extremely close, wavy, longitudinal lines]	With distinct transverse or oblique striation
7. Tergal sculpture	Mit netzartiger Chagrinierung, . . . ohne Punktierung [With reticulate sculpture, . . . without punctation]	Finely but distinctly punctured

the possession of tergal pubescence and enlarged head. Further, the two species agree in the colour pattern and presence and distribution of white tomentum-like hairs on the head and mesosoma. But they may easily be distinguished by the characters shown in Table 1.

FEMALE POLYMORPHISM. As indicated in the description, the females show a conspicuous polymorphism due to cephalic allometry



Figs. 18-21. *Halictus latisignatus* Cameron: Cephalic polymorphism in females (Scale given, 0·5 mm.). 18-19. Large female; 20-21. Small female. Both, from front and in profile

(Figs. 18-21). To show this clearly, the measurements of various head parts of one small and one large female were converted into ratios to mesosomal width (=distance between outer margins of tegulae, 2·06 mm. in the small female and 2·75 mm. in the large one) and the relative values of the larger female were divided by the corresponding values of the small female. The results are shown in Table 2.

TABLE 2

COMPARATIVE TABLE OF MEASUREMENTS OF FEMALES OF *Halictus latisignatus*

Part measured	Ratio of part measured to mesosomal width		Ratio large ♀/small ♀
	small ♀	large ♀	
Eye length ..	0·62	0·60	0·96
Eye width (seen laterally) ..	0·24	0·23	0·96
Head length ..	1·04	1·06	1·02
Scape length ..	0·41	0·49	1·02
Upper interorbital distance ..	0·68	0·77	1·07
Interocellar distance ..	0·15	0·16	1·07
Middle interorbital distance ..	0·78	0·84	1·12
Head width ..	1·02	1·14	1·12
Ocellocular distance ..	0·24	0·27	1·12
Ocellalveolar distance ..	0·34	0·42	1·23
Alveorbital distance ..	0·25	0·31	1·24
Lower interorbital distance ..	0·72	0·91	1·26
Genal width ..	0·38	0·56	1·48
Ocelloccipital distance ..	0·26	0·44	1·69

Obviously, the values may vary a little when a large number of individuals are measured. But the increase of the ratios shows the relative increase in measurements of the large female from the frons upward, posteriorly, and downward. The same tendency is more or less seen in other species with similar macrocephaly (Quénu 1957 ; Sakagami & Fukushima 1961 ; Sakagami & Moure, in press, a).

To show the relation between the macrocephalic tendency and absolute body size, two ratios were chosen: head width/mesosomal width and genal width/eye width. In Fig. 22, these ratios were plotted against the absolute values of head width and lateral eye width respectively. The results clearly show that both head and genal widths allometrically increase with the increase in absolute size, as is known in other species. But the macrocephalic tendency in this species is stronger than in most other cases so far known. Here, one of us (S.F.S.) would

like to repeat a warning against the uncritical application of craniometry to distinguish species in halictine bees.

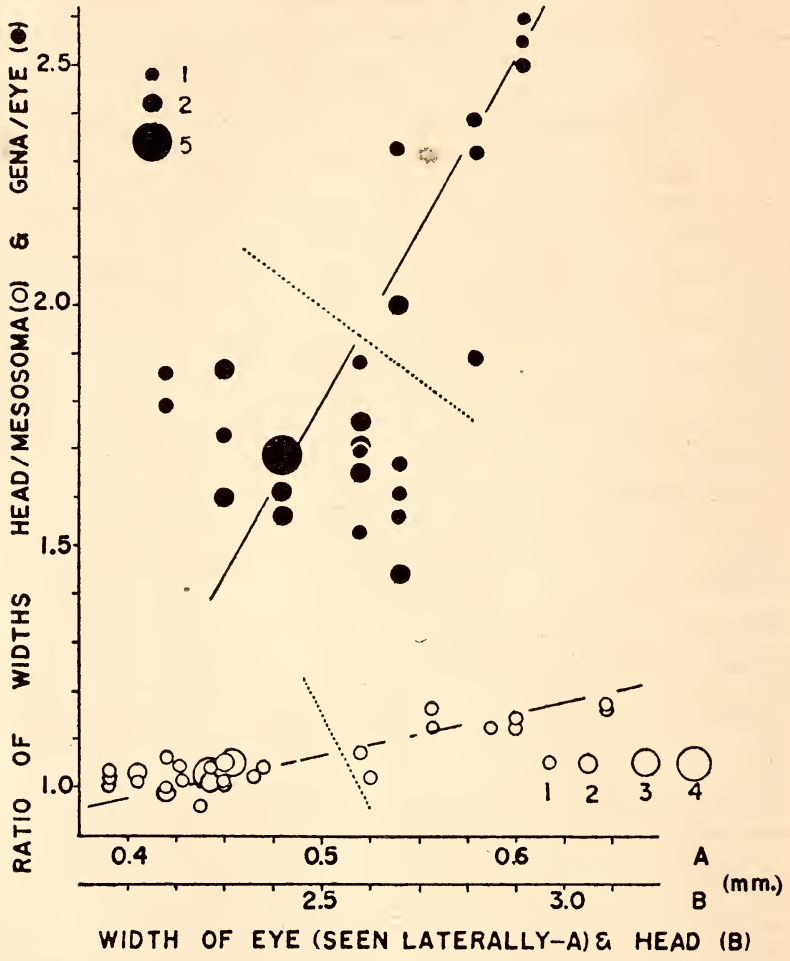


Fig. 22. *Halictus latisignatus* Cameron : Relation between body size and ratios Genal width/Lateral eye width and Head width/Mesosomal width in females. Regression lines are made by eye. Dotted lines indicate approximate division between queen and worker.

As indicated in the description, at least three non-metric characteristics vary in a fashion parallel with the macrocephaly : increased number of hamuli, appearance of the genal process, and decreased density of punctures on the head. The increase of hamuli parallel to the increased body size is known in many other social Hymenoptera (bumble bees, stingless bees, cf. Schwarz 1948) both intra- and interspecifically, and even in cases of isometric body increase. Hence this tendency may be regarded as a general trend in the bees, not specially linked with the

cephalic polymorphism. The appearance of genal processes in large females is known in *Megalopta genalis* Meade-Waldo, a Neotropical nocturnal halictine bee. Michener (1954) regarded *M. fornix* var. *panamensis* Cockerell, a smaller form with normal head and without genal processes, as conspecific with *M. genalis*, the type of which is unusually macrocephalic with strong genal processes (cf. also Sakagami & Moure, unpub.). Apparently *H. latisignatus* shows a parallel variation. It is possible that such genal processes may become fixed specifically, as seen in *H.* (*H.*) *ligatus* Say. In such instances this character may be used as a diagnostic one. Yet it is better not to over-emphasise its value. Recently one of us (S.F.S.) found in a nest of *Megalopta* sp., one female with a normal head while another, a slightly macrocephalic one, had a genal process on one side but not on the opposite side (Sakagami & Moure in press, b).

Decreased density of punctures parallel to increased head size has so far been ignored. One of us (S.F.S.) examined three halictine species, all showing conspicuous cephalic polymorphism: *H.* (*H.*) *scabiosae* (Rossi), *Augochlora semiramis* Schrottky, and *H.* (*Seladonia*) *hesperus* (Smith). This tendency was not found in the first two species, but was in the last, though not so conspicuously as in *H. latisignatus*.

CASTE DIFFERENTIATION. It is known at least in two species with cephalic polymorphism, *H. scabiosae* in Europe (Quénu 1957) and *H.* (*Seladonia*) *aerarius* (Smith) in Japan (Sakagami & Fukushima 1961), that this phenomenon relates to caste differentiation: the large macrocephalic females are queens, the small, microcephalic ones, workers. Considering this fact, some specimens of *H. latisignatus* (all collected on flowers in Lonavla during October 1964 by F.L.W.) were preserved in fixative and the internal features were examined. The results are shown in Table 3.

The relative age was determined by the wear of mandibles and wing margins. Parentheses in the last column indicate a degenerated state. The specimens examined are few in number, and we have not yet had a chance to discover the nest of this species. Nevertheless, the results clearly indicate the occurrence of queen-worker differentiation. A glance at the table shows that all females with head width less than 2·50 mm. (Nos. 1-11) are unfertilized. They are all fully laden with pollen, suggesting active foraging on flowers. Based upon the recent advance in halictine biology, it is impossible to regard them as caring solitarily for their own broods. Their ovaries are mostly undeveloped. Besides the specimens in the table, six small females taken on flowers were examined by F.L.W. as to ovaries but not spermathecae; four of them had undeveloped ovaries, two slightly developed ones. The occasional development of ovaries in workers of queen-right nests of some social

halictine bees is not rare. Therefore, it is certain that these small females were acting as workers.

TABLE 3

INTERNAL FEATURES OF FEMALES (QUEENS AND WORKERS) OF *Halictus latisignatus*

Serial No.	Date of collection	Head width (in mm.)	Age	Pollen loads	Fertilized or not	Ovary development
1	Oct. 20	2·27	old	+	–	(±)
2	18	do.	mid.	+	–	–
3	do.	do.	do.	+	–	–
4	20	2·30	do.	+	–	±
5	do.	do.	old	+	–	–
6	do.	do.	do.	+	–	±
7	26	do.	young	+	–	–
8	18	do.	do.	+	–	–
9	20	2·36	old	+	–	–
10	26	2·38	mid.	+	–	–
11	20	do.	do.	+	–	–
12	26	2·58	young	–	+	–
13	20	2·60	old?	±	+	(±)
14	do.	2·73	young	–	?	±
15	26	2·85	do.	–	+	–
16	20	2·90	mid.	±	+	++
17	do.	do.	old?	±	+	–
18	do.	3·09	do.	–	+	(±)
19	do.	do.	do.	–	+	(±)

On the other hand, all large females except one, the examination of whose spermatheca was unsuccessful, are fertilized. They carry either poor pollen loads or none. The ovaries are mostly still rudimentary or poorly developed or already degenerated. Probably this indicates that these large females collected on flowers were either young individuals before or immediately after starting nests, or those which were quite old and had abandoned the nests. It seems likely that the large females or queens at the peak of reproductive activity usually remain in their nests, so that they are rarely collected on flowers. It is interesting, however,

that one large female with very well-developed ovaries was collected (No. 16 in the table). This may have been from a solitary nest of relatively advanced stage before the production of workers, or may have been taken on the occasional flight of the queen at the peak of reproductive activity (this is occasionally found in the summer matrifilial nest of *Lasioglossum duplex* Dalla Torre, Sakagami, unpub.). Only this individual was middle aged among the large females, and her ovaries were enormously developed, not comparable with the slightly developed ovaries of some small bees (Nos. 1,4,6 in the table). This difference is comparable to that found between queens and workers with developed ovaries in some social species, for instance *Lasioglossum* (*Chloralictus*) *inconspicuum* (Smith) (Michener & Wille 1961).

Therefore, it is clear that the differentiation between queen and worker does exist in this species, though the type of social organization is still not well known.

PHENOLOGY AND FLOWER VISITS. Specimens examined were mostly collected in Lonavla, in the Western Ghats, situated on the Deccan side, 650 m. in altitude, about 65 km. from Poona. It is situated on the edge of the thick monsoon forest which covers the Ghats, and small patches of forest remain here and there at Lonavla. The whole area is basalt with scattered beds of clay. Three seasons can be distinguished in the district: Cold (approximately November-February, air temperature averaging 14-25°C.); Hot (March-May, 23-34°C.), and Rains (June-October, 20-26°C.). The specimens collected in Lonavla are arranged in Table 3 according to this seasonal cycle as follows, each month being divided into three 10-day periods. The relative age was determined by the wear of mandibles and wing margins. The results are shown in Table 4. The collecting was not done quantitatively and the number of specimens is still scanty. But except for the rainy season and December, the collecting covers all months and the distribution shown in the table surely reflects a seasonal shift. The absence of any activities during the rains is definite. During this season the rain is very heavy and almost incessant; almost the whole of the annual rainfall, averaging 4000 mm. or more, occurs during this time. There are few flowers and practically no activity of bees of any kind was seen on occasional visits there. Except for this season, the activities of *H. latisignatus* appear to be continuous (no collecting was done in December), but the peaks of abundance are apparently in May and October, that is the periods before and after the rainy season, and males and large females seem to appear only in these periods. At these times, weather conditions are most favourable, flowers are abundant, and many other species of bees flourish. In contrast to the species in temperate regions, there is no definite seasonal shift in age or caste. Both young

and old workers are captured side by side. Probably nests of diverse stages may occur at the same time, this being characteristic of many tropical species.

TABLE 4

SEASON OF COLLECTION AND AGE OF SPECIMENS OF *Halictus latisignatus* COLLECTED AT LONAVLA

Season	COLD		HOT			RAINS			COLD	
Month	I	II	III	IV	V	VI	VII-IX	X	XI	XII
Males	. . .	. . .	. . .	122	.41	5 . .		. . 1	. . .	. . .
Small females										
young	1 . 3	. . .	. . 2	21 .	28.	. . .		11.	. . 2	. . .
middle	1 . 1	11.	. . 1	1 . 1	14.	. . .		222	1 . 4	. . .
old	3 . 2	2 . .	. . .	3 . 1	. 1 .	. . .		. . 4	2 . .	. . .
Large females										
young	. . .	. . .	. . .	. . .	1 . .	. . .		221	. . .	. . .
middle	. . .	. . .	. . .	. . .	. . .	. . .		. . 2	. . .	. . .
old	. . .	. . .	. . .	. . .	. . .	. . .		. . 4	. . .	. . .

Flower visits have not been systematically observed. There are the following records: *Erioloena candollei* (Sterculiaceae), *Zizyphus* sp. (Rhacmneae), *Leea sambucina* (Ampelidaceae), *Terminalia* sp. (Combretaceae), *Cyathocline lutea*, *Senecio grahami* (Compositae), *Pogostemon purpurascens*, *Dysophyla stellata* (Labiatae), *Celosia argentea* (Amaranthaceae).

SUMMARY

Both sexes of *Halictus* (*Halictus*) *latisignatus* Cameron are re-described. The females of this species have conspicuous cephalic polymorphism. Large females are decidedly macrocephalic, with some associated morphological differentiation. Anatomical examination confirmed that this polymorphism relates to caste differentiation: large females are queens and small females are workers. The phenology and flower associations are briefly treated.

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A list of Planktonic Green Algae from Amritsar, Panjab

BY

MANMOHAN SINGH, M.SC.

S.G.T.B. Khalsa College, New Delhi

The present communication deals with some planktonic green algae collected by the author during January 1949 to March 1950 from some ponds, pools, and ditches in Amritsar and its environs. Although forms such as *Chlamydomonas*, *Pandorina*, and *Eudorina* were met with throughout the year, forms like *Micractinium pusillum* Fres. and *Pteromonas angulosa* Lemm. were encountered only during the latter part of July. The seasonal distribution of some of the forms is shown in the table at pp. 80-82. In all 53 forms are listed in this paper.

1. **Chlamydomonas globosa** Snow. Pascher, Süsswasserflora **4**: 192, f. 130a, 1927.

Cells 13-14 × 10-11 μ. In small ponds. Rarely found.
This is a more robust form than the type.

2. **C. intermedia** Chodat. Pascher **4**: 203, f. 141, 1927.

Cells 8-10 × 12-14 μ. In pools and ditches.
This form is slightly smaller than the type.

3. **C. reinhardi** Dangeard. Pascher **4**: 201-202, f. 140, 1927.

Cells 7-8 × 9-11 μ. In pools and ditches.

4. **C. gelatinosa** Korsch. Pascher **4**: 210, f. 154, 1927.

Cells 14-16 × 17-19 μ. In pools and ditches.

5. **C. umbonata** Pascher **4**: 211, f. 156, 1927.

Cells 10-12 × 11-14 μ. In stagnant water. Rare.

6. **C. proboscigera** Korsch. Pascher 4: 216, f. 161a, b, 1927.

Cells 10-11 × 10-12 μ. In pools and ditches. Rare.
This form is smaller than the type.

7. **C. gloeocystiformis** Dill. Pascher **4**: 224, f. 168,1927.

Cells 9-11 × 13-15 μ. In pools and ditches.

8. **C. gigantea** Dill. Pascher **4**: 283, f. 245, 1927.

Cells 12-16 × 16-25 μ. In ponds and ditches.

9. **Gonium pectorale** Müller. Pascher **4**: 418, ff. 376-379, 1927.

Colony 35-37 μ long; cells 7-9 × 6-7 μ. In ditches.

10. **Pandorina morum** (Müller) Bory. Pascher **4**: 427, ff. 387-389, 1927.

Colony 70-80 × 80-90 μ; cells 20-24 μ broad. In ponds and ditches.

11. **Eudorina elegans** Ehr. Pascher **4**: 440, ff. 394-401, 1927.

Colony 100-115 × 100-115 μ; cells 12-14 μ broad. In ponds and ditches.

12. **E. illinoiensis** Pascher (=*Pleodorina illinoiensis* Kofoid) **4**: 443, ff. 404-405, 1927.

Colony 44-48 × 50-55 μ; cells 4-6 × 7-9 μ broad. In ponds and ditches.

13. **Chlorogonium elongatum** Dangeard. Pascher **4**: 316, ff, 283-284, 284a, 1927.

Cells 4-5 × 40-45 μ. In ponds, forming a greenish scum on the surface along with *Chlamydomonas* sp.

14. **Volvox globator** (L.) Ehr. Pascher **4**: 465, ff. 413-415, 420b, 421, 422, 1927.

Common in small ponds and ditches.

15. **Pteromonas angulosa** Lemm. Pascher **4**: 365, f. 322, 1927.

Cells 16-18 × 20-22 μ. In ponds, forming scum.

16. **Tetraspora gelatinosa** (Vauch) Desvaux. Observ. Pl. Angers 18, 1818; Prescott, Algae West. Great Lake Area 88, t. 5, ff. 3-4, 1951.

Cells 9-10 μ in diameter. In pools and ditches.

17. **Pediastrum simplex** (Meyen) Lemm. Zeit. Fisch 1897 : 180, 1897; Prescott 227, t. 50, f. 2, 1951.

Coenobium 20-22 × 30-34 μ; cells 24-28 μ long. In pools.

18. **P. tetras** var. **tetraedron** (Corda) Rabenh. Flor. Eur. Alg. **3**: 78, 1868; Prescott 227, t. 50, f. 7, 1951.

Cells 7-8 × 14-16 μ. In ponds and ditches.

19. **P. clathratum** Lemm. Lemmermann, Brunnthaler & Pascher in Süsswasserflora **5**: 94, 1915.

Cells 15-18 × 25-28 μ. In pools and ditches.

20. **Micractinium pusillum** Fres. Abh. Sanck. Nat. Ges. Frankfurt a. M. **2**: 236, 1858; Prescott 287, t. 56, f. 8, 1951.

Cells 4-6 μ broad; setae 20-30 μ long. In pools along with *Pandorina* and *Chlamydomonas*.

21. **Tetraedron trigonum** var. **gracile** (Reinch) De Toni, Syll. Alg. **1** : 598, 1889; Prescott 270, t. 61, ff. 14-16, 1951.

Cells 20-24 μ long. In pools and ditches.

22. **T. minimum** (A. Br.) Hanzg. in Hedwigia **27**: 131, 1888; Prescott 267, t. 60, ff. 12-15, 1951.

Cells 6-14 μ long. In pools and ditches.

23. **Ankistrodesmus falcatus** var. **mirabilis** (W. & G. S. West) G. S. West, Treat. Brit. Fresh Wat. Algae 224, 1904.

Cells 1-2 × 30-34 μ. In pools and ditches.
This form is smaller than the type.

24. **A. spiralis** (Turner) Lemm. Arch. Hydrobiol. Planktonk. **4**: 176, 1908; Prescott 254, t. 58, ff. 11-12, 1951.

Cells 7-9 × 35-40 μ. In pools and ditches.

25. **Actinastrum hantzschii** var. **fluviatile** Schroder. Forsch. Biol. Stat. Plön. **7**: 20, 1890; Prescott 284, t. 65, f. 1, 1951.

Cells 1-2 × 14-16 μ. In pools and ditches.

26. **Kirchneriella lunaris** (Kirchner) Moebius, Abh. Sanck. Natur. Ges. Frankfurt a.M. **18**: 331, 1894; Prescott 258, t. 58, f. 2, 1951.

Cells 3-5 × 4-7 μ. In pools and ditches.

27. **Crucigenia rectangularis** (A.Br.) Gay. Recherches Devel. Classif. Alg. Vert. 100, 1891; Prescott 285, t. 65, f. 9, t. 66, f. I, 1951.

Cells 2-3 × 5-6 μ. In pools and ditches.
This form is smaller than the type.

28. **Scenedesmus obliquus** (Turpin) Kütz. in Linnaea **8**: 609, 1833; Prescott 279, t. 63, f. 17, 1951.

Cells 2-3 × 10-11 μ. In pools and ditches.

29. **S. dimorphus** (Turpin) Kütz. in Flora **16**: 608, 1833, Prescott 277, t. 63, ff. 8-9, 1951.

Cells 3-5 × 16-20 μ. In pools and ditches, along with *Coelastrum*, *Pediastrum* and *Ankistrodesmus* spp.

30. **S. bijuga** (Turpin) Lagerheim in Nuova Notarisia **4**: 158, 1893; Lemmermann, Brunnthaler & Pascher, Süsswasserflora **5**: 167, 1915.

Cells 4-6 × 14-16 μ. In pools and ditches.

31. **S. arcuatus** Lemm. in Forsch. Biol. Stat. Plön **7**: 112, 1899a; Prescott 275, t. 62, ff. 6-7, 1951.

Cells 5-6 × 8-10 μ. In pools and ditches. Rarely found.

32. **S. abundans** var. **brevicauda** G.M. Smith in Trans. Wis. Acad. Sci. Arts Letters **18**: 468, 1916.

Cells 3-4 × 6-7 μ. In ponds and puddles. Rarely found.

This form has sometimes two spines between two poles instead of four as in the type.

33. **S. quadricauda** var. **bicaudatus** Chodat. Lemmermann, Brunnthaler & Pascher, Süsswasserflora **5**: 165, 1915.

Cells 3-4 × 10-11 μ. In pools and ditches.

34. **S. quadricauda** var. **longispina** G.M. Smith in Trans. Wis. Acad. Sci. Arts and Letters **18**: 480, 1916.

Cells 4-6 × 11-15 μ. In pools and ditches.

35. **S. opoliensis** Richter in Zeit. Angw. Mikro. **1**: 7, 1896.

Cells 3-4 × 4-12 μ. In pools and ditches. Rarely found.

36. **Coelastrum microporum** Naeg. Lemmermann, Brunnthaler & Pascher, Süsswasserflora **5**: 194, 1915.

Colony 35-37 μ, broad; cells 10-12 μ broad. In pools and ditches.

37. **C. cambricum** Archer. Lemmermann, Brunnthaler & Pascher, Süsswasserflora **5**: 196, f. 311, 1915.

Colony 35-45 μ broad; cells 7-12 μ. In small ponds.

38. **Closterium acerosum** (Schrank) Ehr. West & West, Brit. Desmid. **1**: 146, t. 18, ff. 2-5, 1904.

Cells 30-35 × 230-250 μ; apices 8-10 μ broad. In pools and ditches.

39. **C. acerosum** var. **elongatum** Bréb. West & West, 148, t. 18, f. 1, 1904.

Cells 35-45 × 350-400 μ; apices 10-12 μ. In pools and ditches.

40. **C. strigosum** Bréb. West & West 165, t. 21, ff. 6-7, 1904.

Cells 10-14 × 150-200 μ. In pools and ditches.

This is much smaller than the type.

41. **C. ehrenbergii** Meneg. West & West 143, t. 17, ff. 1-4, 1904.

Cells 85-90 × 380 μ, apices 7-8 μ. In small pools and ditches.

This form is much smaller than the type.

42. **C. stellenboschense** Hodgetts in Trans. Roy. Soc. S. Africa **13**: 74, f. A, B.F., 1925.

Cells 10-11 × 90-100 μ. In pools and ditches.

43. **C. pseudodianae** Roy. West & West 132, t. 15, ff. 7-8, 1904.

Cells 10-12 × 150-200 μ, apices 2-3 μ broad. In pools and ditches. Rarely found.

This form differs from the type in not being straight in the centre.

44. **C. cornu** Ehr. West & West 157, t. 20, ff. 1-5, 1904.

Cells 1-10 × 110-120 μ; apices 2-3 μ. In pools and ditches.

45. **C. tumidum** Johnson. West & West 156, t. 19, ff. 15-18, 1904.

Cells 10-14 × 92 μ; apices 2-4 μ. In ponds and ditches. Rarely found.

46. **C. costatum** Corda. West & West 120, t. 13, ff. 1-3, 1904.

Cells 40-46 × 200-230 μ; apices 10-15 μ. In pools and ditches. Rarely found.

This form differs from the type in having smaller cells and lesser number of pyrenoids.

47. **Pleurotaenium ehrenbergii** var. **crenulatum** (Ehr.) Krieger. Kryptogamenflora **13** (3) : 413, t. 43, f. 6, 1937.

Cells 525-575 μ long ; breadth at isthmus 30-33 μ ; apices 21-23 μ. In ponds, pools and ditches.

48. **Cosmarium granatum** Bréb. West & West, 186, t. 63, ff. 1-3, 1905.

Cells 16-18 × 20-23 μ ; isthmus 3-6 μ. In pools and ditches.

49. **C. granatum** var. **subgranatum** Nordst. West & West 188, t. 63, ff. 5-8, 1905.

Cells 15-17 × 20-24 μ ; isthmus 5-7 μ. In pools and ditches.

50. **C. ocellatum** Eicheler & Gutw. West & West 144, t. 58, f. 6, 1905.

Cells 16-19 × 20-25 μ ; isthmus 5-7 μ. In pools and ditches.

51. **C. subtumidum** Nordst. West & West 192, t.63, ff. 18-20, 1905.

Cells 16-20 × 20-25 μ ; isthmus 8-9 μ. In pools and ditches.

This form is slightly smaller than the type.

52. **C. phaseolus** var. **minor** Boldt. West & West 159, t. 60, f. 15, 1905.

Cells 15-20 × 20-25 μ ; isthmus 5-6 μ. In pools and ditches. Rarely found.

53. **C. sub-broomei** Schmidle. West & West, Brit. Desmid. **4** : 23, t. 100, f. 10, 1911.

Cells 35-40 × 50-53 μ ; isthmus 12-15 μ. In pools and ditches.

Acknowledgements

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TABLE

SEASONAL DISTRIBUTION OF SOME PLANKTONIC GREEN ALGAE IN AMRITSAR AND ITS ENVIRONS

Month and Season	Minimum Temperature ° F.	Maximum Temperature ° F.	Average Rainfall (in metres)	Condition of the ponds and ditches	Algae collected
SUMMER					
May	75·7	104·1	0·014	Nearly all ponds and ditches dry up	*Pandorina morum* *Eudorina elegans* *Scenedesmus quadricauda* var. *bicaudatus* *Chlamydomonas globosa*
June	80·9	113·7	0·014	do.	*Scenedesmus bijuga* *Crucigenia rectangularis* *Kirchneriella lunaris* *Chlamydomonas reinhardii* *Chlamydomonas gloeocystiformis*
RAINY SEASON					
15-31 July	80·3	97·3	0·164	Ponds, pools, and ditches half full ; water turbid	*Chlamydomonas gelatinosa* *Micractinium pusillum* *Pteromonas angulosa* *Cosmarium granatum* *Closterium stellenboschense*
August	79·2	94·9	0·154	do.	*Pandorina morum* *Eudorina illinoiensis* *Volvox globator* *Scenedesmus abundans* var. *brevicauda*

1–15 September	74·8	94·9	0·054	All ponds full; water clears up	*Chlamydomonas gigantea* *Pandorina morum* *Scenedesmus dimorphus* *Closterium tumidum*
AUTUMN					
16-30 September and October	63·2	92·3	0·008	Water present in deep ponds	*Closterium cornu* *Volvox globator* *Chlamydomonas intermedia* *Eudorina illinoiensis* *Pandorina morum*
1-15 November	51·4	81·4	0·002	Shallow ponds dry up	*Chlamydomonas proboscigera* *Actinastrum hantzchii* var. *fluviatile* *Ankistrodesmus falcatus* var. *mirabilis* *Eudorina illinoiensis* *Cosmarium subtumidum*
WINTER					
16–30 November	do.	do.	do.	Only big ponds contain water	*Scenedesmus opoliensis* *Scenedesmus obliquus* *Ankistrodesmus falcatus*
December	44·2	70·8	0·012	do.	*Gonium pectorale* *Volvox globator* *Pediastrum simplex* *Pediastrum tetras* var. *tetraedron*
January	43·7	66·9	0·027	Ponds fairly full	*Eudorina elegans* *Pandorina morum* *Closterium pseudodianae* *Cosmarium granatum* var. *subgranatum* *Chlamydomonas umbonata* *Coelastrum microporum*

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TABLE—(*Continued*)

Month and Season	Minimum Temperature ° F.	Maximum Temperature ° F.	Average Rainfall (in metres)	Condition of the ponds and ditches	Algae collected
February	47·5	71·2	0·029	do.	*Chlorogonium elongatum* *Tetraspora gelatinosa* *Cosmarium ocellatum* *Closterium costatum* *Closterium acerosum* *Tetraedron trigonum* var. *gracile* *Eudorina elegans* *Pandorina morum* *Coelastrum cambricum*
SPRING					
March	56·3	83·2	0·025	Ponds half full	*Scenedesmus arcuatus* *Closterium ehrenbergii* *Cosmarium sub-broomei* *Cosmarium phaseolus* var. *minor* *Closterium strigosum*
April	66·5	95·7	0·012	Water at the bottom of the deep ponds and tanks	*Tetraedron minimum* *Pediastrum clathratum* *Ankistrodesmus spiralis* *Scenedesmus quadricauda* var. *longispina* *Pleurotaenium ehrenbergi* var. *crenulatum* *Closterium acerosum* var. *elongatum*

Contribution to the Biology of the Indian Starred Tortoise *Testudo elegans* Schoepff—I

BY

S. D. Jayakar and H. Spurway

Genetics and Biometry Laboratory, Government of Orissa, Bhubaneswar

(*With fourteen figures*)

Introduction

As we expect *Testudo elegans* Schoepff[1], like its close relatives, to be long lived, and as we also possess conditions where some individuals breed freely, we are planning this paper as the first of a series.

Smith (1931) gives the range of *elegans* as 'Central and Southern India, extending west as far as Sind and south to Ceylon'. Boulenger (1890) had already given 'India (except Lower Bengal) extending west to Sind; and Ceylon'. Our colleague Ajit Kisor Ray saw individuals during December 1942 and 1943 in Dacca district, now in East Pakistan, on the dry stubble of rice fields after harvest. In Mewar, now part of Rajasthan, from where Hutton (1837, calling the species *T. geometrica*) and Ceylon, from where Deraniyagala (1939) described wild individuals, these lived on dry stony ground on which grass grew in tussocks.

Stock, and Early Observations in Calcutta

All individuals not laid in the menagerie were purchased from dealers in Calcutta. The original female, M, was given to us in mid-June 1960. She had been a small child's pet and had been isolated from other members of her species for about one year. We kept her on a concrete-floored roofed verandah in north Calcutta. She ate little and was very passive, being considerably more shy of humans than the individuals of *T. graeca* which are similarly kept in Europe. Unlike the latter and Hutton's animals, she refused to eat leaf vegetables (cabbages or *sag*) and was fed on various legumes and lady's-fingers or *bhindi* (the fruits

[1] If it is considered desirable to split the genus *Testudo* L. the species *elegans* would be placed in the genus *Geochelone* Fitzinger (Loveridge & Williams 1957). We have used these authors' terms for the scutes and bones of the shell.

of *Hibiscus esculentus*). However, she resembled Hutton's animals both in frequently entering the dish of water, with which she was provided, and in defecating in it. Also like his animals, when handled she voided a colourless urine containing little white solid matter.

During the late autumn and winter of 1961-62, M performed an action which we have not yet seen performed by another tortoise. She walked briskly towards human feet from several metres away and bit the toes whether these were naked, in socks, or leather shoes. Less often she walked repeatedly over the instep. During this time, even though it was winter, her appetite improved and she became in every way a more interesting pet who seemed to enjoy being with humans in the house.

We purchased a male who did not react to her, but whom she circumambulated repeatedly before losing interest. Before 17/ii/62 we purchased another two tortoises, one of whom (W) had a broken shell and was considered the smallest female the dealer had to offer. M and W were kept together and separate from the other two, both males, except when under continuous observation. No sexual behaviour was seen, perhaps because of the weather, though all four animals were active and fed well. The new three did not urinate when handled.

No attempts were made to mate the animals after 6/iii/62 owing to pressure of other work.

On the morning of 11/viii/62 a pool of mucilaginous blood, not unlike menstrual blood, was found on the verandah which was only 2·76 sq. m. in area and contained only the animals M and W and a water dish. The plastron of M was clean, while that of W was bloody, but no more so than if it had walked through the blood. It was not clearly bleeding from any orifice or wound. However, during this examination it was realized that W had developed so as to have become recognizable as a male. His penis was examined, bathing the animal stimulating an erection, and this organ was in no way raw or injured. Next morning there was a smaller pool of blood, and on 13/viii/62 a table-spoonful only. No such blood has been seen since, and the plastron of W, which measured 9·3 cm. on 17/ii/62, was 10.6 cm. long on 14/viii/62. Therefore, it is when they reach this range of size that we may expect to be able to sex the animals hatched in the menagerie.

Habits in the Bhubaneswar Environment

On 23/viii/62 these four animals were liberated in a walled garden in Bhubaneswar (Unit 5, Type VIII, No. 2). In this they can walk freely over virtually all the unroofed area, i.e. a pavement of 122 sq. m. and two unpaved areas—a western of 51 sq. m. and a north-eastern of 21 sq. m. On these areas of soil various trees and woody shrubs are

cultivated, but the herbs are self-sown and are cleared at intervals. Only two species of plants have been observed to have any valence for the tortoises; they shelter under the dense rows of a white double variety of *Jasminum sambac* and they eat the leaves and the flowers of *Hibiscus rosasinensis*, especially the flowers which have fallen and are partly decayed. They are still offered *bhindi* and beans and these seem to form their major source of food. It is possible that M approaches the kitchen door to ask for food, but her movements are neither regular enough nor brisk enough to make this certain. M swallows the thin facial bones of goat and also nibbles leached cuttlefish ' bone ', both of which are sources of calcium which tortoises are known to seek. She will not however eat crustacean cuticle or avian egg-shell, cooked or raw[1]. Neither the adults nor the baby tortoises will eat any flesh so far offered to them, though the occasional nips they give to one another's shells seem to be a feeding not an aggressive movement. Deraniyagala reports that in Ceylon they eat young snails, and Loveridge & Williams (1957) that African species eat carnivore faeces, both sources of calcium. However, M has been seen eating fowl faeces, moving deliberately across the pavement from stool to stool, being chased by a male who attempted to mount whenever she paused to feed. Loveridge & Williams (1957) quote a report of the emydine *Clemmys caspica* habitually eating human faeces. Therefore, faeces seem to be used by tortoises as sources of other food requirements besides calcium.

Until 25/xii/64 the animals were collected and vegetables were offered them, and all four usually ate at least once a day. It was then realized that this was a constant disturbance to some individuals, which the branches of the *Hibiscus* trailing on the ground made unnecessary. Since 26/xii/64 kitchen vegetables have been offered only when an animal was seen walking actively. This practice has revealed that while M has eaten freely every few days since then, the three males are still (30/iv/65) not moving about freely. For example, W: he was discovered on a heap of stones on 13/i where, as he was covered with whitewash, he must have been for over a week during which time the wall above him had been painted. He remained on these stones until, on 21/ii, he was found on the pavement and ate *bhindi* as soon as he was offered some. He had returned to his stone heap within 1·5 hours. He has been found feeding, or active enough to be fed, only twelve times since (including twice on one day) though he has not been seen on the stones since 12/iii. The other two males have been seen even less. On one of the appearances of W (the second, on 3/iv), he was walking closely behind M. There was no attempt at copulation. Judging from previous years we do not expect sexual behaviour to begin until the monsoon in June

[1] The hens eat tortoise egg-shell greedily.

when these animals, like Hutton's, spend much time marching briskly on the pavement during rain. M has been the individual most frequently seen doing this, but she may be followed by one or more males. Thus the annual cycle of behaviour is similar to that in Mewar, and our animals, especially the babies to be described below, also show least activity during the hottest part of the day during the dry season. Deraniyagala wrote: ' The animal emerges from its shelter . . . at about 5 p.m., and continues to be active until about 7 a.m.' Our individuals, both young and old, out of doors and in artificial light, resemble the Mewar population and appear to sleep during the night.

Intra-specific Behaviour

After liberation in the walled garden, all the animals grew quickly. Partly because of this and partly because they rubbed off the various nail varnishes with which they were marked, the identities of the two original males were lost. They were not subsequently distinguished until 25/viii/63 when they were named R and S, the latter having lost part of his 3rd vertebral epidermal scute exposing parts of the 3rd and 4th neural bones and the 3rd and 4th left pleurals. No new growth of horn has been seen at the site of this wound.

The only social behaviour observed was sexual, and of low intensity or at least inconclusive. It has been performed by all three males. The male placed his forelegs on the carapace of M so that these embraced the dome. M, if walking, immediately withdrew her legs partially so she rested on her plastron. In this position copulation is impossible. The male remained supported by the female's carapace with only his hind feet on the ground. He swung his tail round under the female's supracaudal, but with only tentative movements. We have not seen an extrusion of a penis in this context, let alone an attempt at intromission. During this activity the males produced intermittent throaty grunts at intervals of about five seconds. If only heard, this grunting would be interpreted as accompanying copulatory thrusting. This behaviour is usually first discovered by this noise. We have never seen any preliminary recognition movements, which may be because all our individuals have long been familiar with one another; nor any courtship, for example the male knocking with his plastron on the carapace of the female, such as Auffenberg (1964) describes in the related *T. travancorica*.

Frequently, during an attempted copulation another male was close by, usually touching with his carapace the carapace of one or both of the pair. Often all four adults were touching, and two or more males mounted in turns, as Hutton also observed. Similarly, two or three males would follow the female at the same time, usually in single file

remarkably evenly spaced. During this marching in tandem, one male sometimes performed exactly similar mounting on the one in front. As would be expected the lower male walked away, whereas M usually sat passively and apparently indefinitely. These homosexual mountings were often asymmetrical and on a region of carapace which precluded any possibility of intromission. Similar clumsiness was seen also in a few heterosexual attempts.

We have never seen any reaction of one male to another that could be interpreted as territorial or agonistic behaviour, and their association during sexual behaviour would make this unexpected. Hutton described mutual frontal shovings in which one animal, apparently deliberately, sometimes turned the other off its feet onto its carapace. This behaviour has been interpreted by later authors as agonistic (' the males fight for the females '). That this action is also performed by females, as Hutton emphasizes, does not necessarily contradict this interpretation.

Eggs and Oviposition

M has laid at least 16 eggs while under observation (Table 1). These, like those observed by Hutton and Deraniyagala, were ellipsoidal, with white, matt, hard, brittle shells. Though we have not seen an attempted copulation consummated, at least 13 eggs were fertile. As tortoises of several species have laid fertile eggs four years after separation from a male (Goin & Goin 1962) it is possible that these fertile eggs were sired before M's capture in 1959. However, the observation that the first egg found was the only one that seems to have been unfertilized, and that this was followed by a period during which every egg found has been fertile, suggests that these eggs were sired by one or more of the males R, S, and W.

The egg 62I was found lying on the ground in an exposed position where it could not have been missed. When it was candled on 28/x/62, it appeared clear like an infertile hen's egg. Since a reptile egg, as a rule, begins development in the oviduct (Goin & Goin 1962), the presumption of its sterility is probably correct. It was not buried but kept for many weeks, and only discarded when it began to smell unpleasantly.

The second egg, 63I, was similarly found in a conspicuous place and similarly presumed new laid. 64XIII was found under foliage. It had a hole in its shell plausibly pecked by a domestic fowl, and was filled with soil.

M was seen laying the clutch 64I-64VII. This oviposition had begun by 17.58 during dusk on 18/iv, was continuing at 20.00, and completely finished by half an hour after midnight. As the beam of an electric torch caused her to stop digging and withdraw her foreparts, she was

TABLE 1

No.	laid	where	size (cm.)	weight (gm.)	hatched	incubation period (days)	hatching weight (gm.)
62I	17/x/62	surface	5.1×3.7	—	not fertile	—	—
63I	26/iii/63	surface	—	—	15/vii/63	111	13.87
64V	18/iv/64	buried	4.25×3.5	—	4/vi/64	47	16.13
II	do.	do.	4.35×3.55	—	4/vi/64	47	18.94
VI	do.	do.	4.4×3.55	—	11/vi/64	54	21.53
I	do.	do.	4.05×3.15	—	18/viii/64	122	14.43
III	do.	do.	3.95×3.1	—	22/viii/64	126	11.93
VII	do.	do.	4.4×3.3	—	29/viii/64	133	13.77
IV	do.	do.	4.65×3.4	—	12/ix/64	147	15.22
VIII	—	—	—	—	found 26/vi/64	—	weight when found 20.66
IX	—	one at least	—	—	3/vii/64	—	19.14
X	—	buried with	—	—	3/vii/64	—	19.07
XI	—	64 XII	—	—	3/vii/64	—	20.74
XII	—	buried	—	—	died near term	—	—
XIII	—	—	4.4×3.55	—	found empty 27/xii/64	—	—
65I	(?) 29/iii/65	(?) surface	4.06×3.01	22.39	—	—	—

not watched. She dug with her hind feet until her hind quarters were partially buried and in no way appeared to behave differently from the females described by Hutton and Deraniyagala. Next morning, the site of her pit did not differ from the surrounding earth. When excavated, the pit was swarming with ants, and the site had perhaps been chosen to exploit this. The eggs were found touching one another in a clutch, the top of which was about 5-6 cm. and the bottom about 15 cm. below the soil surface. Though the excavation was extended for about 10 cm. in all directions no more eggs were found. The next day, M had mud on her supracaudal and adjacent left marginal and trivial smudges on adjacent scutes. She was washed, and was not found similarly muddy until 21/xii/64. Therefore the five young animals found between 26/vi and 3/vii must have been laid earlier. However we have evidence that two of these, and most probably four, were laid in a hole about 40 cm. from the hole excavated on 19/iv. As the latter was by then completely obliterated, this distance is only an estimate. This hole, which descended vertically and was about the diameter of a young tortoise, contained fragments of egg shell and a putrid embryo very near term (64XII). Three young (64IX, 64X, and 64XI) were all a few metres from this hole, walking briskly away from it in various directions. Heavy rain was falling, so the sharp crisp edge of the hole was evidence that it had been opened minutes before it and the young tortoises were discovered. The first seen (64IX) was being followed by S in the manner in which he follows adult tortoises.

How much earlier than 18/iv these four eggs were laid is conjectural. We will argue below that the time between the two clutches was very short. It is not impossible that these 11 eggs were all laid on 18/iv/64 before midnight. In support of this interpretation are the observations by Deraniyagala that the Ceylonese specimens lay several clutches only a few days apart. Hutton obtained a clutch in 1834 (or 1835) and, presumably, 1836. Both were of four eggs, and this number is often quoted as typical of the species. Deraniyagala gives four as the maximum laid in one pit, while stating: ' Three to six eggs are laid at a time and two or three batches appear to be laid annually, for specimens dissected after oviposition contain half developed eggs '. M thus seems to be more fecund than the animals previously described.

Whether the last egg found (65I), which has not yet hatched (30/iv/65)[1], was buried or laid on the surface is uncertain. It appeared in a place where it had not been visible two hours previously. It was embedded in a slight depression of the soil surface. No mud had been seen on the carapace of M suggesting she had buried eggs since 21/xii/64; however, as heavy rain had just fallen on 29/iii, this could have either washed

[1] Since, discovered to be addled—S. D. J.

M clean or uncovered an egg that had been buried earlier. Shadows were visible on candling the egg but were not certainly an embryo.

Hatching

All undamaged eggs, except 62I, were buried individually *c.* 5 cm. deep in damp soil in small open glass jars, immediately after measuring if this was done. These jars were kept, unwatered, indoors in a cupboard. The times taken to hatch are given in Table 1. These are measured to the first appearance of the baby tortoise, whether it was first discovered free of both the soil and the egg-shell or just visible through cracks in the soil surface while still buried. Some of these babies took almost twenty-four hours to finish dragging themselves out of the soil, but this could be hurried by putting them in a strong light. However, no question about the definition of the day of hatching obscures the observation that the periods from laying to hatching of the best documented group 64I-64VII, all of which were kept in apparently identical conditions, form two groups; i.e. the tortoises can be classified into the *quick* developers, and the *slow* developers, hereafter referred to as the ' quicks ' and the ' slows '. The great range and the bimodality associated with very little variation within each group suggest that there may be a genetic difference between the two groups. Table 1 shows that all the slows were lighter at birth than all the quicks. Judging from the duration of its laying-hatching period, and confirmed by its hatching weight, 63I is judged to be a slow and will be considered with them. Tortoises 64VIII-64XI could have been laid at any time prior to the washing of M's shell on 19/iv/64. We have given evidence that three of them were found almost immediately after emerging from the earth; by their weights when found these are judged to be quicks, as is 64VIII, though this animal may have fed, perhaps for some days, before it was discovered.

The egg-shell was found in two main pieces each including a narrow end always filled with earth, and many small crumbs. This confirms that these tortoises, like the animals observed by Vallee (quoted by Wright, n.d.), emerged through the side of the egg, not through an end, like the *Pseudemys scripta troostii* babies described by Cagle (1950). One of these halves of the shell was always found at the depth where the egg had been buried, and contained a discrete lump of soil. This suggests that before the animal attempts to struggle upwards and while it is still in the shell, it releases some fluid from either the bladder or the amnion. No organic structure was discovered in these lumps, which had apparently anchored the half shells, facilitating the animals' climbing out of them. The other main piece of shell was pulled off by the passage through the soil.

All the animals had a caruncle, or egg tooth, a small chisel-shaped blade about 1·5 mm. long just ventral to the nostrils on the dorsal end of the narrow anterior edge of the beak on the upper jaw. These were not shed but wore away, so that there has often been doubt as to whether they were still present or not. The extremes among the fully documented tortoises were 64VI who is recorded as keeping its egg tooth 40 days, and 64III who lost it when between 202 and 209 days of age. All the slows kept their caruncles longer than the quicks. 64VIII had lost its caruncle 4 days, and 64IX between 28 and 35 days, after discovery. The others kept them for over forty days.

The tortoises seen to hatch had a median transverse fold in their plastra showing how they were packed inside the shell. This fold approximated to the sutures between the pectoral and abdominal scutes, and thus was anterior to the comparable fold in the *Pseudemys scripta* (Cagle 1950) which crossed the abdominals. The plastra straightened out gradually.

All tortoises were hatched, or found, with a vestige of the yolk sac protruding ventrally in the mid-line between the two abdominal scutes of the plastron and usually also separating the anterior parts of the femoral scutes (see Fig. 3). At hatching this yolk sac was sometimes a spherical pulsating bladder 10-40 mm. in diameter preventing the animal walking, and sometimes already a flat pad. It was in the latter condition in 63I though this animal was helped from its shell and the soil within an hour of being discovered. Though these yolk sacs were covered with mucus and therefore collected dust and grit, in all animals they were withdrawn into the plastron within a few days, usually within 48 hours, but in 64IV it remained thus vulnerable for 6 days and was once noted as bleeding from a scratch. The yolk sacs of 64VIII and 64IX were more withdrawn when found than we have seen in animals hatched in the collection, but those of 64X and 64XI were not so. The median suture and the paired sutures between the abdominals and the femorals did not resemble the other sutures of the plastron until after a period ranging from 13 to 27 days, during which period irregular wisps of epidermis were attached to them. The scute surface was scarred in the region where the yolk sac had protruded.

Tortoise 64II took a half-hearted bite at a fragment of its own egg-shell and 63I behaved similarly to the uncooked shell of a hen's egg. No others paid any attention to egg-shell. Eating has appeared as functionally ineffective intention movements, first observed on the second day of independent life. The movements have grown gradually in intensity and effectiveness. Undoubted mouthfuls have been taken when the animals were four days old. The increase in weight during the first week shows that they had ceased to depend on their yolk sacs for nourishment. Within a week of birth they ate greedily.

Care of the Young

From 2/ix/63 to 31/vii/64 the baby tortoises were kept in an exposed place out of doors in a wooden vivarium (1). This was a wooden box 50 cm. × 40 cm. × 40 cm. high standing on legs, with holes in the floor and containing potsherds, gravel, and sloping soil so that it drained like a window-box. The lid was $\frac{2}{5}$ wood and $\frac{3}{5}$ rabbit wire. Various pots and potsherds for shade have been provided on the highest ground which is under the wooden part of the lid. Invariably during the middle of dry days and, except during the first week of life, during the night, the animals have been found under these shelters. A flat dish of water 3 cm. deep with vertical sides has been provided. The animals, especially during the dry season, have been found bathing in this. 63I, during its first few weeks of life, was kept in various improvisations of the final design used. As these did not possess adequate protection from crows and squirrels, they were kept indoors during the night, and much of the day. The later babies were put out of doors in this vivarium as soon as their yolk sacs had been withdrawn sufficiently to permit them to walk. On 31/vii/64 a second vivarium (2) of identical design was put into service and the animals divided equally between them, and on 21/viii/64 a third (3). These vivaria have been cleaned out only when the drainage system has been blocked, or some servicing has seemed necessary to the structure. This has been done twice for vivarium 1, and vivarium 2 has been replaced by a new structure, vivarium 4. Food debris has been removed and the soil has been flooded at least once a week. Surprisingly few faeces have been seen, and there has been no sign of the soil becoming fouled. The soil has impacted, and no plants have established themselves.

The distribution of the animals between the vivaria is important, and is a consequence of the discipline with which they have been weighed and measured. Since 5/vi/64, the first Friday on which there has been more than one baby, the weight and four linear measurements have been taken every Friday. The animals have been weighed in random order after being washed. When all tortoises have been weighed, the four measurements are taken on the first weighed, then on the second and so on. Ever since more than one vivarium has been in use, when four tortoises have been both weighed and completely measured, these four have been given a few moments swimming and then placed in vivarium 1, the second four are measured, allowed to swim, placed in vivarium 2 (or 4), and the last four similarly in vivarium 3. Thus the whole group of young tortoises are considered to have been kept in one environment, being equally exposed both to any features peculiar to one vivarium, and to any pathogens and parasites. The development of any peck order must also have been complicated.

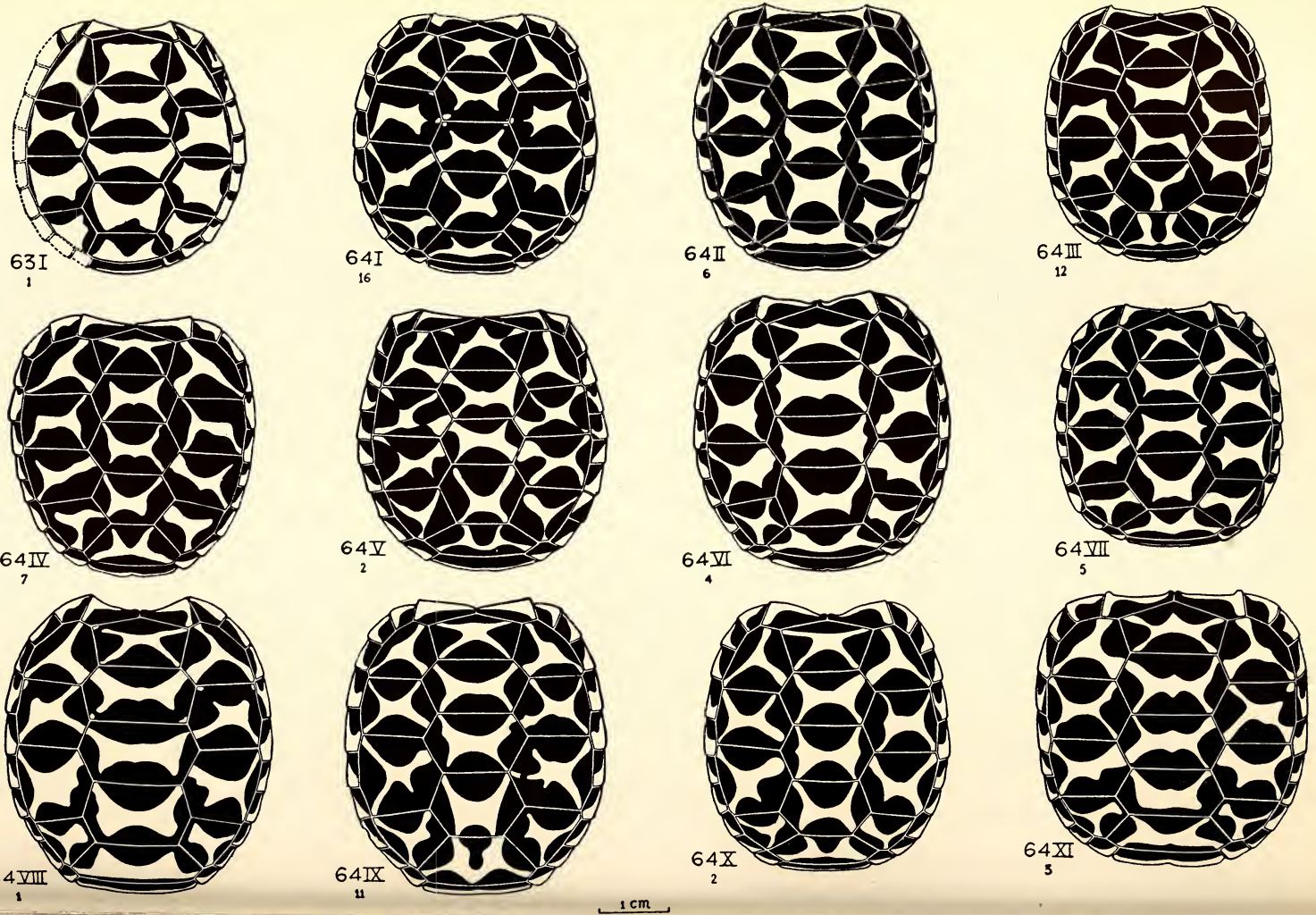
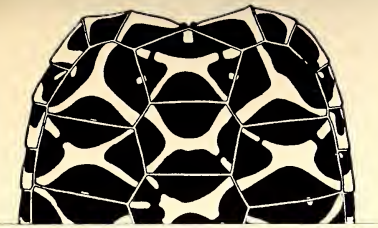
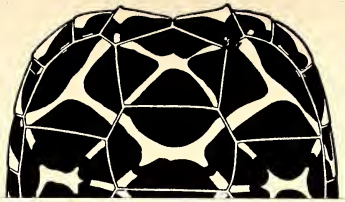
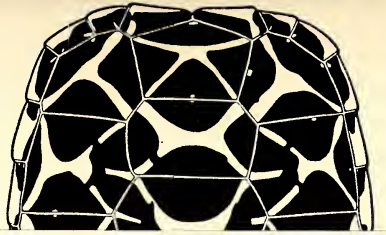


Fig. 1. Carapaces, life size, soon after hatching (631 from a photograph). The age in days after hatching under the number of the tortoise.

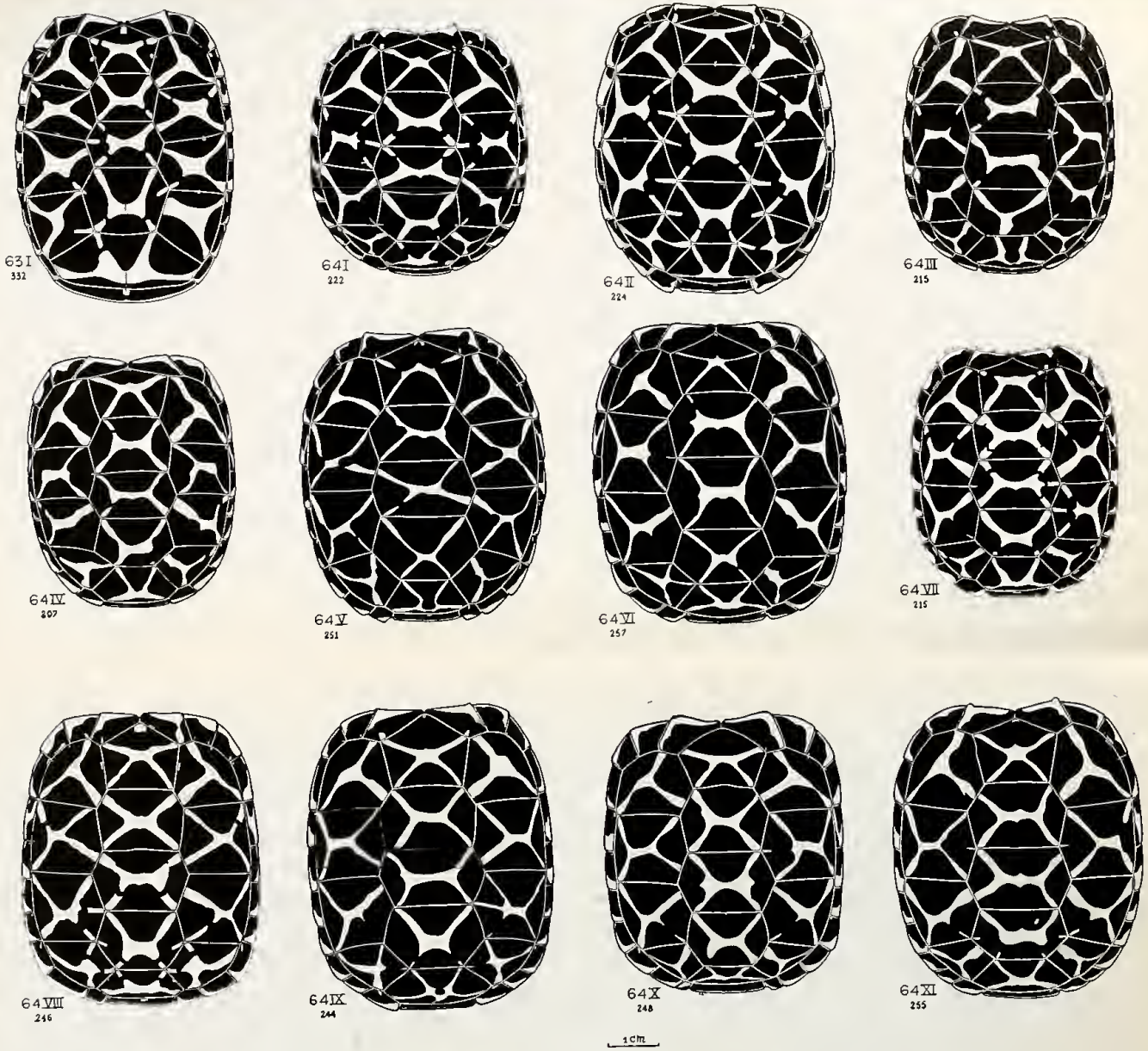



Fig. 2. Carapaces, life size, during second six months of life. The age in days as in Fig. 1.

During this weekly handling, the animals have produced considerable quantities of greenish brown faeces, invariably preceded by a colourless, or rarely orange, transparent urine, and erratically by a white flocculent urine also. The consequent soiling of themselves is the reason for the double washing. As faeces and uric acid deposits are both inconspicuous in the vivaria there is a suggestion that the weekly weighing and measuring may have imposed an unnatural periodicity on evacuation.

The baby tortoises have been fed from the beginning on the same food as the adults, but the beans and *bhindi* are, perhaps unnecessarily, split lengthways in order to make it easy for them to obtain purchase. The brownish green faeces have been seen only after eating became normal. Most urine has been transparent, liquid, and colourless. The youngest age at which white solid uric acid has been recognized in the urine was 49 days (64VII). Two of the older 1964 animals also first produced this form of urine on the same day. The production of solid urine is intermittent. Its absence is not evidence that uric acid is not the main nitrogenous end product (Moyle 1949).

The Shell Patterns and their Development

As we know of few pictures of the young of this species we publish drawings of the carapaces (Figs. 1 and 2) and plastra (Figs. 3 and 4) of these animals when approximately newly hatched (those of 63I drawn from photographs) and during their second six months of life. These drawings are diagrammatic, firstly because they exaggerate the widths of the marginal and caudal scutes and secondly because they do not show variation in pigmentation, the light parts having been ivory or cream sometimes with milky details, and the dark parts a sepia-horn colour of varying intensities. Therefore they should not be considered seriously except for the purpose for which they were drawn, to record the pattern of pigmentation at various ages. Considering the carapaces of the newly hatched tortoises (Fig. 1), the contrast between the two colours was always extreme. In the centre of each vertebral and costal scute but not coinciding even approximately with the granular central region, there was a light area more or less oblong in all vertebrals and the 2nd and 3rd costals, the long axis being parallel to the long axis of the scute and at right angles to the head-tail axis of the tortoise. From each corner of this area, a broad band extended towards the two upper and two lower corners of the scute crossing the smooth area round the granular portion. The patterns in the 1st and 4th costals were similar, but in the former always, and in the latter usually, triradiate. These are in contrast to the quadriradiate patterns of the 1st and 4th costals in the young individual pictured by Loveridge & Williams (1957, Plate 8A) of the similarly pigmented *Psammobates geometricus*, the

African species with which Hutton confused *elegans*. The outer, caudal, and sometimes some of inner margins of the marginals, and the hind margin of the supracaudal were pale, and the rest of these scutes dark. In the drawings can be seen how much an incompleteness of various bands and the presence of extra cusps complicated what we have suggested to be the basic pattern. In the carapaces of four tortoises small discrete pale areas near the margins of the scutes are shown. These had a milkier, more transparent, colour than the central parts of the other pale areas, as did some of the tips of the latter where they touched the margins of the scutes. These were areas left unpigmented as the scute had increased in area by deposition of material round its margin. That this secondary pattern was the most developed in 64VIII confirms the evidence provided by its yolk sac and egg tooth that it was not found the day it hatched.

Both Deraniyagala and Smith (1931) describe other infantile colours and patterns which we have not seen.

The limbs, head, and trunk of the hatchlings were ivory-coloured with a few dark blotches. The scales were clearly defined.

A scute increases in size by the deposition of material including pigment round its margins increasing the area of the smooth border. Therefore gaps in this pigmentation, which we see positively as the development of the rays of the stars which give this species its name in English, must also originate at the margin. Comparing Figs. 1 and 2, we see that if a pale ray extended to the margin of the scute at hatching this ray has usually continued unbroken. Those rays which did not reach their appropriate margin have usually remained separated by a pigmented area from any unpigmented area originating at the nearest point on that margin. Therefore though pale areas have appeared in the angles to which such primary rays were pointing, thus confirming our interpretation of the specific pattern, the imperfections in this pattern at hatching are as a rule still visible at 8 months at least. However there are exceptions (e.g. vertebral 2 of 64VIII and right costal 3 of 64IX) in which pigment has been removed from the scute so that a ray broken at hatching has become continuous with age. Therefore some reorganization of tissue is revealed to be taking place other than at the edge of the scute. This would be expected, as scutes injured in the centre are reported to be able to heal and regrow (Gadow 1901). Secondary unpigmented areas have tended to arise from the angles of the scutes but later from the sides also. Their points of origin tend to be evenly spaced. The boundaries between pigmented and unpigmented areas have remained smooth as long as growth continued smoothly, i.e. the rays are remarkably even in width. However after a slowing, or cessation of growth, the resumption of the band may have been slightly shifted (e.g., in vertebral 3 of both 64VI and 64VIII). In Fig. 2 the

Fig. 3. Plastrons, life size, soon after hatching (63I from a photograph). The age in days as in Fig. 1.

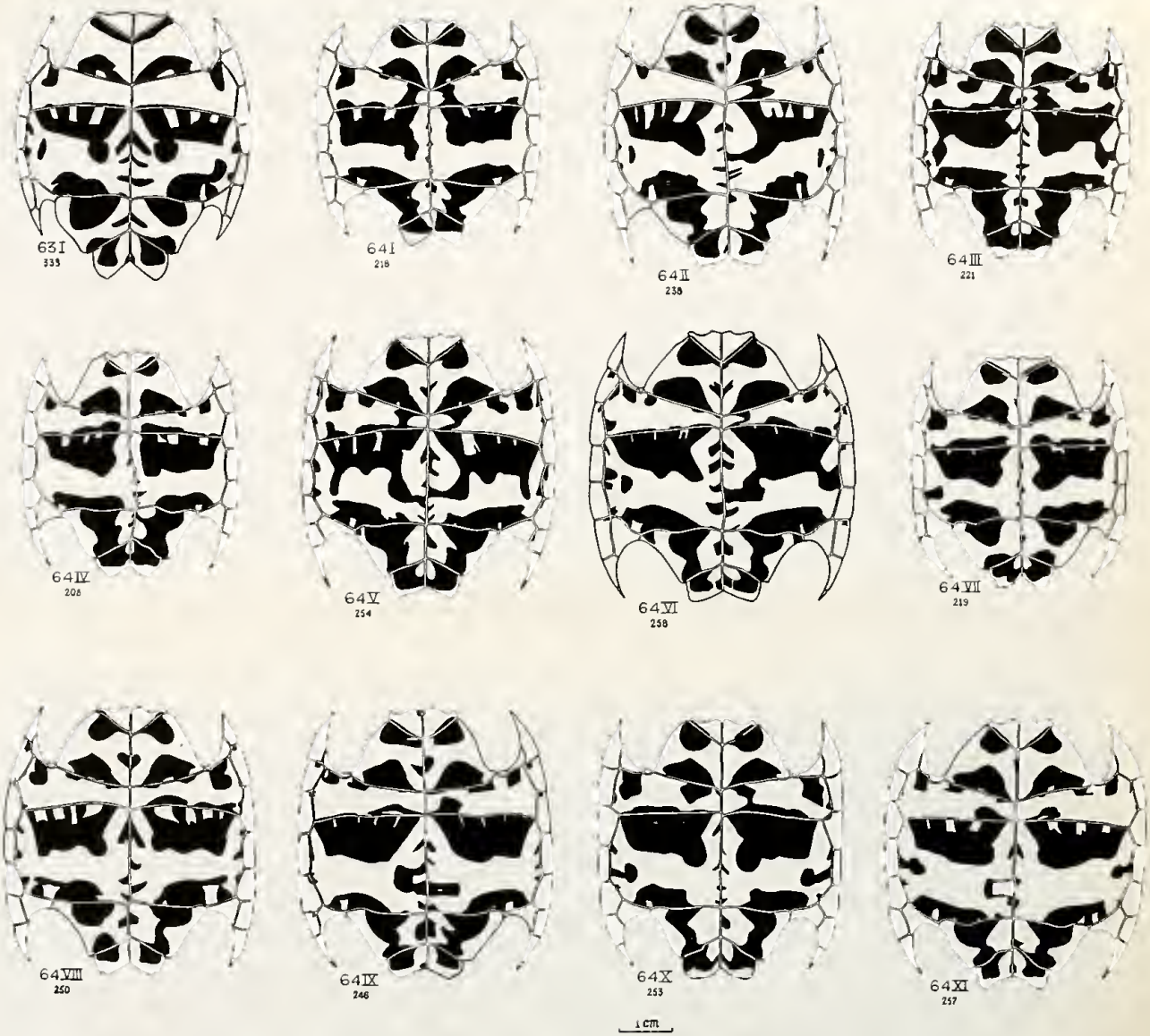


Fig. 4. Plastrons, life size, during second six months of life. The age in days as in Fig. 1.

carapace of 63I, considered to be a slow, was drawn during the eleventh month of life, being ten weeks more than the age of the next oldest animal at drawing. It will be noticed that this carapace is neither the largest nor has the most developed secondary pattern.

As the variations in colour of the pigmented areas of the plastra were considerable at birth, the black and white drawings of these (Fig. 3) have to be more diagrammatic than those of the carapaces. However the shapes of the plastra shown in these drawings are not diagrammatic. As Cagle (1950) has described, young tortoises change their shapes during the first week of life, straightening out after having been folded within the shell. Therefore there was variation in how visible, in a ventral view, were the submarginal scutes in the axillary and inguinal notches (Fig. 3). In all tortoises, adult and young, 2 axillaries and one inguinal are now visible. In one infant, on one side only, by forcing back the tissue of the foreleg, a third axillary anterior to the others can be seen. This suggests that not only this third axillary, but the two additional inguinals, described by Deraniyagala, may be hidden by the limbs in living tortoises, at least of our population.

The greater part of the plastral area is pale, on which were various pigmented areas, all in contact with the margin of a scute, with the exception of three lateral spots in 64II. All tortoises had transverse pigmented areas along the cephalad margins of the humerals, the abdominals, the femorals, and the anals, and along the caudal margins of the humerals, the abdominals, and the femorals. Other markings were variable. Considering only the eleven 1964 babies, 18 out of 22 gulars had some black along the posterior margin, two animals being asymmetrical. All but one (64IV) had some pigmentation along the anterior margins of both pectorals, and in six tortoises bands of pigment extended on at least one side from the anterior to the posterior edges of the scutes near the median sutures. All tortoises except 64VII and 64VIII had similar longitudinal bands crossing the femoral scutes. These were completely absent in 64VII, and only the left was present in 64VIII. A few tortoises had isolated patches both median and lateral, symmetrical or asymmetrical, on the abdominals. 64I and 64IX had some pigment on both of the more lateral axillaries, and 64VII had it on the right only. 63I, the drawing of which is from a photograph, would seem to have had several unique features. These patterns cannot be ranked in a sequence according to area of pigmentation ; we cannot infer that one animal has a generally more developed pattern than another.

When we compare Fig. 3 with Fig. 4, we find both that the postnatal pigment deposition on the plastron differs more from the prenatal deposition than it does on the carapace, and that more components in the pattern (e.g. on the right abdominal of 64III, the left gular of 64VIII, and all pigment in the axillaries) have disappeared completely. Con-

sidering the transverse black bands edging most of the plastral scutes, and comparing Figs. 3 and 4, it will be seen that some growth has taken place in the centre of the scutes, but that this is small in amount compared with the increase in area due to deposition at the margins. On both the transverse and longitudinal margins of the posterior plastral scutes, new tissue is laid down so that it is banded light and dark at right angles to its direction of growth. In the period considered, most growth took place round the edges of the abdominals which have consequently changed most in appearance. The gulars have grown but have altered little in pigmentation. Pigment has begun to appear in the ventral surfaces of the marginals.

Growth Rates

63I was first weighed and measured on 19/vii/63 (i.e. 4 days after hatching), again on 16/viii/63, and subsequently at roughly weekly intervals except for a gap from 25/xi/63 to 17/xii/63. 64II and V, and 64VI were first weighed and measured the day after they hatched, i.e. on 5/vi and 12/vi/64 respectively. All other tortoises were weighed and measured the day they hatched or were found. On and after 5/vi/64 all tortoises already hatched have also been weighed and measured every Friday, in the randomized order which has already been described.

The tortoises have been weighed by difference in a triple beam balance. During their first few weeks they were weighed in a petri dish or watch glass, but later they had to be wrapped tightly in a polythene bag held with paper clips to minimise movement.

The four linear measurements were made with vernier calipers. These were : (1) the median length of the carapace, made with one jaw of the calipers in the anterior groove ; (2) the median length of the plastron on which there is both an anterior and posterior groove for the jaws of the calipers ; (3) the maximum width ; and (4) the maximum height. Measurements 3 and 4 were made by moving the jaws of the calipers to and fro until they just touched the animal. Measurement has become progressively easier as the shells have hardened, both because the animals have reduced power to change their shape, and also because there is less danger of the shell being deformed by pressure of the calipers. The presence of the yolk sac together with the convexity of the plastron often made the first measurement of the height (4) bizarre. Measurement 3 is the carapace width of other authors. In this species the lateral margins of the two rows of main plastral plates curve up to join the lower edges of the marginals smoothly in an unbroken steep curve making any separate measurement of their width difficult or impossible.

The individual growth curves for all measurements for all tortoises up to and including 12/ii/65 are shown in Figs. 5-9, and Table 2

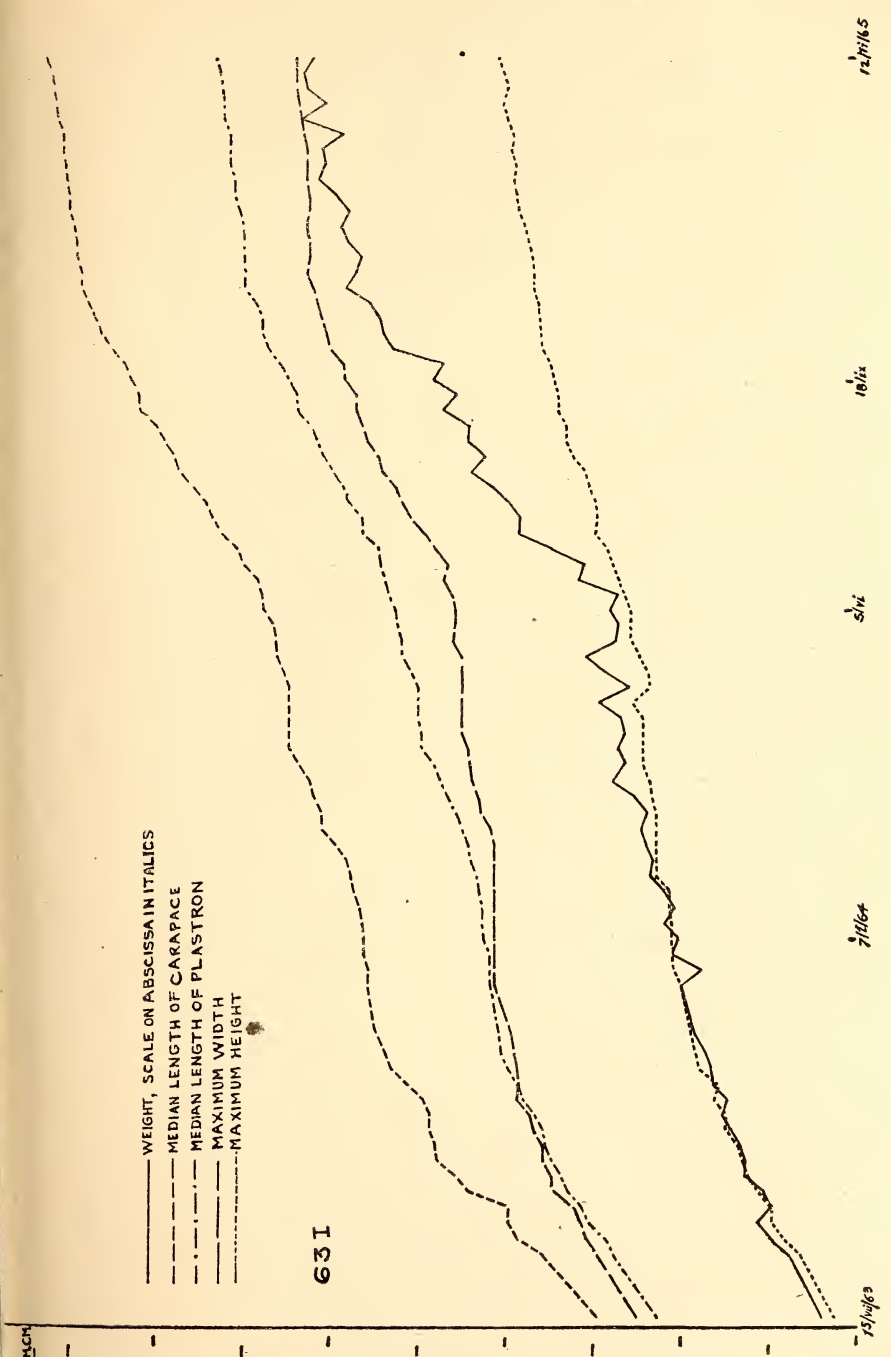


Fig. 5. Growth curves of tortoise 631
Vertical line represents day of hatching

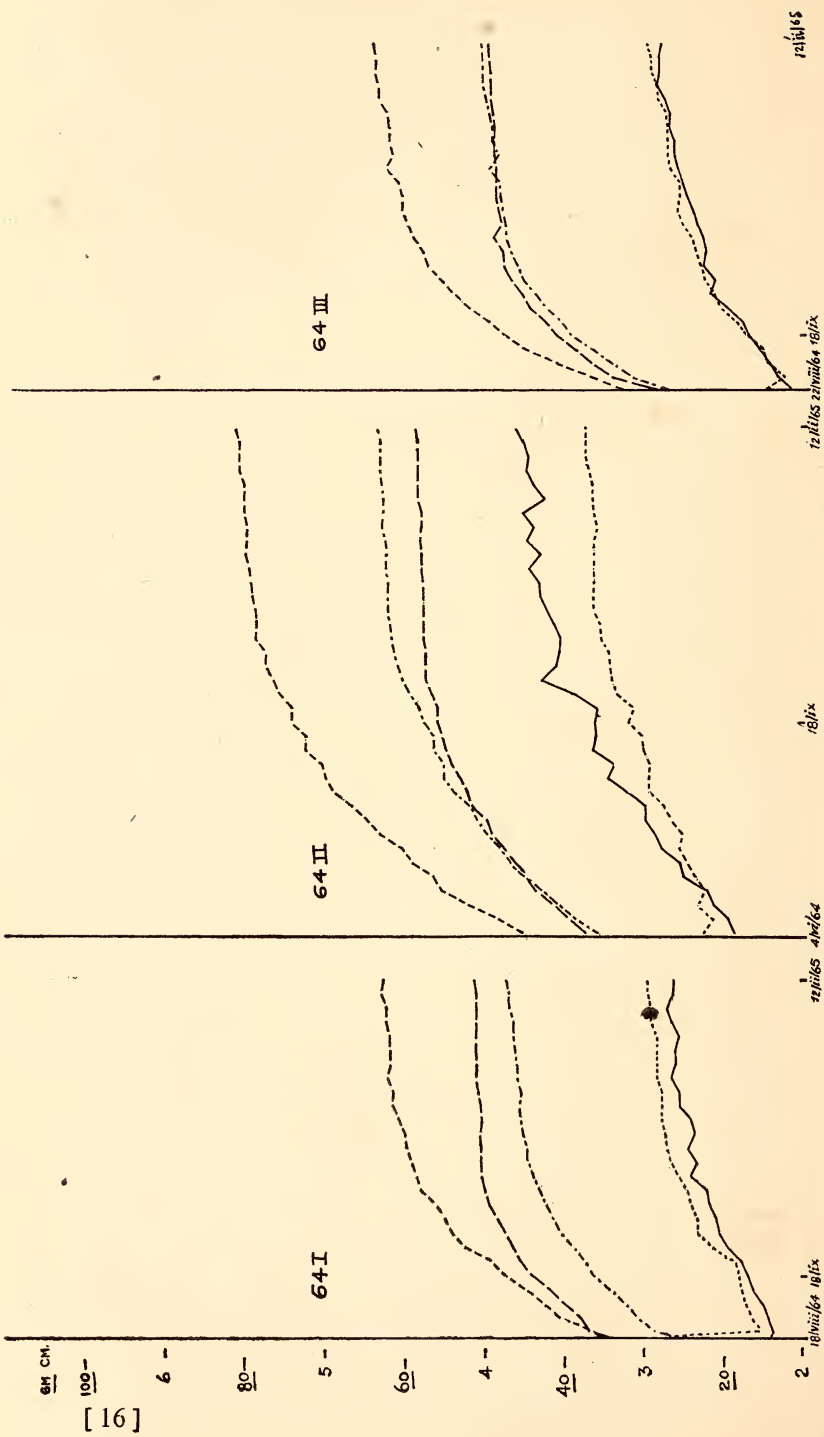


Fig. 6. Growth curves of tortoises 64I, 64II, and 64III
Key as per Fig. 5

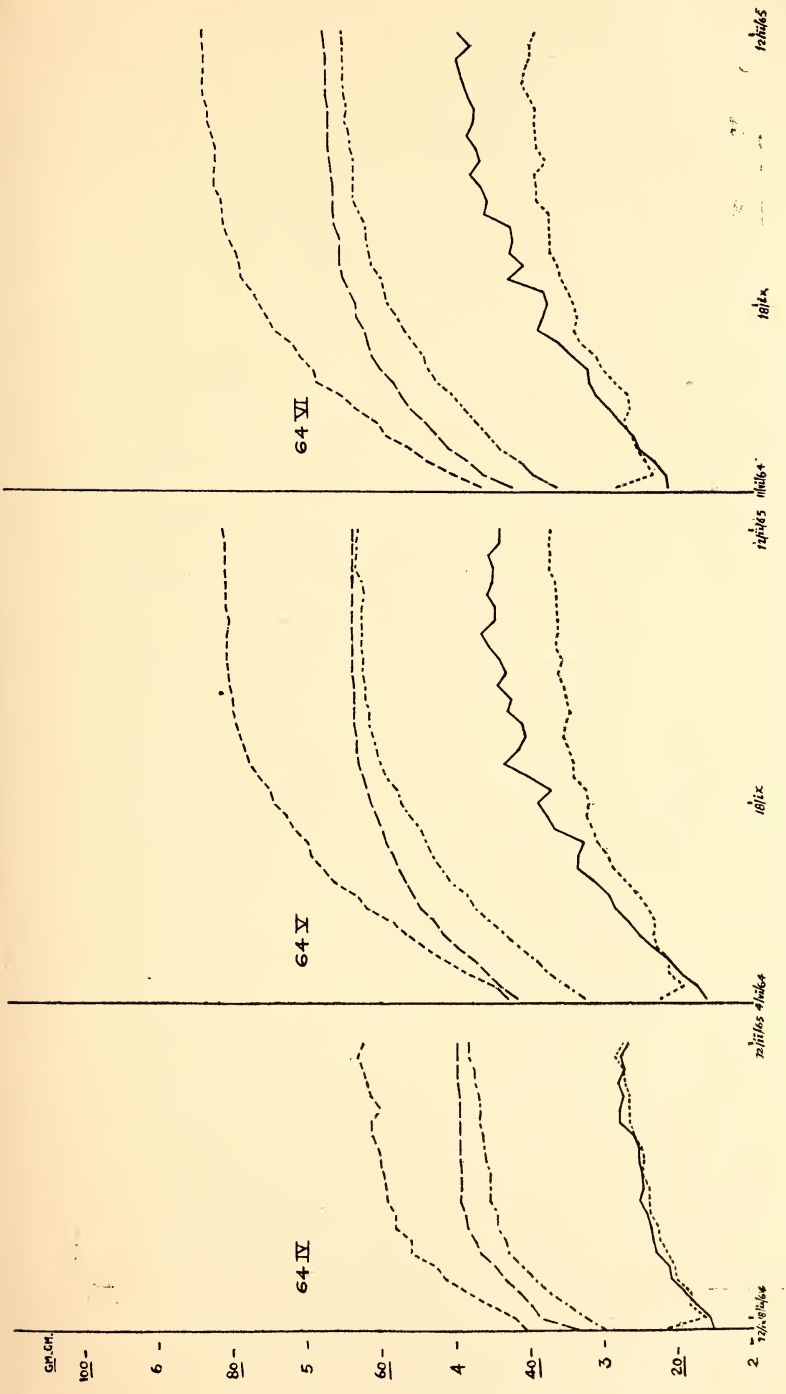


Fig. 7. Growth curves of tortoises 64IV, 64V, and 64VI
Key as for Fig. 5

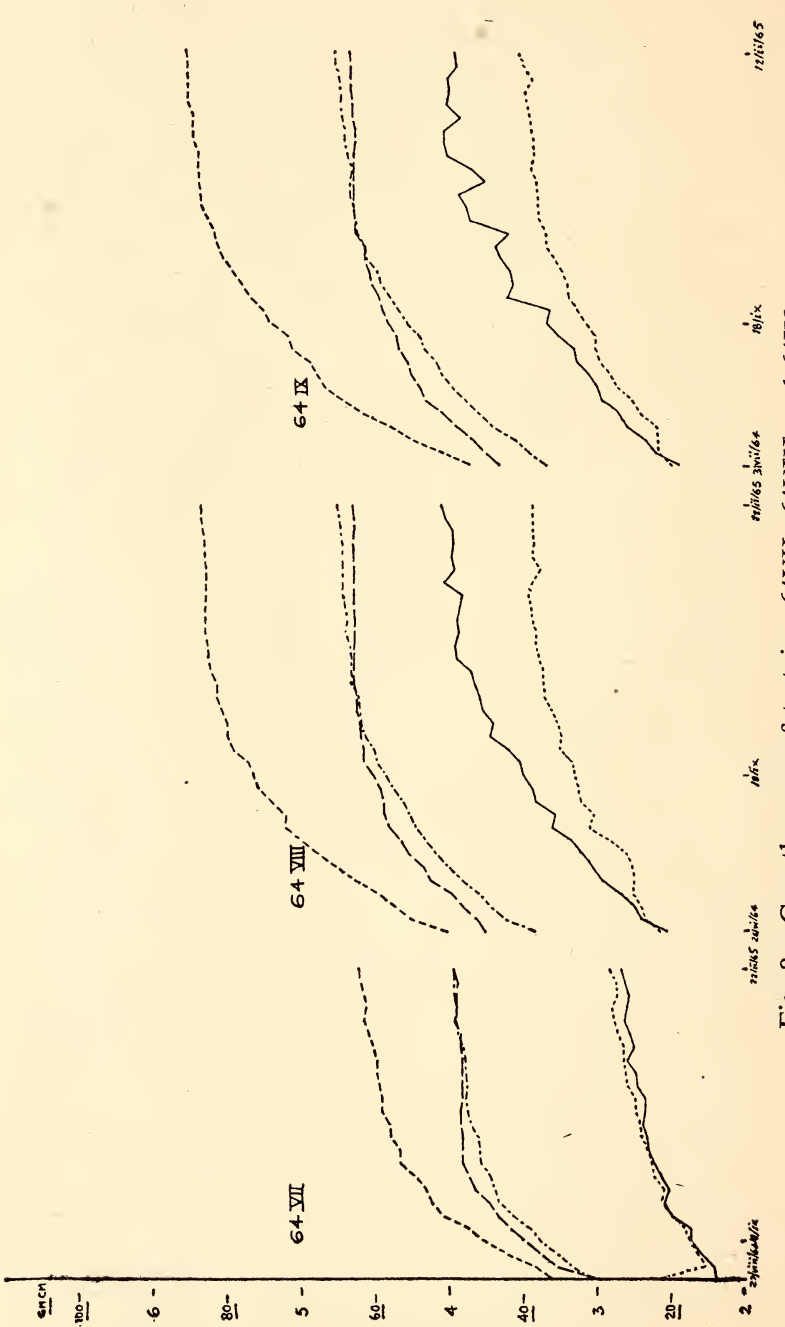


Fig. 8. Growth curves of tortoises 64VII, 64VIII, and 64IX
Vertical line represents date of hatching when known with certainty. Remaining Key as for Fig. 5.

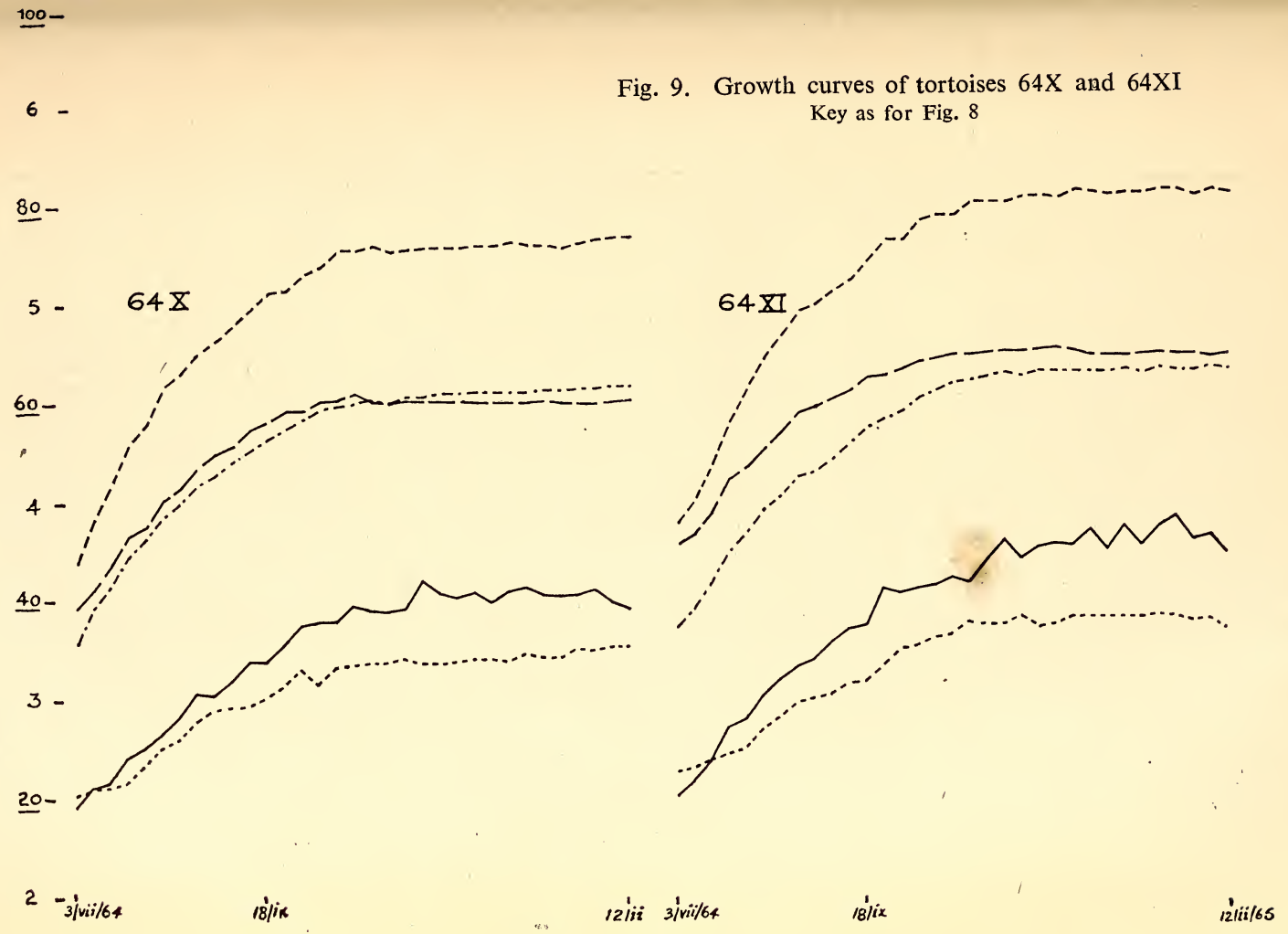


Fig. 9. Growth curves of tortoises 64X and 64XI
Key as for Fig. 8

TABLE 2

	Max. (°C.)	Min. (°C.)	Rainfall (mm.)	No. of days with rain		Max. (°C.)	Min. (°C.)	Rainfall (mm.)	No. of days with rain
1963					1964				
March	37.2	16.6	22.7	4	March	38.0	16.7	25.2	3
April	39.6	19.6	46.9	3	April	41.7	20.4	58.0	6
May	39.6	19.6	161.2	9	May	40.3	21.6	73.8	7
June	37.6	23.5	113.2	16	June	42.9	24.5	93.6	16
July	33.7	23.5	304.4	26	July	31.9	22.4	565.0	28
August	33.6	22.6	474.6	27	August	33.6	23.6	367.0	25
September	34.5	22.9	216.3	14	September	33.0	23.6	312.8	26
October	33.3	20.5	340.5	19	October	33.8	19.7	77.0	12
November	32.7	15.2	T	1	November	31.9	12.5	0.3	1
December	30.4	11.2	0	0	December	31.1	10.7	0	0
1964					1965				
January	31.8	12.8	0	0	January	30.6	10.7	16.6	3
February	36.6	16.0	24.8	8	February	33.1	14.3	10.0	3

summarizes some environmental data for the relevant period. The scale for the linear measurements and that for the weights (labelled in italics) were chosen for their convenience in Fig. 5. That the height curve and the weight curve for some of these tortoises are often parallel, and even overlap for long periods (in particular 64III), was surprising, considering that weight would be expected to be roughly a cubic function of a linear measurement.

The graph for 63I (Fig. 5), which is the only tortoise which has lived through two summers, shows that its growth was much reduced during the winter and the drier part of the hot season. It may not be a coincidence that growth was resumed after 5/vi/64, i.e. immediately after the hatching of the next season's eggs. At hatching, the length of the plastron was less than the width, but the graphs crossed on 1/xi/65, i.e. 109 days after hatching.

The 1964 babies have already been divided into the quicks, heavier at hatching, and the slows. The flattening out of the curves in the cold season is evident, growth being only slight after about the first week of November. At hatching, the length of the plastron was always less than the width (except for 64VII immediately after hatching) but, as would be expected from the adult shape, this difference narrowed steadily after birth for all tortoises, and for some of the young tortoises the length has overtaken the width. If one considers the period between hatching and the crossing of the two curves, i.e. from hatching to that date on which the plastron was at least as long as wide and after which date remained so, the tortoises fall into three groups (Fig. 10). The period for 64II is 29 days, for 64III and 64VII-X it is between 119 and 146 days and for the other five is not yet known. We have already stated that for 63I this period is 109 days, which makes it plausible that 63I belongs to the ' narrows ' as we will refer to tortoises 64III and 64VII-X, 64II being called ' very narrow ' and the rest ' broad '.

We have, therefore, according to the two criteria, six possible groups of which only 5 groups are represented.

	Broad	Narrow	V. Narrow
Slow	64I, 64IV	64III, 64VII, 63I	
Quick	64V, 64VI, 64XI	64VIII, 64IX, 64X	64II

Initially, the growth rate of each of these groups was considered separately, but it became obvious that, at least until we have more individuals, the *growth increments* for all the slows could legitimately be averaged, and similarly for all the quicks. Table 3 shows the means of the different measurements at hatching for the various groups excluding 63I and 64VIII. The results are not unequivocal, but the difference between the broads and narrows is that the broads were already wider

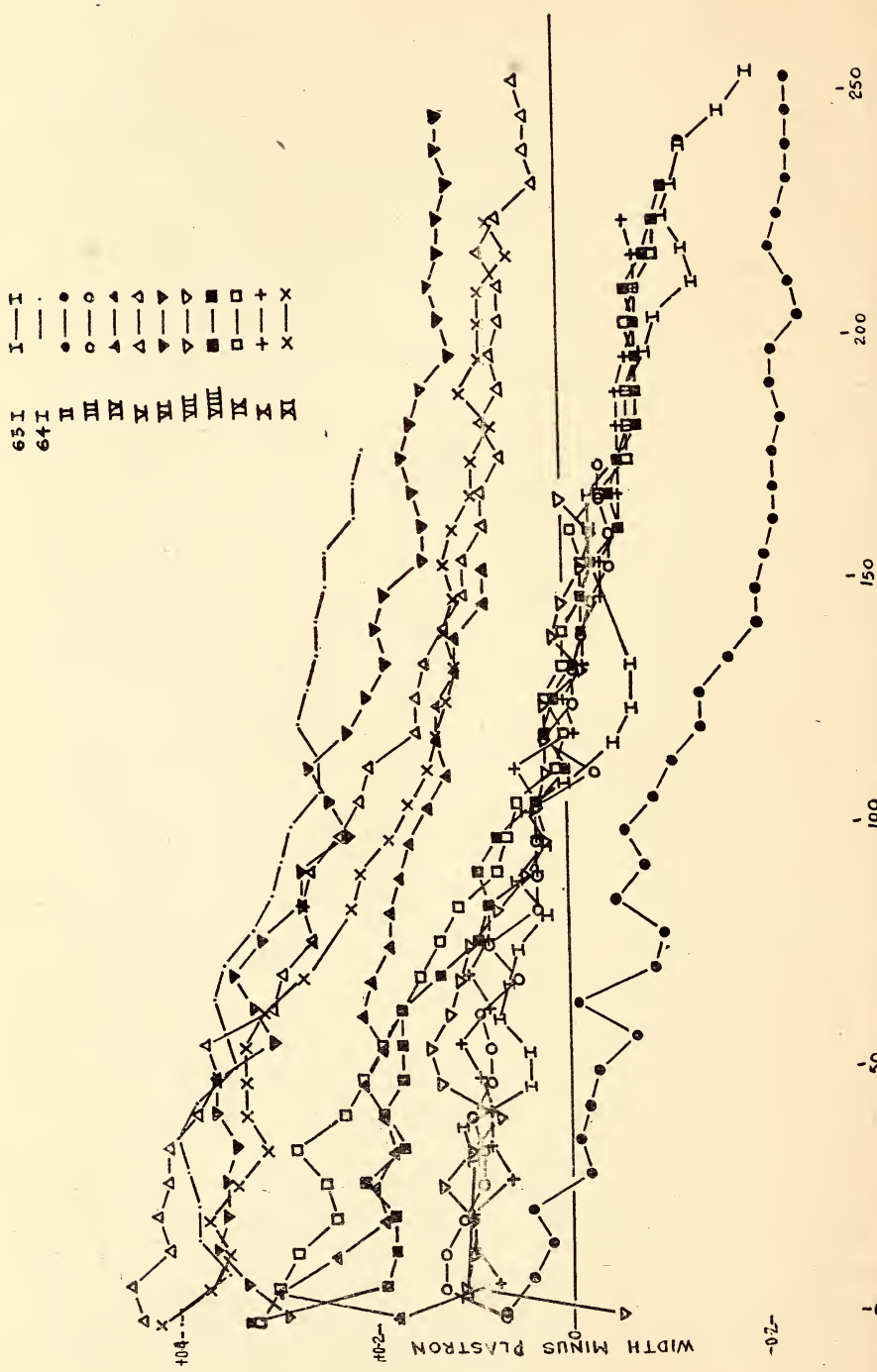


Fig. 10. Change in width minus plastron length with age

at birth than the narrows. However, it appears also that among the slows, the broads have longer carapaces and are heavier than the narrows.

TABLE 3

MEAN OF MEASUREMENTS AT BIRTH FOR THE DIFFERENT GROUPS (EXCLUDING 63I AND 64VIII)

	broads	narrows	v. narrow
WEIGHT			
slows	14.8 (14.4-15.2)	12.8 (11.9-13.8)	
quicks	19.4 (16.1-21.5)	19.1 (19.1)	18.9
CARAPACE			
slows	3.40 (3.28-3.52)	3.22 (3.14-3.30)	
quicks	3.79 (3.64-3.91)	3.79 (3.70-3.88)	3.78
PLASTRON			
slows	2.92 (2.83-3.02)	2.94 (2.86-3.03)	
quicks	3.28 (3.13-3.39)	3.32 (3.29-3.36)	3.30
WIDTH			
slows	3.20 (3.18-3.23)	2.96 (2.93-2.98)	
quicks	3.66 (3.57-3.81)	3.58 (3.47-3.68)	3.37

The carapace length/height ratio was calculated for each tortoise at intervals of 4 weeks. The ratios did not show any trend, nor were they different for different tortoises. The values thus obtained varied from 1·56 to 1·70 with a mode at 1·65. The carapace length/width ratio of course showed a steady increase with age, being between 1·02 and 1·12 at birth and 1·27 for 63I at the age of 80 weeks.

Fig. 11 shows the average increase in plastron length for all the quicks and slows, in one week from hatching (rounded off to the nearest Friday), in the second week, and so on. The births of the two groups occurred in different seasons of the year, and were, on the average, 21 June and 28

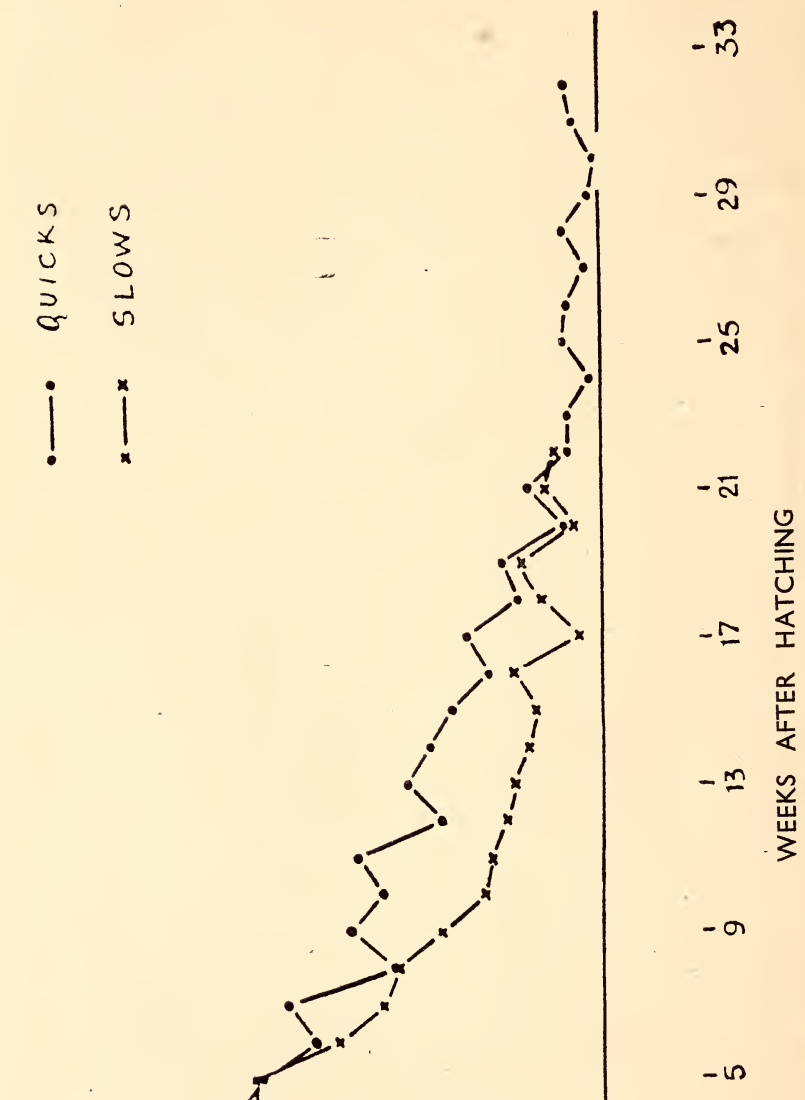


Fig. 11. Mean weekly increase in plastron length. Quicks—animals with short laying-hatching period (i.e. 64II 64V, 64VI, 64VIII-64 XI) ; slows—animals with long laying-hatching period (63I, 64I, 64III, 64IV, 64VII). See text.

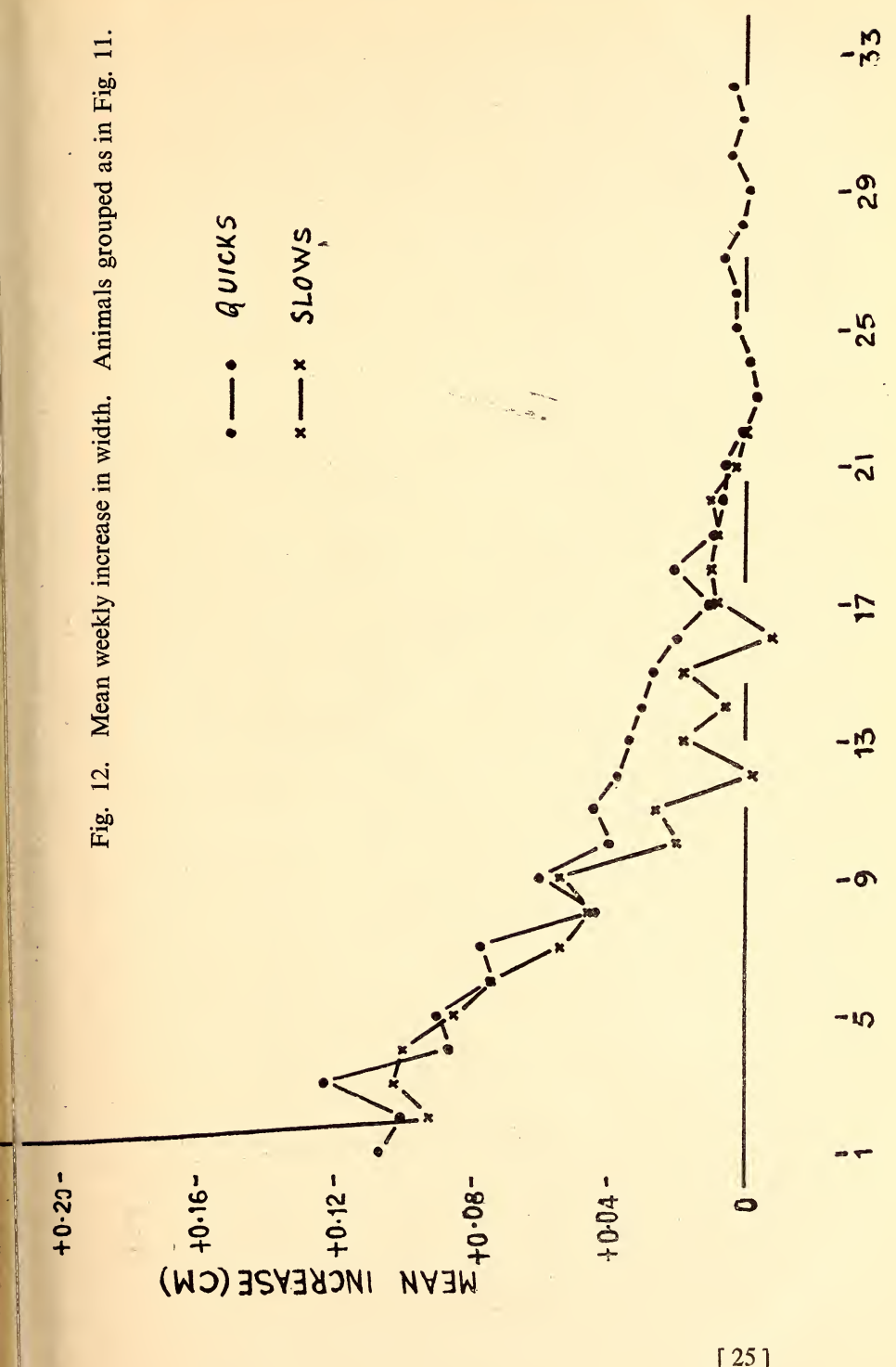


Fig. 12. Mean weekly increase in width. Animals grouped as in Fig. 11.

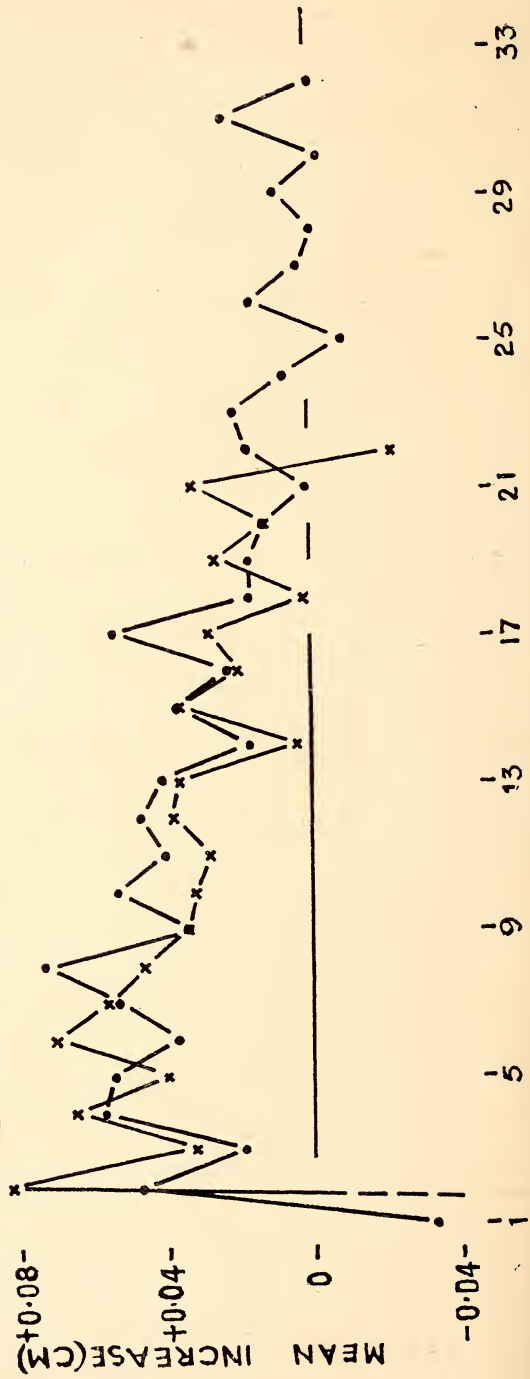


Fig. 13. Mean weekly increase in height. Animals grouped as in Fig. 11.

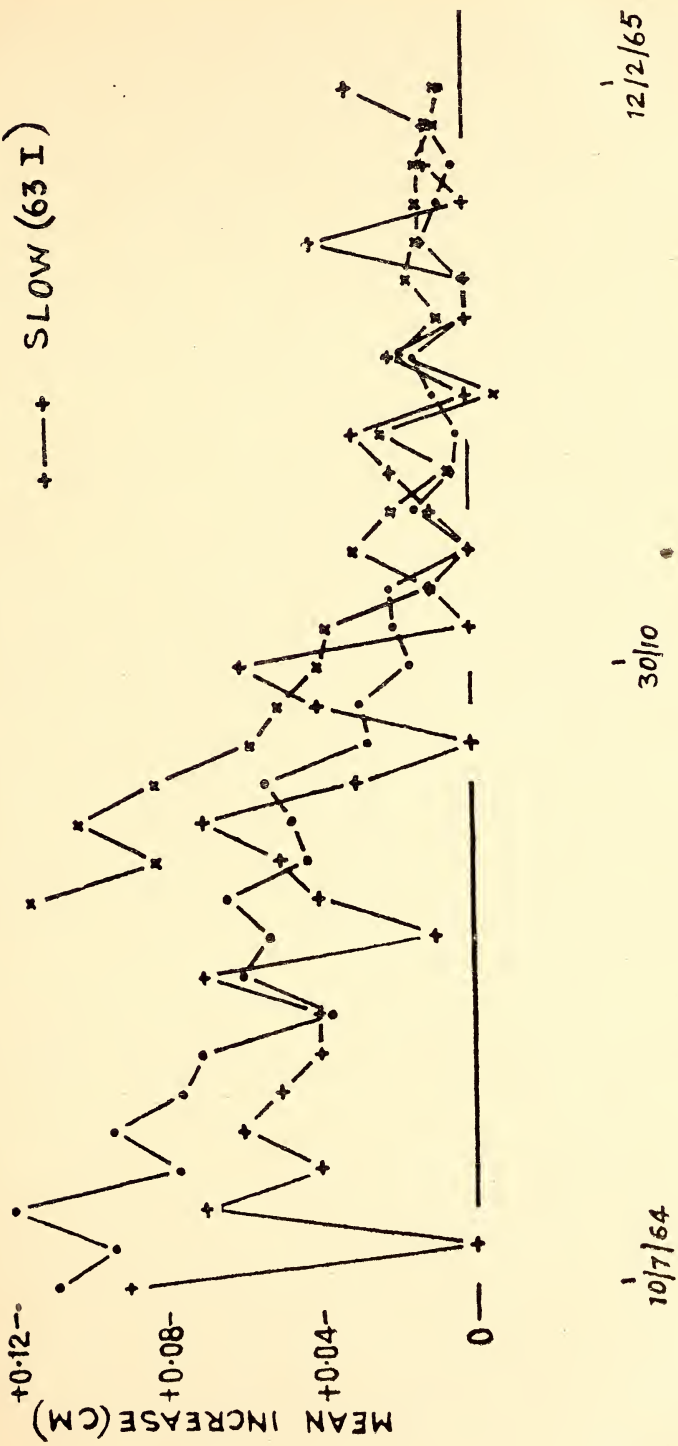


Fig. 14. Mean increase in plastron length with calendar week. Quicks as in Fig. 11 ; 63I separated from 64 slows.

August for the 1964 young. As the growth rates of poikilotherms would be expected to depend to a large extent on the weather, we cannot expect the two curves in Fig. 11 to be similar. However, the growth rates for the two groups do appear to be similar from the second to the ninth week of life, as are the equivalent curves for the width (Fig. 12) and the height (Fig. 13). The curves for carapace length are similar to those for the plastron, but those for weight show too many fluctuations to be informative. From the tenth week onwards, the slows show consistently lower growth rates in all linear measurements. This may be due to the fact that for them this represents the period from about November 1 onwards when growth in all tortoises started slowing down with the onset of winter (see Figs. 5-9). The gradual decline in growth rate, reflecting the onset of the cold weather, is more clearly shown by Fig. 14, which graphs the increases in plastron lengths averaged for a calendar week separately for the three age groups, i.e. 63I, 64 quicks, and 64 slows. The curves for the other linear measurements are again similar, and the weight curve again shows too violent fluctuations to be useful.

Table 4 shows the means for all tortoises of the correlation coefficients between weekly increments in the different measurements, and of each with weight. These correlation coefficients were greatly influenced by the high growth rates immediately after hatching. The highest value, as one would expect *a priori*, is that between the two lengths, and is very high indeed. As far as linear measurements for this species are concerned, we confirm Cagle (1950) that the length of the plastron is the most satisfactory, being not only the most objective to make, but possessing the highest correlation with other measurements. It is followed by the length of the carapace, and then the width. The height is unsatisfactory. These comments hold only for measuring with a pair of calipers.

TABLE 4

MEAN CORRELATIONS BETWEEN WEEKLY GROWTHS

	Wt.	C.L.	P.L.	W.	H.
Weight	—	—	—	—	—
Carapace length	+ 0.4786	—	—	—	—
Plastron length	+ 0.4175	+ 0.8550	—	—	—
Width	+ 0.3124	+ 0.7622	+ 0.8432	—	—
Height	+ 0.3858	+ 0.5168	+ 0.4872	0.3728	—

DISCUSSION

We have discussed previously (Jayakar & Spurway 1964) the bimodality in the times observed between laying and hatching. We have not yet discovered any comparable record concerning either tortoises or any

other species with a comparable life span. We compared it with the variation in age at puberty, which seems characteristic of long-lived groups with low reproductive rates. However, in a species which takes over two years to reach sexual maturity it is not easy to see in detail how a delay of three months between the hatching of sibs would appreciably decrease the danger of inbreeding.

Slow developers have so far been consistently smaller at birth than quick developers. This initial lag has not been made up so far because the seasonal fall in temperature slowed the growth of the slows a shorter time after their hatching, thus reinforcing their initial handicap. A second grouping can be made according to the length compared with the width of the plastron. As in adults males are relatively narrower than females, the puberty of our young is eagerly awaited to see whether this difference reveals that they can be sexed within a few weeks of hatching.

To us it seems a coincidence[1] that while we have been collecting these data on tortoises we have also been making observations on individuals of the lapwing *Vanellus malabaricus* that nest in another part of our garden. We have therefore attended both to the considerations that made avian genera extremely small (in e.g. Baker 1922-1930) and to the reconsiderations (e.g. Bock 1958) that have resulted in the recent reduction of so many of these genera to synonymy (Ripley 1961). This study of another group makes us for the moment unconvinced by the evidence on which Loveridge & Williams (1957) argue that the genus *Testudo* should be split.

The palaeontological approach to bones may have left an impression that they are conservative in evolution in more ways than is correct. Because the phylogeny of many major groups can be induced convincingly from mutual relations between bones, it does *not* follow that their form, including degree of development, and ossification, should be conservative during the ecological divergence of speciation, especially as bones are known to be relatively easily altered by use during development. The skeletons of animals may perhaps be particularly changeable because so many of the selection pressures acting on them are imposed by the physical properties of the non-living, including non-organic, world. To put it another way the skeleton, to a large extent because of its own rigidity, may be exposed relatively more than other systems to one-way or only weakly reciprocal selection pressures (Spurway 1955). Given the involved nature of ecological interactions it is impossible to say that our tortoises' preferences for putrid hibiscus flowers or fowl faeces do not, or could never, exert a selection pressure on the plant or avian species concerned (as the various movements used in drinking can

[1] What is *not* a coincidence is how much of the literature here discussed we have seen through the kindness of Dr. Ernst Mayr.

have no influence on the physical properties of water). However any such selection pressure would seem to be slight when compared with the selections imposed on the tortoises' feeding mechanism by the action of ingesting material with such textures. This malleability of the skeleton is in contrast to the observed conservatism of courtship movements in evolution. These latter are not only preferentially under reciprocal selection pressures, but these pressures act coincidently on the same mendelian population. This capacity for mutual adjustment seems to provide a buffering action against change. Therefore the selection pressure for reproductive isolation during a speciation process seems to influence communicatory behaviour by altering only morphological adjuncts and the rate and frequency of movements, which movements differ very little, if at all, in their *form* at the level of specific differences.

Auffenberg (1964) is working on the comparative ethology of tortoise courtships. When more of his results are published we may consider that they justify relatively small generic divisions. But until we have as shrewd a suspicion of the details of what tortoises do with their skulls as Bock (1958) has of what plovers do with theirs, we do not want to accept phylogenetic lines based on inductions from differences between these skulls, and from similar skeletal details.

For example, we have mentioned that our tortoises are coprophagous and eat other offal, and we have found references to similar food habits. We have not seen this generalized as a capacity of the group, though there are several suggestions that such food preferences may be widespread among them. Among these are : (1) the doubt concerning many species as to whether they are carnivorous or herbivorous ; (2) the acceptance with which meat, i.e. already dead prey, is accepted by species judged to be carnivorous ; (3) the acceptance, or even seeking out, of nutritive substances for which they can have had no previous learnt or unlearnt experience, e.g. bread-and-milk and the bands of lime-wash used to mark out tennis courts on grass. Among animal species there is a correlation between the capacity to survive in captivity, which tortoises notoriously possess, and scavenging feeding habits. An increase or decrease in the proportion of putrid food in a diet are examples of the minor variations in behaviour which we would expect to exercise selection pressures, changing, for example, triturating surfaces on the bones of a jaw.

Summary

Three male and one female *Testudo elegans* have been observed for several years. Their environments and some of their habits are described. Sixteen eggs have been found. Two of these were certainly laid singly on the surface of the soil and one certain clutch of seven was

buried. Twelve eggs have hatched. Laying-hatching time has ranged between 47 and 147 days. It has so far been bi-modal. There has been no post-natal mortality. The shell patterns at hatching, and after six months of life, are pictured. The pattern alters mainly, but not exclusively, by additions at the growing margins of the individual scutes. Growth curves through 12/ii/65, when the animals' ages ranged from 578 to 153 days have been constructed. The *slow* developers were smaller at hatching than the *quick* developers, and have remained so because they have postnatal growth rates similar to the quicks, including the responses of these to climatic conditions. It is possible to classify the animals as *narrow* and *broad* individuals. Both shapes are found among both the quicks and the slows. One exceptionally narrow individual may represent a discrete third group.

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(*Continued, p.* 114)

Note added in proof

Dimond [*Nature* **208** (5008): 401-402] suggests that our 64I-VII hatched at the same time but the four which we call slows remained in the soil, being nourished by their yolk sacs; as they were still enclosed in their shells when they rose to the surface this suggested subterranean hatching did not involve freeing from the shell. We consider it unlikely that a baby tortoise even so enclosed could remain buried in only 1 litre of soil in a small glass jar less than 6 cm. below the surface for between 75 and 100 days without any visible disturbance of this surface. When the animals did reach the surface, the protruding yolk sacs of 3 out of the 4 slows were larger, i.e. still contained more yolk, than the yolk sacs of 2 of the 3 quicks. The delay in hatching of the slows may be due to some hiatus in development rather than to uniformly slower rate of development throughout the pre-hatching period, but we do not think this hiatus occurs after pipping.

S. D. J.
H. S.

Life Forms and Biological Spectrum of Lolab Valley, Kashmir, in relation to Climate

BY

M. K. WALI[1]

Department of Botany, S.P. College, Srinagar

(*With a text-figure*)

Raunkiaer (1934) lays great stress on climate as a factor governing the vegetation of a place. He believes that temperature is a factor of the greatest importance in determining plant distribution. He coined the term ' Life Form ' which he defined ' as the sum of the adaptations of the plant to climate '. Commenting on the usefulness of Raunkiaer's ' Life Forms ', Braun-Blanquet (1932) says : ' Each plant community consists of a definite group of life forms. Each habitat favours certain groups of life forms and almost excludes others. The more extreme the habitat conditions the sharper the selection and the more pronounced are the ecological characteristics of the life forms. For this reason biological spectra for decidedly pioneer associations best reflect the ecological relations of the habitat.' The life forms of Raunkiaer have proved of outstanding value from the ecological standpoint. The system has been modified to suit new demands by Braun-Blanquet (1932), Oosting (1956), and Dansereau (1957).

The present study deals with the application of Raunkiaer's Life Form system as modified by Braun-Blanquet (1932) to the forests of a beautiful side valley of Kashmir, Lolab. Lolab Valley is situated between 74° 15′ and 74° 32′ E. longitude and 34° 25′ and 34° 42′ N. latitude. The area covers about 200 sq. km. with an altitudinal range of 1687 m. to 3846 m.

The climate of Kashmir as exemplified by the station Srinagar presents some peculiarities. It is cool during winter, the mean temperature of the coldest month January being 0·3° C. The mean of the minima of the same month is −4·2° C. The absolute minimum recorded is −7·4° C. July is the hottest month with its mean temperature 24·4° C. and the mean of the maxima 30·8° C.

[1] Present address : Botanical Laboratories, Ecology Division, University of Copenhagen, Denmark.

The precipitation is more or less well distributed throughout the year though the maximum is during the short days of the year (winter and spring) and most of it in the form of snow. There is a small dry season during the summer month June ; this coupled with not very low winter temperatures gives the climate a mediterranean rhythm. The recent works on phytogeography (Emberger, Gaussen, *et al.* 1962, Bagnouls & Meher-Homji 1959) classify Srinagar under sub-mediterranean climate with one month dry.

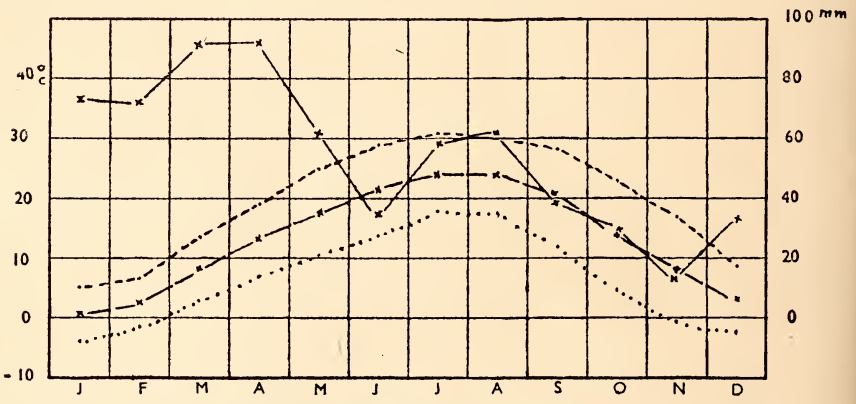
The data on the climate of Srinagar are presented in the text-figure, since there is no meteorological observatory at Lolab proper.

SRINAGAR

Long. : 74°50 E.
Lat. : 34°05 N.
Alt. : 1587 m.

Data for the period : 1891-1940

(cf. Meteorological Tables of observatories) in India.



Ombrothermic diagram of Srinagar

Precipitation (mm.)

Mean temperature (°C.)

Mean maximum temperature (°C.)

Mean minimum temperature (°C.)

The area abounds in rich coniferous forests. The principal species are *Abies pindrow*, *Cedrus deodara*, *Picea smithiana*, and *Pinus wallichiana*.

Following the system as adapted by Braun-Blanquet (1932), the life forms of the area are as under :

I. THEROPHYTES (Th). Annuals, that complete their life cycle (from germination to ripe seed) within a single vegetative period : *Amaranthus paniculatus* L., *Apium graveolens* L., *Asperula brachyantha* Boiss., *Atropa*

acuminata Royle, *A. belladona* L., *Chenopodium album* L., *Dianthus jacquemontii* Edgew., *Hyoscyamus niger* L., *Origanum vulgare* L., *Papaver dubium* L., *Pleurogyne spathulata* Kern, *Scrophularia himalensis* Royle, *Silene conoidea* L., *Solanum nigrum* L., *Stachys floccosa* Benth., *Stellaria media* L., *Swertia petiolata* Royle, *Trichodesma indicum* R. Br.

II. Hydrophytes (HH). Water plants, with perennating organs submerged under water during the unfavourable season :

Ranunculus trichophyllus Chaix.

III. Geophytes (G). Earth plants, with perennating organs buried in the substratum and little exposed to the unfavourable season: *Adonis aestivalis* L., *Actaea spicata* L., *Allium atropurpureum* Wald. & Kit., *Anemone biflora* DC., *A. obtusiloba* D. Don, *A. rivularis* Buch.-Ham., *Androsace sarmentosa* Wall., *Aquilegia vulgaris* Wall., *Arisaema helleborifolium* Schott., *A. tortuosum* Schott., *A. wallichianum* Hook. f., *Chrysopogon gryllus* Trin., *Colchicum luteum* Baker, *Corydalis cornuta* Royle, *Cynodon dactylon* Pers., *Delphinium denudatum* Wall., *D. incanum* Royle, *Epimedium elatum* Morr. & Dcne., *Euphorbia wallichii* Hook. f., *Fumaria parviflora* Lam., *Fritillaria roylei* Hook., *Gagea kashmiriensis* Tur., *Geranium pusillum* L., *Geum urbanum* L., *Iris enseta* Thunb., *I. nepalensis* Don, *I. spuria* L., *Lagotis glauca* Gaertn., *Lychnis coronaria* Lam., *Malva parviflora* L., *M. sylvestris* L., *Nepeta cataria* L., *N. elliptica* Royle, *N. linearis* Royle, *Oryzopsis aquiglumis* Duth., *O. munroi* Stapf, *Oxalis acetosella* L., *O. corniculata* L., *Paeonia emodii* Wall., *Pennisetum flaccidum* Griseb., *Podophyllum emodi* Wall., *Polygonatum multiflorum* All., *P. verticillatum* All., *Potentilla nepalensis* Hook., *Ranunculus arvensis* L., *R. laetus* Wall., *R. hirtellus* Royle, *R. muricatus* L., *Sedum adenotrichum* Wall., *Silene inflata* Sw., *Stipa sibirica* Lam., *Thalictrum cultratum* Wall., *Trillium govanianum* Wall., *Tulipa stellata* Hook.

IV. Hemicryptophytes (H). Plants with vegetative buds at the level of the ground and substratum :

Androsace rotundifolia Hardw., *Arctium lappa* L., *Astragalus leucocephalus* Grah., *Caltha palustris* L., *Capsella bursa-pastoris* Moen., *Carduus natans* L., *Caucalis latifolia* L., *Chrysanthemum cinerariaefolium* Vis., *Cnicus involucratus* DC., *Convolvulus hastatus* Lam., *Cynanchum jacquemontianum* Dcne., *Cynoglossum glochidiatum* Wall., *C. microglochin* Benth., *Echinops niveus* Wall., *Epilobium hirsutum* L., *Erysimum altaicum* Mey., *E. hierciifolium* L., *E. repandum* L., *Fragaria vesca* L., *Galium aparine* L., *G. rotundifolium* L., *Gentiana argentea* Royle, *G. moorcroftiana* Wall., *Impatiens balfourii* Hook. f., *I. thomsonii* Hook. f., *Lathyrus altaicus* Led., *Lycopsis arvensis* L., *Macrotomia benthami* DC. *Medicago minima* L., *Myosotis caespitosa* Sch., *M. sylvatica* Hoffm., *Potentilla clarkei* Hook. f., *P. reptans* L., *Primula denticulata* Sm., *P.*

rosea Royle, *Senecio chrysenthemoides* DC., *Sisymbrium irio* L., *Taraxacum officinale* Wigg., *Tragopogon pratense* L., *Viola serpens* Wall.

V. Chamaephytes (Ch). Plants with vegetative organs from 20-30 cm. above soil :

Angelica archangelica L., *Artemisia maritima* L., *Cannabis sativa* L., *Carex muricata* L., *Chenopodium botrys* L., *Codonopsis ovata* Benth., *Cyperus pilosus* Vahl, *Geranium nepalense* Sw., *Girardinia heterophylla* Dcne., *Heracleum candicans* Wall., *Herniaria hirsuta* L., *Hibiscus trionum* L., *Hypericum perforatum* L., *Leontopodium alpinum* Cass., *Morina longifolia* Wall., *M. persica* L., *Pedicularis siphonantha* Don, *Phytolacca acinosa* Roxb., *Polygonum affine* Don, *P. alpinum* All., *P. amplexicaule* Don, *Rumex acetosella* Don, *R. hastatus* Don, *Salvia lanata* Roxb., *S. moorcroftiana* Wall., *Sassurea lappa* Clarke, *Scrophularia variegata* Beib., *Scutellaria linearis* Benth., *Strobilanthes atropurpureus* Nees, *Swertia petiolata* Royle, *Thymus serphyllum* L., *Urtica dioicia* L., *Verbascum thapsus* L., *Veronica agrestis* L., *V. anagallis* L., *V. arvensis* L., *V. biloba* L., *V. persica* Poir.

VI. Nanophanerophytes (N). Plants with vegetative organs less than 2 metres above soil :

Aralia cachemirica Dcne., *Asparagus filicinus* Ham., *Berberis lycium* Royle, *B. pseudoumbellata* Par., *Bergenia ligulata* Engl., *B. ciliata* Blatter, *Cassiope fastigata* Don, *Cotoneaster baccilaris* Wall., *C. microphylla* Wall., *Daphne oleoides* Schr., *Desmodium podocarpum* DC., *D. tiliaefolium* Don, *Deutzia corymbosa* R. Br., *Elaeagnus umbellata* Thunb., *Indigofera atropurpurea* Buch.-Ham., *I. gerardiana* Wall., *I. hebepetala* Benth., *Jasminum humile* L., *Juniperus communis* L., *J. recurva* Ham., *Lespedeza eriocarpa* DC., *L. gerardiana* Grah., *L. sericea* Miq., *Lonicera angustifolia* L., *L. quinquelocularis* Hardw., *Rhododendron anthopogon* Don, *R. campanulatum* Don, *Ribes rubrum* L., *Rosa macrophylla* Lindl., *Rubus ellipticus* Sm., *Salix elegans* Wall., *Sambucus ebulus* L., *Skimmia laureola* Seib. & Zucc., *Spiraea bella* Sims, *S. lindleyana* Wall., *S. vestita* Wall., *Staphylea emodii* Wall., *Viburnum foetens* Dcne.

VII. Phanerophytes (PH). Plants with vegetative organs more than 2 metres above soil :

Abies pindrow Spach., *Acer caesium* Wall., *A. pictum* Thunb., *Aesculus indica* Hiern, *Betula utilis* Don, *Cedrus deodara* Loud., *Celtis australis* L., *Corylus colurna* L., *Fraxinus floribunda* Wall., *Juglans regia* L., *Morus alba* L., *Parottia jacquemontiana* Dcne., *Picea smithiana* Wall., *Pinus wallichiana* A. B. Jack., *Prunus armeniaca* L., *P. cerasus* L., *P. communis* Huds., *P. cornuta* Wall., *Pyracantha crenulata* (Roxb.) Roem., *Pyrus lanata* Don, *P. pashia* Buch.-Ham., *Rhus succedanea* L., *Salix tetrasperma* Roxb., *Taxus bacata* L., *Ulmus wallichiana* Planch.

VIII. LIANAS (L). Plants that are climbers :

Clematis montana Buch.-Ham., *Dioscorea deltoidea* Wall., *Hedera nepalensis* K. Koch, *Rosa moschata* Mill., *Rubus paniculatus* Sm., *Vitis lanata* Roxb., *V. vinifera* L.

IX. EPIPHYTES (E). Plants that are epiphytes : nil.

X. PARASITES (P). Plants that are parasites :

Hypopithys lanuginosa Nutt., *Cuscuta europea* L., *C. reflexa* Roxb.

The plant-climate of the region according to Raunkiaer (1934) is characterized by the life-form (or the life-forms) which in the biological spectrum of the region exceed the percentage of the same life-form in the normal spectrum. The normal spectrum is defined as the spectrum given by the entire phanerogamic flora of the world.

Raunkiaer grouped the phytoclimates of the earth into four main types :

1. representing high percentage of Phanerophytes as in the wetter parts of the tropics ;
2. the Chamaephytes with a fair proportion of Geophytes in cool climates ;
3. the Hemicryptophytic type in the cold temperate climate ; and
4. the Therophytic type in the arid zones.

In Table I, the biological spectrum of Lolab Valley is compared with the normal spectrum of Raunkiaer (1934). This comparison reveals a Geo-Chamaephytic plant-climate for the Lolab area. Geophytes are almost 6 times higher in Lolab (23·8% against 4% in the normal spectrum) and Chamaephytes twice as much (17·2% against 9% of the normal spectrum). It may be mentioned that the percentage of Nanophanerophytes slightly exceeds that of the normal spectrum (17% and 15% respectively).

As the climate of the region may be best described as moderately cool, the assigning of the spectrum of Lolab Valley to Geo-Chamaephytic type seems to be in fair consonance with the classical concept of Raunkiaer's system : the prevalence of Chamaephytes with a high proportion of Geophytes in cool climates. The substratum, a loose fertile upper-soil horizon, also appears to favour the development of rhizomatous geophytes.

It would be interesting to compare the spectrum of Kashmir, which climatically is classified as sub-mediterranean, with those of the mediterranean region, the cold temperate, and the arctic zones.

The first obvious difference as may be made out from Table II is the gradual decrease of Phanerophytes (PH+N) from the sub-mediterranean Kashmir area through the mediterranean and temperate regions to the arctic zone. Inversely proportional to this is the gradual rise of Hemicryptophytes from the comparatively warmer Kashmir climate to the

TABLE I

BIOLOGICAL SPECTRUM OF THE VEGETATION OF LOLAB VALLEY, KASHMIR

Life Forms		Th	HH	G	E	H	P	Ch	L	N	PH	Total
Total species	..	18	1	54	—	40	3	39	7	39	25	226
Percentage of species	..	7·9	0·4	23·8	—	17·6	1·3	17·2	3·0	17·2	11·0	100
Normal spectrum	..	13	2	4	3	26	—	9	—	15	28	100

TABLE II

BIOLOGICAL SPECTRA FOR VARIOUS COUNTRIES

Countries	Climatic type	Life Forms (Percentages)				
		PH+N	Ch	H	Cryptophytes G+HH	Th
Kashmir Lolab	Sub-mediterranean (1 month dry)	28·2	17·2	17·6	24·2	7·9
Italy*	Mediterranean (3 to 6 months dry)	12	6	29	11	42
Paris Basin*	Temperate (0 month dry)	8	6·5	51·5	25	9
Greenland*	Arctic	—	27·5	52·5	18	2

*Spectra after Walter (1960)

arctic type. Another feature that needs mention is the high proportion of Therophytes (42%) in the mediterranean climate of Italy. This is due to the long summer drought (3 to 6 months) prevailing in the country.

All this is in agreement with Raunkiaer's system.

In India, a number of workers have worked out biological spectra of various regions. Bharucha & Ferreira (1941) worked out the biological spectra of Matheran and Mahableshwar. Pandeya (1954) utilized the system for determining the extent of overgrazing in grasslands of Saugor. Shah (1956), Jindal (1956), Ansari (1956), and Lakshamanan (1962) while working in different regions of Bombay applied the method to various plant communities.

Their studies were chiefly concerned with the association-environment relationship and, as only fragments of the total vegetation of the region were considered, naturally they did not expect the spectrum of a biotically disturbed community to be in accordance with the phanerophytic phyto-climate to be expected for a tropical country like Bombay covered with a moist deciduous forest. Further, in a grassy community, even a tree species in its younger stage would behave as a chamaephyte rather than a phanerophyte, thus tending to shift the spectrum of the grazed grassy association away from the forest type (Meher-Homji 1962).

The present investigation relates to a fairly large area that is disturbed biotically to a very small extent, and that may be the reason for this region giving results in agreement with Raunkiaer's hypothesis. However, some objections may be raised to his system. The present area abounds in rich coniferous forests, and it seems paradoxical to assign to such a tree-covered area a Geo-Chamaephytic spectrum. The tree species though much fewer in number than the herbs and shrubs are physiognomically dominating.

There would be very little change in the spectrum of the forest stands if the few trees that compose it are counted or not, for numerically the herbaceous, bulbous, and shrubby species are many more in the understoreys and undergrowth and give a Geo-Chamaephytic phyto-climate. However, if those very trees were to be cut down, this would totally change the landscape and the physiognomy of the country without effecting any change in the biological spectrum (Meher-Homji 1960).

A defect in Raunkiaer's system is that it does not give importance to the frequency-dominance of the species. A very common species or a very rare one both count just as one. In this connection, Carles (1948) has proposed to calculate the '*real*' biological spectrum by consideration of the percentage cover of each life form in an association and not only by that of the number of species of a life form.

In view of the dominance of the conifers in this area it may be suggested that, after all, the adaptations of plants to the climate may appear by more than one morphological criterion : firstly, through the

numerical prevalence of geophytic-chamaephytic mode of life; secondly, the conifers, though few in number of species, through their physiognomic dominance point to their ability to conquer the area.

Finally, it may be pointed out that Raunkiaer's system does not consider the geological history of the country and that at least a part of the flora could be the remnant of the climate of the past.

Summary

Raunkiaer's Life Form system, as applied to the forests of Lolab Valley in Kashmir, is presented in the paper. The area shows a numeric prevalence of geophytes and chamaephytes and is in consonance with Raunkiaer's system. The merits and demerits of the Life Form system, as proposed by Raunkiaer, are discussed.

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Hazaribagh National Park (Bihar) re-visited[1]

BY

JAMAL ARA

(*With a map*)

SYNOPSIS

On a suggestion made by the Secretary of the Bombay Natural History Society, an Ecological re-survey of the Hazaribagh National Park was carried out after five years, in two visits during 1965. The first visit was from March 7 to March 11, when a halt was made at the Tourist Lodge, and an intensive sampling of the areas sampled in 1959, as also some new areas, was carried out. The second was from March 22 to March 31. On this occasion the halt was outside the National Park, and by daily visits the fringes and border areas were investigated, particularly to determine the extent of poaching and the routes used for it.

The sampling method was the same as described in my earlier paper. The results show that birds, both in numbers and species, as well as Sambar (*Cervus unicolor*) and Spotted Deer (*Axis axis*) have increased. The other animals have either diminished or remained static. Floristically, there are signs of seral retrogression, and gully erosion was on the increase.

1. GENERAL

The factor that finally led to the Park being located here in preference to other sites was accessibility to visitors and tourists, so as to attract them in increasing numbers. This expectation has been more than fulfilled, and between January and December 1964 over 30,000 people visited the Park. Unfortunately the majority of those who come have no interest either in wild life or forest scenery or Nature Conservation. The normal sequence is to arrive in the Park with transistors or amplified gramophones, stay at the Tourist Lodge, make a lot of noise, leave the area in an insanitary condition, and depart. During my stay at the

[1] For the first report on the Hazaribagh National Park, see the *Journal* Vol. 57, pp. 325-338.

Tourist Lodge, a batch of students and teachers from the Ranchi College went through this routine, and not one word did I hear about animals, the impressive landscape, or the flora and allied subjects. Rather, a visit to the National Park is one of the things that must be done in order to qualify for the small talk of sophisticated society.

On the other hand, the attitude of the Forest Department also appears to be to convert the Park into a picnic spot, and all activity is directed towards that end by increasing amenities and accessibility. Their aim is to attract the maximum number of people, and from the trends shown up to March it is clear that the 1965 figure for visitors will be much higher than the 1964 one.

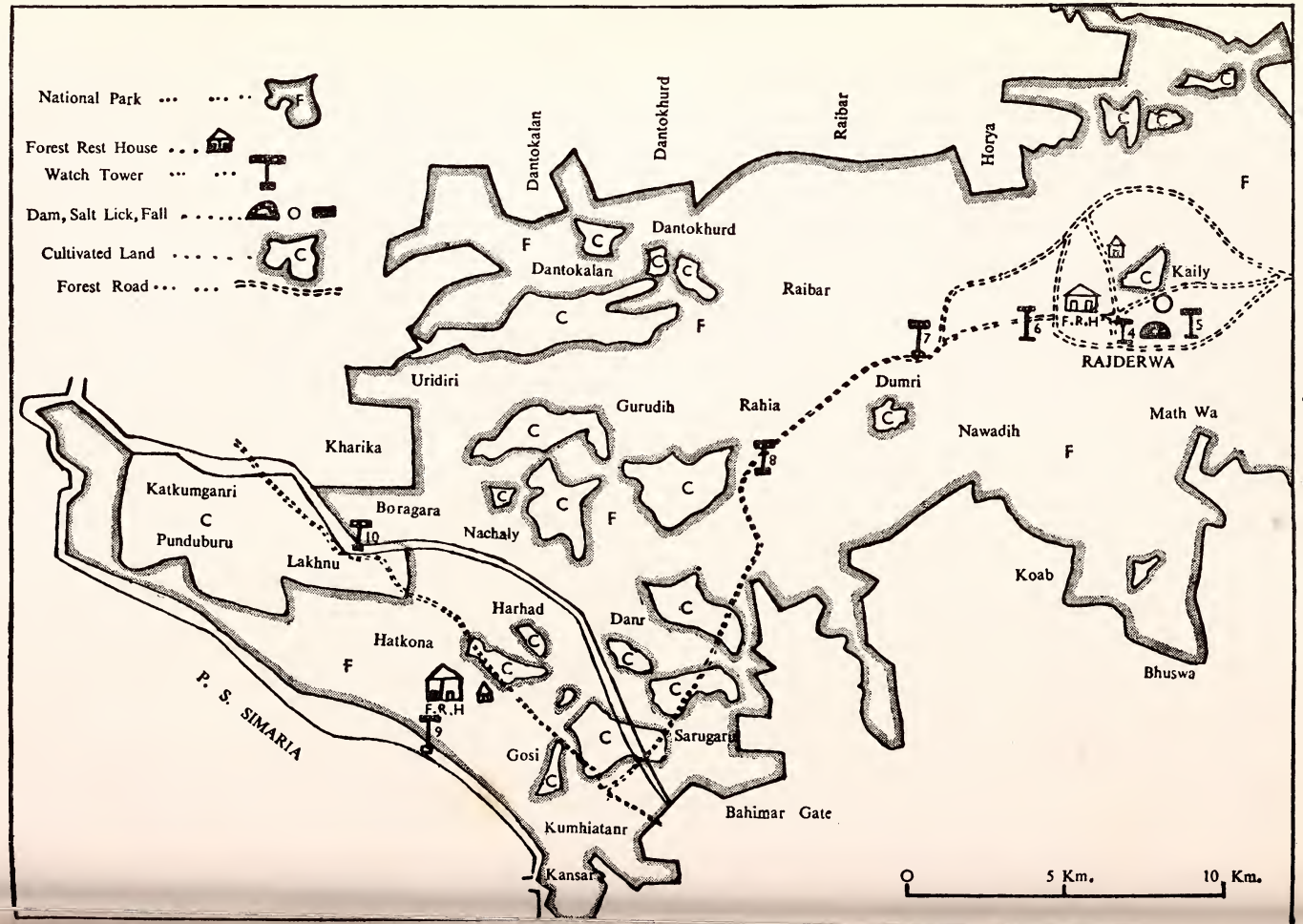
There has been a change in the set-up and numbers of staff. The Game Warden is now a Forest Ranger, but posted at Hazaribagh and assisted by an Assistant Game Warden, who is a Deputy Ranger, and 20 Game Guards. None of the staff has received any special training ; their background is just the normal Forestry training given to staff of this rank, of which wild life forms a very small part. At the same time staff amenities inside the Park are poor. There are no means of communicating with Headquarters in an emergency nor is any transport available. There are no medical facilities nor any arrangements for the education of children. The staff is consequently dissatisfied and regards posting to the Park as a form of punishment.

(ii) The legal status is as woolly as ever. In spite of the lapse of ten years it is still a Sanctuary created by executive order, and no action has been taken for enacting legislation on the lines of the Model Act circulated by the Indian Wild Life Board. This reinforces the plea for the creation of a separate department under the Central Government for looking after Sanctuaries and National Parks, for obviously the Forest Department have no time for it. Lack of legislation gives rise to some curious situations. Officially the use of transistors and loudspeakers is forbidden, but nobody bothers because there is no section of the Forest Act under which action can be taken for a breach of this regulation.

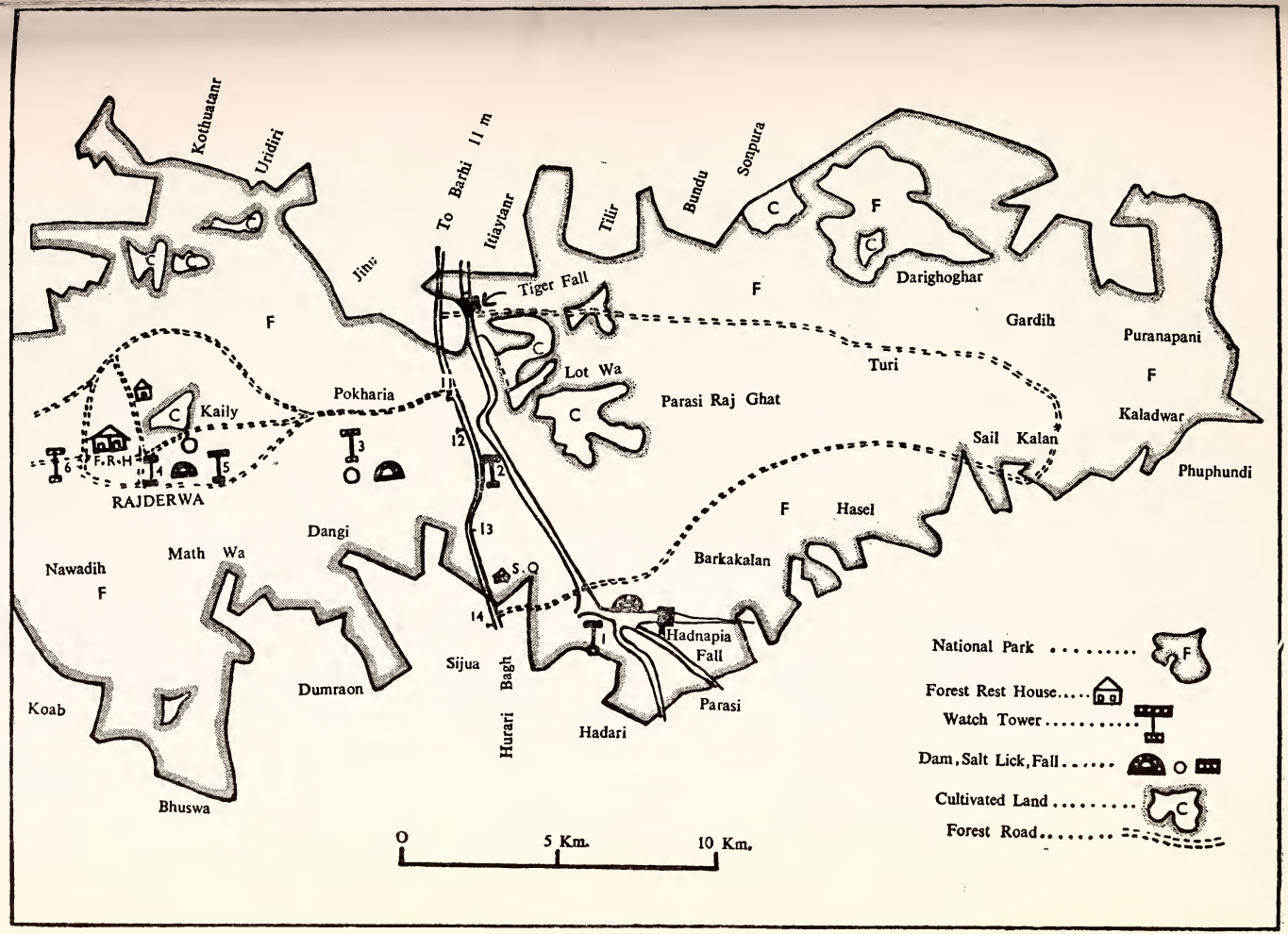
(iii) The boundaries are still unfenced, and there does not appear to be any scheme for doing so.

2. Amenities

Construction work on a large scale is still going on. The length of roads has been doubled from 65 to 130 km. and, in addition to the Rest House and Tourist Lodge, a small cottage to provide family accommodation was under construction at the time of my visit. There are plans to build more of them, as also another 4-roomed Tourist Lodge. On the artificial lake near the Tourist Lodge, an Island Canteen has been set up,



Hazaribagh National Park—western portion



Hazaribagh National Park—eastern portion

reasonably well stocked with food-stuffs and a great attraction to potential visitors, who are assured of the availability of food. The tariff is reasonable.

Some curious innovations have been made. Some Governor suggested that ' ready-made ' animals should be available in the Park so that even the most casual visitor, who came only for an hour or so, could see something. This suggestion has been carried out. In an enclosure near the Rest House, enclosed in deer-proof fencing, is kept a solitary Spotted Deer.

In the garage are a number of large bird cages containing a few *Laqqua* pigeons and mynas. And if, while taking tea in the canteen, you find a Sarus Crane begging for titbits, do not assume that a wild one from the Park has become so familiar due to protection. No, a pair was purchased from a Calcutta dealer and introduced in the Park. It seems a true pair was not obtained, as one of them flew away, but the other stayed behind as it had a damaged wing and spends its time tramping round the Canteen and Tourist Lodge.

3. Ecology

Despite protection for ten years, there has been no improvement in the flora, rather there are distinct signs of seral retrogression. At the time of my visit, the Park presented an extremely bleak appearance, as early burning operations were in full swing. Every day a number of workers would set out to carry out the burn, causing great disturbance to the animals, both by the noise and the fire throughout the day. The annual fire tracing of the view strip and the roadsides has now become so extensive as to cover the bulk of the area, and there was evidence that at some places the burn had been a very fierce one. Smouldering logs and smoking stumps, several days after the burn had been carried out, proved that in those areas at any rate the departmental operations had got out of hand. Bark scorching of thin barked trees like *Gardenia* sp. was seen at a number of places, and many young trees of *Boswellia serrata* (Hindi : *salai*) had their lower branches completely burnt.

The objective of these burning operations is two-fold: (1) to prevent fires in the hot weather, and (2) the hope that, since the fire will have reduced the undergrowth, even a casual visitor motoring along the roads will be able to see wild animals through lack of cover. How far the Department has succeeded in the first, I cannot say, though they claim that there has been no fire in the National Park for the last five years. As for the second, the effect is just the opposite. Animals have been driven more and more into the deeper recesses of the forest, and are more difficult to see today than they were five years ago. Even then they were scared.

The results of this annual burning have been disastrous in other directions as well. The proportion of Spear Grass (*Heteropogon contortus*) is increasing everywhere, and is slowly forming a dense impenetrable mat, at the expense of the other herbaceous flora. I could find no natural regeneration anywhere of either Sal or the other main tree species.

There has been no improvement in the canopy density of the main crop, *Shorea robusta* (Hindi : *sal*), and the average is about 0·5 to 0·6. At the same time the absence of any regeneration means that, as these trees die, no others will come up to replace them, and over a period of time the entire floristic composition of the forest will change, probably for the worse. The evidence provided by the very large view strip cut on both sides of the road leading from the Tourist Lodge to the National Highway, a kilometre away from the latter, is unmistakable. An area of 40-50 hectares has been clear-felled, with just a few seed bearers of Sal and other species randomly distributed. The strip had been burnt a few days before I reached the Park, and presented a scene of unbelievable desolation. There were no signs of any shrubby undergrowth, whereas the *H. contortus* was already springing back to life. It was easy to visualize what the area would look like after it had recovered from the effects of the burn : a veritable sea of knee-high spear grass with the odd tree sticking out, stark and grotesque. No animal will come out in this large blank traversed by a road with fairly heavy traffic upon it.

The intensity of grazing has increased considerably within this period of five years, and takes place much more openly and boldly now. Formerly much of the grazing was on the sly; now cattle are met all over the place. The village located in the heart of the Park, within a few kilometres of the Tourist Lodge, has a fairly large number of buffaloes and enjoys prescriptive rights of grazing. Consequently, for quite some distance around that village the forest is honeycombed with tracks. Along with grazing, lopping, felling of young trees, and removal of *Bauhinia vahlii* (Hindi : *mahul*) bark for rope-making also goes on. In the interests of the Park, this village must be acquired and the inhabitants re-settled somewhere outside.

On the periphery of the Park are a number of villages, and cattle from all of them graze in the Park itself. As such, a large number of footpaths lead in from the boundary and penetrate several kilometres inside. The density of the tracks is thickest on either side of the new road built from the main approach road to the Bahimar Gate, a road which is very little used by visitors so far. The total area of the forest commanded by the tracks is surprisingly large, and all along them are signs of illicit fellings and rope making. One of the worst villages is Garu, which has a mixed Santhal and Birhor population. The Santhals kill animals for selling

meat and skins ; the Birhor's sole means of livelihood is rope making either from Sabai grass (*Ischaemum angustifolium*) or the bark of *Bauhinia vahlii*. Both the tribes find the National Park very convenient for their activities.

Considering each of the forest sub-types differentiated in my previous paper, the following changes were noticed :

TYPE A. There is distinct evidence of retrogression. *Nyctanthes arbortristis* (Hindi : *harsinghar*) is spreading, and the *Flacourtia ramontchi* (Hindi : *katahi*) has larger and more persistent spines, at places it looks almost like a strange variety of cactus.

SUB-TYPE A1. There has been little change in this sub-type, probably on account of its xerophilous nature. The bamboo clumps, however, are beginning to get congested and the culms themselves are thin and willowy. In spite of total protection for nearly 10 years now, I could not find a single bamboo culm 50 mm. in diameter.

TYPE B. This has been the worst sufferer of all the types due to the annual burning. There are no traces left of fire-tender shrubs like *Indigofera pulchella* (Hindi : *jirut*) and *Flemingia chappar* (Hindi : *galphuli*) indicating that the site quality has undergone a deterioration. One looks in vain for the dense bushes of *Bauhinia vahlii* seen on the first visit ; fire and rope-makers between them have played havoc with it. Even in this type, which looks like a climax formation, there is no natural regeneration of either Sal or of any of the Terminalias.

TYPE C. There has been no change in this type. The lake behind the dam near the Tourist Lodge is silting up badly, and also getting choked with weeds, particularly *Aponogeton* (Hindi: *ghechu*). This stream, the Rajederwa Nalla, is the only large one throughout the area, and any degradation in it will make the water supply position more acute.

Gully erosion everywhere was much more noticeable on this occasion than on the previous one, and the heads of some of them are advancing very fast indeed. Several gullies are already 8-10 metres wide and 2-3 metres deep. The rate of advance is anything up to 3 metres annually, as estimated from the manner in which the plant roots had become exposed. Soil conservation is not taboo in any National Park, and it is not quite clear why measures to control gully erosion have not been taken so far. As a matter of fact, I could find little purpose or direction in the management of the National Park. The entire concentration is on building more buildings and constructing more roads. Of scientific steps to improve the forest and increase the proportion of wild life, I could not find a single sign. I had a feeling that the Forest Department have little interest in these matters, and are content with having established something which is attracting an increasing number of visitors every year.

4. Sampling Methods

The sampling method was the same as on the previous occasion, but the area was gone over more intensively. The new road from the 9th kilometre of the approach road to the Tourist Lodge leading to the Bahimar Gate and many tracks in that area had not been visited on the last occasion. Observations were carried out throughout the day and late into the night as well. The days were neither hot nor the nights cold.

5. Distribution of Fauna by forest types

The maximum concentration of fauna continues to be in Ecological Type B wherever it occurs, particularly in the valley bottoms. The centre of gravity stays in the valley between the Bahimar Road and the opposite hills, on either side of a road leading past the staff quarters, and another one has developed in the valleys on either side of the new road taking off from the 9th kilometre of the main approach road. Running these two a close second is a large, deep valley near Watch Tower No. 5, which has a perennial stream running through it, and a journey along the by-pass road leading to it from the Tiger Trap is a rewarding experience. At all these places, however, the main increase has been in the number of Sambar (*Cervus unicolor*) and Spotted Deer (*Axis axis*). On the other hand Nilgai (*Boselaphus tragocamelus*) and Gaur or Indian Bison (*Bos gaurus*) appear to have been driven out of the area. The Assistant Game Warden claims that he and some of his Game Guards have seen a White Tiger in the vicinity of Watch Tower No. 5 but, before accepting it, I would await independent confirmation by some naturalist.[1] I did not see it myself. The bird fauna is no longer distributed by Ecological Sub-types, is much more scattered and mixed up, and this sub-type does not present any special features now.

The valley on either side of the road leading past the Staff Quarters to the Bahimar Road, which contains forests belonging to Sub-type B, can have its animal population increased considerably by improving the water supply and closing down burning operations. A stream runs through, but at the time of my visit was already drying up, though it was only early March. Several very convenient spots exist where a small weir can be built, which will store water throughout the hot weather, and lead to a concentration of fauna.

Type A. Does not provide the richest bird life now. The Spotted Deer (*Axis axis*) too are no longer concentrated in this type. On the last

[1] A white tiger was shot in Hazaribagh District by one Mr. Wakefield about the year 1934. The shooting of another white tiger in that area in 1958 is referred to by Mr. E. P. Gee in Vol. **56** of the *Journal* at p. 583.—Eds.

occasion, the bulk of the Nilgai (*Boselaphus tragocamelus*) were found in this sub-type, but this time neither did I see a single one nor found any hoof prints. Indian Hares (*Lepus n. ruficaudatus*) and pigs (*Sus scrofa cristatus*) have been reduced in numbers. The frequent signs of digging by pigs, so common on the last visit, are much less frequent now.

Type C. The Redwattled Lapwings (*Vanellus indicus*) are no longer confined to the artificial lake. They have spread out as well as increased in numbers.

Two resting places of Sambar (*Cervus unicolor*) and Spotted Deer (*Axis axis*) were seen, but the places are not mentioned here because people will go and disturb their peace. The Sambar herd was about a dozen strong and the herd of Spotted Deer had about six animals.

6. Results

A change has been made in the table. The numbers seen in the sampling area (20% of the total area of the Park) are given in columns 2 and 3, so that a ready comparison of the results of the two surveys is possible.

Species	Number seen in Sample Area 1965	1959/60	Remarks
1. Common Langur (*Presbytis entellus*)	not seen	not seen	Reported by staff to be present in large numbers near the villages.
2. Tiger (*Panthera tigris*)	nil	2	Staff claim an increase to 20.
3. Leopard (*Panthera pardus*)	2	2	Staff agree that numbers have remained more or less constant.
4. Mongoose (*Herpestes edwardsii*)	4	4	———
5. Jackal (*Canis aureus*)	not seen	not seen	According to staff number increasing specially around villages.
6. Fox (*Vulpes bengalensis*)	10	frequent	———
7. Wild Dog (*Cuon alpinus*)	8	not seen	Staff report that on the periphery numbers have increased.
8. Sloth Bear (*Melursus ursinus*)	4	6	———
9. Palm Squirrel (*Funambulus pennanti*)	6	2	———

Species	Number seen in Sample Area 1965	1959/60	Remarks
10. Indian Hare (*Lepus nigricollis ruficaudatus*)	common	very common	Seem to have diminished in numbers.
11. Gaur or Indian Bison (*Bos gaurus*)	nil	4	Was an over-estimate last time. Staff claim that a single herd comes in for 3-4 months every year, following a well-defined route for both inward and outward journeys.
12. Nilgai (*Boselaphus tragocamelus*)	nil	3	Appear to have definitely gone away.
13. Sambar (*Cervus unicolor*)	30	6	———
12. Spotted Deer (*Axis axis*)	50	30	———
13. Muntjac (*Muntiacus muntjak*)	4	4	———
16. Wild Boar (*Sus scrofa cristatus*)	common	common	Though still common, the numbers have definitely gone down.

The Assistant Game Warden claimed that Fourhorned Antelope (*Tetracerus quadricornis*) were to be found in sufficient numbers in the Park, and one had been shot by an employee of a Public Sector Corporation, who had been caught and suitably punished. A visiting naturalist, however, was of the opinion that they might be Chinkara (*Gazella g. bennetti*). The latter is more probable, because Chinkara do occur in the Hazaribagh district. Not having seen either, I have not included any of them in my list.

From the Table it is obvious that except for the Sambar (*Cervus unicolor*) and the Spotted Deer (*Axis axis*), none of the other animals have increased during this interval of five years. And all of them, despite protection for ten years now, continue to be extremely shy and afraid of man. The slightest movement makes them dive for cover. As they retreat, their cautious backward glances reveal terror in their eyes. To see any animal in daylight is a near impossibility. I am of the firm opinion that animals in the Singhbhum Sanctuaries are far bolder than in the National Park. Visitors who have gone round other National Parks in India are rather surprised to find animals so few in numbers and so difficult to see, in spite of the area being better watered and less heavily grazed. Staff attribute this state of affairs to the presence of-

Wild Dogs. I differ. It is well known that Wild Dog packs are always on the move and never stay long in any one place. Their presence can have a temporary effect only, and in any case the sufferers should have been the Ungulates which are increasing.

I feel that annual burning and the heavy construction programme, both of which involve large bodies of men tramping noisily over the forests all the time, as also a certain amount of poaching, are responsible. Instead of the animals responding to protection and coming out into the open, they keep well hidden. Formerly, deer used to come quite close to the Staff Quarters, right into the open, but now they never break cover. The Tiger has been affected the most. In spite of the nights being moonlit ones in March and water holes few, neither did I see Tiger, nor did I hear the roar of any or come across pug marks. Yet, the Singhbhum Reserves resound with the roar of tigers during March and April, particularly when the moon is up.

At the same time, there are neither the resources nor the effort to effectively control poaching, particularly along the periphery. Though I spent long hours in the field surveying extensively, I never met a single Game Guard or any other member of the Staff out patrolling. Again, though most poachers use motor vehicles, the Staff have only bicycles to cope with them. Mention must be made of the activities of a Shikar Agency. It guarantees tigers for Rs. 10,000 to foreign tourists, and carries out the guarantee by arranging a shoot just outside the boundary of the National Park. There are reports that on occasions tigers have been beaten out or lured outside the Park by baits being tied up just clear of the demarcation line. This is little different from organized poaching.

In the Island Canteen there is a book in which visitors record the animals they have seen. I do not feel very happy about many of the entries. During my entire stay, I noticed that the set programme for visitors was to arrive at the Canteen by the main approach road leading in from the National Highway, partake of refreshments, and leave by the by-pass road via Watch Tower No. 5, the departure from the Canteen being usually around 7.30-8 p.m. Identification of animals from the fleeting glimpses obtained with a spot-light from a fast moving vehicle at night is a job from which even experts will shrink ; yet the entries in the book have been made on just this kind of evidence. The most honest entry was by a member of the Staff of the U.K. High Commissioner, who recorded that the only animal he saw was a chicken in the Canteen, which was very tasty !

BIRDS. Compared with the mammals, birds have definitely increased and are really bold. Leaf warblers (*Phylloscopus* sp.) were so many that it appeared as if they had assembled for migration. They

spent the whole day on the lawn near the Canteen, restlessly flickering their wings and tails. It was really fascinating to watch them from such close quarters—now on the lawn, the next minute atop a bush, then on to a tree and back again to the lawn. The Redbreasted Flycatchers (*Muscicapa parva*) were also quite plentiful, and the breasts of the males were a beautiful red. It is possible to approach quite close to all the birds, terrestrial and arboreal. Given below is a list of the birds seen on this survey. Variations in the status of individual species compared with the last survey are indicated against each. The arrangement and nomenclature are according to the SYNOPSIS by Dillon Ripley.

1. Pond Heron, *Ardeola grayii* : Infrequent, mostly around the lake.
2. Cattle Egret, *Bubulcus ibis* : About 3-4 near villages in field.
3. Night Heron, *Nycticorax nycticorax* : Once heard after dusk, not seen. The Heronry near Watch Tower No. 5 has disappeared.
4. Whitenecked Stork, *Ciconia episcopus* : Not seen this time.
5. White-eyed Buzzard Eagle, *Butastur teesa* : 2 near Watch Tower No. 5. Loud mewing call. Shy, shunned observation.
6. Whitebacked Vulture, *Gyps bengalensis* : Large flocks circling the Park.
7. Crested Serpent Eagle, *Spilornis cheela* : Seen quite often.
8. Redheaded Merlin, *Falco chicquera* : 1-2 seen often.
9. Kestrel, *Falco tinnunculus* : A single bird.
10. Black Partridge, *Francolinus francolinus* : Not seen on this visit.
11. Red Junglefowl, *Gallus gallus* : Many seen around the new road from km. 9 of main approach road to Tourist Lodge, going to the Bahimar Gate. I think they are confined to that area.
12. Peafowl, *Pavo cristatus* : Not seen, but once heard. Staff say very common.
13. Sarus Crane, *Grus antigone* : Tamed specimen.
14. Indian Moorhen, *Gallinula chloropus* : Large numbers on the artificial lake.
15. Redwattled Lapwing, *Vanellus indicus* : Quite numerous.
16. Yellow-wattled Lapwing, *Vanellus malabaricus* : Less than the Redwattled Lapwing.
17. Green Sandpiper, *Tringa ochropus* : About 4. I think they gathered *en route* to breeding ground.
18. Wood- or Spotted Sandpiper, *Tringa glareola* : 2 seen near stream.
19. Common Sandpiper, *Tringa hypoleucos* : Not seen.
20. Woodcock, *Scolopax rusticola* : Only 1 seen. Rich marbled plumage was difficult to separate from the wood. A slight movement betrayed it. The bird left the next day.

21. Little Stint, *Calidris minutus* : More in number than the sandpipers.
22. Blue Rock Pigeon, *Columba livia* : Not seen.
23. Rufous Turtle Dove, *Streptopelia orientalis* : One or two seen feeding here and there.
24. Ring Dove, *Streptopelia decaocto* : Very common.
25. Spotted Dove, *Streptopelia chinensis* : Common. Number definitely increased.
26. Large Indian Parakeet, *Psittacula eupatria* : Not many.
27. Roseringed Parakeet, *Psittacula krameri* : Common. One nest with young in hollow of *Madhuca latifolia* (Hindi : *mahua*) tree.
28. Papiha, *Cuculus varius* : Heard and seen near Watch Tower No. 5.
29. Indian Cuckoo, *Cuculus micropterus* : Not seen, but its familiar call *utho-dekho* once heard in the jungle on the path leading to the village.
30. Dusky Horned Owl, *Bubo coromandus* : Only 2 seen on the road to the Bahimar Gate.
31. Mottled Wood Owl, *Strix ocellata* : Not observed.
32. Jungle Nightjar, *Caprimulgus indicus* : Loud *wak-kukroo.* Common.
33. Longtailed Nightjar, *Caprimulgus macrurus* : Seen as soon as evening falls. The place resounds with *chounk-chounk-chounk* repeated up to 40-50 times, at intervals of a second. Common.
34. Common Indian Nightjar, *Caprimulgus asiaticus* : *took-took-took-tukru.* Common.
35. Franklin's Nightjar, *Caprimulgus affinis* : *chwees-chwees.* Common.

    Note. As soon as dusk fell, all the Nightjars would start calling from all sides, as if in competition. They would wheel and fly, almost at head height. They were most frequent in the burnt areas.
36. Whiterumped Spinetail, *Chaetura sylvatica* : Not seen.
37. House Swift, *Apus affinis* : Large flock which used to fly over the artificial lake.
38. Palm Swift, *Cypsiurus parvus* : In small numbers with the House Swifts at the same place.
39. Pied Kingfisher, *Ceryle lugubris* : Only 2 birds seen near the Tourist Lodge.
40. Common Kingfisher, *Alcedo atthis* : No increase in numbers. Only 1-2 seen occasionally near the Tourist Lodge.
41. Whitebreasted Kingfisher, *Halcyon smyrnensis* : More frequently seen. Number has increased.

42. Green Bee-eater, *Merops orientalis* : About 6, which used to gather about the stream near the canteen. Seen capturing insects on the edge.
43. Roller, *Coracias benghalensis* : Has increased in numbers from the last time. 3 pairs seen.
44. Green Barbet, *Megalaima zeylanica* : Commonly met with wherever the *simul* (*Salmalia malabarica*) tree was in bloom. Very fond of sipping the nectar.
45. Crimsonbreasted Barbet, *Megalaima haemacephala* : Common. Preparing for nesting.
46. Goldenbacked Woodpecker, *Dinopium benghalense* : Only 2 chasing each other among the highest trees near the stream on the Main Road.
47. Mahratta or Yellowfronted Pied Woodpecker, *Dendrocopos mahrattensis* : Common, specially near the burnt areas.
48. Pigmy Woodpecker, *Dendrocopos nanus* : Frequent.
49. Skylark, *Alauda gulgula* : Large flock near burnt up area, feeding with the Paddyfield Pipit (*Anthus novaeseelandiae*).
50. Common Swallow, *Hirundo rustica* : A large flock near Tourist Lodge. Used to fly all day on Rajaderwa Nalla. Included this year's young, distinguishable from adults by smaller size, absence of steel-blue gloss, shorter less deeply forked tail, and dull buff tinted face. Suddenly departed on March 10, 1965. Place then taken by House and Palm Swifts.
51. Grey Shrike, *Lanius excubitor* : Frequent.
52. Rufousbacked Shrike, *Lanius schach* : Seen in display.
53. Golden Oriole, *Oriolus oriolus* : Not seen.
54. Blackheaded Oriole, *Oriolus xanthornus* : Quite common. Musical call.
55. Black Drongo, *Dicrurus adsimilis* : Have increased in numbers from last time.
56. Whitebellied Drongo, *Dicrurus caerulescens* : Not many this time. A few here and there specially on Simul trees in flower.
57. Greyheaded Myna, *Sturnus malabaricus* : A few small flocks on Simul flowers.
58. Common Myna, *Acridotheres tristis* : Has increased from last time. Now 2-3 pairs can be seen around the Tourist Lodge, staff quarters, and in the burnt up areas.
59. Treepie, *Dendrocitta vagabunda* : Frequent.
60. Jungle Crow, *Corvus macrorhynchos* : Common.
61. Pied Shrike, *Hemipus picatus* : Frequent. More near burnt up area.
62. Large Cuckoo Shrike, *Coracina novaehollandiae* : Only two near

the village forest above stream. Very noisy, attracting attention.

63. Scarlet Minivet, *Pericrocotus flammeus* : One or two, mostly on Simul flowers.
64. Small Minivet, *Pericrocotus cinnamomeus* : Large flocks. Common.
65. Iora, *Aegithina tiphia* : Increased from last time.
66. Goldfronted Chloropsis, *Chloropsis aurifrons* : Not seen.
67. Jerdon's Chloropsis or Leaf Bird, *Chloropsis cochinchinensis* : Quite common.
68. Redwhiskered Bulbul, *Pycnonotus jocosus* : Not seen.
69. Redvented Bulbul, *Pycnonotus cafer* : Increased very much over last time.
70. Rufousbellied Babbler, *Dumetia hyperythra* : Flock near Watch Tower No. 5.
71. Yelloweyed Babbler, *Chrysomma sinensis* : 4-6 in tall grass near canteen.
72. Jungle Babbler, *Turdoides striatus* : Increased.
73. Brown Flycatcher, *Muscicapa latirostris* : Mouse-brown above ; dull white below ; some whitish bars in wings and tail ; a flock of 6 near stream.
74. Redbreasted Flycatcher, *Muscicapa parva* : Plentiful.
75. Tickell's Blue Flycatcher, *Muscicapa tickelliae* : Not seen this time.
76. Verditer Flycatcher, *Muscicapa thalassina* : Only one on footpath to village.
77. Greyheaded Flycatcher, *Culicicapa ceylonensis* : Near Watch Tower No. 5, in Salai (*Boswellia serrata*) patch.
78. Whitebrowed Fantail Flycatcher, *Rhipidura aureola* : On village footpath. Very bold.
79. Rufousfronted Longtail Warbler, *Prinia buchanani* : Seen on Rajaderwa Stream in tall grass. A shrill call *chirup-chirup* betrays the bird. Small flock of 4-5.
80. Plain Longtail Warbler, *Prinia subflava* : 4-5 on Bahimar Road near a ravine covered with grass. Sharp note like *weep-weep* uttered when one or two birds swing on grass.
81. Jungle Longtail Warbler, *Prinia sylvatica* : Not observed.
82. Tailor Bird, *Orthotomus sutorius* : Common. A half nest in a *Holarrhena* bush.
83. Eastern Orphean Warbler, *Sylvia hortensis* : Not seen this time.
84. Brightgreen Leaf Warbler, *Phylloscopus nitidus* : Very common and bold.
85. Largecrowned Leaf Warbler, *Phylloscopus occipitalis* : Not seen this time.

86. Magpie Robin, *Copsychus saularis* : Not seen.
87. Black Redstart, *Phoenicurus ochruros* : A flock of 7-8 near burnt up area. Gathered there to depart.
88. Pied Bush Chat, *Saxicola caprata* : Near burnt up area.
89. Jerdon's Bush Chat, *Saxicola jerdoni* : Near burnt up area. Flight direct and strong, but flies only short distances.
90. Indian Robin, *Saxicoloides fulicata* : Very common all over. In full song.
91. Paddyfield Pipit, *Anthus novaeseelandiae* : Large flock near burnt up area feeding with Skylarks (*Alauda gulgula*).
92. Yellowheaded Wagtail, *Motacilla citreola* : A few on the stream near the main road.
93. Grey Wagtail, *Motacilla caspica* : More than the White Wagtail. Breast turning golden.
94. White Wagtail, *Motacilla alba* : 1-2 only.
95. Tickell's Flowerpecker, *Dicaeum erythrorhynchos* : Frequently seen on Simul flowers.
96. Purple Sunbird, *Nectarinia asiatica* : Plentiful.
97. White-eye, *Zosterops palpebrosa* : Small flock of 4 near stream on Main Road.

Three mixed hunting parties invariably used to gather in the morning and around 3 p.m. in the afternoon, so punctually that it seemed as if the members had a watch apiece. The parties were :

I. *On Footpath to Village.* Small Minivets, Ioras, Indian Robins, Jerdon's Chloropsis, Large Cuckoo Shrikes, and Purple Sunbirds.

II. *Near Watch Tower No.* 5. Rufousbellied Babblers, Brightgreen Leaf Warblers, Whitebellied and Black Drongos, Jungle Babblers, Treepies, Jerdon's Chloropsis, Northern Green Barbets, Green Bee-eaters, Mahratta Woodpeckers, Scarlet Minivets, Ioras, Blackheaded Orioles, Pigmy Woodpeckers, Sunbirds, and Greyheaded Flycatchers ; all on Simul tree.

III. *Near Canteen.* Blackheaded Orioles, Redvented Bulbuls, Spotted Doves, Purple Sunbirds, Green Bee-eaters, Black Drongos, Jungle Babblers, Jerdon's Chloropsis, Redbreasted Flycatchers, Crimsonbreasted Barbets, Grey and White Wagtails, Ioras, Whitebreasted and Common Kingfishers, Common Mynas, Plain Longtail Warblers, Small Minivets, Grey Shrikes, Brightgreen Leaf Warblers, Treepies, and Goldenbacked Woodpeckers. But the Red- and Yellowwattled Lapwings, Pond Herons, and Indian Moorhens keep to themselves.

Taking both the visits, the total number of species observed in the National Park now stands at 97, which is still short of the 108 observed

in the Kodarma Sanctuary, only 55 km. to the north. The game birds, particularly Grey Partridge, Spurfowl, and Quail continue to be absent, as well as kites and Hornbills.

The Black Drongos have increased considerably within these five years, whereas the Whitebellied Drongos appear to have been reduced.

7. Recommendations

If the Bihar Forest Department are at all serious about this area being a real National Park, the steps indicated below must be taken without any delay. If, however, the sole intention is to create a picnic spot then the present *laissez faire* policy can continue. The measures I have in mind are :

1. Immediate legislation to put the Park on a firm legal basis. Unless the Forest Department take the initiative and press strongly for it, such a Bill will never be placed before the Assembly.

2. A proper plan of management, something on the lines of a Forest Working Plan, should be drawn up, so that there is a properly defined policy in respect of the Park.

3. The entire boundary of the Park must be fenced.

4. All burning operations must cease and construction activity be cut down to a minimum. Selected blank areas can be given over to the cultivation of pulses for attracting deer. At least this will serve the purpose of making it a Deer Park.

5. The Watch Towers, which contrast with the landscape and drive away animals, should have their outlines softened by a liberal planting of foliaceous creepers. If any more Watch Towers are contemplated, they should be of rough hewn timber, and so constructed as to merge in the background. They should not offend aesthetically.

6. Staff for the Park must have specialized training in Animal Ecology and Management. Dehra Dun can consider having special classes for training Officers, Forest Rangers, and Deputy Rangers. Game Guards can be trained in the States themselves, provided the higher echelons have the correct background. Further, for creating better interest, the Staff should be given Special Pay, and arrangements made for proper medical attention to them and their families, as well as special provision for the education of their children.

7. A Jeep is a *sine qua non* for efficient patrolling and the elimination of poaching.

8. Acknowledgements

I thank the Bombay Natural History Society for the contribution which made this re-survey possible. I also thank Mr. S. Muhammud, Conservator of Forests, Hazaribagh Circle, and Mr. D. P. Sinha, Divisional Forest Officer, for help and co-operation. Special mention must be made of the Assistant Game Warden, Mr. Razzaque, whose constant attention and genuine desire to make my work a success was one of the pleasantest experiences I had during my stay in the Park. Special thanks are also due to Mr. Sami Ahmad, who in spite of ill health was my constant companion throughout the Survey.

The Sessile Barnacles (Cirripedia) of the Bombay Coast

BY

ASHOK A. KARANDE AND V. C. PALEKAR

Naval Chemical & Metallurgical Laboratory, Naval Dockyard, Bombay

(*With a map, four plates, and twenty-two text-figures*)

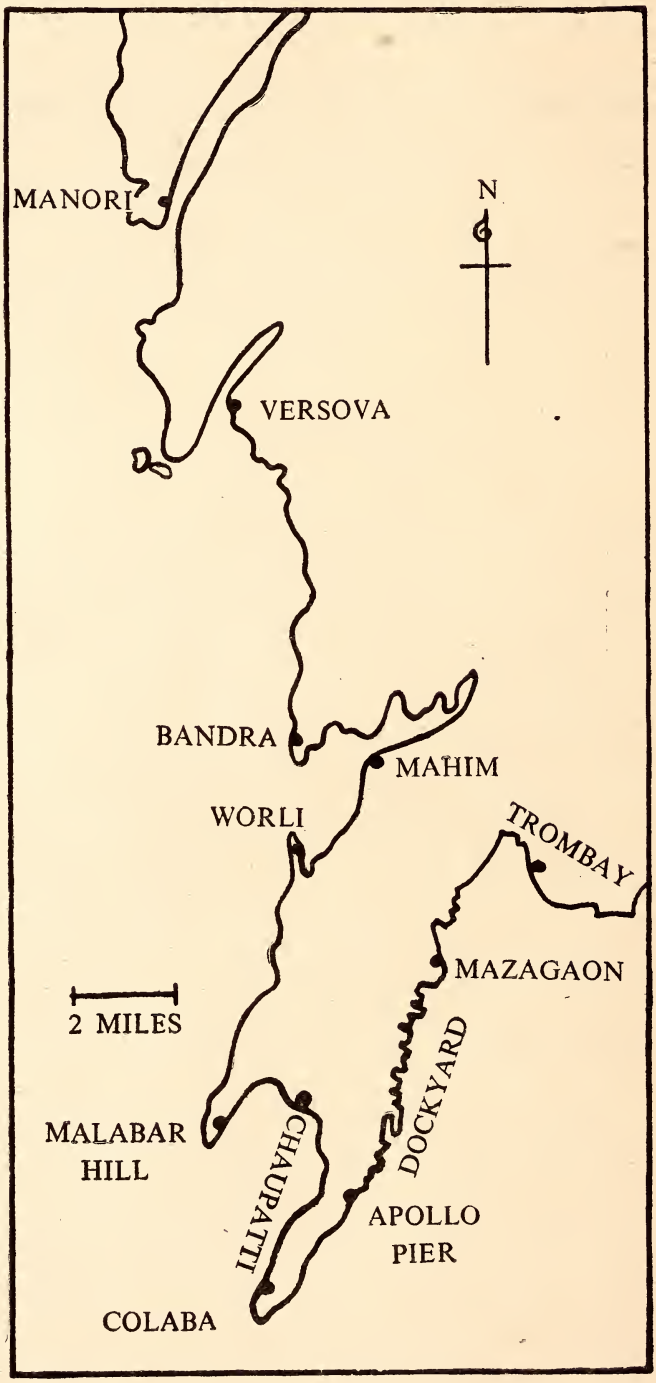
INTRODUCTION

Amongst the very varied forms belonging to the fouling community, the barnacles constitute an important group. They are commonly found on underwater structures such as hulls of ships, buoys, floating rafts and wharfs, jetties, chains, sea-water conduits, etc. On account of their great productivity, gregarious habit, and nature of settlement they are of greater importance than other fouling groups, and have attracted the attention of the biologist and the paint technologist.

Information on the Indian cirripedes is rather scattered and only during recent years have efforts been made towards a systematic survey of the barnacles of the Indian Ocean, the Bay of Bengal, and the Arabian Sea. Noteworthy contributions on this subject are those from Annandale (Daniel 1956) whose collections included specimens from Ceylon and the Andaman sea also. Nilsson-Cantell's (1938) study of collections made by Annandale covers 73 species and subspecies of sessile barnacles. Sundara Raj (1927) recorded five species of cirripedes from Krusadi Islands. The recent account of the cirripedia of Madras by Daniel (1956) has added to current knowledge of this group along the Indian coast.

In the course of studies on the incidence and nature of fouling at different places on the Bombay coast a large collection of barnacles has been made and it has been possible to add eleven more species, subspecies, varieties, and forms to the four already recorded along the Bombay shores (Bhatt & Bal 1960 ; Nilsson-Cantell 1938 ; Karande & Palekar 1963a).

The majority of the barnacles reported in this paper were collected from intertidal rocks and sea-walls, as well as from submerged structures such as buoys, fenders, piers, and frequently chains, anchors, and underwater hulls of ships of the Indian Navy. The intertidal collections were generally made from different localities around Bombay, viz. Naval



Map of Bombay and its surroundings

Courtesy : Bombay Natural History Society and B.F. Chhapgar & S.R. Sane

Dockyard, Apollo Pier, Colaba (Cuffe Parade), Mazagaon, Mahim, Bandra, Versova, and Manori Island (see Map on p. 140). The barnacles at Trombay were collected from panels suspended from Burmah-Shell Refineries Pier and those at Apollo Pier from this Laboratory's experimental raft moored at Middle Ground.

The usual method was employed of cleaning the valves, mouth-parts, and other appendages of the specimens with caustic potash. The diagrams were made with the help of the camera lucida.

CIRRIPEDES FROM BOMBAY

Suborder	..	BALANOMORPHA Pilsbry, 1916
Family	..	BALANIDAE Gray, 1825
Sub-family	..	BALANINAE Darwin, 1854
Genus	..	**Balanus** Da Costa, 1778

Subgenus **Megabalanus** Hoek, 1913

1a. **Balanus tintinnabulum** var. **tintinnabulum** Linne, 1758
1b. **Balanus tintinnabulum** var. **zebra** Darwin, 1854

Subgenus **Balanus** Da Costa, 1778

2a. **Balanus amphitrite** var. **variegatus** Darwin, 1854
2b. **Balanus amphitrite** var. **communis** Darwin, 1854
2c. **Balanus amphitrite** var. **hawaiiensis** Broch, 1922
2d. **Balanus amphitrite** var. **cochinensis** Nilsson-Cantell, 1938
2e. **Balanus amphitrite** var. **denticulata** Broch, 1927
2f. **Balanus amphitrite** var. **insignis** Nilsson-Cantell, 1938
2g. **Balanus amphitrite** var. **venustus** Darwin, 1854
3. **Balanus calidus** Pilsbry, 1916

Subgenus **Chirona** Gray, 1835

4a. **Balanus amaryllis** forma **euamaryllis** Broch, 1922
4b. **Balanus amaryllis** forma **nivea** Gruvel, 1905

Subfamily TETRACLITINAE Nilsson-Cantell, 1921

Genus **Tetraclita** Schumacher, 1817

5. **Tetraclita purpurascens** Wood, 1818

Family CHTHAMALIDAE Darwin, 1854

Genus **Chthamalus** Ranzani, 1817

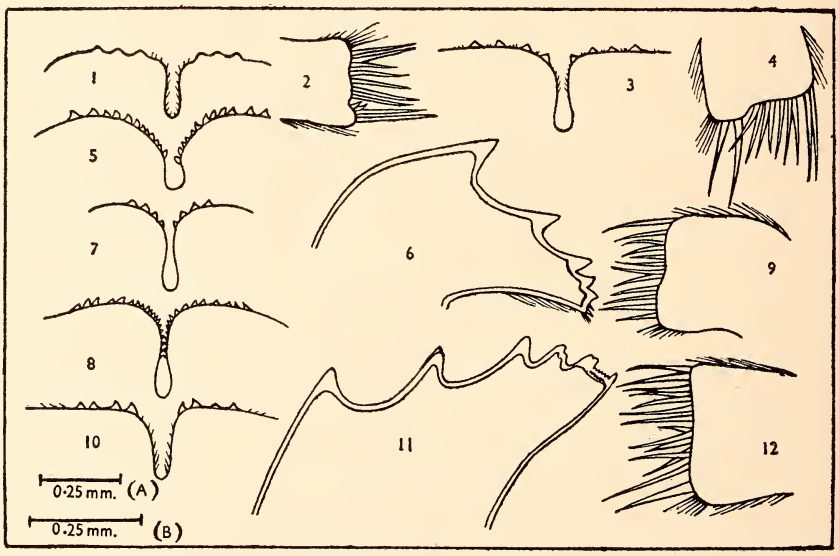
6. **Chthamalus malayensis** Pilsbry, 1916
7. **Chthamalus withersi** Pilsbry, 1916

DESCRIPTION OF SPECIES

1a. **Balanus tintinnabulum** var. **tintinnabulum** Linne, 1758

(Text-figs. 1 and 2 ; Plate I, Fig. 1 ; Plate III, Row 1)

Occurrence. Frequently occurring along Versova and Manori shores. Also found on hulls of ships.



Text-figures 1-12

1. *Balanus tintinnabulum* var. *tintinnabulum* : Labrum ; 2. ditto: Maxilla I ; 3. *Balanus amphitrite* var. *variegatus* : Labrum ; 4. ditto: Maxilla I; 5. *Balanus amphitrite* var. *communis* : Labrum ; 6. ditto: Mandible; 7. *Balanus amphitrite* var. *denticulata* : Labrum ; 8. *Balanus amphitrite* var. *hawaiiensis* : Labrum; 9. ditto : Maxilla I ; 10. *Balanus amphitrite* var. *insignis* : Labrum ; 11. ditto : Mandible; 12. ditto : Maxilla

NOTE : Figs. 1 and 2 drawn to scale (A); Fig. 3 to 12 to scale (B).

Remarks. This large-sized barnacle (Plate I, Fig. 1) measures up to 55 mm. in carino-rostral diameter. Tergum (Plate III, Row 1) with distinct articular ridge ; articular ridge of scutum (Plate III, Row 1) half as long as tergal margin and ending in a free point. Hairy labrum Text-fig. 1) with three teeth on each half, one or two of them being some-

times reduced or absent. Specimens from Madras described by Daniel (1956) do not show any teeth on the labrum. Mandible with five teeth, the second and third being bifid ; maxilla I (Text-fig. 2) with pair of long spines at apex, another at base, and ten smaller spines in between.

1b. **Balanus tintinnabulum** var. **zebra** Darwin, 1854

Balanus tintinnabulum var. *zebra* Darwin, 1854 ; Weltner, 1897 ; Gruvel, 1905 ; Stubbings, 1961.

(Plate I, Fig. 2)

Occurrence. Found on underwater hull of ship. This is the first record of this variety in Indian waters.

Remarks. On account of close resemblance, likely to be mistaken for *B. t. tintinnabulum.* However, Hiro (1939) has distinguished this variety from the others by the wide transversely striated radii with rose-tinted margins adjoining the parietes (Plate I, Fig. 2). Spur and articular groove of tergum narrow.

2a. **Balanus amphitrite** var. **variegatus** Darwin, 1854

(Text-figs. 3 and 4 ; Plate I, Fig. 3 ; Plate IV, Row 1)

Occurrence. Very common form. Occurs predominantly on submerged structures like piles, buoys, and test panels at Trombay and in Bombay Harbour. Also, invariably present on underwater hulls of ships.

Remarks. The specimens measure 20 mm. or more in carino-rostral diameter (Plate I, Fig. 3). Short articular ridge of tergum (Plate IV, Row 1) rounded at free end. Articular and adductor ridges of scutum (Plate IV, Row 1) fairly well developed.

Labrum hairy (Text-fig. 3), with four teeth on either side of notch. Mandible with five teeth, fourth and fifth of which are reduced. Maxilla I (Text-fig. 4) has broad step at basal end, a pair of long spines at apex, and another at base, and ten small spines in between.

2b. **Balanus amphitrite** var. **communis** Darwin, 1854

(Text-figs. 5 and 6 ; Plate I, Fig. 4 ; Plate IV, Row 2)

Occurrence. A widely occurring variety along Bombay shores. Generally found on rocks, piles, fenders, chains, etc. Also on shells of living or dead crabs and molluscs. Specimens are found to crowd in patches on underwater hulls of ships along with *B. a. variegatus.* Hiro

(1939) points out that in Japanese waters specimens do not settle on intertidal rocks whereas this is most common in Bombay waters.

Remarks. Carino-rostral diameter about 13-14 mm. (Plate I, Fig. 4). Scutum reddish brown (Plate IV, Row 2), with conspicuous white stripe along tergal margin (see Plate I, Fig. 4). Opercular valves smaller than in other varieties. Short articular ridge and short spur of tergum also distinguish this variety from others in *amphitrite* series. Articular ridge of scutum (Plate IV, Row 2) extends half way along tergal margin. A small ridge along the adductor ridge marks an important distinguishing feature of this variety. As characteristic of the *amphitrite* series, each segment of the third cirrus has six recurved spines and six long spines. Deeply notched labrum (Text-fig. 5) with 12-13 spines on each half of hairy margin. Mandible (Text-fig. 6) has five teeth and one or two tooth-like spines at lower end.

2c. **Balanus amphitrite** var. **hawaiiensis** Broch, 1922

Balanus amphitrite Pilsbry, 1928.

(Text-figs. 8 and 9 ; Plate I, Fig. 5 ; Plate IV, Row 3)

Occurrence. Intertidal variety abundantly found on rocks along Chaupati Sea Face with *B. a. cochinensis* and *B. a. communis.* First recorded in Bombay by Bhatt & Bal (1960).

Remarks. The specimens measure 13-15 mm. in diameter. Parietes dirty white with violet vertical stripes (Plate I, Fig. 5). Easily distinguished from other varieties by sinuous suture between its opercular valves. A second distinctive external feature is horizontal disposition of opercular valves in contrast to inclined position in other varieties. Tergum of characteristic shape (Plate IV, Row 3), its pointed articular ridge slightly projecting out of scutal margin of tergum. Broad rounded spur short, crests for carino depressor muscles distinct, articular furrow broad. Scutum (Plate IV, Row 3) has well developed articular and adductor ridges. Labrum (Text-fig. 8) has about 18 teeth on either side of notch. Lower angle of mandible bears 2-3 spines. Maxilla I (Text-fig. 9) has 11-12 spines.

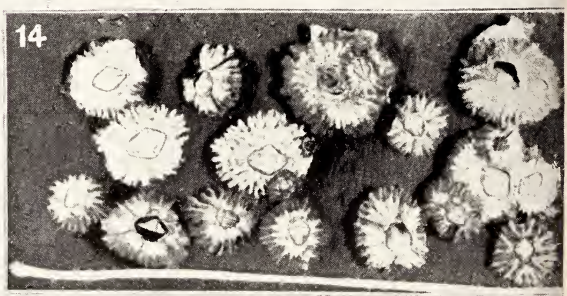
2d. **Balanus amphitrite** var. **cochinensis** Nilsson-Cantell, 1938

(Plate I, Fig. 6 ; Plate IV, Row 4)

Occurrence. Abundantly located on intertidal rocks at Chaupati. First described by Nilsson-Cantell (1938) from Cochin backwaters.

Remarks. The specimens measure 12-13 mm. in carino-rostral diameter (Plate I, Fig. 6). Distinguishable from *B. a. communis* by absence of white stripe along tergal margin of scutum. Opercular valves (Plate

1. *Balanus tintinnabulum* var. *tintinnabulum* ; 2. *Balanus tintinnabulum* var. *zebra* ; 3. *Balanus amphitrite* var. *variegatus* ; 4. *Balanus amphitrite* var. *communis* ; 5. *Balanus amphitrite* var. *hawaiiensis* ; 6. *Balanus amphitrite* var. *cochinensis* ; 7. *Balanus amphitrite* var. *denticulata*



8. *Balanus amphitrite* var. *insignis* ; 9. *Balanus amphitrite* var. *venustus* ; 10. *Balanus calidus* ; 11. *Balanus amaryllis* forma *euamaryllis* ; 12. *Balanus amaryllis* forma *nivea* ; 13. *Tetraclita purpurascens* ; 14. *Chthamalus malayensis* ; 15. *Chthamalus withersi*

IV, Row 4) closely conform to description given by Nilsson-Cantell (1938). Labrum has about 15 teeth extending within notch. Typical *amphitrite* mandible, with one or two spines on lower angle.

2e. **Balanus amphitrite** var. **denticulata** Broch, 1927

(Text-fig. 7 ; Plate I, Fig. 7 ; Plate IV, Row 5)

Occurrence. Found at Trombay and in Bombay Harbour.

Remarks. Carino-rostral diameter *c.* 8-10 mm. (Plate I, Fig. 7). Parietes dull white with very faint thin violet lines (Stubbings 1961), unlike var. *communis* where they are broader and darker. Opercular valves (Plate IV, Row 5) similar to those of West African specimens described by Stubbings (1961). Spur of tergum slightly longer than in var. *communis*. Valves generally weak. Drawn-out carinal margin at apex of the tergum in Bombay specimens is also seen in West African forms. Labrum (Text-fig. 7) has four teeth on each half, as noted by Stubbings (1961) in his specimens. As pointed out by him the separation of this variety from var. *communis* is virtually impossible without examination of the labrum. Mandible with five teeth.

2f. **Balanus amphitrite** var. **insignis** Nilsson-Cantell, 1938

(Text-figs. 10-12 ; Plate II, Fig. 8 ; Plate IV, Row 6)

Occurrence. Generally found on test panels at Trombay. Earlier reported from Cochin by Nilsson-Cantell (1938).

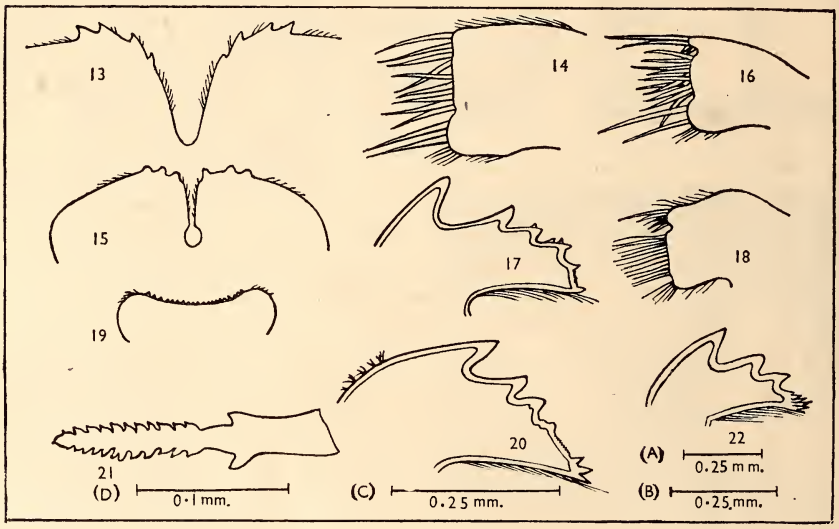
Remarks. Cylindrical in form. Specimens measure about 15 mm. in carino-rostral diameter (Plate II, Fig. 8). Dull white parietes with indistinct pinkish vertical lines. Shell base is strong and porous. The opercular valves, typical of this variety, are covered by yellow epidermis. Narrow tergum, with long curved spur (Plate IV, Row 6). Carino-basal margin curved inside and crests for depressor muscles distinct. Occludent margin of scutum (Plate IV, Row 6) thick. Labrum has four teeth on each half of hairy margin (Text-fig. 10), sometimes one or two being reduced. Mandible has five teeth (Text-fig. 11), the second bifid, the fourth and fifth spinose. Lower angle bears one or two spines. Maxilla I (Text-fig. 12) has 12 spines.

2g. **Balanus amphitrite** var. **venustus** Darwin, 1854

(Text-fig. 13 ; Plate II, Fig. 9 ; Plate IV, Row 7)

Occurrence. Occasionally found on test panels on experimental raft in Bombay Harbour.

Remarks. The specimens measure 20 mm. in carino-rostral diameter (Plate II, Fig. 9). Pale pink parietes have rosy vertical cut lines. Basi-carinal margin of tergum larger than that found in other varieties and



Text-figures 13-22

13. *Balanus amphitrite* var. *venustus* : Labrum ; 14. *Balanus calidus* : Maxilla I; 15. *Balanus amaryllis* forma *euamaryllis* : Labrum ; 16. ditto : Maxilla I; 17. *Tetraclita purpurascens* : Mandible ; 18. ditto : Maxilla I ; 19. *Chthamalus malayensis* : Labrum ; 20. ditto : Mandible ; 21. ditto : Toothed spine; 22. *Chthamalus withersi* : Mandible

Note. Figs. 15 and 16 drawn to scale (A); Fig. 13, 14, 17-19, and 22 to scale (B) ; Fig. 20 and 21 to scales (C) and (D) respectively

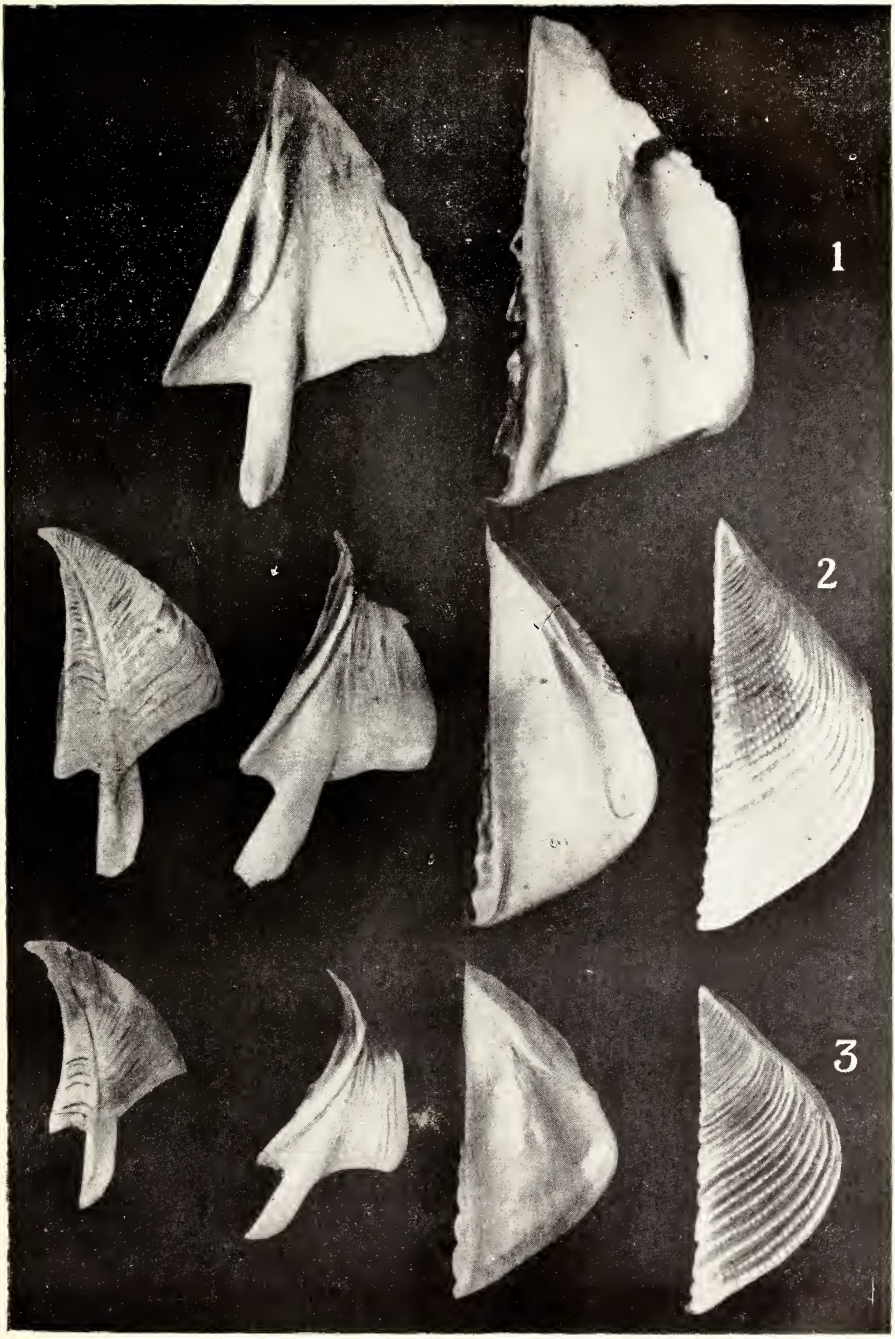
hollowed out (Plate IV, Row 7). Spur uniformly broad, and slightly larger than basi-scutal margin. Spur-fasciole broad. Scutum has distinct growth lines (Plate IV, Row 7). Articular ridge of scutum extends slightly more than half the length of tergal margin. Adductor ridge distinct. Pit for lateral depressor muscles deep. Labrum has four teeth on either side of notch (Text-fig. 13). Mandible has five teeth, fourth and fifth being reduced.

3. **Balanus calidus** Pilsbry, 1916

Balanus spongicola var. *with the walls slightly folded longitudinally* Darwin, 1854.

(Text-fig. 14 ; Plate II, Fig. 10)

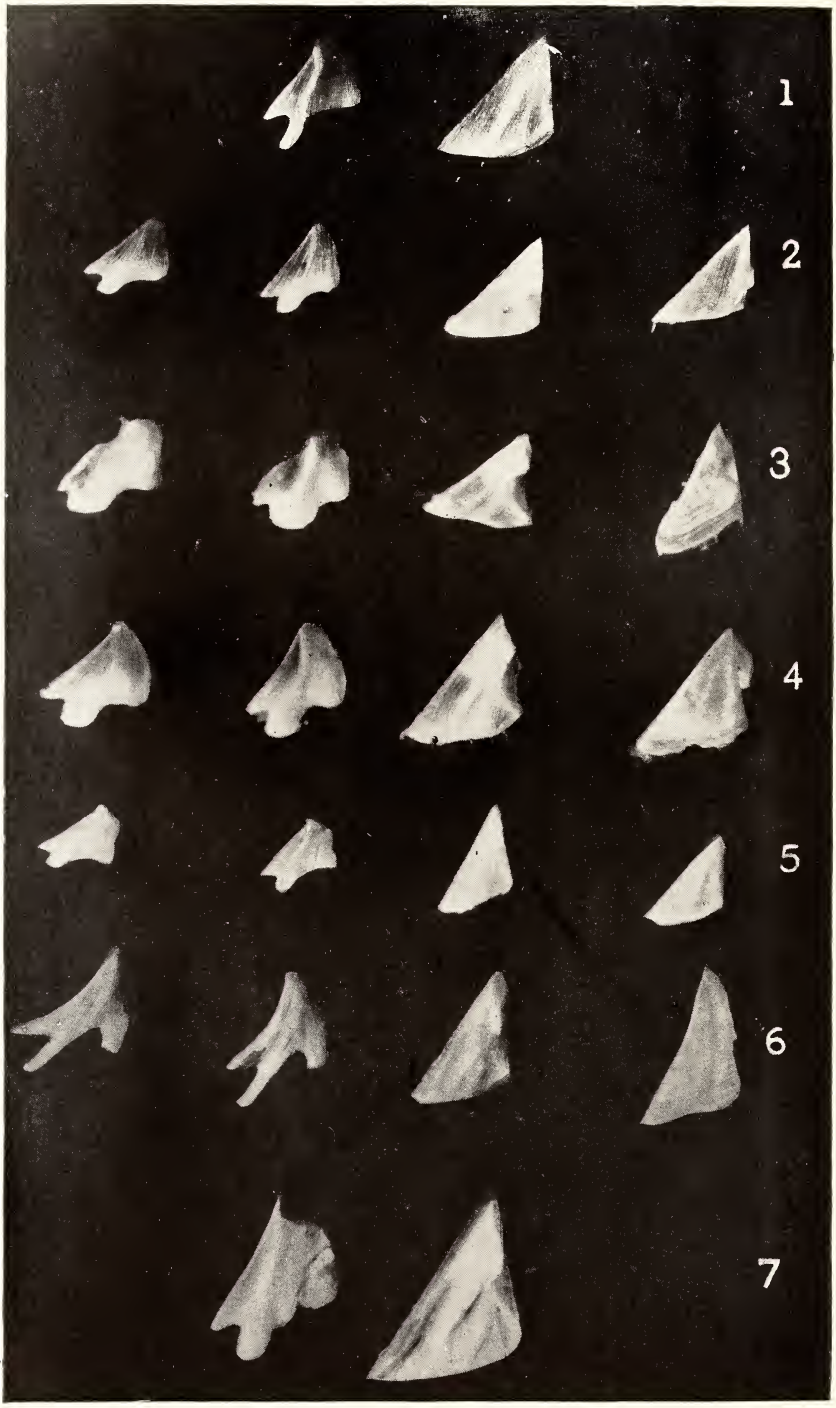
Occurrence. Only two specimens, encountered on test panels on experimental raft moored in Bombay Harbour. Daniel (1956) recorded this species from Madras for the first time in India.



Opercular valves of Barnacles

Row 1. *Balanus tintinnabulum* var. *tintinnabulum*; Row 2. *Balanus amaryllis* forma *euamaryllis*; Row 3. *Balanus amaryllis* forma *nivea*

Note. From left to right in each row : tergum outer view, tergum inner view, scutum inner view, and scutum outer view



Opercular valves of Barnacles

Row 1. *Balanus amphitrite* var. *variegatus* ; Row 2. *Balanus amphitrite* var. *communis*; Row 3. *Balanus amphitrite* var. *hawaiiensis* ; Row 4. *Balanus amphitrite* var. *cochinensis* ; Row 5. *Balanus amphitrite* var. *denticulata* ; Row 6. *Balanus amphitrite* var. *insignis*; Row 7. *Balanus amphitrite* var. *venustus*

Note. From left to right in each row : tergum outer view, tergum inner view, scutum inner view, and scutum outer view

Remarks. Tubulo-conical in shape. Carino-rostral diameter of specimens 20 mm. (Plate II, Fig. 10). Radii narrow and oblique, with crenated edges. Spur of tergum slightly curved. Scutum has distinct growth lines, and articular ridge half as long as tergal margin. Labrum has four teeth on either side of median notch. Mandible has five teeth. Maxilla I with poorly developed lower step, and bears pair of long spines similar to those on upper angle ; between the two pairs of spines about 7-8 short spines (Text-fig. 14).

4a. **Balanus amaryllis** forma **euamaryllis** Broch, 1922

(Text-figs. 15 and 16 ; Plate II, Fig. 11 ; Plate III, Row 2)

Occurrence. Very common in Bombay Harbour, Trombay, Versova, and on hulls of ships.

Remarks. Carino-rostral diameter of specimens from 30 to 50 mm. (Plate II, Fig. 11). Articular and adductor ridges of tergum (Plate III, Row 2) very poorly developed ; broad spur crenated along free end. Articular and adductor ridges of scutum also weakly developed (Plate III, Row 2). Labrum deeply notched, and bears three teeth on each half of hairy margin (Text-fig. 15). Mandible has five teeth. Maxilla I (Text-fig. 16) has distinct upper and lower steps with two long spines on each, and 9-10 sub-equal spines in between the steps ; a notch at the base of the upper step has three to four smaller spines.

4b. **Balanus amaryllis** forma **nivea** Gruvel, 1905

(Plate II, Fig. 12 ; Plate III, Row 3)

Occurrence. Common at Manori. Also noted on hulls of ships.

Remarks. Carino-rostral diameter of specimens 25 mm. (Plate II, Fig. 12). Radii crenulated and narrower than in forma *euamaryllis*. This form is distinguishable externally from forma *euamaryllis* by its smooth shell and uniformly disposed, distinct, longitudinal lines on parietes. As noted by Daniel (1956) sculpture on opercular valves (Plate III, Row 3) of this species less developed than in forma *euamaryllis*. Mouth parts similar to those of forma *euamaryllis*.

5. **Tetraclita purpurascens** Wood, 1818

(Text-figs. 17 and 18 ; Plate II, Fig. 13)

Occurrence. First reported from Madras by Daniel (1956), and subsequently by Bhatt & Bal (1960) from Bombay. Found in abundance on intertidal rocks at Cuffe Parade.

Remarks. The carino-rostral diameter measures 14-15 mm. (Plate II, Fig. 13). Shell dorso-ventrally flattened. Labrum devoid of teeth. Mandible (Text-fig. 17) has 5-6 teeth, with a pecten between last two teeth. Third and fourth teeth have one or two short spines. Maxilla I (Text-fig. 18) has slight notch, and bears about 19-20 spines.

6. **Chthamalus malayensis** Pilsbry, 1916

Chthamalus challengeri f. *krackatanensis* Broch, 1931.
Chthamalus moro Pilsbry, 1916 ; Broch, 1931 ; Hiro, 1937, 1939 ; Nilsson-Cantell, 1934.

(Text-figs. 19-21 ; Plate II, Fig. 14)

Occurrence. Karande & Palekar (1963a) have reported many specimens of this species in and around Bombay. Occurs on intertidal rocks, concrete structures, and sometimes on stems of plants.

Remarks. Carino-rostral diameter generally 9-10 mm., maximum 14 mm. (Plate II, Fig. 14). Conically depressed, ridged shell, almost rounded. Opercular valves show variations similar to those noted by Utinomi (1954). Spurless tergum, with 4-5 short crests for carinal depressor muscles. Hairy labrum, with 15-16 teeth (Text-fig. 19). Mandible and Maxilla I similar to those of specimens from Formosa (Hiro, 1939). Mandible has pecten of 8-15 teeth below the fourth tooth, and lower angle has 3-5 teeth (Text-fig. 20). Cirrus II with both toothed and serrated spines (Text-fig. 21), the former varying from 3-10 in number. *Chthamalus moro* has been found to be synonym of *Chthamalus malayensis* by Hiro (1937) and this has been confirmed by the present authors (Karande & Palekar 1963b).

7. **Chthamalus withersi** Pilsbry, 1916

(Text-fig. 22 ; Plate II, Fig. 15)

Occurrence. Abundant on intertidal rocks and concrete structures at several places in Bombay. Recorded earlier from Thana near Bombay by Nilsson-Cantell (1938).

Remarks. Carino-rostral diameter 8-9 mm. (Plate II, Fig. 15). Parietes dirty brown with a broadly ribbed surface. Shell base membraneous. Alae broad. Opercular valves similar to those described by Nilsson-Cantell (1938). Sutures between valves simple. Labrum has numerous minute teeth along hairy margin. Mandible has three large teeth and a pecten with 7-8 spines (Text-fig. 22). Maxilla I has two distinct notches. Cirrus II has no pectinated spine.

General Remarks

Of the fairly rich cirripede fauna around Bombay fifteen forms are described here. Of these, *Balanus amphitrite* var. *communis*, *B. a.* var. *hawaiiensis*, *B. a.* var. *cochinensis*, *Chthamalus malayensis*, *Ch. withersi*, and *Tetraclita purpurascens* are most commonly noted in the intertidal zone, on rocks and structural materials. *B. a.* var. *communis*, however, frequently occurred on the underwater hulls of ships. Reference may be made here to the observation of Hiro (1939), who states that in Japanese waters *B. a. communis* and *B. a. hawaiiensis* are exclusively found on the underwater hulls of ships and on submerged structures.

Amongst the barnacles reported in this paper, *B. a. communis*, *B. a. variegatus*, *B. amaryllis euamaryllis*, *B. a. nivea*, and *B. tintinnabulum tintinnabulum* largely contribute to the fouling community on ships of the Indian Navy. Our observations at various localities in Bombay also reveal that the first three barnacles noted above occur in large abundance on test panels over a major part of the year. At Manori, however, *B. amaryllis euamaryllis* and *B. a. nivea* are common on intertidal rocks. In like manner, *B. t. tintinnabulum* is also plentiful, forming beds on surf-washed rocky shores at Marine Drive and Manori and at Middle Ground (off Apollo Pier). The specimens on the hulls of ships are generally smaller in size than those on rocks.

Review of the systematic positions of the various species described has revealed some points of taxonomic interest. As regards *B. a. denticulata*, Utinomi (1960) has reported that this variety is a synonym of *B. a. hawaiiensis*. His observations are supported by Costlow & Bookhout (1958) while comparing larval developments of *B. a. denticulata* and *B. a. hawaiiensis*. Also, Stubbings (1961) in his description of West African forms has stated that the separation of variety *communis* from var. *denticulata* is virtually impossible without examination of the labrums, and he prefers to separate these two varieties 'solely (as) a matter of convenience' without giving final views on the *communis-denticulata* problem. The present observations on *B. a.* var. *denticulata* at Bombay conform to the description of the West African specimens of Stubbings. Our study indicates that var. *communis* and var. *hawaiiensis* are clearly distinguishable from one another, but the separation of var. *communis* from var. *denticulata* is virtually impossible without examination of the labrum. In view of the uncertainty in the taxonomic positions of the three varieties under reference, it was felt reasonable to place them separately pending detailed clarification as suggested by Stubbings (1961).

Amongst the Chthamalidae of Bombay, the species recorded earlier are *Ch. withersi* (Nilsson-Cantell 1938) and *Ch. challengeri* (Bhatt & Bal 1960). Of these *Ch. withersi* has been noted in abundance at various places, while *Ch. challengeri* is absent from the collections made during

the present work. In addition to these two species, *Ch. malayensis* occurred plentifully in and around Bombay. Pilsbry (1916) observes that ' the differences between *Ch. malayensis* and *Ch. challengeri* are not very important ', and this has been supported by Nilsson-Cantell (1938). Hiro (1939) adds that ' externally the young specimen (of *Ch. malayensis*) is hardly distinguishable from *Ch. challengeri* owing to conic shape but the larger ones are quite different '. The specimen of *Ch. malayensis* from Bombay, however, could be easily identified by the presence of three spines on the lower angle of the mandible and the number of crests for carinal depressor muscles on the tergum. A close scrutiny of the specimens of *Ch. malayensis* from Bombay has further exhibited an interesting taxonomic feature as a result of the disparity in their opercular valves. Pilsbry (1916) and Nilsson-Cantell (1938) distinguished those with the sinuous suture between the opercular valves as *Ch. malayensis* and others with the straight suture as *Ch. moro*. From a detailed study of both these types, Utinomi (1954) considered them as synonymous. From critical observations on characters like opercular valves, cirrus II, mandible, and maxilla I in these specimens, the present authors confirm the synonymy suggested by Hiro (Karande & Palekar 1963b).

From a general literature survey of the cirripedian fauna, it is observed that the cirripede barnacles from Bombay chiefly comprise the Indo-Pacific forms with Malayan elements. Of the fifteen barnacles reported from Bombay, two viz. *B. a. cochinensis* and *B. a. insignis*, both originally described by Nilsson-Cantell (1938), exclusively belong to the Indian Ocean. The former is recorded from Cochin (W. India) and the latter from Sumatra. The Chthamalid barnacles described here have been earlier reported from Malay Archipelago, Formosa, and Japan. Amongst others *B. a. hawaiiensis*, *B. a. variegatus*, *B. amaryllis euamaryllis*, *B. a. nivea*, and *Tetraclita purpurascens* have been recorded from the Indian Ocean. In view of the synonymy between *B. a. hawaiiensis* and *B. a. denticulata*, Utinomi (1960) records a world-wide distribution of the former species. Three other barnacles described in the present account, viz. *B. a. communis*, *B. a. venustus*, and *B. t. tintinnabulum*, are also widely distributed and have been reported from the Malay Archipelago, the Pacific Ocean, the Mediterranean Sea, the Atlantic Ocean, and the Indian Ocean.

Acknowledgements

Our grateful thanks are due to Shri S. K. Ranganathan, Officer-in-Charge, Naval Chemical and Metallurgical Laboratory, for encouragement and valuable guidance in the preparation of the manuscript of this paper. Thanks are also due to Shri R. Shiragaonkar, Institute of Science, Bombay, for his help in the preparation of the illustrations.

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Littoral and Parasitic Isopods from Kerala : Family Anthuridae—1

BY

N. KRISHNA PILLAI

Marine Biological Laboratory, Trivandrum, Kerala State

(*With four text-figures*)

For our knowledge of the isopod fauna of the Indian waters we are indebted to Stebbing (1904a, 1905), Barnard (1935, 1936), and Chopra (1923, 1930). The present study, conducted during the period 1951-54, showed that our fauna is comparable to that of any other region with respect to abundance and variety. Hoping to stimulate further work on the subject I present the results of my study in a series of short papers, and begin with the family Anthuridae.

This work was done during the tenure of a scholarship, for which I take this opportunity to thank the Government of India and the University of Kerala. My sincere thanks are due to Dr. C. C. John, former Professor of Marine Biology and Fisheries, under whose supervision this work was done.

Family ANTHURIDAE

So far nine species belonging to six genera have been recorded from the Indian waters. Of these four were collected from Kerala, three from Ceylon, and one each from Chilka Lake and the Arakan coast. The present collection includes six genera which can be distinguished by the following key :

1. Carpus of peraeopods four to seven underriding propodus, mouth parts normal.....2
   Carpus of peraeopods four to seven not underriding propodus, mouth parts modified.....5
2. Maxilliped three- to four-segmented.....3
   Maxilliped five-segmented.....4
3. Second segments of maxillipeds fused.....*Xenanthura*
   Second segments of maxillipeds not fused.....*Cyathura*

4. Pleon segments distinct, third segment of maxilliped as broad as the adjacent segments, body pigmentation simple. . . *Apanthura*
   Pleon segments indistinct, third segment of maxilliped narrower than the adjacent ones, body pigmentation conspicuous..... *Mesanthura*
5. Statocyst present, maxilliped four-segmented, second segment produced..... *Accalathura*
   Statocyst absent, maxilliped three- or four-segmented, second segment not produced..... *Paranthura*

Xenanthura Barnard, 1925

This genus includes only three species, two of which appear in my collection. A revised definition of the genus, key to the species, and detailed descriptions of *X. orientalis* and *X. linearis* have been published (Pillai 1963).

Xenanthura orientalis Barnard

Xenanthura orientalis Barnard, 1935, p. 307, figs. 17a-h ; Pillai, 1963, p. 265, fig. 1.

Distribution. This species has so far been recorded only from brackish water localities in Kerala, south India.

Xenanthura linearis Pillai

Xenanthura linearis Pillai, 1963, p. 268, figs. 2-3.

Distribution. Like *X. orientalis*, this species has been recorded only from brackish water localities in Kerala, south India. It can tolerate nearly fresh water.

Cyathura Norman & Stebbing, 1886

According to Barnard (1925) *Cyathura* includes a few species without eyes and others with brush-like first antennae. He expressed the opinion that these species might have to be removed from *Cyathura*. In the present collection I have observed variation in the presence or absence of the eyes. Specific identification of the following three species is, therefore, made with some reservation. The three species differ thus :

1. Inner border of palm of first peraeopod with a tooth near the base, unguis long.....2
   Inner border of palm of first peraeopod without a tooth, unguis short..... *pusilla*
2. Fifth segment of first peraeopod projecting..... *carinata*
   Fifth segment of first peraeopod not projecting..... *indica*

Cyathura carinata (Kroyer)

Cyathura carinata Norman & Stebbing, 1886, p. 124; Barnard, 1925, p. 140.
Cyathura estuarius Barnard, 1914, p. 334a, pl. 27D.

Length 7·0 mm.

Distribution. This species is common in the estuarine region at Quilon, Kerala. It has been previously recorded from China, East London, Algoa Bay, North Atlantic, Mediterranean, and the Baltic Sea.

Cyathura pusilla Stebbing

Cyathura pusilla Stebbing, 1904a, p. 9, pl. 6B; 1910, p. 91; Barnard, 1925, p. 140.

Length 5·6 mm.

Distribution. This species has been recorded only from Ceylon and British East Africa.

Cyathura indica Barnard

Cyathura indica Barnard, 1925, p. 140, pl. 4, fig. 7; 1935, p. 306.

Length 5·7 mm.

Distribution. This species has been previously recorded from Singapore, Thailand, Ceylon, Pamban, and Kerala.

Apanthura Stebbing, 1900

Apanthura sandalensis Stebbing (Fig. 1)

Apanthura sandalensis Stebbing, 1900, p. 621, pl. 65a; Barnard, 1925, p. 141.
Apanthura dubia Barnard, 1914, p. 342a, pl. 28D.

Body is rather slender and of uniform width. Head is nearly half the length of the first peraeon segment. Eyes are present. Peraeon segments one to three are subequal, four to seven are longer. Pleon is fully segmented. First peduncular segment of first antenna is setose, flagellum is three- to four-segmented, flagellum of second antenna is four-segmented. Third segment of the palp of the mandible is very short and carries two apical setae. Maxilliped is four-segmented. Carpus of first peraeopod is triangular and slightly projecting at its apex, propodus has a small projection in the middle of its inner border, dactylus when closed overreaches the apex of the fifth segment. Second peraeopod is gnathopodal in character, carpus is considerably immersed in the merus, propodus is ovate. Seventh peraeopod has its carpus slightly underriding the propodus and carries two inner spines. Telson is linguiform, with a narrowly rounded apex, its dorsal surface is minutely spiny. Exopod of uropod is elongated and very slightly overreaches the telson.

Length 7·0 mm.

A single specimen was obtained in the plankton collected at Trivandrum.

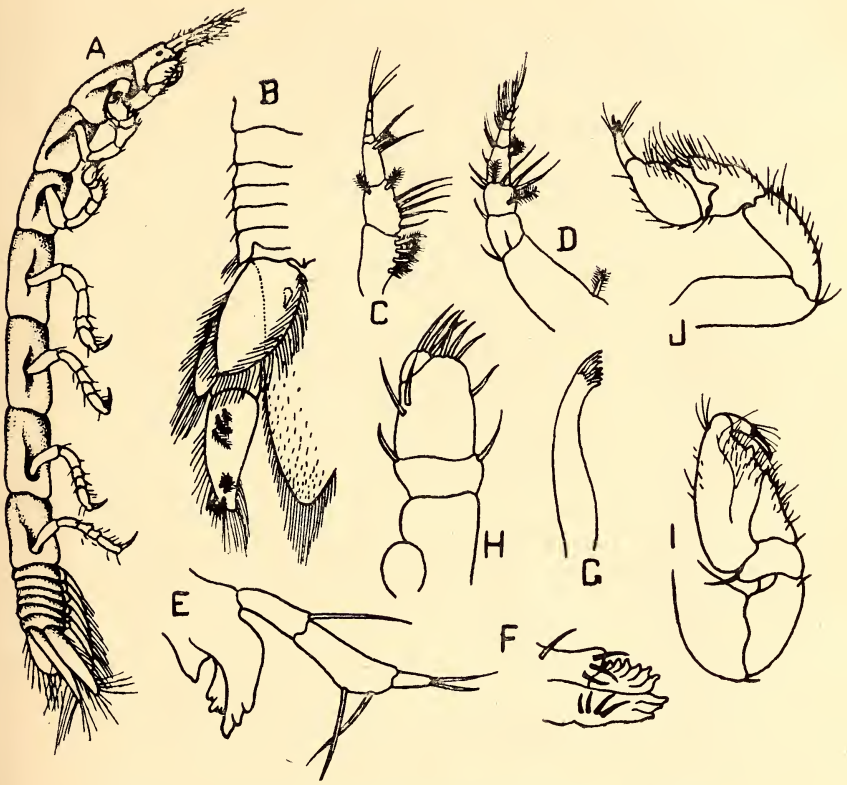

Fig. 1. *Apanthura sandalensis* Stebbing. Female

A. Lateral view; B. Posterior part of body, dorsal view; C. First antenna; D. Second antenna; E. Mandible; F. Same, cutting edge enlarged; G. First maxilla; H. Maxilliped; I. First peraeopod; J. Second peraeopod

Distribution. This species has been previously recorded from Loyalty Islands, South Africa, Chilka Lake, and Kerala.

Remarks. The presence of a tooth on the palmar border of the first peraeopod is an important character of this species. Barnard (1925, p. 141) says that this tooth may or may not be present. But in the illustrations published by him (1914, pl. 28D) and in the cotype in the British Museum (*vide* Barnard 1925, p. 141) a tooth is present at the base of the propodus. In my specimen there is a conical tooth-like projection in the middle of the inner border and the border of the palm distal to the tooth is straight. The inner surface of the carpus and the propodus is setose. The first peraeopod of my specimen is very much like that of *A. africana* Barnard (1914).

Mesanthura Barnard, 1914

Mesanthura maculata (Haswell) (Fig. 2)

Mesanthura maculata Barnard, 1925, p. 141; Kirtisinghe, 1931, p. 129.

Head is slightly longer than broad, with a prominent blunt rostrum. Eyes are large and well developed. Peraeon segments one to six are

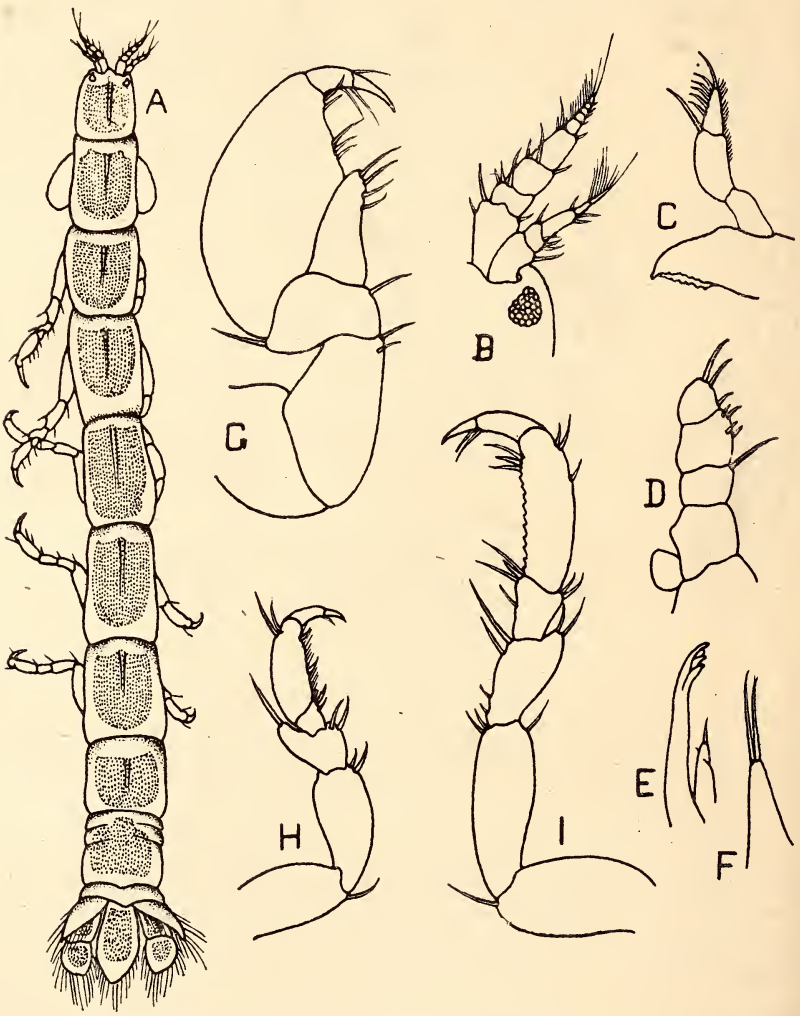

Fig. 2. *Mesanthura maculata* (Haswell). Female

A. Dorsal view; B. Cephalon and antennae, dorsal view; C. Mandible; D. Maxilliped; E. First maxilla; F. Second maxilla; G. First peraeopod; H. Second peraeopod; I. Seventh peraeopod

subequal in length, seventh is smaller. Pleon is as long as the seventh peraeon segment and its first two septa are laterally visible. Flagellum

of first antenna is three-segmented and slightly brush-like. Flagellum of second antenna is four- to five-segmented. Mandibular palp is stout, second segment is swollen, with a long inner spine, third segment is triangular and small with a row of setae, its outer border is hairy, cutting edge of the mandible is feebly serrate. First maxilla is apically quadridentate, its inner lobe is small and is tipped with a small spine. Second maxilla is a simple conical lobe tipped with two long spine setae. Carpus of first peraeopod is apically blunt and projecting, propodus is swollen, dactylus is short. Propodus of posterior legs is serrate on the inner border.

Length 10·0 mm.

Several specimens were collected from the inter-tidal region at Cape Comorin.

Body is whitish with black chromatophores distributed in a very characteristic manner. The cephalon, peraeon segments, and the pleon have a prominent dorsal patch, the telson and the two segments of the endopod of the uropod are also similarly coloured.

Distribution. Port Jackson, Victoria, South Australia, New Zealand, and Ceylon.

Accalathura Barnard, 1925

Accalathura borradalei (Stebbing) (Fig. 3)

Calathura borradalei Stebbing, 1904a, p. 700, pl. 49A; Chilton, 1924, p. 881.
Accalathura borradalei Barnard, 1925, p. 149.

Length 10·0 mm.

Body white with branched chromatophores forming distinct patterns.

Several specimens were collected from the inter-tidal region at Quilon.

Distribution. Maldive Islands, Thailand and India.

Remarks. This species can be recognized by the following characters. First antenna is slender and the second is very stout. Third segment of the palp of the mandible carries a row of prominent spines. Distal part of the first maxilla has about eleven backwardly directed teeth. Second segment of the maxilliped is produced forwards into a large apically rounded lobe reaching the middle of the fourth segment. Propodus of the first peraeopod is produced at its inner proximal part, its inner border is prominently setose, dactylus is strong and spiny along the inner border. Propodus of second peraeopod is ovate and armed along the inner border with five strong spines. Seventh peraeopod is very long, carpus has four and the propodus six spines arming

the inner border. Telson is perfectly linguiform, with broadly rounded apex. There is a prominent median statocyst.

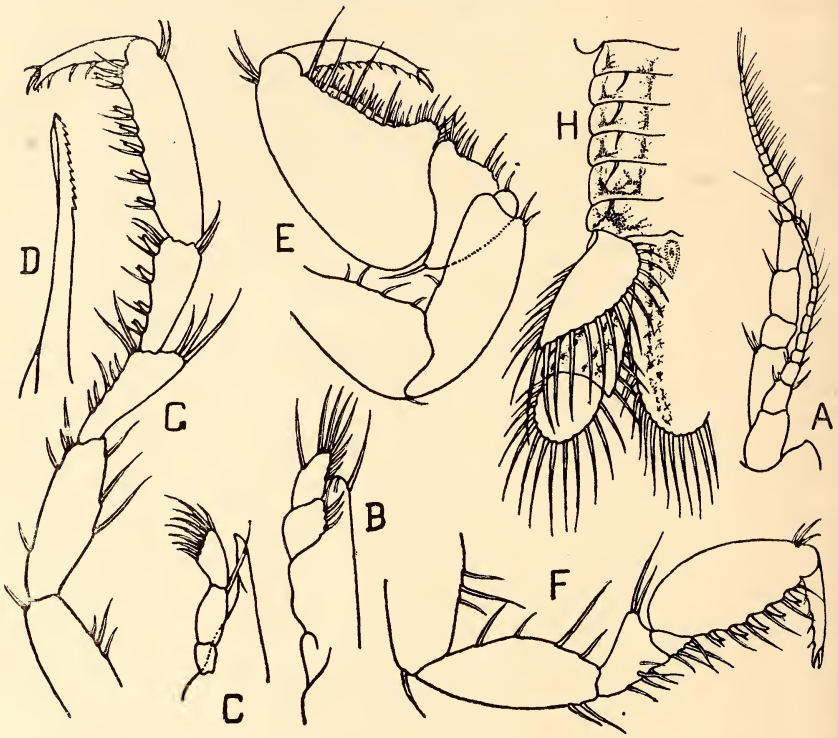

Fig. 3. *Accalathura borradalei* (Stebbing)

A. First and second antennae; B. Maxilliped; C. Mandible; D. First maxilla; E. First peraeopod; F. Second peraeopod; G. Seventh peraeopod; H. Posterior part of body, dorsal view

Paranthura Bate & Westwood, 1868

Paranthura plumosa sp. nov. (Fig. 4)

Body gradually broadens to the fifth peraeon segment. Head is slightly longer than broad and about two-thirds the length of the first peraeon segment. Rostrum is small and the antero-lateral corners of the head are produced. Eyes are well developed. First peraeon segment is the narrowest and the seventh is the shortest. Pleon is short and longer than the seventh peraeon segment, segmentation is visible, last pleon segment is produced at its postero-median part.

First antenna is shorter than second, peduncle is three-segmented, first segment is large and almost twice as long as broad, the rest of the appendage is sharply bent outwards. Flagellum is five-segmented. First antenna of the male is longer than second, peduncle is three-segmented

and the flagellum is eight-segmented and stouter than the peduncle, each flagellar segment carries a bunch of long hairs very much similar to that of *Leptanthura tenuis* G.O. Sars. Second antenna is similar in both

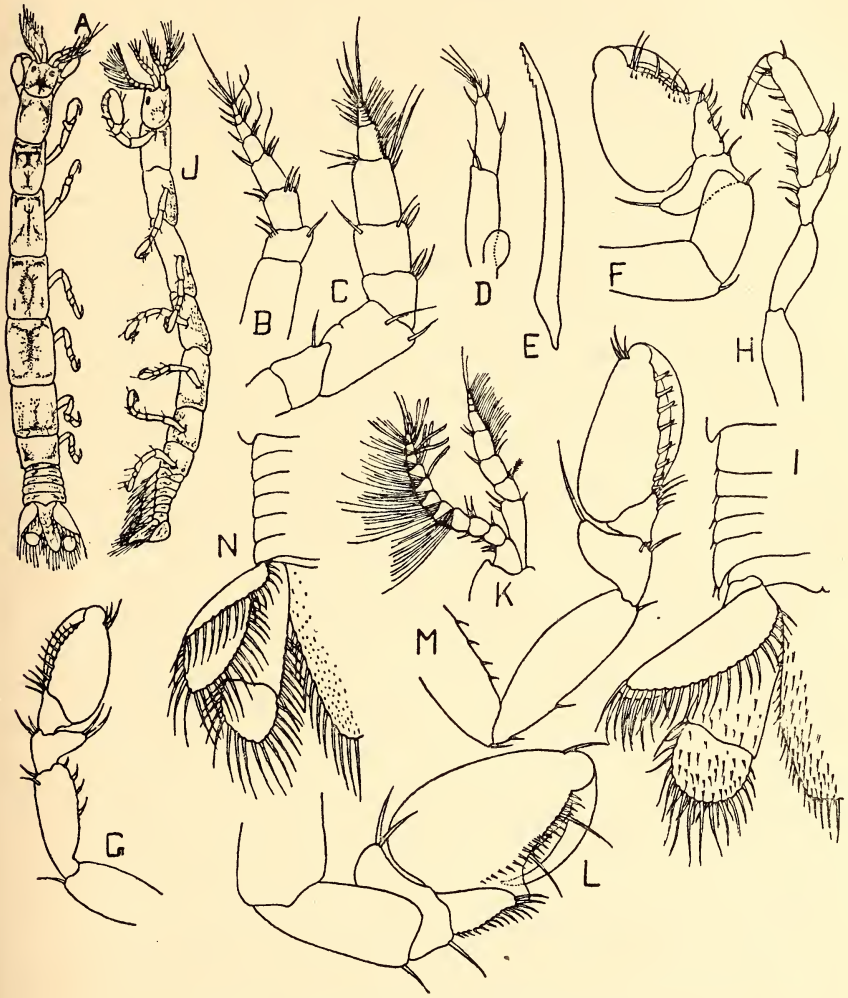

Fig. 4. *Paranthura plumosa* sp. nov.

A–I. FEMALE : A. dorsal view ; B. First antenna ; C. Second antenna ; D. Maxilliped ; E. First maxilla ; F. First peraeopod ; G. Second peraeopod ; H. Seventh peraeopod ; I. Posterior part of body, dorsal view
J–N. MALE : J. Lateral view ; K. First and second antennae ; L. First peraeopod ; M. Second peraeopod ; N. Posterior part of body, dorsal view

sexes, second segment of the peduncle is large and the rest of the appendage is bent outwards, in the female the flagellum is composed of a large basal segment and a series of small segments, in the male it is clearly four-segmented. Incisor process of the mandible is long, first

and third segments of the palp are subequal, third segment carries a comb of setae. First maxilla is long, with backwardly directed teeth at the distal part. Maxilliped is four-segmented but the fourth segment is very small and apically setose.

Basis and ischium of first peraeopod are almost of the same length, merus is dorsally produced, propodus is roughly oval, with a proximal basal expansion overlapping the tip of the carpus, dactylus is long and reaches the carpus when closed. In the male the palmar surface of the propodus is more densely setose. Second and third peraeopods are subsimilar, with the basis and ischium elongated, propodus is elongate ovate with the palmar border armed with eight spines, dactylus is short. Posterior peraeopods are slender and long, propodus is elongate cylindrical, with two basal and one apical spine on the lower border.

Endopod of uropod is as long as the telson, its free segment is slightly broader than long and its dorsal surface is setose, exopod is ovate and slightly shorter than the endopod, its margin is crenulate. Telson is somewhat linguiform and slightly bulged in the middle, distal border is subtruncate and the dorsal surface is setose. In the male the telson is perfectly linguiform, with rounded distal border. Free segment of the endopod of the uropod is slightly different in shape from that of the female.

Length 10·0 mm.

Body is white, with branched chromatophores on the dorsal side of the head and peraeon segments.

Several specimens were collected from empty tubes of sabellid worms at Quilon. Holotype female and allotype male are deposited in the Indian Museum, Calcutta.

Remarks. The female of *P. plumosa* closely resembles *P. bellicauda* Miller & Menzies (1952) in the general shape of the body and in the nature of the caudal fan. But the shape of the pleon is totally different in these two species. The male of *P. bellicauda* is unknown. *P. plumosa* also resembles *P. ostergaardi* Miller & Menzies (1952) in the nature of the pleon, in the structure of the first antenna, and in the segmentation of the maxilliped. But the shape of the body is different. Miller & Menzies do not say anything of the sexual dimorphism in these species; it is very pronounced in *P. plumosa.*

According to Barnard (1925) the flagellum of the second antenna in both sexes is formed of a single flattened segment and this is very characteristic of the genus *Paranthura.* In *P. plumosa* the flagellum in the female is composed of a large basal segment followed by a series of small segments and in the male clearly four-segmented. This is almost like the flagellum of *P. bellicauda* and *P. ostergaardi.* In his definition of the genus Barnard also stated that the maxilliped is three-segmented. But as observed by Miller & Menzies in *P. bellicauda*

and *P. ostergaardi*, the maxilliped in *P. plumosa* is four-segmented. Miller & Menzies suggested that this might be a useful subgeneric character. But before coming to a conclusion it is necessary to examine all the other species. As observed by Miller & Menzies this segment can be easily overlooked and might actually be present in many other species. As the genus *Paranthura* includes a large number of species a division is desirable, provided it is based on firm grounds.

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A Note on the Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia held at Bangkok, Thailand

November 29 to December 4, 1965

BY

E. P. GEE

(*With a plate*)

A conference on Conservation of Nature and Natural Resources in Tropical South-east Asia was held at Bangkok in Thailand from November 29th to December 4th, 1965, followed by several days of field trips to areas of conservation interest in Thailand. The conference was sponsored by the International Union for Conservation of Nature and Natural Resources in association with the National Research Council of Thailand (the host organization), and co-sponsored by the Food and Agricultural Organization of the United Nations, and the United Nations Educational, Scientific and Cultural Organization.

The purpose of this international scientific and technical conference was to focus attention on the conservation of nature and natural resources in South-east Asia. The chief objectives were to bring together those concerned with and knowledgeable about the various aspects of conservation in the region, to provide the opportunity for and to facilitate exchange of information, ideas and experience between those present; and to collect, compile and make available for consideration at the conference and for later reference a body of authoritative background information on the subject.

Until recently most attention from the developed countries of the world to conservation has been focussed on Africa. The theme of this conference, 'Conservation Spotlight on Tropical South-east Asia', was intended to express the growing national and international concern with conservation in this region. The emphasis in the programme was on the ecological aspects of conservation and the ecological approach to it in South-east Asia, on education and training, and on the exchange of information and techniques. There had been a growing interest and

Above: The Thailand subspecies of Browantlered Deer *Cervus eldi siamensis* in the Bangkok Zoo. November 1965. *Below:* Asiatic Twohorned Rhinoceros *Didermocerus sumatrensis* in the Copenhagen Zoo. It is a female, and is the only one of its kind in captivity in the world.

(*Photos: E. P. Gee*)

concern with increasingly urgent conservation problems in the countries of South-east Asia; and the Eighth General Assembly of the I.U.C.N. held in 1963 at Nairobi approved of a South-east Asia Project. Stage I of this project was an ecological survey and assessment within many of the countries of the region. Stage II was the conference. In addition to the Plenary Sessions, there were five main technical sessions, and these were: International Biological Programme, Ecology, Education and Training, Threatened Species and National Parks. The subjects were presented by selected speakers and discussants, and open floor discussions followed. The panel papers and background papers were made available to all participants.

The conference was attended by over 150 participants from about 30 countries in South-east Asia and elsewhere. No representative came from Burma, Cambodia, North Vietnam and North Korea; but all the other countries were represented—even Indonesia, Laos and South Vietnam. In fact one of the outstanding features of the conference was the interest shown in conservation by countries in the grip of unsettled political conditions, and their determination to carry through their conservation programmes in spite of difficulties.

The compiler of this note attended the conference by invitation and in his personal capacity, and 'unofficially' represented India as an observer. He read a paper, at the request of the Programme Organizer on 'Threatened Species of large Mammals in Tropical South-east Asia, and the Importance of Sanctuaries (including National Parks and Reserves) in their Conservation'. He was also invited to be an honorary vice-chairman at one of the technical sessions.

The official definition of conservation in India is 'Planned management and wise use of natural resources'. Some much fuller and more illuminating definitions were voiced at the conference. Among these were 'Conservation is a positive, constructive, commonsense approach to use and management of all the basic natural resources on which our survival and development are based' by Dr. Lee Talbot. And by the same eminent biologist: 'Conservation is not just the concern of a small band of singleminded enthusiasts; it affects all of us; it is the business of all of us; it is a subject that we and our organizations and our governments must take seriously.'

Of natural resources the Deputy Prime Minister of Thailand in his inaugural address said: 'Natural resources are essential to any nation's survival; they are a necessary foundation to economic and social development; and they are a heritage beyond value for the future.'

One of the most obvious opinions that emanated from the discussions at the conference was that (South-east) Asia has its own peculiar set of ecological, social and other problems that affect conservation; and that conservation in (South-east) Asia must be considered in the context of

that continent, and that standards and procedures from other parts of the world cannot be directly applied to conservation in this region.

Some of the thirty-six resolutions approved by the concluding session of the conference are of special interest to India, and are reproduced below.

2. *Resource inventories, research and land use programmes.*

Considering that information on natural resources requires to be based on comprehensive resource inventories, drawn up on established principles and including reference to socio-economic factors such as land tenure and agricultural methods—

and *recognizing* that in planning the management and utilization of natural resources, it is essential that these resources be treated as a whole and that the research services supporting them should be inter-disciplinary—

The IUCN Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia, meeting at Bangkok on 4 December 1965—

RECOMMENDS the organization in all countries of national resource inventories, the establishment of research services on an inter-disciplinary basis, the setting aside of adequate samples of the main types of environment for research purposes, and the framing and application of land use policies on the basis so provided.

15. *Action programmes for threatened species.*

Considering that the Red Data Book of the Survival Service Commission of IUCN lists 14 species of mammal and 24 species of birds in South-east Asia, which there is good reason to believe are approaching extinction—

and *recalling* the economic, scientific, ethical, and aesthetic reasons for safeguarding and rehabilitation of such species, while it is still possible to do so, and the urgency involved—

The IUCN Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia, meeting at Bangkok on 4 December 1965—

RECOMMENDS that the Governments of the countries of the Region be invited to set up programmes, in consultation with their scientists and with the assistance of international organizations concerned, especially IUCN's Survival Service Commission and the International Council for Bird Preservation, to ensure that essential measures to safeguard and rehabilitate species threatened with extinction are instituted and implemented urgently.

23. *Controlled breeding of threatened species in captivity.*

Bearing in mind that the decline and extinction of species is often due

to alteration or destruction of their habitat, and that sometimes it is impossible to halt such processes in time to ensure recovery of the species conserved—

The IUCN Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia, meeting at Bangkok on 4 December 1965—

RECOMMENDS the establishment under controlled conditions by responsible institutions and approved individuals, of breeding stocks of such threatened species, and further recommends that, on the advice of scientists and organisations concerned with this problem, Governments should be asked to enact legislation to permit and encourage, but under strict control, such emergency measures for the rehabilitation of these species.

24. *Use of explosives and toxic vegetable substances in fishing.*

Convinced that the wholesale and unselective disturbance and destruction of fish stocks and their habitat by the use of explosives and toxic vegetable substances, can too easily lead to a catastrophic decline and perhaps total elimination of economically valuable fish resources—

The IUCN Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia, meeting at Bangkok on 4 December 1965—

RECOMMENDS that Governments should be asked to examine the use of these methods with the greatest care and to place them under the strictest control or prohibit them entirely.

25. *Strengthening and consolidating the National Parks system.*

Recalling the recommendations of the First World Conference on National Parks (Seattle, July 1962) and of Resolution No. 12 C./2.213 of the General Conference of UNESCO (12 December 1962) as endorsed by the U.N. General Assembly (16 December 1962), in favour of conservation of natural resources, fauna and flora—

being aware of the importance of National Parks, and equivalent reserves not only for the enjoyment of the people, but also for scientific study, watershed protection, wild life sanctuary and protection of natural monuments and phenomena—

and *considering* that areas set aside for such purposes are only a small fraction of the total area of most countries, seldom exceeding 2 or 3 per cent.—

The IUCN Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia, meeting at Bangkok on 4 December 1965—

RECOMMENDS that pressures on duly constituted Park areas for use for purposes contrary to the principles on which Parks are set up, should be

discouraged, diverted or totally barred, and that all Governments of the Region should be asked not only to establish an adequate system of National Parks, but ensure that it is placed on a firm permanent legal basis.

31. *Siting of Highways, Railways, and Power Lines in relation to National Parks.*

Bearing in mind the possibility of adverse consequences to National Parks and equivalent Reserves, arising from the construction of major lines of communication through them—

The IUCN Conference on Conservation of Nature and Natural Resources in Tropical South-east Asia, meeting at Bangkok on 4 December 1965—

RECOMMENDS that when routes for such communication are being planned, experts on conservation should be consulted at an early stage, with a view to reducing disturbance to a minimum.

Three new genera of *Grallatotermes* complex (Isoptera: Termitidae: Nasutitermitinae)

BY

P. K. SEN-SARMA

Branch of Forest Entomology, Forest Research Institute, Dehra Dun

(*With eight text-figures*)

INTRODUCTION

The generic status of the group of termites formerly included by various authors in the genus *Grallatotermes* was not definite from the time Holmgren (1912) proposed the name *Grallatotermes* as a monotypic subgenus of the now defunct genus *Eutermes* Hagen with *Termes grallator* Desneux as the type species. Desneux (1905) described the species *grallator* on the basis of a collection of soldiers and workers made by Biro in 1901 at Graget Island, New Guinea. Oshima (1914, 1917, 1920) described three species from the Philippine Islands, viz. *Eutermes* (*Grallatotermes*) *luzonicus* Oshima, *E.* (*G.*) *brevirostris* Oshima, and *E.* (*G.*) *panayensis* Oshima, under the subgenus *Grallatotermes*. These species have been subsequently found to belong to the genus *Nasutitermes* Banks (*vide* Light & Wilson 1936). In 1917, K. & N. Holmgren described from south India a new species, *Eutermes* (*Grallatotermes*) *grallatoriformis* K. & N. Holmgren. Snyder (1925) described from the Papuan region (Santa Cruz Archipelago) another new species of the subgenus *Grallatotermes*, namely *Nasutitermes* (*Grallatotermes*) *oceanicus* Snyder. Subsequent examination proved that it is a synonym of *Nasutitermes novarum-hebridarum* (K. & N. Holmg.) (*vide* Snyder 1949, p. 290). In 1930, Light raised the subgenus *Grallatotermes* to generic rank and added a new species, *G. admirabilis*, to it from the Philippines. Kemner (1931) described *Grallatotermes weyeri* from Amboina. In 1936, Light & Wilson described a second species of *Grallatotermes*, namely *G. splendidus*, from the Philippines. Snyder (1949) catalogued the following five species under the genus *Grallatotermes*: *admirabilis* Light, *grallator* (Desneux), *grallatoriformis* (K. & N. Holmgren), *splendidus* Light & Wilson, and *weyeri* Kemner. In 1954, Harris added another new species, *Grallatotermes africanus*, from East Africa. Recently

Chatterjee & Thapa (1964) described a new species, *Grallatotermes niger*, from south India. On the basis of the structure of imago-worker mandibles and a constellation of other characters in soldiers and workers, it has been observed that in this complex more than one genus is involved. Unfortunately, no specimen of *G. splendidus* Light & Wilson and *G. weyeri* Kemner was available to me. The three new genera described here are based on the following species: *G. admirabilis* Light, *G. grallatoriformis* (K. & N. Holmg.), *G. niger* Chatterjee & Thapa, and *G. africanus* Harris.

This study shows that the genus *Grallatotermes* and its three allied new genera correctly belong to the *Paracornitermes* branch of the diphyletic tree of the subfamily Nasutitermitinae and not to the *Procornitermes* branch as mentioned by Ahmad (1950) and Sands (1957). It is worth mentioning that the imago-worker mandibles of *G. splendidus* Light & Wilson as illustrated by Ahmad (1950) indicate that *splendidus* correctly belongs to *Procornitermes* branch. This explains the erroneous conclusion of Ahmad.

Material and Method

This study is based primarily on the termite collection present at the Forest Research Institute, Dehra Dun. The species *G. africanus* was, however, obtained through the courtesy of Dr. W. V. Harris, British Museum (Nat. Hist.), London, to whom my grateful thanks are due. Details of the material studied have been given under the respective genus.

The specimens were studied in alcohol under a binocular dissecting microscope. Mandibles were, however, studied after dissection. The drawings were made with the help of a camera lucida.

Systematic descriptions

1. Genus **Grallatotermes** Holmgren

= subgenus *Grallatotermes* of *Eutermes*, Holmgren, 1912, *K. Sven. Vet. Akad. Handl.*, **48**, pp. 59-62, 65.

< subgenus *Grallatotermes* of *Eutermes*, Oshima, 1914, *Annot. Zool. Japonensis*, **8**, p. 581.

< subgenus *Grallatotermes* of *Eutermes*, Oshima, 1917, *Annot. Zool. Japonensis*, **9**, p. 198.

< subgenus *Grallatotermes* of *Eutermes*, K. & N. Holmgren, 1917, *Mem. Dept. Agr. India*, **5**, p. 163.

< subgenus *Grallatotermes* of *Eutermes*, Oshima, 1920, *Philippine J. Sci.*, **17**, p. 505.

< subgenus *Grallatotermes* of *Nasutitermes*, Snyder, 1925, *J. Washington Acad. Sci.*, **15**, pp. 439-440.

< genus *Grallatotermes*, Light, 1930, *Philippine J. Sci.*, **42**, pp. 16-17, 19, 40.

< genus *Grallatotermes*, Kemner, 1931, *Fysiogr. Sallsk. Handl.*, N. F. **42**, p. 46-50.
< genus *Grallatotermes*, Light & Wilson, 1936, *Philippine J. Sci.*, **60**, pp. 476-479.
< genus *Grallatotermes*, Snyder, 1949, *Smith. misc. Coll.*, **112**, p. 314.
< genus *Grallatotermes*, Harris, 1954, *Proc. roy. ent. Soc. Lond.* (B), **23**, pp. 135-137.
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Type species. *Grallatotermes grallator* (Desneux)(= *Termes grallator* Desneux, 1905).

Holmgren (1912) proposed the name *Grallatotermes* as a monotypic subgenus of the now obsolete genus *Eutermes* Hagen for *Termes grallator* Desneux which became the type species by monotype and absolute tautonymy (*vide* Article 30, International Rules of Nomenclature). Subsequently several species were included in it as mentioned earlier. In 1930, Light raised the subgenus to generic rank.

On the basis of this study the present author cannot refer any other species to the genus *Grallatotermes* as restricted by him.

Holmgren (1912) characterized the subgenus *Grallatotermes* as follows: 'Nase Kurz, sehr breit kegelförmig. Antennen 13-gliedrig, 3. Glied mehr als zweimal so lang wie 2., 4. Kurzer als 3., Kopf hinter den Antennen nicht hantelförmig eingeschnürt'. [" Nasus short, rather broadly conical. Antennae 13-segmented, segment 3 more than twice as long as 2, 4 shorter than 3. Head behind the antennae is not constricted."] As the above description is meagre and as no other description is available, the genus has now been redefined.

Material

One vial containing one soldier and one worker collected from New Guinea by Dr. Burger on 20-vii-1912. Det. by N. Holmgren a '*Eutermes* (*Grallatotermes*) *grallator*'.

Description

1. IMAGO. Not known so far.

2. SOLDIER (Fig. 1). Head-capsule and antennae somewhat dark reddish brown, thoracic tergites brown, abdominal tergites pale brown with darker margins.

Head pear-shaped from above, with short hairs, length to base of rostrum a little more than maximum width, with a shallow constriction behind base of antennae. Rostrum markedly conical with broad base, apex slightly up-lifted in profile. Antennae with 13 segments, 3rd segment longer than 2nd. Mandibles vestigial, each with a short mandibular blade vestige ('points' and 'lateral spinous

process'), left mandible with a distinct tooth on apex of blade vestige, right mandible without a tooth.

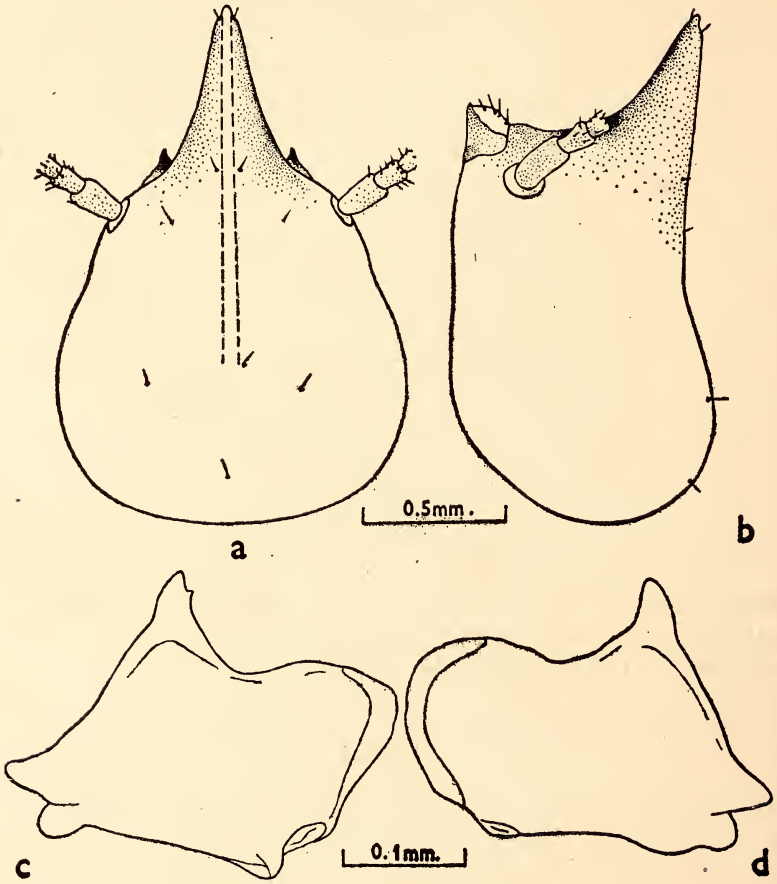

Fig. 1. *Grallatotermes grallator* (Desneux). Soldier caste.
a. Head, dorsal view; *b*. Head, side view; *c*, *d*. Left and right mandible respectively

Pronotum saddle-shaped. Legs long in relation to body-length, hind femora reaching beyond tip of abdomen, tibial spurs 2:2:2.

Abdomen with no hairs on tergites, with many short and long hairs on sternites.

3. WORKER (Fig. 2). Head brown, antennae, labrum, and pronotum paler than head, postclypeus similar to frons in colour.

Head suboval, nearly as broad as long, epicranial suture distinct, fontanelle plate suboval, almost medially situated. Antennae with 14 segments. Postclypeus weakly inflated, length about one-third of maximum width. Anteclypeus subtrapezoid. *Mandibles*: Left mandible

with an apical and two marginal teeth, apical distinctly shorter than first marginal (distance 0·02 mm.), left mandibular index (linear distance between the tips of apical and first marginal tooth divided by the linear distance between the pointed tips of the first marginal and second marginal) 0·25, angle between apical and first marginal

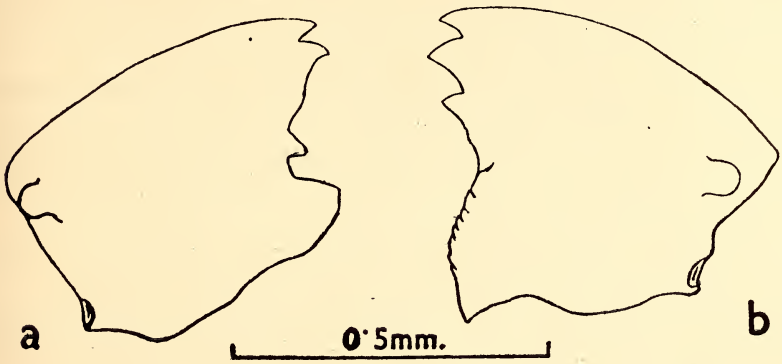

Fig. 2. *Grallatotermes grallator* (Desneux). Worker caste.
a, b. Left and right mandible respectively

about 45°, first marginal large, its posterior edge undulating and not straight, with a rounded notch in front of second marginal (3rd marginal of other) which is small and separated from the molar area by a deep concavity. Right mandible also with an apical and two marginal teeth; apical shorter than first marginal, right mandibular index 0·83; first marginal large, its anterior edge somewhat convex, posterior edge weakly concave; second marginal tooth smaller than first marginal, its posterior edge almost five times longer than its anterior edge; molar area large, almost equal to rest of mandibles (index 0·95), surface convex and serrated.

Comparison

The structure of imago-worker mandibles clearly shows that the genus *Grallatotermes* Holmgren belongs to the *Paracornitermes* branch of the subfamily Nasutitermitinae and not *Procornitermes* branch as suggested by Ahmad (1950) and Sands (1957). The imago-worker mandibles of the *Paracornitermes* branch are characterized by the posterior edge of the first marginal tooth of the left mandible being sinuate and by the presence of a distinct notch in front of the first marginal. On the other hand, in the *Procornitermes* branch the posterior edge of the first marginal tooth of the left mandible of imago-worker is straight and there is no notch in front of the first marginal. Ahmad's erroneous conclusion is apparently due to the

fact that he examined the imago-worker mandibles of *G. splendidus* which is very different from the type species in the structure of imago-worker mandibles.

The genus *Grallatotermes* possesses several primitive characters in both soldier and worker castes. They are as follows:

Soldier: Mandibular blade vestige of left mandible has a small but distinct marginal tooth at the apex; rostrum is short and markedly conical; head-capsule is short and somewhat pragmatic.

Worker: Postclypeus is weakly inflated, its length is about one-third of the maximum width; mandibles are more or less generalised, without enlargement of apical tooth, and with distinct undulation on the posterior edge of 1st marginal; the left mandibular index is very low (0·25).

The closest relative of *Grallatotermes* appears to be the Australian genus *Occasitermes* as is evidenced by the size of the blade vestige of the soldier mandibles, and the general structural pattern of imago-worker mandibles. But *Occasitermes* does not possess any marginal tooth on the mandibular blade vestige in the soldier caste, and the left imago-worker mandible has a higher tooth index (0·50). Among the nasute soldiers, the genus *Grallatotermes* is unique in having an extremely short and markedly conical rostrum accompanied by rather long antennae. It appears that the genus *Grallatotermes* is a primitive genus which has become endemic in New Guinea after its origin from a primitive extinct ancestor.

2. Genus **Philippinitermes** gen. nov.

= Genus *Grallatotermes*, Light, 1930, *Philippine J. Sci.*, **42** (1), pp. 40-41.
< Genus *Grallatotermes*, Light & Wilson, 1936, *Philippine J. Sci.*, **60** (4), p.476.
< Genus *Grallatotermes*, Snyder, *Smith. misc. Coll.*, **112**, p.314.

Type species. *Philippinitermes admirabilis* (Light), new combination (=*Grallatotermes admirabilis* Light 1930).

The single species *P. admirabilis* (Light) now constitutes this new monotypic genus. The species has been adequately described by Light (1930). The generic diagnoses and comparison are given below.

Material

One vial containing 1 imago, 16 soldiers, and 16 workers in spirit, all Cotypes, collected at Negros, the Philippines (2000 ft.) by S.F. Light (No. 571) on 11-v-1921, det. S. F. Light as *Grallatotermes admirabilis*.

Description

1. IMAGO. Head black, postclypeus paler than frons; wings somewhat opaque, pale brown; pilose with numerous short hairs.

Head suboval ; longer than wide (without eyes) ; posterior margin semi-circular behind. Eyes large and projecting. Ocelli large, elongated, and very close to eyes, from which they are separated by less than half their short diameter. Fontanelle plate conspicuous, white, translucent, triangular, and medially situated. Postclypeus moderately swollen, length almost one-fourth of maximum width. Antennae with 15 segments, segment 3 either as long as 2 or slightly shorter. Mandibles: as in worker.

Pronotum flat, with a very weak notch in the centre. Wings covered with minute stellate papillae, with numerous short hairs distally.

2. SOLDIER (Fig. 3). Head black, thorax and legs bright yellow, abdominal terga black-brown.

Head broadly pear-shaped ; dorsal profile with a well-marked concavity near the middle of head, much elevated at vertex, moderately projecting behind, with a weak constriction behind the base of antennae. Rostrum short, conical, with a broad base, moderately up-lifted in profile. Antennae long, considerably longer than head, with 13 segments, segment 3 almost twice as long as 2. Mandibles with long non-dentate, thin blade vestige without any sensory chitinous patch.

Pronotum saddle-shaped, with a median groove on the surface, no notch on margins. Legs long, hind femur distinctly shorter than abdomen.

Abdominal tergites with a few short hairs at posterior edge.

3. WORKER (Fig. 4). Head and abdominal tergites black.

Head broadly oval, epicranial suture prominent, two shining translucent, white oval bodies, one on either side, situated on the arms of epicranial suture. Fontanelle plate large, triangular, white. Antennae with 14 segments, segment 3 as long as or a little longer than 2, 4 shortest. Postclypeus swollen, length about a third of maximum width. *Mandibles* : Left mandible with its outer margin having a broad concavity at the distal third ; with an apical and two marginal teeth, apical as long as first marginal, left mandibular tooth index 0·33, angle between the apical and first marginal *c.* 45°, first marginal long, its posterior edge undulating posteriorly, with a rounded notch in front of the 2nd marginal which is separated from the molar area by a concavity. Right mandible also with an apical and 2 marginal teeth ; apical only a little shorter than first marginal, apical tooth distance 0·025 mm. Right mandibular tooth index 0·83, first marginal almost triangular, 2nd marginal low, its posterior edge less than 5 times the anterior edge, molar

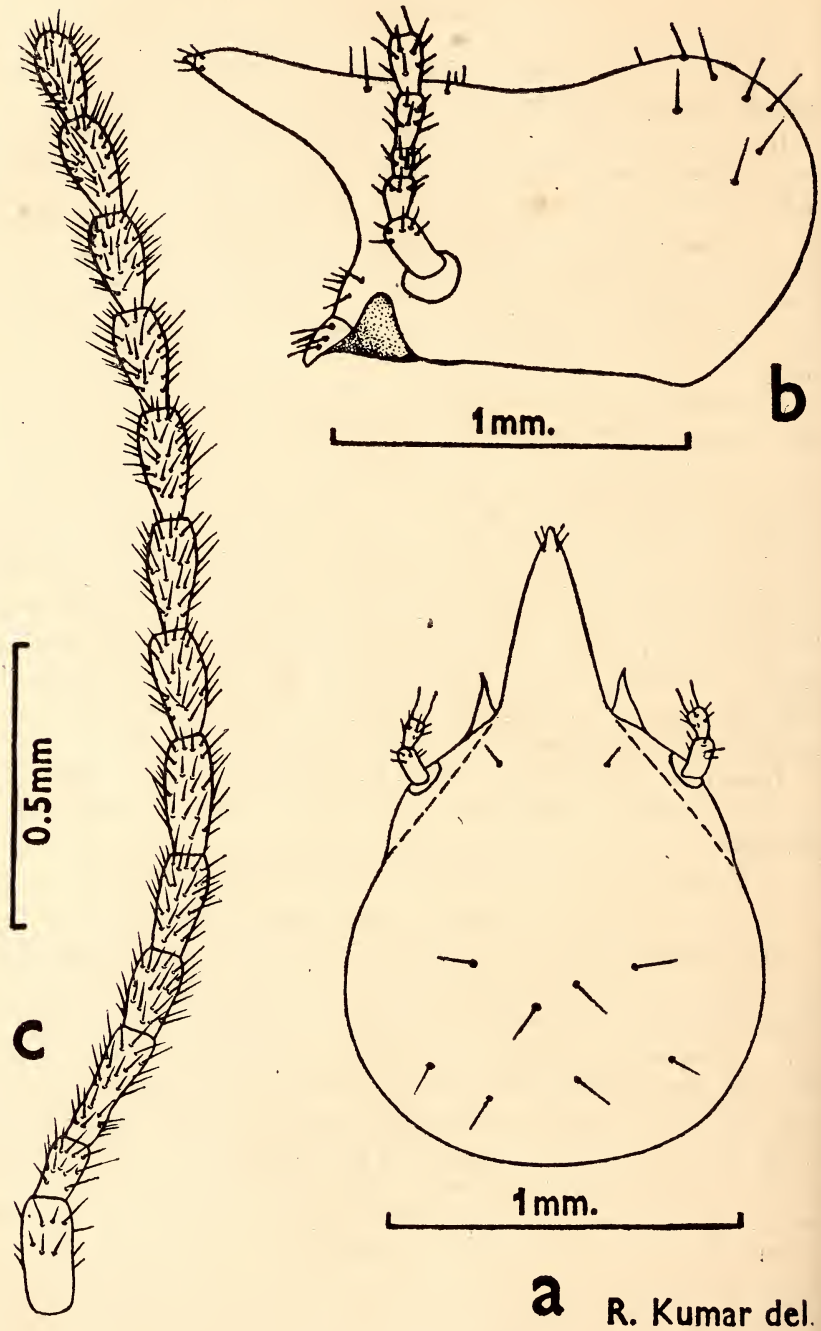

Fig. 3. *Philippinitermes admirabilis* (Light). Soldier caste.

a. Head, dorsal view ; *b*. Head, side view ; *c*. Right antenna

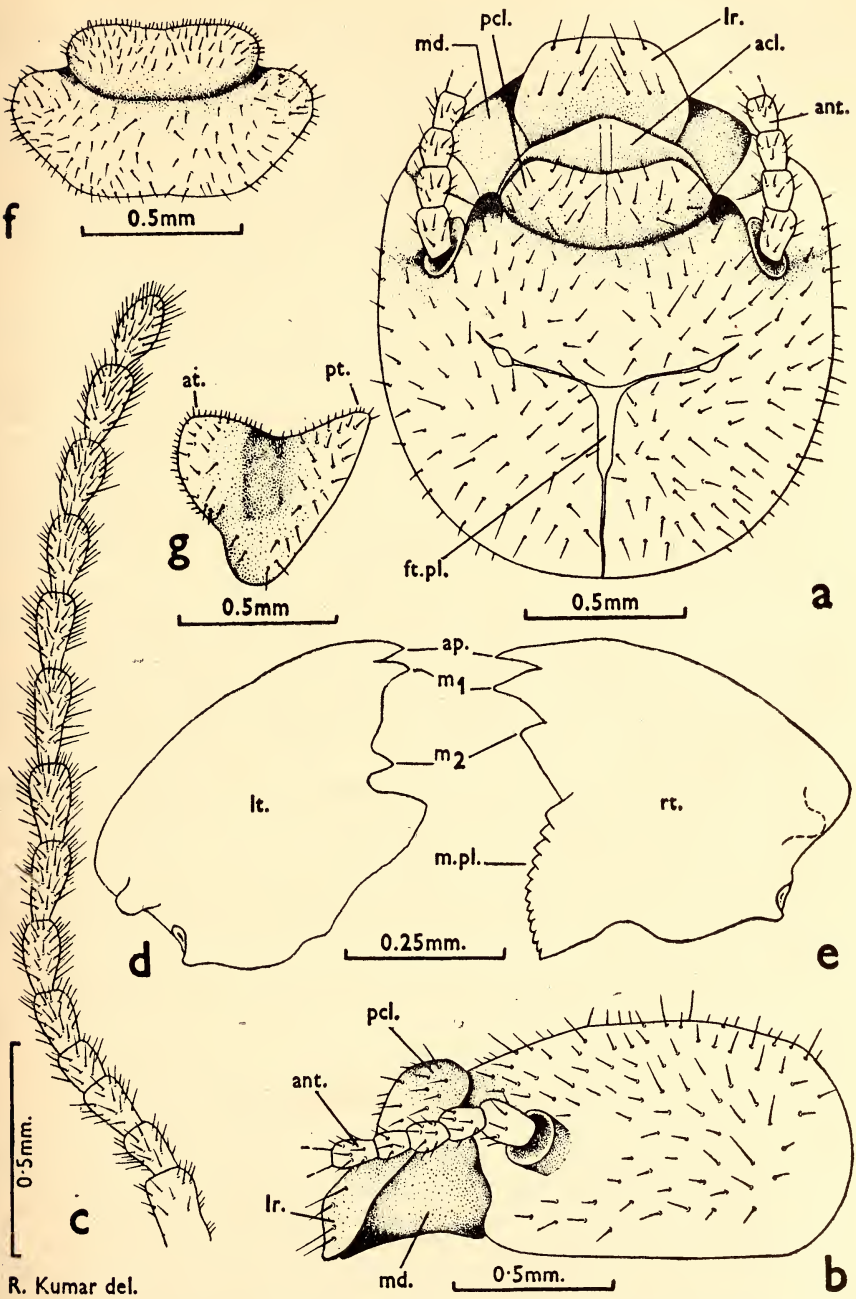

Fig. 4. *Philippinitermes admirabilis* (Light). Worker caste.

a. Head, dorsal view ; *b.* Head, side view; *c.* Left antenna; *d, e.* Left and right mandible respectively ; *f.* Pronotum, dorsal view ; *g.* Pronotum, side view

acl., anteclypeus ; *ant.*, antenna ; *ap.*, apical tooth : *at.*, anterior ; *ft. pl.*, fontanelle plate ; *lr.*, labrum ; *lt.*, left ; *md.*, mandible ; m_1-m_2, first and second marginal tooth respectively; *m. pl.*, molar plate ; *pcl.*, postclypeus ; *pt.*, posterior

area almost equal to rest of mandibles, highly rugose. Pronotum strongly saddle-shaped, densely pilose.

Comparison

Philippinitermes admirabilis (Light) differs from *Grallatotermes grallator* (Desneux) as follows:

Soldier. Blade vestige of mandibles are much longer than in *grallator*, non-dentate and thin. Antennae of *Philippinitermes* are not unusually long. Hind femur distinctly shorter than abdomen in *admirabilis.*

Worker. In *P. admirabilis*, apical in left mandible as long as first marginal but distinctly shorter in *grallator*, left mandibular index is 0·33 in *admirabilis* as against 0·25 in *grallator*, posterior edge of first marginal is comparatively less elevated than in *grallator.* In *admirabilis*, posterior edge of 2nd marginal of right mandible is straight (not concave) and is much less than 5 times the anterior edge.

From *Afrograllatotermes africanus*, *Philippinitermes admirabilis* can be distinguished on the basis of the following important characters:

(i) Length of postclypeus in imago caste of *admirabilis* is one-fourth of maximum width whereas it is only a little smaller than half the maximum width in *africanus.*

(ii) Unlike *africanus*, the soldier mandibles in *admirabilis* have a much longer blade vestige and are devoid of any thin chitinous patch at the apices of the molar area.

(iii) The notch in front of the 2nd marginal in the imago-worker mandibles is rounded and broad in *admirabilis*, while it is very sharp and acute in *africanus.*

For comparison with *Indograllatotermes*, see under that genus.

3. Genus **Indograllatotermes** gen. nov.

= subgenus *Grallatotermes* of *Eutermes*, K. & N. Holmgren, 1917, *Mem. Dept. Agr. India*, **5**, p. 163.
≺ genus *Grallatotermes*, Snyder, 1949, *Smith. misc. Coll.*, **112**, p. 314.
≺ genus *Grallatotermes*, Ahmad, 1958, *Biologia*, **4**, p. 127.
= genus *Grallatotermes*, Chatterjee & Thapa, 1963, *Indian Forester*, **90**, pp. 210-214.

Type species. *Indograllatotermes grallatoriformis* (K. & N. Holmgren), new combination [= *Eutermes* (*Grallatotermes*) *grallatoriformis* K. & N. Holmgren 1917].

Other species: *Indograllatotermes niger* (Chatterjee & Thapa), new combination (= *Grallatotermes niger* Chatterjee & Thapa).

Material

(i) One vial containing one soldier and one worker, in spirit, collected at South Kanara, south India, by T. B. Fletcher (No. AAB), det. N. Holmgren as '*Eutermes* (*Grallatotermes*) *grallatoriformis*'.

(ii) One vial containing two workers, in spirit, collected at Jell-Kab, Anamalais, south India, by V.S. Iyer on January 1914, det. N. Holmgren as '*Eutermes* (*Grallatotermes*) *grallatoriformis*.'

(iii) One vial containing several soldiers and workers, all from Holotype colony, in spirit, collected at Mt. Stuart Block, Tunacadur Range, Top Slip, Madras, ex *Alstonia scholaris* green standing tree, by R. M. Misra (No. 1455) on 20-ix-1962, det. P. N. Chatterjee & R. S. Thapa as '*Grallatotermes niger*'.

Description

1. IMAGO. Not known so far.

2. SOLDIER (Fig. 5). Head brown to dark brown, body yellowish.

Head-capsule pear-shaped from above, with a few short hairs, with a shallow constriction at base of antennae. Rostrum cone-shaped with broad base, apex slightly up-lifted in profile. Antennae with 13 segments, 3rd two-and-a-half times longer than 2nd. Mandibles vestigial, each with a short non-dentate blade vestige, without any hyaline cuticular patch on the molar area.

Pronotum saddle-shaped. Legs long, hairy, hind femur reaching beyond the tip of abdomen.

Abdominal tergites with a few short hairs.

3. WORKER (Fig. 6). Head brown to black, abdominal tergites pale brown to smoky brown.

Head broadly oval, epicranial suture prominent, two shining translucent oval bodies, one on either side, situated on the arms of epicranial suture. Fontanelle plate large, triangular. Antennae with 12 to 14 segments. Postclypeus swollen, length distinctly less than half the width. Labrum dome-shaped. *Mandibles*: Left mandible with its outer margin uniformly convex, with an apical and two marginal teeth, apical distinctly shorter than first marginal (distance 0·025 to 0·038 mm.), left mandibular index 0·33; first marginal prominent, its posterior margin undulating, with a rounded notch in front of second marginal. Right mandible also with an apical and two marginal teeth, apical only a little shorter than first marginal, distances between apical and first marginal and first marginal and second marginal equal (index 1·0);

first marginal almost triangular; second marginal shorter than first marginal, its posterior edge nearly twice the anterior edge; molar area large, equal in length to rest of mandible (index 1·0).

Pronotum strongly saddle-shaped, densely pilose.

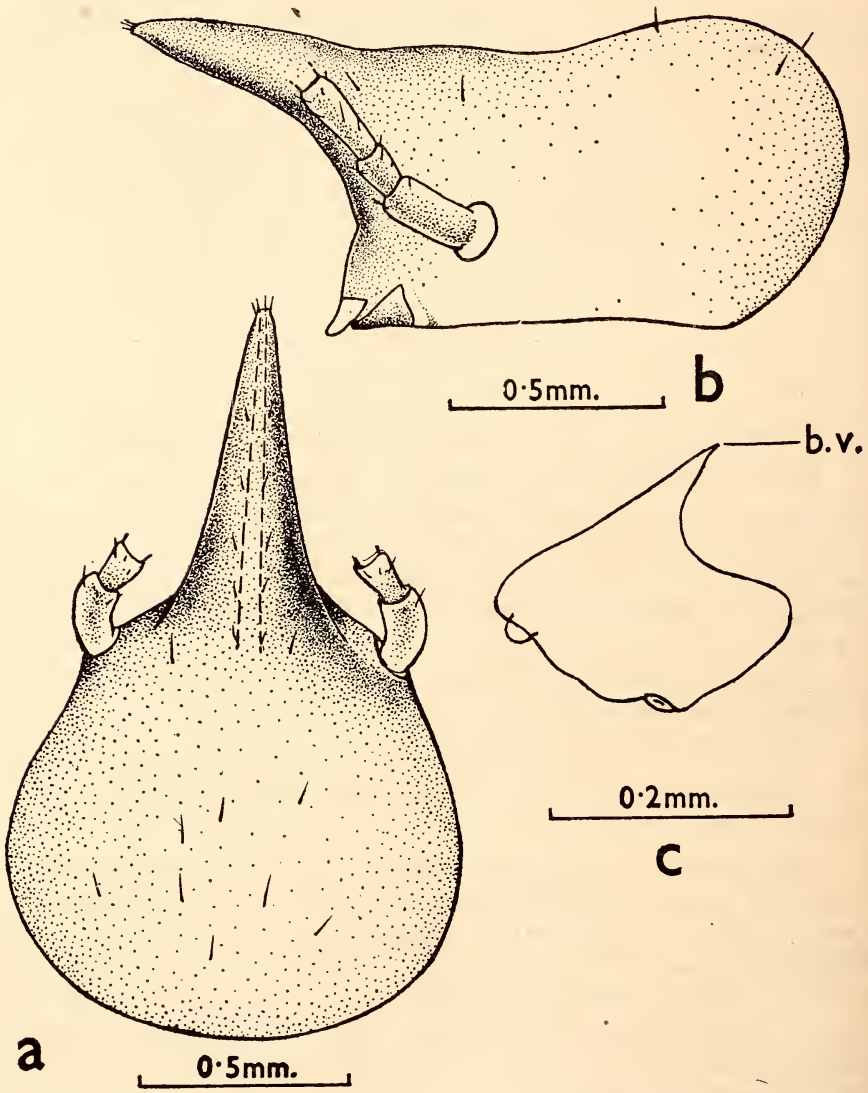

Fig. 5. *Indograllatotermes grallatoriformis* (K. & N. Holmgren). Soldier caste.

a. Head, dorsal view; *b*. Head, side view; *c*. Left mandible
b. v., blade vestige

Comparison

Indograllatotermes gen. nov. differs from *Grallatotermes* in having non-dentate mandibular blade vestige in the soldier caste. With regard to imago-worker mandibles, *Indograllatotermes* differs from *Grallatotermes* as follows: Left mandibular index 0·33 as against 0·25 in *Grallatotermes*, right mandibular index 1·0 as against 0·83 in *Grallatotermes*, molar area of right mandible equal in length to rest of mandible (index 1·0) (shorter in *Grallatotermes*, index 0·95); posterior margin of second marginal tooth of right mandible almost twice the anterior margin (five times in *Grallatotermes*).

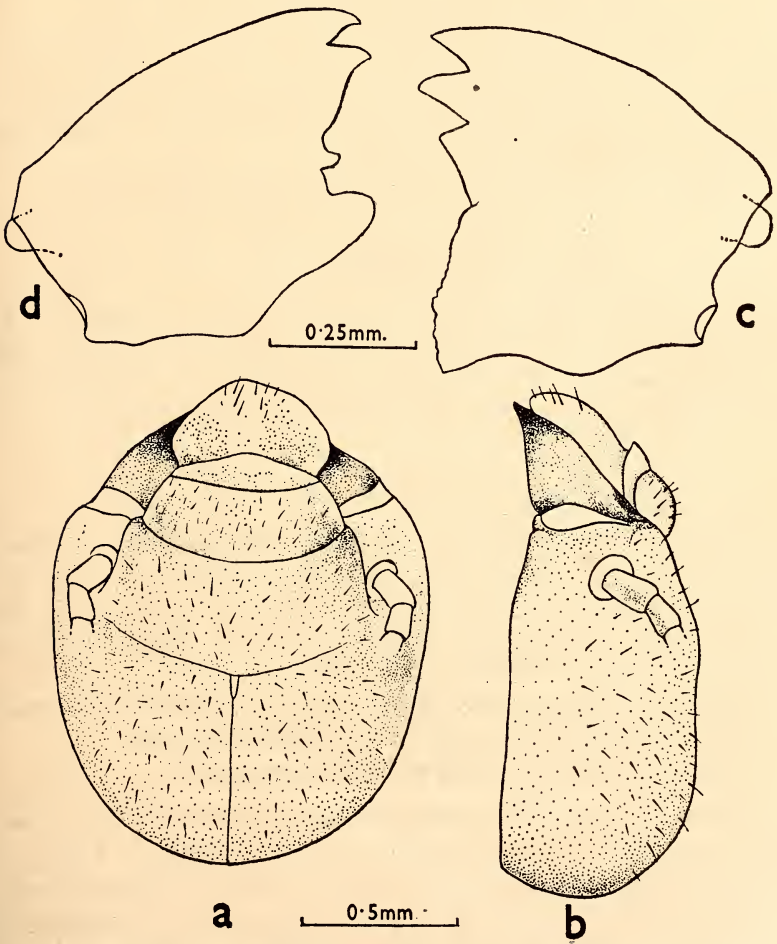

Fig. 6. *Indograllatotermes grallatoriformis* (K. & N. Holmgren). Worker caste.

a. Head, dorsal view; *b*. Head, side view; *c*., *d*. Right and left mandible respectively

From *Philippinitermes*, *Indograllatotermes* differs as follows:

Soldier. Mandibular blade vestige shorter than in *Philippinitermes*, hind femora reaching beyond the tip of abdomen (falling short in *Philippinitermes*).

Imago-worker. Left mandible with its apical tooth closer to first marginal in *Philippinitermes* than in *Indograllatotermes*; right mandibular index 1·0 in *Indograllatotermes* as against 0·83 in *Philippinitermes*; and posterior margin of second marginal of right mandible almost twice the anterior margin in *Indograllatotermes* (five times in *Philippinitermes*).

4. Genus **Afrograllatotermes** gen. nov.

= genus *Grallatotermes*, Harris, 1954, *Proc. roy. Ent. Soc. Lond.* (B), **23**, pp. 135-137.

Type species. *Afrograllatotermes africanus* (Harris), new combination (=*Grallatotermes africanus* Harris, 1954).

The genus is at present represented only by the type species.

Material

One vial with 1 imago, 5 soldiers, and 4 workers, Paratypes and Paramorphotypes from the type colony, collected from 'arboreal nest in wood land' at Ngameni, NE. Tanganyika, by P. B. Kemp on 21-xii-1950, det. W. V. Harris as '*Grallatotermes africanus*'.

Description

1. Imago. Head-capsule dark brown, postclypeus similar to head in colour. Head-width across eyes more than head-length up to hind margin of postclypeus; frontal area depressed; eyes large; ocelli large, oval, almost touching the eyes; postclypeus with its length a little lesser than half its width; mandibles as in worker.

Pronotum as wide as head across the eyes; wings densely covered with minute stellate papillae and with numerous short hairs.

Abdomen uniformly covered with short pale hairs.

2. Soldier (Fig. 7). Head broadly pear-shaped from above, dorsal profile with a well-marked concavity near the middle of head; with a weak constriction behind the base of antennae; rostrum weakly cone-shaped, slightly up-lifted in profile; antennae with 14 segments, 3rd segment only a little longer than 2nd; mandibles vestigial, each with a short non-dentate blade vestige; with a pale, hyaline cuticular patch at the distal part of molar area of each mandible.

Pronotum saddle-shaped.

3. WORKER (Fig. 8). Head broadly oval, epicranial suture prominent. Fontanelle plate triangular, white, and almost medially situated. Antennae with 15 segments, segment 3 as long as 2. Postclypeus swollen, length a little shorter than half its width. *Mandibles:* Left mandible with an apical and two marginal teeth, apical equal in length to and not shorter than first marginal, left mandibular index 0·35, angle between apical and first marginal *c.* 45°, first marginal large, its posterior margin weakly undulating posteriorly, with a sharp notch in front of second

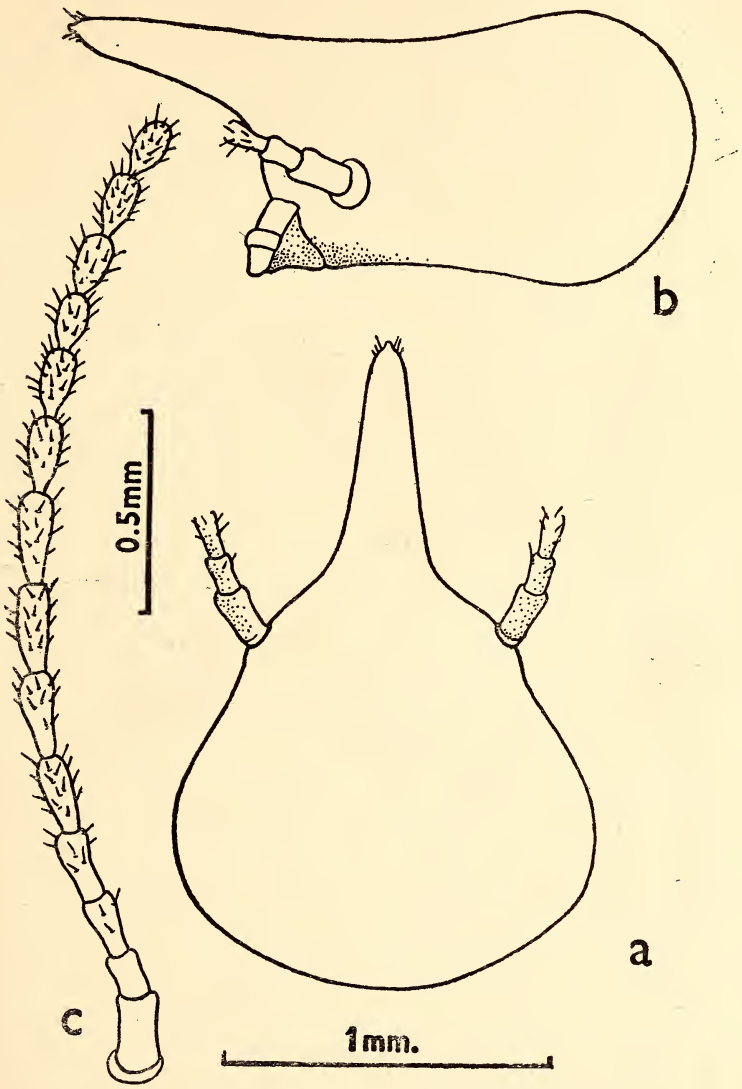

Fig. 7. *Afrograllatotermes africanus* (Harris). Soldier caste.
a. Head, dorsal view ; *b.* Head, side view ; *c.* Right antenna

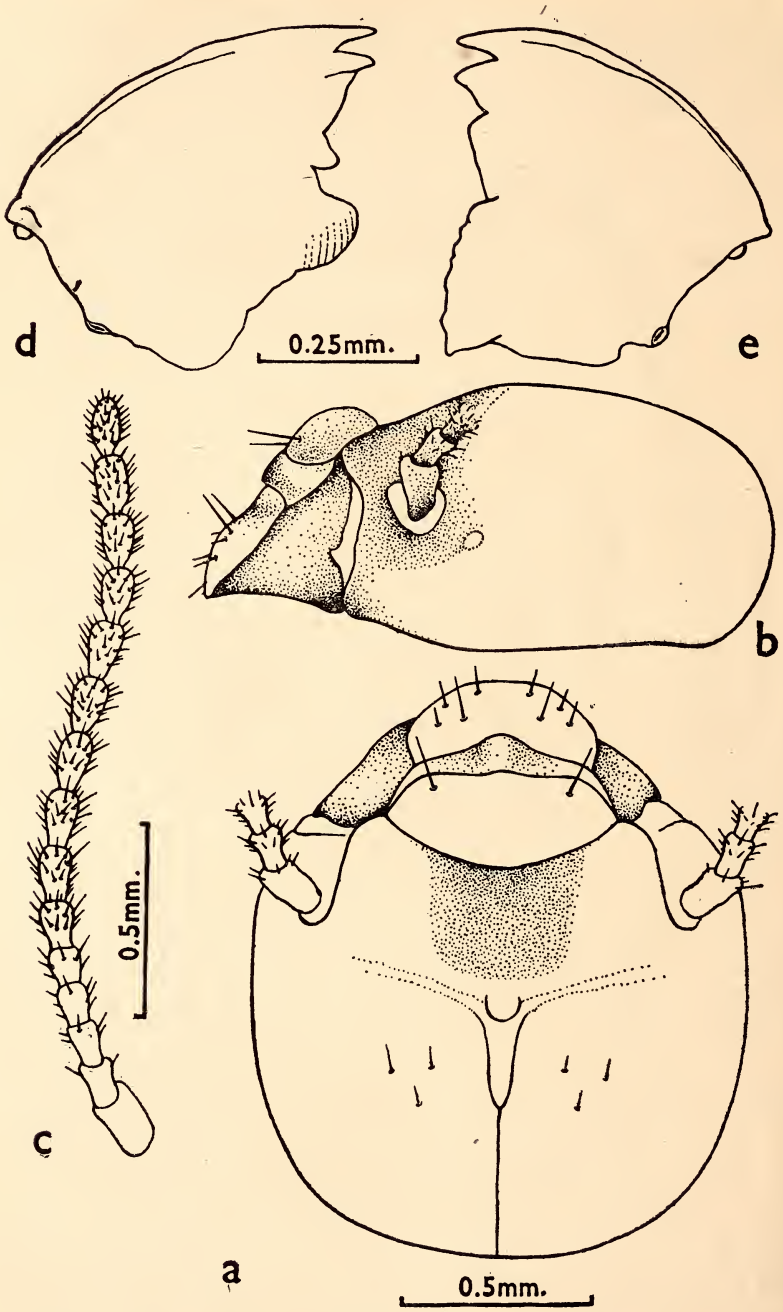

Fig. 8. *Afrograllatotermes africanus* (Harris). Worker caste.

a, Head, dorsal view ; *b*. Head, side view ; *c*. Right antenna ; *d*, *e*. Left and right mandible respectively

marginal which is small but prominent. Right mandible also with an apical and two marginal teeth, apical tooth as long as first marginal; right mandibular index 0·81; first marginal large, anterior margin somewhat straight, posterior margin weakly undulating; second marginal short, its posterior edge almost thrice of anterior edge, molar area large, equal in length to rest of mandibles (index 1·0), greatly serrated.

Comparison

The genus *Afrograllatotermes* is unique among the genera of *Grallatotermes* complex in having a pale hyaline cuticular patch at the distal part of the molar area of mandibles of the soldier caste. It shares this character with two highly evolved genera, viz. *Trinervitermes* in *Procornitermes* branch and *Convexitermes* in *Paracornitermes* branch. It is not possible to explain the exact significance of this structure but it certainly indicates a phylogenetic advance. It is, therefore, certain that the genus *Afrograllatotermes* is the highest evolved in the *Grallatotermes* line of evolution.

From the genus *Grallatotermes*, *Afrograllatotermes* differs as follows:

Soldier. Shape of rostrum is different in these two genera, rostrum in *Afrograllatotermes* is much less conical than in *Grallatotermes*; mandibular blade vestige without any tooth in *Afrograllatotermes* (a tooth is present on the left mandible in *Grallatotermes*), and the pale hyaline cuticular patch is totally absent in *Grallatotermes*.

Worker. Left mandible with the apical tooth equal in length to the first marginal tooth and with a sharp notch in front of the second marginal tooth in *Afrograllatotermes* (apical shorter than first marginal and with a shallow notch in front of second marginal tooth in *Grallatotermes*). Right mandible with the posterior edge of the second marginal teeth almost thrice the length of anterior margin in *Afrograllatotermes* (five times in *Grallatotermes*).

Synopsis

The genus *Grallatotermes* Holmgren has been redefined. A detailed description of the genus and its comparison with related genera have been given. It is now certain that *Grallatotermes* is a monotypical genus which is endemic in New Guinea. Three new genera related to the genus *Grallatotermes* have been described on the basis of the species which were earlier included in the genus *Grallatotermes* Holmgren. The three new genera are: *Philippinitermes*, *Indograllatotermes*, and *Afrograllatotermes*.

Inter-relationships of these genera have also been discussed. It is pointed out that all these genera correctly belong to *Paracornitermes* branch of the subfamily Nasutitermitinae and not to *Procornitermes* branch as mentioned by earlier authors.

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Reviews

1. THE MAMMALS OF ARABIA. Volume I. Introduction, Insectivora, Chiroptera, Primates. By David L. Harrison. pp. xx+192 (30·8 × 21·8 cm.). With 60 plates and 47 text-figures. London, 1964. Ernest Benn Limited. Price 7 guineas net.

This volume deals with 53 of the 142 mammals found in the Arabian Peninsula, which for the purpose of this work includes Iraq, Syria, and Sinai. The introduction, dealing with the country and its climate, mammalian fauna and its geography, special adaptations like hairy feet, desert coloration, feeding and drinking habits, makes interesting reading.

The rest of the work deals with the different species one by one and covers 4 hedgehogs, 6 shrews, 42 bats, and 1 baboon. Though such field notes as are available are included, most of it is of a technical nature and of interest mainly to the systematist. From this point of view, however, it is very thorough and covers most of the known ground together with an appreciable amount of research carried out by the author. It is interesting to note that several species were described in the *Journal of the Bombay Natural History Society*, recalling the fact that during the First World War members of the Expeditionary Forces in that area collected many items of natural history interest which were routed to specialists through the Society.

The book is photo-reproduced and printed offset, resulting in some of the photographs being extremely dark. The text is printed in two columns with the attendant disadvantages. The tables are not very well separated from the text and the names of the species dealt with do not stand out as they should.

Incidentally, R. W. Hayman of the British Museum in his Foreword draws attention to the fact that ' one of the peculiarly distinctive features of the zoological scene in Britain, both today and in the past, is the frequent appearance of the dedicated amateur (using that word in its best sense to indicate one who is whole-heartedly devoted to his chosen subject but earns his living in other fields). From the days of Gilbert White onwards there has never been any lack in this country of keen and energetic persons willing and able to devote all their leisure time to the pursuit of the natural sciences, to the great and lasting gain thereof.' The author has a name well known in natural history circles, both his father and brother having achieved considerable prominence in the ornithological world.

As in India and other 'developing' countries, all wild life is threatened with extinction, the lion and the onager having already gone.

This is an indispensable work of reference for any study of the mammals of the Middle East and we await the second volume with interest.

H. A.

2. ISRAEL NATURE NOTES. By Paula Arnold. pp. 148 (24·5 × 17 cm.). With many illustrations. Haifa, Israel, 1965. Shalit Publishers Ltd.

These charming little sketches were originally written for the Nature column of *The Jerusalem Post*. The pieces which have been brought together in this book are arranged by months, so that plants, animals, and birds are described at the time of year when they are seen. Mrs. Arnold has a very pleasant style, and writes mainly from her own experience. Spring comes early to Israel, and in January the hills are ablaze with scarlet anemones, cyclamen, hyacinth, and crocus. By July these have been replaced by tough flowering plants and thistles. Against this background a great variety of animal life flourishes. Sunbirds, bulbuls, mongooses, and bee-eaters are found in Israel. The species are different from the species we have in India, but their ways are very similar. There was a time when sunbirds were rare in Israel, but since irrigation has transformed the Coastal Plain they have rapidly extended their range, and from 1948 have stayed in winter thus becoming residents.

There is a great deal of interesting information here. For example, baby hedgehogs are born snow-white, and with soft hair (fortunately for mother hedgehogs) which falls and is replaced by prickles. There are, also, some inaccuracies—the hyrax is the closest living relative of the elephant and not of the rhinoceros, and cockroaches do not have grubs but emerge from their egg-cases as small cockroach-shaped nymphs.

The amusing illustrations by Meir Ronnen add to the attractiveness of the book.

R. R.

3. ECOLOGY OF PLANT GALLS. By M. S. Mani. Monographiae Biologicae, Volume XII. pp. xii+434 (15×24 cm.), 164 figs. and 9 plates. The Hague, 1964. Dr. W. Junk, Publishers. Price Cloth: Dutch guilders 40; U.S. $ 11.25

The close interdependence between plants and animals is an extremely interesting biological phenomenon and its importance in the cross pollination of plants and the commercial utilization of honey are features of significant value to plant, animal, and human life. An equally important biological aspect related to this is the production of plant galls of various shapes. These galls are pathologically developed cells, tissues, or organs which arise as a result of hypertrophied growth due to the influence or activity of parasitic organisms like bacteria, fungi, nematodes, and insects. Further, they serve as unique examples of interaction and adaptation between the plant and the gall-inducing organism. Though galls have been observed and known from quite a long time, there is no comprehensive work so far covering all their aspects. From this point, it is most opportune that a thorough account on galls has been ably presented in this treatise by Dr. M. S. Mani, who is well known for his valuable and extensive collections of galls from the Himalayas and other parts of India and for his authoritative knowledge on their structure and ecology.

In the first chapter, an account is given of the current ideas of galls, followed by gall-bearing and gall-inducing plants in the next. The third chapter deals with the general morphology and structure of galls. The developmental structure of the galls on different parts of plants are treated in the next five chapters. In chapters nine, ten, and eleven, all aspects of the ecology of zoocecidia are described in a very interesting manner. Features of galls caused by fungi, bacteria, and viruses are dealt with in chapters twelve and thirteen. In the penultimate chapter, dealing with the development and growth of galls, problems like etiology, histology, general characters of cecidogenesis, and the broad principles of morphogenesis of galls are pointed out in all their aspects. The last chapter is a particularly able and carefully written review on plant galls and cancerous growths in animals. The author concludes in the last paragraph of this chapter that any cell of any tissue of an animal can turn neoplastic. Both in plant and animal neoplasia, the continuing cause of malignancy is not in the carcinogenic factors, but in the cell itself. In a way, plant tumor cells are considered as cancerous in the wide sense of the term. The bibliography cited at the end of the book is extensive and well selected and consists of 1300 references, thus providing ample material for further study.

There are 164 text-figures, most of which are original; the sources for the others are properly mentioned in each case. The black-and-white photographs printed on 9 plates are excellent and are so vivid that a person interested in the study of galls can easily identify them without any difficulty.

The author should be warmly congratulated on writing this thought-provoking book on the ecology of plant galls. The printing is neat and

the get-up excellent. A valuable and well written work of this nature should stimulate an interest in students of biology and nature lovers for more intensive studies on these galls. A book of this nature must find a place in the libraries of all scientific institutions.

K. SUBRAMANYAM

4. SEASHORES. By S. M. Marshall and A. P. Orr. pp. 58 (21×17 cm.). Illustrated in colour and line drawings by Glenn Steward. Edinburgh/London, 1965. Oliver & Boyd. The Open Air Library 1. Price 10*s.* 6*d.* net.

SEASHORES which, with OUR FRIENDS THE SPIDERS published somewhat earlier, begins a new series of nature study books for young people gives the series a good start. In the few pages available to them the authors and the artist manage between them to cover a wide area, telling their readers in simple terms enough about numerous forms of animal and vegetable life to make them want to find out more for themselves, which after all is the essence of good teaching. The book is written for English readers but, as most of the forms dealt with are to be found on Indian shores, the book will make a good present for our young people.

The reviewer hopes that in the next edition a minor inaccuracy at page 18 will be corrected: the list, in the first paragraph, of animals with backbones is not wide enough to include all the animals dealt with in Chapter 10.

E. V.

5. CONTRIBUTIONS TO THE INSECT FAUNA OF FORMOSA I. Results of the Lepidopterological Society of Japan Expedition to Formosa in 1961. Special Bulletin of the Lepidopterological Society of Japan No. 1. pp. v + 252 (26 × 18 cm.). With 9 monochrome plates and many line drawings. Osaka, Japan, 1965. Lepidopterological Society of Japan. Price $ 7.

In 1961 the Lepidopterological Society of Japan sent a 7-man expedition to Taiwan for a month. Besides butterflies and moths the expedition collected Coleoptera, Hymenoptera, Hemiptera, Diptera, Odonata, Mecoptera, Psocoptera, and Thysanoptera. This special volume brings together the reports of the various specialists. Apart from a ceratopogonoid midge (*Forcipomyia latipes*) recorded for the first time from the island, on a species of dragonfly not previously on its

host-list, no midges and mosquitoes were collected ; these groups are being studied as part of a NAMRU project on Taiwan.

There is a paper on the chromosome numbers of Formosan butterflies, and notes on abundance and host-plants have been made for several species. There are also some excellent photographs of various stages of some species. The other papers are taxonomic. The Society is to be congratulated on an impressive number of new records and new species. Six specimens of the beetle *Acontosceles hydroporoides* were collected, a species which has not been seen since the original description from Kumaon in 1924. This is surely a comment on our lack of knowledge of this and other groups. One looks forward to seeing the results of the other expeditions planned to follow this one.

I would like to see many more photographs and to know how the biology of the various lepidopteran species compares with that in other parts of their range.

R. R.

6. THE FLORA OF DELHI. By J. K. Maheshwari. pp viii+447 (24×16 cm.). New Delhi, 1963. Council of Scientific & Industrial Research. Price Rs 28/- or 56*s*. or $ 8·00.

This is undoubtedly a welcome contribution to our knowledge of the flora of a very important region—the capital of India. Its value is enhanced by the comprehensive way in which it is made useful for laymen and students of Botany.

This volume contains information on the main geographical and geological features, a short history of previous published work, and the method of study by the author. He has also given, for the benefit of students, his observations on the vegetation of Delhi, including the seasonal occurrence of plant communities and the vegetation of various habitats in the neighbourhood of Delhi. Plants under cultivation are enumerated, and also the weeds. A few pages are devoted to the listing of introduced plants.

Three tables, containing the number and percentage of families, genera, and species; a comparison of the dominant families in India, Rajputana, the Gangetic Plain, and Delhi State; and the areas of origin of plants of Delhi, are included in a 'Statistical Synopsis of the Indigenous Flora'.

Great pains have been taken by the author to bring the nomenclature in line with the International Code. Very useful keys are provided for the families, genera, and species. The notes and references are very carefully made and will be found very valuable by those who use this work.

The volume contains information about 942 species of flowering plants under 549 genera and 120 families. Of these, 411 species are found exclusively under cultivation and 531 are considered to be growing wild or naturalised.

The work is based mainly on the collections of the author himself.

There is no doubt that this publication will become very popular and it is expected that the next edition will include a companion volume with diagrams and photographs of the plants described.

It is to be fervently hoped that many similar floristic and monographic works carried out by other botanists will see the light of the day with the help of the Council of Scientific & Industrial Research and other similar institutions.

P. V. BOLE

7. UNDERSTANDING ANIMALS. By Gerhard Gronefeld. Translated from the German by Gwynne Vevers and Winwood Reade. pp. 320 (26×18 cm.). With 24 coloured and many monochrome plates. London, 1965. William Heinemann Ltd. Price 45*s*. net.

This is certainly an exceptional book. The 320 pages consist of almost equal numbers of pages of text and of full-page photographs of birds and animals, mostly taken in zoos or in some other form of captivity or domestication.

The author is a professional photographer and the pictures are consistently good. The captions to the photographs, which are often in series, to some extent repeat or are repeated in the text.

The text consists mainly of anecdotes of the author's experiences at circuses and at the highly specialized institutions with which names like Konrad Lorenz and H. Hediger are associated. The circus and zoo stories can be passed on to the layman but, when he deals with the more technical matters which have to be told in simple language, the accounts sometimes appear too simple. In addition to the pictures, however, the book gives us an inkling of aspects of behaviour studies which are far ahead of what has been attempted in India—Chapter 4, for instance, deals with Mr. Walther of the Kronberg Reserve of Animal Research, who on all fours 'grazed' with a herd of Dorcas gazelles and, entering their paddock in the right order of priority, spent the night with them.

The translation of the title is perhaps unfortunate, but the book will certainly help to arouse interest in the right direction.

H. A.

8. AN INTRODUCTION TO THE STUDY OF TROPICAL PLANKTON. By John H. Wickstead. pp. 160 (24·6×18·3 cm.). With 4 black-and-white plates, 11 text-figures, and 181 classification figures. London, 1965. Hutchinson & Co. (Publishers) Ltd. Price 25*s*. net.

This is a simple but excellently written book on the plankton of the tropical waters. The book is divided into two parts. The first part deals with methods of collection and analysis of plankton, supported by clear labelled drawings of the equipment used.

The second part contains useful descriptions in general terms of the important groups of planktonic forms, their size, important common forms, and general features of distribution. The groups are Phytoplankton and Protozoa, Coelenterates and worms, smaller Crustaceans, larger Crustaceans, Molluscs, smaller groups, Echinoderms and Chordates, and, finally, some less frequently taken animals.

The most important part of the book consists of the lucidly drawn simple figures 1-181 of typical planktonic forms commonly encountered in tropical waters. The figures are grouped on the basis of affinities and systematics of the forms concerned.

Particularly for teaching plankton sorting to new students in Marine Biology and Oceanography, the figures of the planktonic forms are very useful. This is in fact the first book to deal exclusively with tropical plankton and will therefore meet the long-standing requirements for teaching plankton in our higher secondary schools and colleges. Dr. Wickstead deserves congratulations for filling up an important gap in the available books on plankton.

T. S. S. RAO

9. ETHIOPIAN EPISODE. By Leslie Brown. pp. 160 (24×16 cm.). With 10 coloured and 26 black-and-white illustrations. London, 1965. Country Life Limited. Price 42*s*. net.

This is an account of a trip, sponsored by the International Union for the Conservation of Nature and the World Wildlife Fund, to the highlands of Ethiopia to enquire into the present status of the Walia Ibex, *Capra walie*, and the Mountain Nyala, *Tragelaphus buxtoni*.

While Addis Ababa and a few other airports are well known, Ethiopia is still isolated from the rest of the world for want of suitable roads and means of transport. It is also a large country and distances are often two or three days of hard driving between one large town and another.

Both the species were found but, as the author states in the preface, these are not tales of danger and blood-thirsty bandits, and the only anxious moment was when he himself 'was mistaken for a bandit and was in slight danger of elimination by the forces of law and order'. As compared to Kenya and other parts of Africa, the total amount of wild life seen was relatively small but the author notes various little-known species seen in the course of his travels, by Landrover and on foot.

The pictures representing scenery are excellent and are reminiscent of portions of the Ghats near Bombay, though on a much larger scale—some of his camps were over 11,000 feet above sea-level.

As in India, the main menace to all wild life is the local shikari who, in the absence of suitable administration, is not at all concerned with edicts or legislation. The habitats of both these animals however are high in the hills and not densely populated, so it is hoped that it will be possible to take satisfactory steps for their preservation before it is too late.

H. A.

10. BOTANICAL LATIN. History, Grammar, Syntax, Terminology and Vocabulary. By William T. Stearn. pp. xiv+566, (22×14·5 cm.), ff. 41. London, 1966. Nelson, Price 105*s*.

Let me begin with the price of this book; one hundred and five shillings is a stiff price for a book of this size, a price that is going to restrict its widespread use very seriously, at least in India; the price in India at present will be about Rs. 110. I consider this a great pity, for the book is one that ought to be in the hands of every systematic botanist in the country, especially of those doing research in any branch of systematics. The book fills a great need; with its help it will be possible for botanists to translate from Latin into English, and, if the book is fully mastered, it may also help in translating from English into Latin, I mean correct and intelligible Latin.

The book opens with an 'apologia pro libro meo'; the author need make no apology for such a book; we do not have any other book giving the information of the present one. The author explains in this introduction his aims in writing the book and gives some interesting details of the very hard work of preparation; suffice it to say that the author read through the more important botanical books published after Linne in Latin and made or prepared slips for the various words or terms used in such books. Whilst reading this book I have been reminded more than once of the famous expression 'tantae molis erat romanam condere gentem'!

Part One is introductory; the author explains the development of botanical Latin terminology, in which we find words that may also be found in the classics, but with quite a different meaning. However, I must confess for myself that knowing classical Latin and botany I have generally found it easy to read through such botanical classics as De Candolle, Saccardo, and the like. In this part there is a chapter on the pronunciation of Latin; I found this chapter of great interest. I may be wrong, but my impression after teaching botany to Indian students for many years is that some of the difficulties experienced by Indian students in the spelling of Latin plant names is due to the confused pronunciation inherited from Britain. This difficulty is enhanced by the fact that in India we do not seem to have either the *Traditional English* or the *Reformed Academic* methods, but some sort of half-way mixture of the two. At any rate I for one am very strongly for the Reformed Academic method, or even for the Church method, rather than the Traditional English or the adaptations we find in India.

Part Two deals with Grammar, and covers pages 59 to 139, the respective chapters being on Nouns, Adjectives and Participles, Adverbs, Numerals and Measurements, Pronouns, Prepositions, Conjunctions, Verbs. The reader will find a mine of information under these various chapters, and, what I find highly commendable, the examples are usually taken from botanical terms. The rules about genders, a very troublesome business for students of Latin, are here reduced to the minimum, but generally every substantive mentioned in the book bears an indication of its gender.

Part Three deals with Diagnoses and Descriptions. The original Linnaean diagnoses consisted of few words, such words being in the ablative; the meaning of such phrases was perfectly clear. But when the number of species under a genus increased beyond certain limits, as happened in the nineteenth century, it became necessary to give much longer descriptions. Let me quote from the author: 'The publication of such comparatively long diagnoses by nineteenth-century authors, who understood very well the distinction between a diagnosis in the ablative dependent upon the generic name and a true description with the organs independently described in the nominative, has misled later authors apparently unaware of this distinction into publishing very long descriptions in the ablative. For this there is no justification in history or convenience.' Personally I feel that descriptions (I mean true long descriptions, not short diagnoses) in the ablative are not so clear as those in the nominative, or perhaps such ablative descriptions require much greater attention on the part of the reader. I shall give two examples from pages 169-170. '*Hygrophorus speciosus* Peck. Pileo ex ovato vel subconico expanso, margine tenui recurvo, *glabro, glutinoso, saepe minute umbonato, nitide rubro vel coccineo, demum lutescente . . .*'

As the description stands, the words which I have italicized might grammatically go with *pileo* or with *margine*; the reader has to make an effort and guess. This description was published by Saccardo in SYLLOGE FUNGORUM in 1887; the same was given by Bresadole in ICONOGR. MYCOL. in 1928: '*Hygrophorus speciosus* Peck. Pileus carnosus, tenuis, e campanulato expansus et umbonatus, laete flavus, umbone aurantio-fulvus, glaber, glutinosus, glutine hyalino, 2-6 cm. latus . . .' In this second description the reader needs make no special effort to understand all the details. To help botanists the author gives in this part examples taken from the great masters in Algae, Fungi, Lichenes, Bryophyta, Pteridophyta, Spermatophyta, which every botanist ought to follow faithfully, I mean, as to the method of making a description.

There is a chapter on punctuation, and I found it more than usually interesting; my interest came from the fact that punctuation, or the want of it, in English descriptions to be translated into Latin has often been very trying for me in the past. Some of my correspondents seem to think that their description is a particularly good one when it consists of a full page of text with one final stop at the end of the page and no other sign of punctuation in the rest. My job then becomes not one of translation but one of interpretation, of a text that possibly is not quite clear in the mind of the writer. On more than one occasion I have had to return original papers to their authors with a request to cut page-long paragraphs into short sentences with appropriate punctuation. Dr. Stearn remarks: 'Within limits there are no hard and fast rules about punctuation; its functions are to make for clarity and ease in comparing one description with another and to prevent ambiguity; provided these ends are achieved, a little variation from customary usage does no harm.'

There is a chapter, pp. 236-259, on the important subject of colour terms; in Latin such terms were both reduced in number and vague in meaning; this deficiency in colour terms has induced some writers to say that the ancient Greek and Latin authors were weak in colour perception; they were particularly short in terms for indicating blue, green, grey, and brown colours. The author gives a summary of Latin colour terms taken from Lindley and Jackson for common plants, and from Elias Fries for fungi.

Another set of chapters deals with Greek words in botanical Latin, with descriptive terminology, with chemical reactions and tests, etc.

Part Four contains the longest chapter of the book, Ch. XXV, Vocabulary, covering pages 377 to 548. I find this one of the best parts of the book. Words, English or Latin or at times even Greek, are given in alphabetical order, usually with cross references; they are given with indication of their declension, and of the more important cases, usually genitive and ablative, gender of the names, meaning or meanings

of the same, etc. I have gone through each one of these pages, and think that I have learnt much from their perusal.

The *Synopsis Polyglotta* on pages 552-555 seems to me somewhat out of place in this book; if the reader can understand English sufficiently well, this *Synopsis* is not needed; if he cannot understand English, then the value of the whole book becomes rather questionable. Another point on which I am not able to make up my mind is the matter of the illustrations in the text. In a book of plant morphology or systematics, they would be excellent; but in the present book I fail to see their special utility, and they do certainly help to enhance the final cost of the publication.

To sum up, then, I consider the book deserving of the highest commendation for systematic botanists that may wish to read the classics in this line of science as well as for those who attempt translations from English into botanical Latin. I only wish that the price had made it more accessible to the general botanical student in India.

H. SANTAPAU

Other Books Received

OUR FRIENDS THE SPIDERS. By T. H. Gillespie. pp. 58 (21 × 17 cm.). Illustrated in colour and black-and-white by David Pratt. Edinburgh/London, 1964. Oliver & Boyd. The Open Air Library 2. Price 10*s*. 6*d*. net.

THE BEHAVIOUR OF ARTHROPODS. By J. D. Carthy. pp. 148 (5½ × 8½ inches). 41 black-and-white figures (drawings and graphs). Edinburgh/London, 1965. Oliver & Boyd. University Reviews in Biology 1. Price 12*s*. 6*d*. net.

THE METABOLISM OF INSECTS. By Darcy Gilmour. pp. 195 (5½ × 8½ inches). 32 black-and-white figures (diagrams). Edinburgh/London, 1965. Oliver & Boyd. University Reviews in Biology 4. Price 15*s*. net.

INTERNATIONAL REVIEW OF GENERAL AND EXPERIMENTAL ZOOLOGY. Volume 1. Edited by William J. L. Felts and Richard J. Harrison. pp. xi + 445 (23·5 × 15·5 cm.). With many figures and graphs. New York/London, 1964. Academic Press. Price $ 14·50.

METHODS OF ANIMAL EXPERIMENTATION. Volume 1. Edited by William I. Gay. pp. xv + 382 (23·5 × 15·5 cm.). With many illustrations. New York/London, 1965. Academic Press. Price $ 13·50.

THE ORCHIDS OF BOMBAY. By H. Santapau, S.J. and Z. Kapadia. pp. 239 + vi (25 × 16·5 cm.). With 54 line-drawing and monochrome plates. Delhi, 1966. The Manager of Publications, Government of India. Price: Inland Rs 15·50; Foreign 36*s.* 2*d.*; $ 5.58.

THE FLORA OF PAVAGADH. Botanical Memoirs No. 1. By A. R. Chavan and G. M. Oza. pp. vi + 296 (25 × 16·5 cm.). With 2 plates. Baroda, 1966. Department of Botany, M. S. University of Baroda. Price Rs 12.

Miscellaneous Notes

1. THE INDIAN GERBILLE, *TATERA INDICA* (HARDWICKE), IN WEST BENGAL

Between 27 and 31 January 1966, six Indian Gerbilles [*Tatera indica* (Hardwicke)] were captured in live-traps in Nasibpur, District Hooghly, West Bengal, about 30 miles north-west of Calcutta. All six individuals, probably a family group, were trapped in a small area (*c.* 10×20 metres) covered by low shrubs. The trapping site is about 75 metres from the Tarakeshwar-Calcutta highway and separated from it by a bridged irrigation canal.

The group of animals consisted of the following: an adult male (203·2 gm.), an adult female (176·7 gm.), a young adult male (119·1 gm.), and three juvenile males (44·8, 42·8, 32·5 gm.). The animals were brought to the Johns Hopkins Field Station in Singur, District Hooghly, where they were kept in a pen and fed a diet of rice, moong dal, and occasional bits of meat (which they readily accept). On about 28 February, the older adult male began showing aggressive behaviour toward the younger adult male. Several fights ensued and on 2 March the younger male was killed. The older adult male showed no aggressiveness toward the juveniles.

The adult female was removed to a separate pen on 3 March a few hours before she gave birth to a litter of four young.

Ellerman (1961, THE FAUNA OF INDIA, edited by M. L. Roonwal, Zoological Survey of India) lists four subspecies of *T. indica*, of which only one, *T. i. indica*, is reported from eastern India. He gives the location as 'Midnipur, Bihar' by which I think he probably meant Midnapore, West Bengal, a city about 55 miles to the west of Nasibpur. So far as I know, there are no records of *Tatera* east of Midnapore.

The rats were shown to several farmers of the vicinity and most said that they had never noticed this species before. Two farmers said that they had seen them but only during the last two years. I had for 14 months been doing monthly trapping in fields adjacent to the site and in fields about a quarter of a mile away, but had never taken this animal. Further trapping in fields and banana groves of the neighbourhood has failed to produce any more gerbilles. It would seem probable, then, that *T. indica* has either entered the vicinity only recently or has existed in numbers too small to attract attention. There is a great deal of lorry traffic on the Tarakeshwar-Calcutta highway and it seems possible

that these rodents might have been accidentally introduced in shipments of grain.

I wish to acknowledge my gratitude to the Zoological Survey of India for their taxonomic aid.

JOHNS HOPKINS CENTER FOR MEDICAL
RESEARCH AND TRAINING,
c/o ALL-INDIA INSTITUTE OF HYGIENE
AND PUBLIC HEALTH,
CALCUTTA,
March 14, 1966.

DWAIN W. PARRACK

2. EXTENSION OF RANGE OF *IXOBRYCHUS MINUTUS MINUTUS* (LINNAEUS)—AN ADDITION TO THE AVIFAUNA OF THE BOMBAY AREA

On 21 October 1956, while snipe-shooting at Belapur, Thana, Maharashtra, H. A. put up and collected a bittern which was noted as 'pied-looking'. A Chestnut Bittern [*Ixobrychus cinnamomeus* (Gmelin)] had been flushed about 50 yards away and, upon being told later by the skinner that the collected specimen was of this species, H. A. did not re-examine it and left it to be so registered in the Bombay Natural History Society collections.

While cataloguing the collections, we find that this is a young male of the Little Bittern, *Ixobrychus minutus minutus* (Linnaeus), the blackish primaries and the 152 mm. wing being unmistakable. This species does not appear to have been recorded south of Sind.

75, ABDUL REHMAN STREET,
BOMBAY 3-BR,
BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE,
BOMBAY 1-BR,
September 25, 1965.

HUMAYUN ABDULALI
B. R. GRUBH

3. NOTES ON INDIAN BIRDS 9—*ANSER CAERULESCENS CAERULESCENS* (LINNAEUS) AND *ANSER FABALIS BRACHYRHYNCHUS* BAILLON TO BE REMOVED FROM THE INDIAN AVIFAUNA

Anser caerulescens caerulescens (Linnaeus): Snow Goose

A white goose (B.N.H.S. Reg. No. 15297) shot at Haigham Jheel, Srinagar, Kashmir, on 26 February 1950, while associated with Grey Lags (*Anser anser*), is recorded (Editors, *J. Bombay nat. Hist. Soc.*, 1950) as the first instance of the Snow Goose (*Anser hyperboreus* Pallas)

occurring within Indian limits. Another white goose (No. 15289, Kashmir, 24 May 1914), similar in appearance to the former (except for a pale light brown wash on the upper parts, palest on the head, and the primaries marked with brown rather than grey), is registered as *Anser anser*. I have therefore examined the specimens in detail and find that they are both *Anser anser*. My reasons are set out below.

According to the HANDBOOK OF BRITISH BIRDS (3 : 200), the Snow Goose can be differentiated in the field by two characters : firstly, the intense black tips to the primaries ; secondly, the black cutting edges to the bill. Neither character is found in the specimens. In No. 15289 the primaries, including the tips, are pale brownish ; in No. 15297 they are irregularly marked with grey and black, the first two having their tips and outer webs largely white. As for the bills, now yellowish in both the specimens, neither of them shows any trace of black cutting edges.

In the absence of both these characters and because the measurements, wings 440 and 445, bills from feathers 64 and 60 (slightly chipped), and the number of teeth on the upper mandible, 22 and 24, fall within the known range of both *A. anser* and *A. hyperboreus*, I think that a mistake in identification has been made, both being partial albinos of *Anser anser*. My identification of Sp. No. 15297 has been confirmed by Dr. S. Dillon Ripley II.

Anser hyperboreus Pallas [*Anser caerulescens caerulescens* (Linnaeus) in the SYNOPSIS] must therefore be removed from the Indian list.

Anser fabalis brachyrhynchus Baillon : Pinkfooted Goose

A small goose now bearing B.N.H.S. Reg. No. 15293 was shot at Bikaner, Rajasthan, on 1 December 1948, and noted (Editors, *J. Bombay nat. Hist. Soc.*, 1946) as the first authentic record of the Pinkfooted Goose *Anser fabalis brachyrhynchus* Baillon from India.

As this bird appeared very different from a specimen from Europe, recently acquired by exchange with the Universitetets Zoologiske Museum, Copenhagen, Denmark, I have measured and examined it with care. It is smaller : wing 385 (395-454 in ♀ *brachyrhynchus* in HANDBOOK OF BRITISH BIRDS 3 : 200), tarsus 65 (69-83 for ♂ only), and culmen 44 (37-48). The underparts are uniformly coloured and the wing coverts do not have the pale edges so prominent in *brachyrhynchus*.

The bill was originally noted as ' pinkish ' with a black nail. The nail is certainly dark, but a comparison with the black-tipped bills of the recently received specimens of *Anser f. fabalis* and *A. f. brachyrhynchus* from Europe shows that the Bikaner bird has only a brownish tip and not a black one, while the tip of the lower mandible is still paler and not of the same density as in the others. The black patches at the base of the bill, which are so prominent in both forms of *fabalis*, are also absent.

The shape of the head and bill, and the teeth on the edges, agree with those of the White-fronted Goose [*Anser albifrons albifrons* (Scopoli)]. THE HANDBOOK OF BRITISH BIRDS (3 : 189) states that in this species the nail is dark in juveniles and first winter birds, though the bill is then said to be greyish yellow. I cannot help concluding that this is a juvenile of this species without the white front. This identification has been confirmed by Dr. S. Dillon Ripley II.

This leaves us with Ticehurst 1930, who said : ' Is there any specimen of this goose (*A. brachyrhynchus*) from India in existence? If not, it should be deleted from the Indian fauna.'

75, ABDUL REHMAN STREET,
BOMBAY 3, HUMAYUN ABDULALI
April 5, 1966.

REFERENCES

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4. WHISTLING TEAL [*DENDROCYGNA JAVANICA* (HORSFIELD)] AND OTHER MEMORIES OF ALIPORE ZOO, CALCUTTA

In Vol. **62**(2) of the *Journal*, at pp. 300-301, Mr. Humayun Abdulali writes of the Whistling Teal (*Dendrocygna javanica*) in the Calcutta Zoo. I was Honorary Secretary of the Zoo for many years, and on the Committee of Management, and am still a Life Member. The teal spring from a pair we had in the rhino enclosure for a number of years. These eventually nested and managed to rear a brood in spite of the wallowings of the rhinos. The ducklings were left full-winged and used to fly onto the big tank on the racecourse and generally flighted around. We used to see them at odd intervals and I took several photographs of them. One day, I think during the hot weather, about twenty put in an appearance and settled on the big tank where they stayed for several days. When they left they were seen again shortly after, until a flock of about forty were regularly going in and out. Up to the time of the war, when I left, some eighty to a hundred roosted in the Gardens. I am very

pleased that the numbers have built up now to what may be called almost excessive.

It was my aim and that of the well-known Mr. W. K. Dods to build up a collection of wild birds and as a nucleus various egrets, rails, etc. were released. This must have been around the 1930s. Mr. Dods used to bring in wild-caught birds throughout the cold weather, most of them trapped at Chandpara Camp which was his property, and I used to buy them off the duck-catchers when I was out snipe-shooting around 1928. Those put on the tank were clipped and those released in the duck house left full-winged. Most of the clipped birds left when their primaries grew again. Mr. Dods and I brought back cattle egrets, night herons, darters, various herons, rails, and duck, which we wing-clipped and released unless they were rare in the district when we enclosed them. The kingfishers rarely stayed long after release. Many outsiders of similar species were attracted and took up their roosts in the Zoo, until we sometimes had clearance shoots. The preponderance was of night herons, followed by egrets and darters, and I would say that of these there were several thousands. The Whistlers and the night herons went out at night and came back in the morning, but the reverse was the case with the other birds. It was my intention to have the finest collection of free-flying birds in the world and this I think we achieved even in my time. I released numbers of Java Sparrows but these mostly found their way to the canals round and in Calcutta where the paddy boats came in from upcountry.

Had it not been for the war, I was eventually going to do away with most of the cages. A start had already been made on one side of the Gardens, with excellent results I think. There is also no doubt that it could have been made into one of the finest zoos in the world, with its beauty and magnificent trees many of which were donated by ex-Governors of Bengal in the seventies and eighties.

I think that there was, and still may be, a Galapagos Tortoise which arrived about 1875 and was large even at that time. Its dimensions are written down somewhere in the Garden history. I have long since lost my list of wild birds observed by me in the Gardens. It was quite remarkable if I remember, and showed birds five and six hundred miles out of their range according to Stuart Baker. During my Indian sojourn I unfortunately did not correspond much with the Bombay Natural History Society, and compiled my own notes which were eventually all lost when I was in the army during the war.

En passant it may interest you to know that during a period of twenty years we shot about 60,000 snipe in the usual proportions of fantail to pintail but only 5 Swinhoe.

The large numbers of Teal now visiting the Gardens would be a good

subject for ringing and it would not be difficult to build a pipe to trap them at intervals. Where do these duck moult? In the Gardens?

HIGH HAY BRIDGE,
BOUTH-BY-ULVERSTON, H. A. FOOKS
LANCASHIRE, ENGLAND,
April 6, 1966.

[W. K. Dods, referred to in this note, was a well-known bird shot of those days and is mentioned at p. 68 of Vol. II of Stuart Baker's THE GAME-BIRDS OF INDIA, BURMA AND CEYLON as holding the record bag for one day's shooting, 262 snipe and one quail.—EDS.]

5. THE BAIKAL TEAL, *ANAS FORMOSA* GEORGI: FIRST RECORD FROM KUTCH

We had an interesting duck shoot at Bhimasar, about 36 miles east of Bhuj, on 16 March 1966. The majority of the duck were Common and Garganey Teal and Shoveller, with a sprinkling of Pintail, White-eyed Pochard, Dun-Bird, Spotbill, and Wigeon. In the bag was the rather uncommon Baikal or Clucking Teal (*Anas formosa* Georgi). The skin is in the collection of the Bombay Natural History Society, to whom I am grateful for identifying the bird.

Migration of duck in Kutch was better this year than we have noticed during the past 5 or 6 years. May be it was due to the drought in northern India, or was it owing to the disturbances during the time of migration?

THE PALACE,
BHUJ, KUTCH, MAHARAO OF KUTCH
April 3, 1966.

6. ANOTHER BIRD RECORD FROM KUTCH

On January 1 this year I saw the White-eye (*Zosterops palpebrosa* Temminck) in the Vijaya Vilas Palace grounds at Mandvi; this is the first sight record of the bird within the limits of Kutch. In the early morning in the plantation, while watching the Haircrested Drongo (which incidentally has become a regular visitor since 1959—this year there are in all four birds) and the Blacknaped Blue Flycatcher, I was suddenly attracted by the familiar call notes of the White-eye. I did not have my field glasses with me, but I followed their peculiar notes until the birds flew out and

settled down at some distance; thereafter I was not able to spot them. There were about 8 to 10 birds in the flock. As I left for Bhuj on the 2nd, I was away from Mandvi from the 2nd to the 9th. On my return I again heard the White-eyes and was able to have a good look at them. While I was busy watching them, I suddenly became aware of a new sound about 15 yards away, and was pleasantly surprised to see the second new bird for Kutch, a male Tickell's Blue Flycatcher (*Muscicapa tickelliae* Blyth) perched on a bare twig only about three feet from the ground. After this I saw the bird on two consecutive days during my stay at Vijaya Vilas. It was completely silent except for the sharp *tick tick*, which it repeated every now and then.

BHUJ, KUTCH, M. K. HIMMATSINHJI
January 17, 1966.

[K. S. Dharmakumarsinhji (1955, BIRDS OF SAURASHTRA : 77) and Sálim Ali (1955, Birds of Gujarat. *J. Bombay nat. Hist. Soc.* **52** : 789) both indicate that *Zosterops palpebrosa* is widespread in Saurashtra and the latter has obtained specimens at Amreli and in the Mehsana District. Ticehurst in 'Birds of Sind' (*Ibis* 1923:23) refers to its occurrence in mangrove swamps around Karachi and to its apparent absence from other parts of Sind. The nearest earlier record from Kutch appears to be Humayun Abdulali's (1964, Ornithological Notes of a second trip to the Gulf of Kutch. *J. Bombay nat. Hist. Soc.* **60**:705), who saw it in *Salvadora persica* on Ajar Island in the Gulf of Kutch.

Tickell's Blue Flycatcher (*Muscicapa tickelliae*) is common in Gujarat and Saurashtra, but not yet recorded in Kutch or Sind.—EDS.]

7. NOTES ON SOME BIRDS SEEN IN KASHMIR

My wife and I spent a week's holiday in Kashmir between the 6th and the 13th June 1965. During the course of this visit we made trips from the Nagin Lake to Gulmarg, to Anchar Lake, and to Sonamarg. In this time about 90 species of birds were seen and identified, of which the following have seemed worthy of comment:

913. **Hirundo rupestris** Scopoli: Crag Martin

Bates & Lowther (1952) confess to not having seen this bird within the area of Kashmir that they cover. We saw 2 or 3 birds in the Sind Valley close to the mouth of Nichnai Nullah on the 11th June. This is a species with which I have had experience in Switzerland.

1341. **Pteruthius flaviscapis** (Temminck): Red-winged Shrike-Babbler

This species is not mentioned by Bates & Lowther, and Dillon Ripley (1961) does not specifically mention Kashmir in the range given. I saw one male in pine forest at about 8000 ft. on the ascent to Gulmarg on the 8th June. This is a species I have met several times in northern Thailand.

1614. **Seicercus burkii** (Burton): Yellow-eyed Flycatcher-Warbler

Although Bates & Lowther do not record this species from the part of Kashmir that they cover, Dillon Ripley lists it from Kashmir, possibly not the same part. On the 10th June I found one at close to 10,000 ft. near Sonamarg, moving through pine forest with willow warblers of various species and a Goldcrest. The warblers could not be definitely identified as to species, but with this flycatcher-warbler I have had field experience and a bird in the hand in Thailand, and I am quite satisfied with the field identification.

c/o Pronesiam Inc.,
P.O. Box 326,
Bangkok, Thailand,
November 29, 1965.

E. C. DICKINSON

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8. NEED IN ORNITHOLOGY FOR MORE APPROPRIATE TERM THAN 'SOFT PARTS'

In a letter to *British Birds* (1965, **58**: 101) I. F. Keymer & D. K. Blackmore suggest that instead of the inappropriate term 'soft parts' ornithologists should use 'appendages', an expression already in use in medicinal and veterinary literature. Our ornithological readers will be interested in the comments of Sir A. Landsborough Thomson.

'I have recently described the term as being "somewhat absurd" (1964, *A New Dictionary of Birds*, under TOPOGRAPHY); and where I have occasionally used it myself it has been within deprecatory quotation marks or preceded by "so-called". Several text-books, other than Witherby's, that I have particularly examined all dispense with it, including Ralph S. Palmer's *Handbook of North American Birds* (Vol. I, 1962). Most systematic works nevertheless deal with these characters

in a separate paragraph, unheaded, in a standard location in each description; this is clearly good practice. J. D. Macdonald tells me that those currently working in the Bird Room of the British Museum (Natural History) tend to avoid using the term in print, although otherwise it has convenience for certain limited purposes. Dr. Dean Amadon writes that in the American Museum of Natural History they have all been "bothered by the ambiguity of this term"; but he considers its retention necessary, failing the successful establishment of a better one.

'Professor J. Berlioz tells me that the French equivalent, which he does not regard as wholly satisfactory, is "*parties nues*". Professor E. Stresemann knows of no corresponding term in German; and no such heading is used in the text-books of Dr. Ernst Hartert, Professor G. Niethammer and others.

'My conclusion is that no collective term is required for use in publications; and that it is in fact undesirable to have a formal term embracing such diverse elements as the horny bill, a flabby comb and the irides. If a short term is wanted for colloquial use, I suggest that "bare parts" (in line with the French usage) is as convenient as "soft parts", more readily understandable and less ambiguous. "Unfeathered parts" has been suggested, but it is longer and less free from the ambiguity that it might be taken to include the concealed apteria.

'Your correspondents' suggestion of "appendages of the skin" seems unlikely to gain acceptance. The word "appendages" already has various applications, and it is not appropriate to relatively flat structures such as rhamphotheca or podotheca, and still less to the iris or the buccal cavity. In any event, as your correspondents say, "appendages of the skin" would include the feathers; so the term would not serve the differentiating purpose that is the *raison d'être* of the one to be replaced.'

We may note that in the HANDBOOK OF INDIAN BIRDS, the first volume of which is now in the press, the authors are using the term 'bare parts'.

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE, EDITORS
BOMBAY 1-BR,
April 15, 1966.

9. VISIT BY IUCN DELEGATION TO THE KEOLADEO GHANA SANCTUARY, BHARATPUR, RAJASTHAN, INDIA

(*With two plates*)

A party of some twenty people visited the Ghana, arriving by bus at 2.30 p.m. on Thursday 25th November and leaving again at 10.15 a.m. on the following morning. Conditions at the Sanctuary were said to be unusually good, in that migrant birds from the north were already present in some strength, while due to a late monsoon the breeding colonies of storks, herons, ibises, and cormorants were still occupied, many of the nests containing quite small young. During the very short period spent at the Sanctuary (and including the journeys to and from Delhi), some 130 species of birds were identified. Also seen in the Sanctuary were Blackbuck (*c.* 40), Nilgai (*c.* 10), Chital (*c.* 50), Sambar (3), and Wild Boar (2). A panther was seen as it crossed the road.

H. H. the Maharaja of Bharatpur was kind enough to take my wife and me round the Sanctuary on the afternoon of the 25th when we saw most of the waterfowl species recorded from the area, and a splendid concentration of from 3-4000 Greylag Geese, as well as 150 Barheaded Geese and large flocks of ducks of 15 species, including Cotton Teal.

During the afternoon other members of the party had no difficulty in finding and photographing blackbuck and other antelope, or went by boat to see the colonies of breeding birds in small trees standing in shallow water. These included Painted and Openbilled Storks, Spoonbill, White Ibis, Grey Heron, 3 species of White Egrets, Darters, and two species of Cormorants.

In the evening His Highness entertained the whole party at dinner at the Palace. Accommodation was provided most generously by the Government of Rajasthan at the Rest House in the Sanctuary and at the Hotel near the entrance.

Unfortunately on the morning of Friday 26th the wildfowl near the Rest House, and in the area where the geese had been concentrated the night before, were considerably disturbed by a shooting party. It is a matter of regret that those IUCN representatives who had been out in the boats on the previous evening thus missed the magnificent spectacle provided by the wildfowl concentration.

The Ghana Sanctuary consists of some 7000 acres (*c.* 11 sq. miles) of which about one-third is artificially flooded plain. Banks or bunds provide a number of shallow pans, some of them a square mile or so in extent, which fill at the time of the monsoon in late summer and gradually dry up during the rest of the year. These man-made lakes are surrounded by a forest of low trees and shrubs—mostly *Acacia*,

Zizyphus, etc. The pans are grown up with many species of water plants so that, at the time we were there, little clear open water was to be seen, though over large areas the vegetation did not rise above the surface. Some trees grew along the bunds, on small islands, and in standing water.

After so short a visit it is difficult to draw valid conclusions or make positive recommendations, but certain impressions seem worth recording.

First, the Keoladeo Ghana Sanctuary can provide as fine a spectacle of large water birds as is to be seen anywhere in the world, enhanced by the presence in the vicinity of some of India's most beautiful mammals, of which three at least can be seen without difficulty by any visitor. Secondly, the Sanctuary is not yet a true sanctuary among other reasons because of the considerable amount of shooting which takes place and because of serious overgrazing by domestic animals. Thirdly, the potential use of the wild life in this area as a tourist attraction, for the purposes of education and as a basis for scientific research, is capable of very substantial development at no very great capital cost. It is assumed that such development would have the approval of both the Indian Government and the Government of Rajasthan.

The following suggestions are therefore put forward :

(1) That the sanctuary should be zoned to provide a demarcated area of not less than 3 sq. miles as a strict reserve or true sanctuary, in which no shooting or other disturbance should ever take place, and into which no domestic livestock may enter. It is particularly important that this area should *not* be disturbed by beaters (with or without firecrackers) on shooting days.

(2) That in the zone or zones set aside for wildfowl shooting and in order to ensure that the quality of such shooting is properly maintained, shooting should take place on a small number of days to be agreed with H. H. the Maharaja, preferably not more often than once every 2 weeks (and never on other days) during the open seasons permitted by the law.

(3) That the privilege of grazing domestic animals in the Sanctuary should be strictly controlled in accordance with sound range management principles, which would certainly involve a drastic reduction in present numbers. The factors involved should be carefully studied : for example, although dung deposited on dry land is carefully collected by the graziers for fuel and other purposes, it is possible that the domestic ungulates fertilize the water to the advantage of many waterbird species, and that this fertilization is a significant factor in the wildfowl concentrations. Nevertheless it is likely that something of the order of 1500 domestic livestock feeding in the area would be far

better land use practice from every point of view—Sanctuary, shooting, and the interests of the livestock and their owners—than the present 5600. The recent reduction of domestic grazing by excluding buffalo and cattle during the night is commended as a wise and practical limitation and should be continued.

(4) That at least 12 observation points should be constructed at very carefully selected points where numbers of birds or mammals may concentrate (or be persuaded to concentrate). It is vital that these huts be so placed, and the approaches so screened with reed walls, that observers and photographers can get into and out of the observation points without disturbing the birds or mammals which may be close by. (Plates I and II)

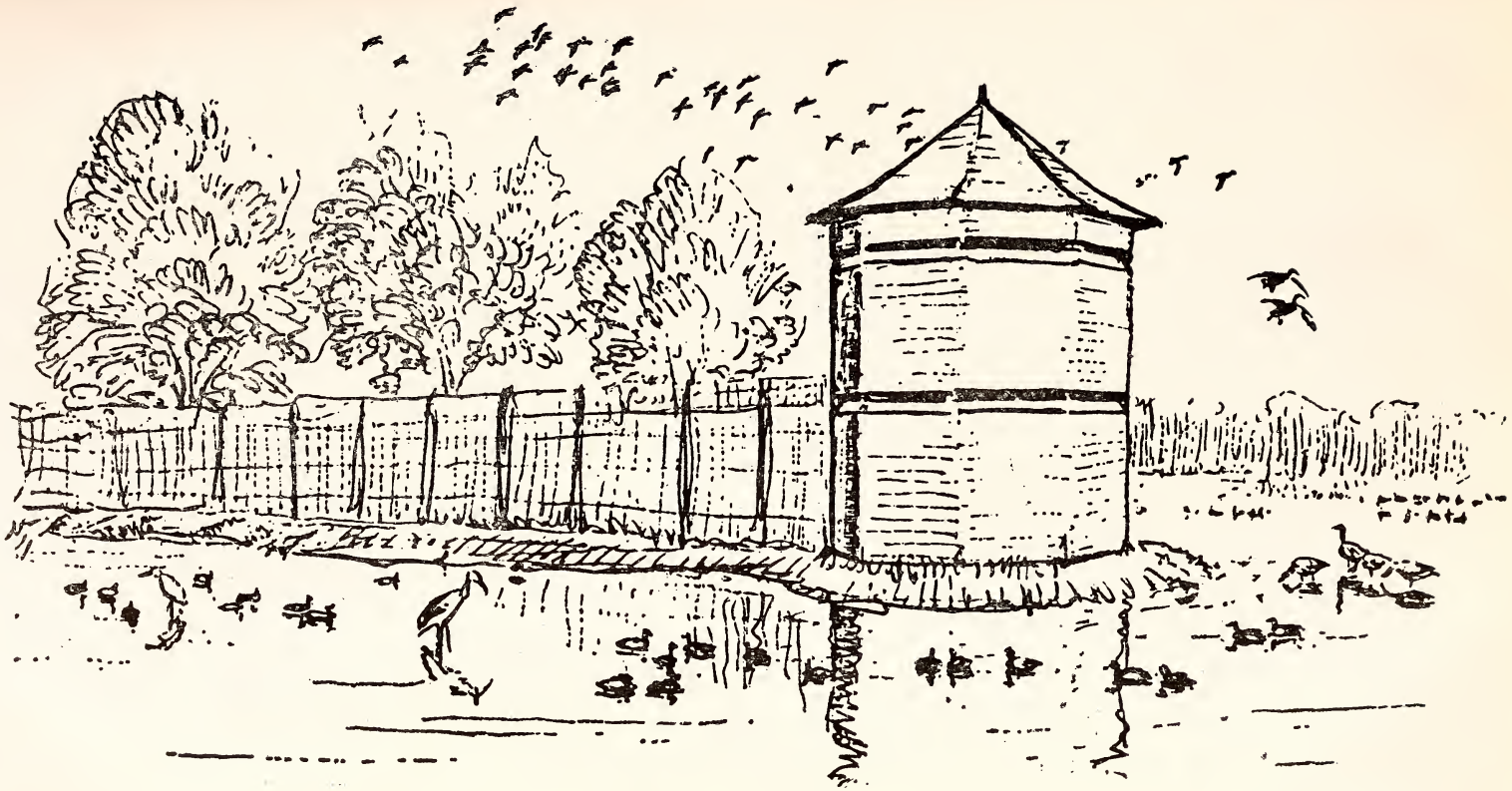
(5) That disturbance to the breeding colonies of birds should be reduced by not allowing boats to go amongst the trees in the main breeding area (where observation towers would provide better facilities for photography). During our visit the boats went so close to the trees that some young birds fell into the water and were drowned. It is essential that boatmen employed in the Sanctuary should, like all other staff, be given a short training course and properly supervised.

(6) That facilities for the accommodation of tourists at the Rest House in the Sanctuary be improved and extended so as to be able to accommodate at least one bus-load of tourists (*c.* 30-35)—preferably two. Standards of comfort must conform to those expected by the majority of travellers visiting India, but this does not rule out the necessity for a proportion of simple, well-designed accommodation within the reach of lower income brackets.

(7) That the Rest House extension should include a dining room and lounge overlooking a substantial expanse of open water so that birds can be observed from these rooms (as well as some of the bedrooms). Mammals should also be accustomed to visiting the area immediately in front of the building by the judicious siting of a salt-lick and by providing an open grass area (periodically cut if necessary) to attract ungulate species to the fresh grass. Needless to say the domestic animals would have to be totally excluded from the Rest House vicinity.

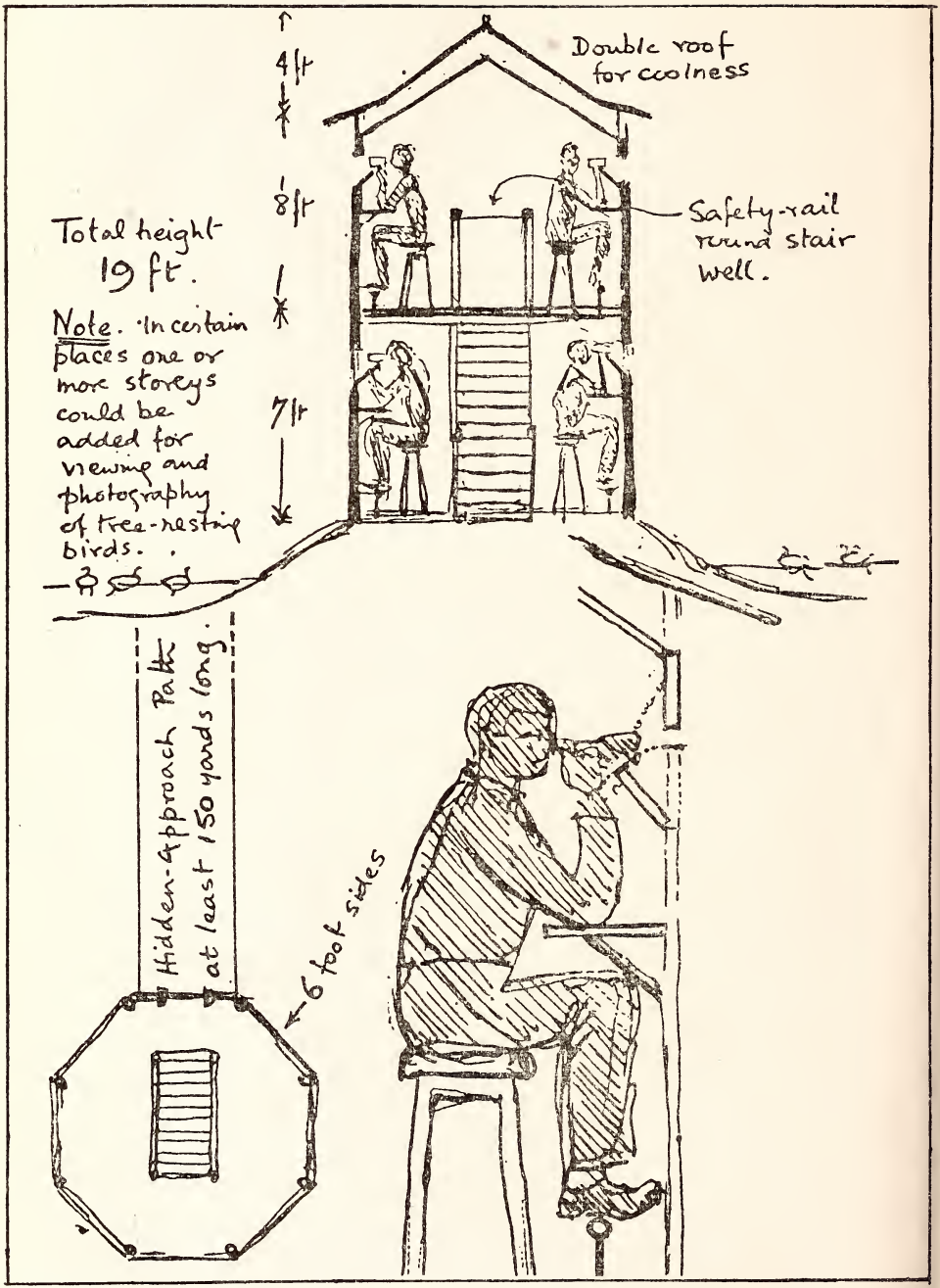
(8) That the area in front of the Rest House should be regularly floodlit during the evening. A device to allow the lights to fade *gradually* at 11.0 p.m. or midnight, rather than being kept on all night, as is the practice at the very successful Tree Tops reserve in Kenya, would probably be best suited to local circumstances and to the 2- to 3-night stay in the Sanctuary which could be expected to interest the ordinary tourist.

(9) That a charge of Rs. 10 per person be made for all foreign tourists visiting the Sanctuary, a contribution to the cost of its proper manage-



del. Peter Scott

Bird Observation Hut : Elevation
For details of construction, see Plate II



del. Peter Scott

Bird Observation Hut: Details

ment which would certainly be willingly paid and indeed normally expected. Consideration could be given to introducing a token entry charge, say one rupee, for Indian nationals, if only to emphasize the value of the Sanctuary, but children under 16 should be allowed in free.

(10) That there should be no introduction whatever of exotic species into the Sanctuary. As emphasized in our general report such introductions are always to be avoided and even re-introductions or artificial amplification of stocks of existing species needs very careful study if it is not to have adverse effects on the habitat and general balance of the fauna.

(11) That facilities be provided for School Parties to visit the Sanctuary and to be shown round by guides capable of explaining its objects and describing the fauna and flora in some detail. Such visits should include access to the special observation points from which the wild life will be seen at especially close quarters.

(12) That facilities be provided for student field study in certain specified parts of the Sanctuary.

(13) That a small research station should be established to form a focal point for all scientific studies taking place in the Sanctuary. For this purpose funds might be sought from international sources such as the World Wildlife Fund.

(14) That very complete check lists be drawn up for the Sanctuary, available in printed form for the tourist, and that ' field guides ' on the Indian fauna and flora should also be available for purchase. It is of the highest importance that these should be scientifically impeccable. This need not make them in any way less attractive to the casual visitor, and the standards of the Sanctuary will be judged by the care with which this sort of literature is prepared.

(15) That as soon as the improved facilities exist (but on no account before), the Sanctuary and its unique interest should be publicized, both nationally and internationally, but especially the latter, on as wide a scale as possible.

For such publicity the assistance of many organizations is available and might well be sought, e.g. The Fauna Preservation Society, the Audubon Society (U.S.A.), the Royal Society for the Protection of Birds (U.K.), the Frankfurt Zoological Society (West German Republic), the Wildfowl Trust (U.K.), and the World Wildlife Fund (Switzerland).

SLIMBRIDGE WILDFOWL TRUST,
SEVERN, GLOUCESTERSHIRE,
ENGLAND,
May 25, 1966.

PETER SCOTT

10. OCCURRENCE OF THE BAT-FISH, *PEGASUS VOLITANS* LINNAEUS (PEGASIFORMES : PEGASIDAE), FROM THE COASTAL WATERS OF INDIA

Day (1889) recorded *Pegasus draconis* Linnaeus from the Andamans ; Johnstone (1904) and Munro (1955) recorded *Pegasus* (*Parapegasus*) *natans* (Linnaeus) from the Pearl Banks of Ceylon; and Munro (1955) recorded *Pegasus* (*Parapegasus*) *volans* (Linnaeus) and *Pegasus draconis* Linnaeus from Ceylon. According to Herre (1953) *Pegasus* (*Parapegasus*) *natans* (Linnaeus) and *Pegasus* (*Parapegasus*) *volans* (Linnaeus) are synonymous with *Pegasus volitans* Linnaeus. The family Pegasidae with one genus, *Pegasus* Linnaeus, with probably two degenerate species, *P. volitans* and *P. draconis*, is Indo-Pacific in its distribution, extending from East Africa to Japan and Australia.

Since Munro's record from the Gulf of Manaar, adults of *Pegasus volitans* Linnaeus have been unknown from the coastal waters of India. Jones & Pantulu (1958) reported a few post-larval stages of *Pegasus* (*Parapegasus*) *volitans* (*natans*) from the Orissa Coast and Krishnamurthy (1961) reported a single larval stage of the same species from the plankton collections off Porto-Novo, considered to be the earliest known stage for this species.

A single adult specimen of *Pegasus volitans* Linnaeus was obtained on 16 March 1965 from amongst the catches of *kondavalai* dragged from within a distance of about half-a-mile from the shore at Kovalam, 30 miles south of Madras. Subsequent catches from the same locality on the 22nd and 23rd March by *kondavalai* yielded no more specimens of this fish, indicating the comparative rarity of its occurrence. This fish is believed to inhabit rocky zones of the shallow in-shore waters, and one of the local fishermen identified it as *nāra ulupāthi* in Tamil—*nāra* refers to foul smell, and this fish is known to emit a foul smell while alive. There are two other local Tamil names for this fish popular among the fisherfolk at Kovalam, *vettu udupāthi* and *paravai udupāthi*, of which the latter refers to the resemblance of this fish to a bird. From the several local vernacular names in vogue, one can guess that this fish, though not reported from India earlier, is not so very rare.

The present specimen measures 57 mm. in total length. The colour in the preservative is dark brown above and paler below. The pectoral fin rays are brown-spotted and there are two dark bands across the caudal fin.

The present specimen of *Pegasus volitans* Linnaeus is deposited in the National Collections of the Zoological Survey of India, Calcutta, with the Registered number F. $\frac{4383}{2}$.

A large agave hedge covered by a complete mass of webs of the spider, *Cyrtophora citricola*, in the neighbourhood of Gonda Station in Madhya Pradesh (Two views)

(*Photos* : *Humayun Abdulali*)

I would like to thank Mr. S. Shanker for collecting the specimen. I am grateful to Dr. P. J. Sanjeeva Raj for guidance and encouragement and to Dr. A. G. K. Menon for helpful suggestions.

Department of Zoology,
Madras Christian College, S. JAYADEV BABU
Tambaram, S. India,
October 26, 1965.

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11. THE WEBS OF THE SPIDER, *CYRTOPHORA CITRICOLA* (FORSKÅL)

(*With a plate*)

A new book on British Spiders reminded me of the paucity of information in India on the subject of spiders, and of a small observation by me made some years ago. While waiting for a train at Gonda Station in Madhya Pradesh (15 March 1959), I pottered about the neighbourhood and noticed a large agave hedge covered by a complete mass of spider webs. The hedge, at the end of a sewage field, was about 20 yards long and 10 feet wide. Every 12 or 18 inches apart was a spider and the whole mass was interspersed with egg cases. Bushes and shrubs near by were similarly covered. The specimens which I obtained were identified at the Zoological Survey of India as *Cyrtophora citricola* (Forskål).

75, Abdul Rehman Street,
Bombay 3, HUMAYUN ABDULALI
December 16, 1965.

[Mr. Hari Narayan Acharya, to whom a draft of this note was shown writes :

'*Cyrtophora citricola* is one of our commonest spiders. Its webs are found on low shrubs, practically every cactus hedge, prickly

pear bushes, *Capparis aphylla*, and on *Acacia* and other thorny trees. Though they are usually found at low level, I have found them at about a height of 8-10 feet. Sometimes they use telephone wires for their home. Though they are found in large colonies, they are neither gregarious nor social: they are individuals in the same web-mass.

'An exhaustive description of this spider with particular reference to its web-building work will be found in Hingston's A NATURALIST IN HINDUSTAN: Ch. X. The Dome-building Spider (*With one plate*). W. M. Wheeler in THE SOCIAL INSECTS at page 9 gives an interesting note on the expanse of the web of these spiders and the peculiar way in which they suspend their egg-sacs in the form of a rosary above their domes. The number of egg-sacs in a single strand varies: the maximum observed by me is up to 8.'—EDS.]

12. THE HOODED GRASSHOPPER, *TERATODES MONTICOLLIS* GRAY: A CORRECTION

(*With a text-figure*)

In the Society's Nature Calendar for the year 1965 the Hooded Grasshopper, *Teratodes monticollis* Gray, is described as being found in western and southern India. With reference to this description Father Richard E. Lane-Smith, S. J., to whom we are grateful, has brought to our notice its occurrence in District Hazaribagh (Bihar State). Enquiry from the Zoological Survey of India reveals that

they have in their collection specimens from the following, among other, districts: Darjeeling and Midnapur in West Bengal; Hazaribagh and Singhbum in Bihar; Ganjam in Orissa; Bangalore and Mysore in Mysore; and Mandla in Madhya Pradesh. We publish this fact to dispel

any impression that might have been created by the description in the Nature Calendar that this important pest of Teak (*Tectona grandis* Linn. f.) is of restricted distribution.

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE, EDITORS
BOMBAY 1-BR,
April 15, 1966.

13. NOTE ON HOW POSITION ON HOST-PLANT AFFECTS PARASITISM ON EGGS OF *PYRILLA PERPUSILLA* WLK.[1]

In autumn 1960 an interesting and unusual example of migration and breeding of the sugarcane leafhopper, *Pyrilla perpusilla* Wlk., on jowar, *Sorghum* sp., was observed at Sehore, Madhya Pradesh. Many grasses and weeds, wheat, and even stones and lumps of soil near by harboured egg-masses. This provided an opportunity for the comparative study of parasitism on the eggs in different parts of the plant. Muliyil & Lakshmanan (1942) found the percentage of egg-parasitism in leaf-sheaths to be 59·8 and on leaves 73·4. Murthy (1952) reported the ratio between the parasitism of eggs laid in the leaf-sheaths and those laid on the leaves as 1 : 4. Lal (1958) mentioned that parasitism of egg-masses laid in leaf-sheaths from October is not so high as of egg-masses laid on leaves from July to September.

The present studies were conducted on jowar in a field at the Institute. Thirty egg-masses were observed at random for each part of the plant, the white fluffy covering over the egg-masses being removed very carefully with a soft camel hair brush. Eggs were counted with the help of a hand lens (10 ×). The data were analysed statistically.

TABLE

AVERAGE PERCENTAGE OF EGG-PARASITISM* AT DIFFERENT PARTS OF HOST PLANT

Lower surface of leaf	Upper surface of leaf	Outer surface of leaf-sheath	Inner surface of leaf-sheath	Stem
64·90	60·30	50·26	39·23	21·69
		C. D. at 5% = 18·09		

* Figures based on combined parasitism by *Tetrastidus pyrillae* Craw. and *Cheilone pyrillae* Mani

[1] Formed part of thesis submitted to Vikram University in 1962 in partial fulfilment of M.Sc. (Agri.) degree.

Parasitism per egg-mass varied between 0 and 100%. The average percentage of egg-parasitism is apparently more on the lower leaf-surface, followed in descending order by upper leaf-surface, outer surface of leaf-sheath, inner surface of leaf-sheath, and stem. Parasitism is significantly greater on the lower and upper leaf-surfaces than on the inner surface of leaf-sheath and the stem. Difference in parasitism between outer surface of leaf-sheath and the stem is also significant.

These results suggest that parasitism is more on the egg-masses which are exposed and easily approachable by the parasites. Least parasitism of egg-masses on the stem, which also are exposed, appears to be contradictory. The best answer seems to be that parasitism is also influenced by the proportion of the host population exposed to attack. As the number of egg-masses on the stem is appreciably low the percentage of parasitism of the eggs situated on it is correspondingly low. And as the number of egg-masses on the upper leaf-surface is less than on the lower leaf-surface the percentage of parasitism is lower in the eggs laid on the former.

Thanks are due to Dr. P. R. Rawat, the then Head of the Entomology Department of the Institute.

RAFI AHMED KIDWAI AGRICULTURAL INSTITUTE,
SEHORE, MADHYA PRADESH, M. K. ZUTSHI[1]
March 5, 1966.

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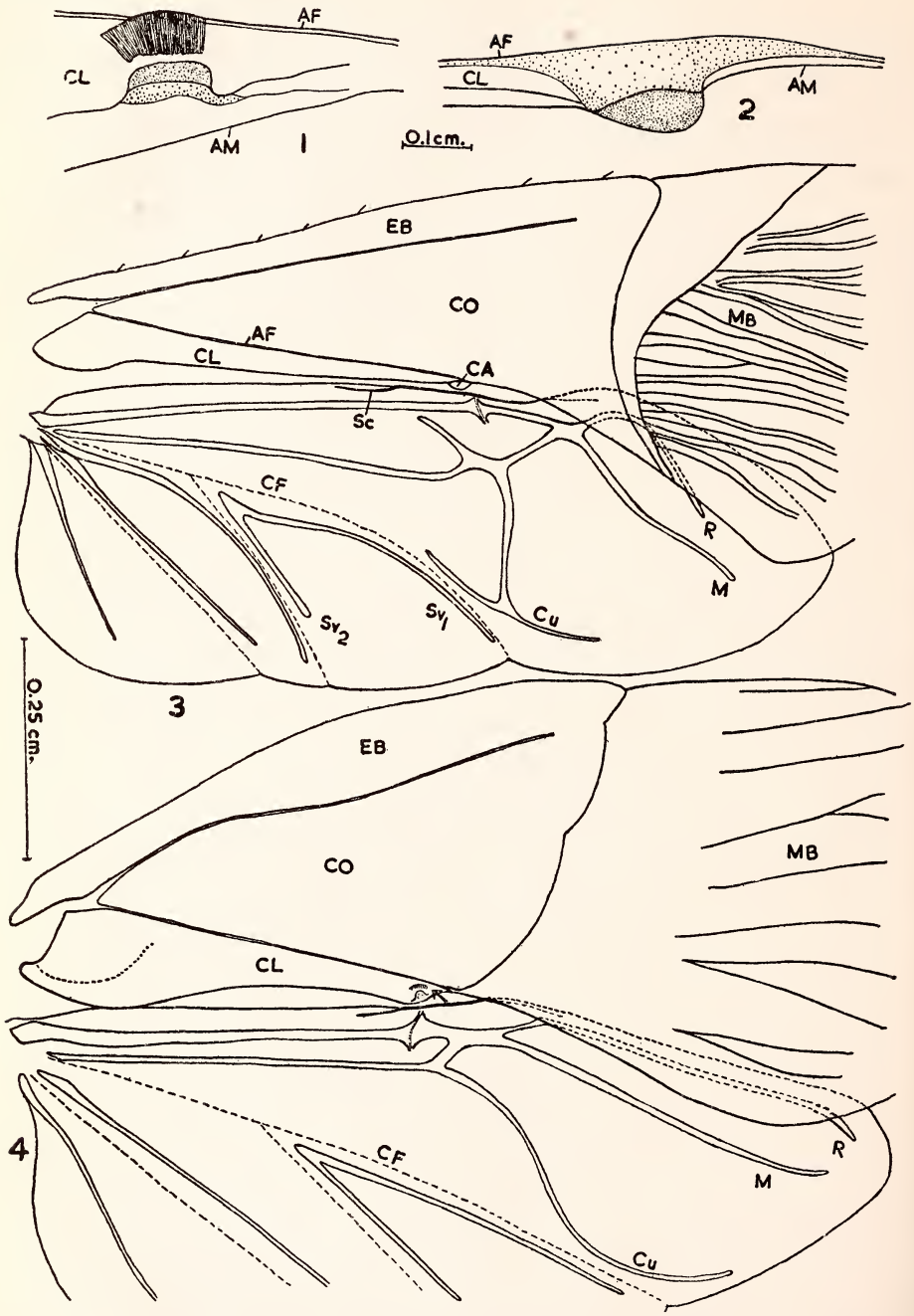
14. WING COUPLING APPARATUS IN CERTAIN HETEROPTERA

(*With a plate containing four figures*)

The wing-coupling apparatus has been examined in a few heteropteran families, namely Pentatomidae, Cydnidae, Dinidoridae, and Scutelleridae. In *Coridius janus* Fabr. (Dinidoridae) this coupling apparatus (Plate, figs. 1 and 4) is situated ventrally at the posterior end

[1] Present address: Scientists' Pool Officer, Directorate of Plant Protection, Quarantine & Storage, New Delhi



1. Wing coupling apparatus of *Coridius janus* Fabr.; 2. Wing coupling apparatus of *Chrysocoris stockerus* Linn.; 3 and 4. Forewing and hindwing of *Chrysocoris stockerus* and *Coridius janus* respectively before coupling. Arrow in 4 shows actual point of coupling.

AF : anal furrow ; AM : anal margin ; CA : coupling apparatus ; CF : cubital furrow ; CL : clavus ; CO : corium ; Cu : cubitus ; EB : embolium ; M : medius; MB : membrane ; R : radius ; Sc : subcosta ; Sv_1 , Sv_2 : secondary veins

of the clavus (CL) region of the hemelytra. The apparatus consists of well-developed setae firmly fixed in the form of a bundle to the inner margin of the anal furrow (AF), and just below it a pad attached to the anal margin (AM) of the hemelytra. The setae and the pad together form a sort of clutch inside which the caesura, the thickened margin of the hindwing, gets firmly fixed at the time of flying. The hemelytra form the main organ of flight (Weber 1930) while the hindwings passively adhere to the forewings. This wing-coupling device is uniform in the species *Dalpada versicolor*, *Dorpius indicus*, *Bagrada picta*, *Nezara antennata*, *Macroscytus expansus*, and *Aethus indicus*.

In *Chrysocoris stockerus* Linn. (Scutelleridae) the coupling apparatus consists of a single large-knobbed structure (Plate, fig. 2) hanging ventrally from the base of the anal margin of the clavus region. During flight this knob-like structure fits into the depression of the hindwing formed by the thickened marginal subcosta (Plate, fig. 3).

With more information about the wing-coupling apparatus in the different families it should be possible to ascertain the taxonomic value of these structures. Besides, such studies are likely to throw light upon the interrelationship of the different families.

Thanks are due to Professor A. K. Datta Gupta for supervising the work and to the Director, Birla Institute of Technology and Science, Pilani, for providing necessary facilities.

Department of Zoology,
B.I.T.S., Pilani (Rajasthan), S. C. GOEL
October 20, 1965.

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15. BIOLOGY OF *CHRYSOPA LACCIPERDA* KIMMINS

(*With two text-figures*)

The material for the study of *Chrysopa lacciperda* Kimmins (Neuroptera : Chrysopidae) was collected on *Kusmi* crops on *kusum*, *Schleichera oleosa* (Lour.) Merr., from the experimental plantations at Namkum and Hesal (about nine miles apart) in Ranchi District

and from *Rangeeni* crops on *palas*, *Butea monosperma* (Lamk.) Taub., at Namkum during July-September 1951, while studying the bionomics of *Chrysopa madestes* Banks. This is a new species and has been described by Kimmins (1955).

Egg. Stalked, laid singly. Bigger than most chrysopid eggs, light green to bluish green. Length of eggs 1·04 mm.; width 0·50 mm.; length of stalk 7·0 to 11·25 mm. Average incubation period 2·3 days (variation 2-4 days for 96 eggs).

Larva (Fig. 1). Passes through three instars. Two pairs of narrow bands on dorsum of head, which are faint in the first

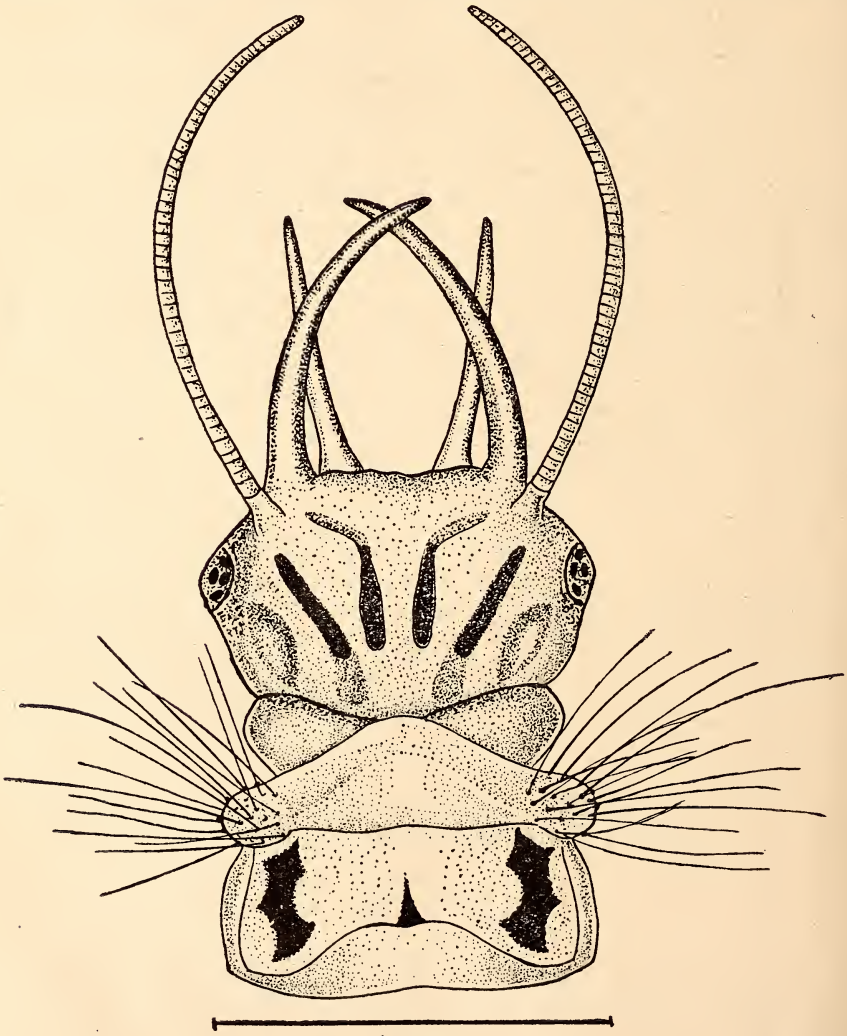

Fig. 1. Head and prothorax of third instar larva of *Chrysopa lacciperda*

instar but black and prominent in the second and third instars; the inner pair arising as faint bands from the inner margin of the base of antennae, converging at mid-line and becoming distinctly black, running posteriorly and ending a little beyond half way; the outer pair arising as distinct black bands from the outer margin of the base of antennae, converging towards the posterior ends of the inner bands and continuing as faint patches till the posterior margin of the head; a faint broad patch between each eye and the posterior margin of the head. A black patch towards each of the outer margins and a black triangular patch touching the posterior margin on the mid-line on the prothorax. Average durations of first, second, and third instars 3·8, 3·2, and 7·3 days (variation 3-7, 3-4, and 6-9 days for 10 larvae) respectively.

Pupa. Cocoon slightly elongate spherical, of dense, pure white silk. Length of cocoon 3-4 mm.; width 2·8-3·7 mm. Changes during the development can be faintly followed through the cocoon. The average duration 7·5 days (variation 4-11 days for 10).

Adult. The adult has been described in detail by Kimmins (loc. cit.). The expanse of the forewings, hindwings, and the length of the body of female 34-40 mm., 30-36 mm., and 13-16 mm. respectively, and of male 30-36 mm., 26-32 mm., and 9-11 mm. respectively. Average longevity of the laboratory-bred females 8·0 days (variation 3-15 days for 6) and of males 6·0 days (variation 1-11 days for 6) and of field-collected females 20·3 days (variation 7-48 days for 6) and of males 12·5 days (variation 2-36 days for 6). Ratio of males to females of the laboratory-bred adults 1 : 1 (total 26 adults: males 13 and females 13) and of the field-collected adults 3 : 4 (total 43 adults: males 19 and females 24).

Abnormality in egg-laying (Fig. 2). An egg with 0·62 mm. stalk was found attached to another egg-bearing stalk (7·75 mm. long) at a distance of 2·5 mm. from the lower end.

Natural enemies. Telenomus sp. (Chalcidoidea: Scelionidae) was the only egg-parasite reared during this study. *Cheiloneurus* sp.(Chalcidoidea: Encyrtidae), *Perilampus* sp. near *hedychroides* Walk. (Chalcidoidea: Perilampidae), and *Brachycurtus* sp. (? *eublemmae* Rao; Gupta 1964) (Ichneumonidae) were reared from the cocoon.

Acknowledgements

The author wishes to thank Dr. G.S. Misra, Director of the Institute, and Dr. A. Bhattacharya, Entomologist, for encouragement, Messrs.

R. D. Eady, G. J. Kerrich, and G. E. J. Nixon of the Commonwealth Institute of Entomology for the identification of the parasites, and

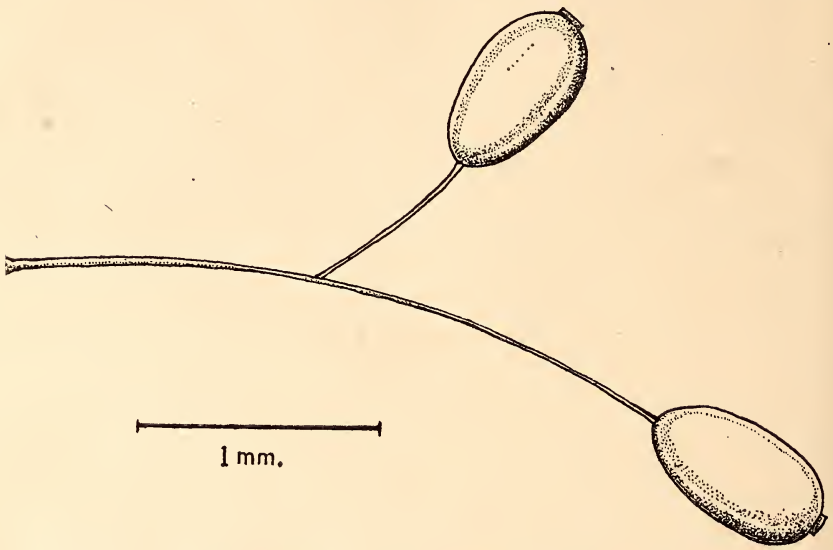

Fig. 2. Abnormality in oviposition of *Chrysopa lacciperda*

Mr. R. L. Singh, Artist and Photographer, for the figures appearing in this note.

DIVISION OF ENTOMOLOGY,
INDIAN LAC RESEARCH INSTITUTE,
NAMKUM, RANCHI,
November 18, 1965.

B. P. MEHRA
Scientific Officer

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16. PARTHENOGENETIC REPRODUCTION IN *ANASTATUS COLEMANI* CRAWFORD (HYMENOPTERA : EUPELMIDAE)

Observations on parthenogenetic reproduction in *Anastatus colemani* Crawford (Hymenoptera : Eupelmidae) were made during studies on the egg-parasites of *Tessaratoma javanica* Thunberg (Hemiptera : Pentatomidae).

Eleven unmated female *A. colemani* were confined, each in a muslin sleeve, on tender branches of *Kusum* [*Schleichera oleosa* (Lour.) Merr.]

together with a pair of *T. javanica*. The bug provided eggs for parasitisation, which were examined daily and parasitised ones removed. If required, fresh host-eggs were provided from cages specially maintained for the purpose, care being taken that no parasite was trapped inside or could enter these cages.

The average pre-oviposition period for an unmated female parasite was found to be 6·4 days (variation 1-13 days for 10 females), which is more than half of that for a mated female (average 9·4 days, variation 4-15 days for 5 females); the oviposition period was 10·4 days (variation 1-24 days for 10 females), which is nearly double that for a mated female (average 5·4 days, variation 2-12 days for 5 females). The average number of eggs laid by one unmated female in a day was 29·9 eggs (variation 3-55 eggs for 10 females), and the maximum number laid by one unmated female in a day 14. Both these figures are higher than those for the mated females (average 17·1 eggs, variation 7-46 eggs for 7 females ; maximum 9 eggs). The average longevity of the unmated female was found to be 18·9 days (variation 9-44 days for 11 females), which is nearly double that for a mated female (average 8·8 days, variation 1-44 days for 362 females).

Of a total of 264 parthenogenetic parasites bred from eleven unmated females, only two were females from two different mothers and the rest males. This type of reproduction has not been recorded in Eupelmidae so far. The life cycle of the two parthenogenetic females extended over 13 and 16 days and longevity to 17 and 3 days respectively. The life cycle of the parthenogenetic males extended to an average of 17·2 days (variation 11-142 days for 262 males). The variation of life cycle during the different parts of the year was on the average 17·1 days (variation 11-21 days for 162 males) during September to October 1955, 139·3 days (variation 138-142 days for 3 males) during October 1955 to March 1956, and 13·4 days (variation 11-17 days for 97 males) during March to April 1956. The longevity of the males was found to average 2·2 days (variation 1-10 days for 213 males). The variation of longevity during the different parts of the year was: average 2·2 days (variation 1-7 days for 162 males) during October 1955, average 8·0 days (variation 4-10 days for 3 males) during March 1956, and average 2·0 days (variation 1-5 days for 48 males) during April 1956.

The author is thankful to Dr. G. S. Misra, Director, and Dr. A. Bhattacharya, Entomologist, for their keen interest.

Division of Entomology,
Indian Lac Research Institute,
Namkum, Ranchi,
December 11, 1965.

B. P. MEHRA

17. INSTINCTIVE BEHAVIOUR IN A WASP, *ODYNERUS* SP.

A little solitary wasp, *Odynerus* sp., dark reddish brown with yellow markings, frequently makes its nest in houses, stuck on to the wall in any convenient place. The nest is a thin-walled mud tube, about 17 mm. long, with a kind of 'spout' at one end. It is divided by a partition in the middle into two cells, where the two eggs are laid, and is provisioned with small caterpillars. The young wasp cuts a round hole in the nest wall to escape.

Some time ago I took a nest from the wall, removing it carefully without breaking it. On examination I found that the tube had not been fashioned where it was adjoining the wall, the wall itself forming that side of the nest. Thus when it was removed, on one side was an open jagged hole, and a wasp could be clearly seen. It had just emerged from the pupa skin and was engaged in gnawing its way out through the mud wall on the opposite side. This it continued to do, though it could at any moment have walked out of the gaping open side. After about 15 minutes it had cut a hole large enough, through which it crawled to escape.

It seems necessary for the wasp to complete the instinctive chain of actions designed for its escape in normal circumstances. When the circumstances are altered and the whole chain of actions is no longer necessary, it is unable to change its behaviour or omit any part.

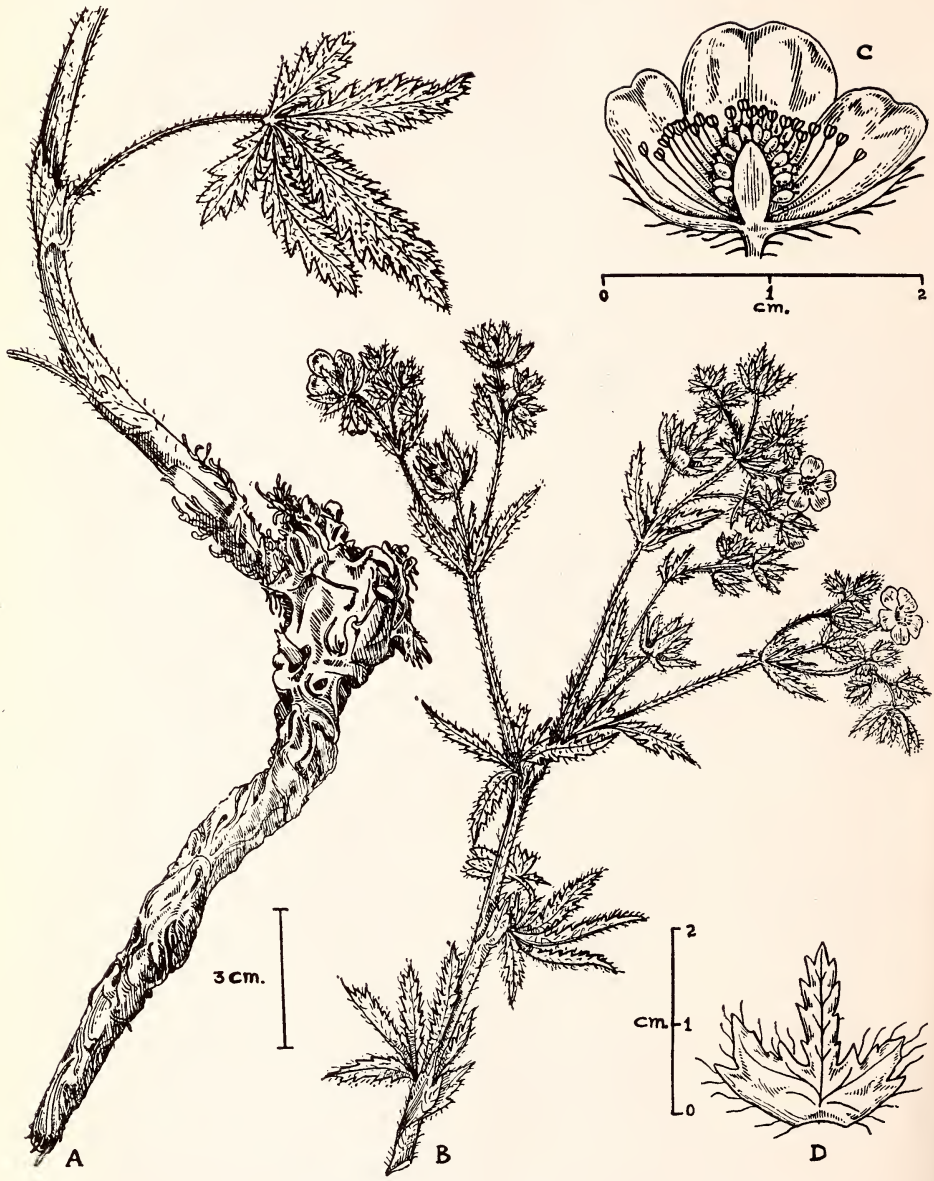
PANCH HOWD,
POONA 2,
March 28, 1966.

F. L. WAIN, S.S.J.E.

18. *POTENTILLA RECTA* LINN. : A NEW RECORD FOR INDIA

(*With a plate*)

During a floristic exploration of Pangi Valley, Chamba District, Himachal Pradesh, in July 1964, the author collected a few specimens from a natural population of a species of *Potentilla* from Kilar at an altitude of 2625 m. This plant could not be compared with any of the Indian species of *Potentilla* and on scrutiny turned out to be *P. recta* Linn. which is a European and N. Asiatic taxon. It appears that there is no previous report on this taxon from India and therefore it is described and illustrated here. The specimens are deposited in the Central National Herbarium, Sibpur, Calcutta, and the Herbarium of the Botanical Survey of India, Northern Circle, Dehra Dun, under the collection No. *N. C. Nair* 32556.



Potentilla recta Linn.

Fig. A. Rootstock. Fig. B. Flowering branch. Fig. C. Longitudinal section of flower. Fig. D. Stipule.

Potentilla recta Linn. Sp. Pl. 499, 1753.

Stout erect herbs. Branches many from a thick woody base. Stem 30-70 cm. high, leafy, dichotomously branched above, villous with long white hairs, pubescent, more or less glandular. Basal leaves palmately 5- to 7-foliate, long-petioled; petiole 3-7 cm. long, sheathing. Upper leaves gradually becoming almost sessile, 3- to 5-foliate or simple and tripartite. Leaflets of lower leaves oblong, obovate, oblanceolate or lanceolate, variable in length and breadth, 4-9 × 0·6-2 cm., terminal leaflet largest; leaflets of upper leaves linear; all sessile and with 7-17 deltoid teeth on either side, villous, veins prominent beneath. Stipules adnate to the petiole, trifid, up to 2 cm. long, hairy. Cymes many flowered with strongly ascending branches. Bracts trifid, 8-10 mm. long, pilose. Flowers shortly stalked, 1·5-2 cm. across, yellow; pedicel of the central flower of each dichasium longest, up to 1·5 cm., others shorter, all pilose or pubescent or both. Epicalyx of 5 episepals equalling and alternating with the sepals, all linear, 6 mm. long, pilose or hispid with white hairs, more so towards the base. Petals obcordate, deeply emarginate, slightly exceeding or equalling the sepals. Stamens 30-35, shorter than petals. Carpels many, glabrous with short styles thick at the base. Stigmas dilated. Achenes half ovoid, vertically wrinkled, glabrous.

The taxon can be easily distinguished from other species of Indian *Potentilla* having digitately compound leaves with 5-7 leaflets as follows:

Flowers crimson or bright pink..... *P. nepalensis*

Flowers yellow

Flowers solitary axillary..... *P. reptans*

Flowers in branched cymes

Receptacle hairy, concealing the achenes

Flowers less than 1 cm. in diameter, achenes smooth..... *P. argentea*

Flowers more than 1 cm. in diameter, achenes wrinkled

Flowers in capitate leafy heads..... *P. desertorum*

Flowers in spreading cymes..... *P. kashmirica*

Receptacle hairy, not concealing the achenes

Flowers less than 1 cm. in diameter, stipules linear lanceolate..... *P. kleiniana*

Flowers more than 1 cm. in diameter, stipules trifid..... *P. recta*

ACKNOWLEDGEMENTS

In conclusion I am thankful to the authorities of the Forest Research Institute, Dehra Dun, for herbarium facilities and to Dr. M. A. Rau for encouragement.

BOTANICAL SURVEY OF INDIA,
63 RAJPUR ROAD,
DEHRA DUN,
February 3, 1966.

N. C. NAIR

19. *COLEOCHAETE PULVINATA* A. BR. FROM GUJARAT, INDIA : A NEW RECORD

(*With three text-figures*)

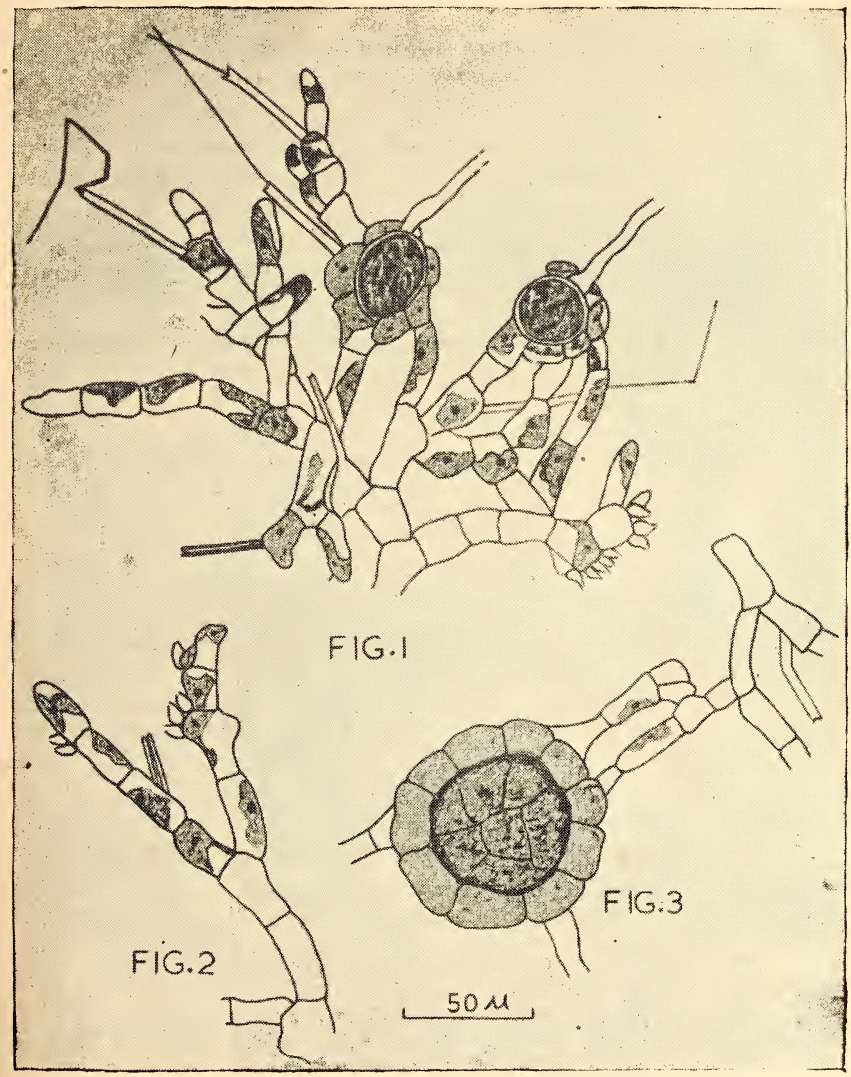
Four species of *Coleochaete* have been recorded from India, namely *C. scutata* Breb., *C. soluta* Pringsh., *C. orbicularis* Pringsh., and *C. nitellarum* Jost. (Biswas 1949, Prasad & Srivastava 1965). The growth is prostrate in all species of *Coleochaete* described so far, except in *C. pulvinata* A. Br. which is heterotrichous in habit (Fritsch 1956, Smith 1950). The present record of *C. pulvinata* from Gujarat is an addition to the Indian algal flora.

The present material was collected in October 1964, from Gangda Pond at Valavao, Baroda District (Gujarat). Two species of *Coleochaete*, *C. orbicularis* Pringsh. and *C. pulvinata* A. Br., occurred together as epiphytes on *Najas*. *C. pulvinata* A. Br. was attached to the leaves of *Najas*, as a hemispherical heterotrichous mass of loosely-arranged branched filaments, surrounded by a mucilaginous envelope and easily detachable.

The plant is irregularly branched. Each cell is generally rectangular and is uninucleate with a single laminate chloroplast and a single pyrenoid within it. The cells are 11·0-15·0μ broad and 22·0-34·0μ long. Some terminal cells bearing antheridia have the diameter up to 19·0μ. In general the cells are 2-2½ times as long as broad. Some cells show a long unbranched seta with a basal gelatinous sheath *c.* 39·6μ long (Fig. 1).

No zoospores or other spores of asexual type were observed in the material. The plant showed different stages of sexual reproduction. It is homothallic. The antheridia and oogonia are borne by different branches of the same plant.

The antheridia are borne in clusters and are laterally placed on first two or three terminal cells of the branches. They are bluntly



Figs. 1-3. *Coleochaete pulvinata* A.Br.

1. Portion of plant, showing branches, setae, oogonia, and antheridia ;
2. Empty antheridia on first three terminal cells ; 3. Spermocarp

conical in shape and are up to 11·0μ long and 3·8μ broad near the base. The antherozoids are liberated by the terminal pores (Figs. 1 and 2).

Oogonia are borne singly at the apices of the branches. In the

majority of cases, fertilized oogonia were observed. The long-necked trichogyne of the oogonium is 45·7-47·0μ long and 5·6μ broad. The egg after fertilization becomes enlarged and fills the whole oogonium. Hence, the walls of the oogonia and oospores are not distinctly marked. The oospore is spherical, a recently-formed oospore being 26·0μ in diameter. The oospore becomes enormously enlarged. At the same time, the cells below the oogonium and those of the neighbouring filaments give rise to branches which envelop the whole oogonium leaving the long trichogyne protruding. Finally, the fructification (spermocarp) is developed. The spermocarp is spherical and 90·5μ in diameter. The central fertile region, about 56·5μ in diameter, is surrounded by a sterile jacket layer of ten cells (Fig. 3).

The general description of the species agrees with that of *C. pulvinata* A. Br. as given by earlier authors (Fritsch 1956, Smith 1950).

DEPARTMENT OF BOTANY,
SARDAR VALLABHBHAI VIDYAPEETH,
VALLABH VIDYANAGAR, GUJARAT,
January 7, 1966.

R. J. PATEL

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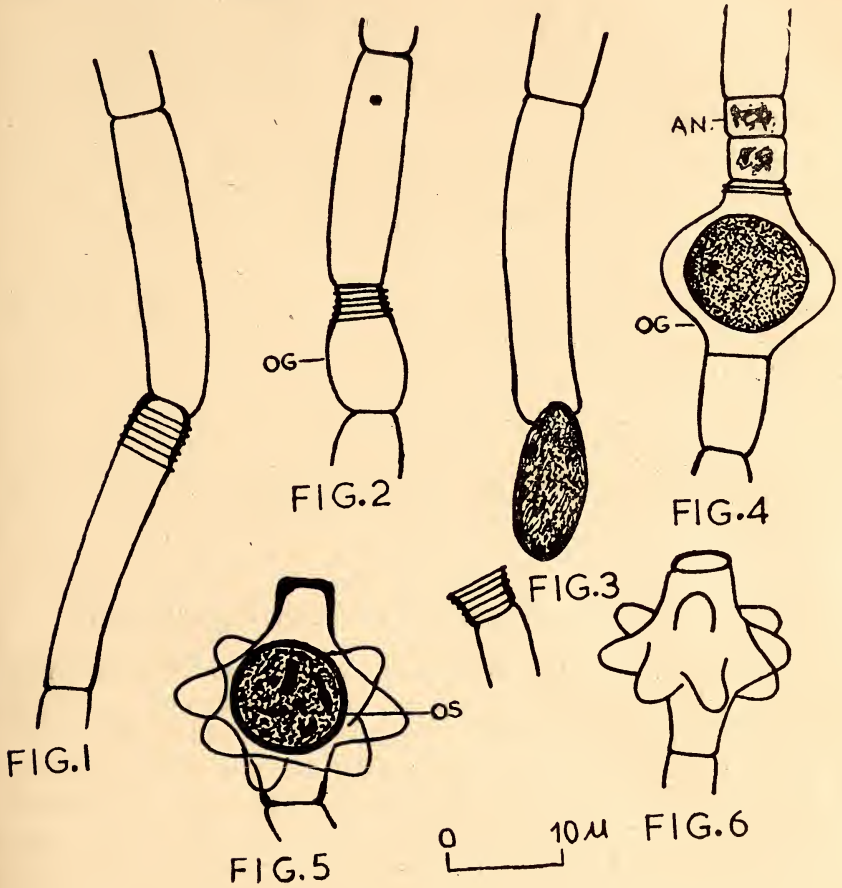
20. OCCURRENCE OF THE ALGA *OEDOGONIUM ITZIGSOHNII* VAR. *MINUS* FROM MAHABALESHWAR, INDIA

(*With six text-figures*)

The occurrence of *Oedogonium itzigsohnii* var. *minus* from India is reported here for the first time. Probably it is a new record for Asia. The material was collected in the third week of October 1954 from roadside ditches in the vicinity of Old Mahabaleshwar. The material is deposited in the Botany Department, Sardar Vallabhbhai Vidyapeeth, Vallabh Vidyanagar.

It is free floating, and is found mixed with other members of the Chlorophyceae and Cyanophyceae. The filaments are 4·3-5·7 μ in diameter. The cells are six to seven times as long as broad (Fig. 1). Zoospore formation was not seen but the content, converted into a

cylindrical structure, was found liberated through a transverse opening near the cap-cells (Fig. 3).



Oedogonium itzigsohnii var. *minus*

Fig. 1. Nature of filament; Fig. 2. Development of an oogonium (OG) in a filament; Fig. 3. Liberation of zoospore; Fig. 4. Oogonium (OG) and two antheridia (AN); Fig. 5. Mature oospore (OS) with processes on the wall of the oogonium; Fig. 6. Obtusely conical processes on the wall of oogonium

The plant is monoecious. The antheridia are epigynous (Fig. 4, AN). They are paired in a majority of cases. Development of oogonium is similar to that of other species of *Oedogonium* (Fig. 2). Oogonia occur singly in the filament. Occasionally two oogonia, side by side, were observed. Length of the oogonium 17·7-22·8 μ, diameter 22·8 μ (Fig. 4, OG). Before fertilization 8-10 obtusely conical processes are developed on the oogonial wall (Figs. 5 and 6). The opening of the oogonium is poriferous. The oospore within the oogonium is spherical

with a smooth thick wall, measuring 11.4-14.3 μ in diameter (Fig. 5, os).

The present plant agrees with the description of *Oedogonium itzigsohnii* var. *minus* given by Hirn (1900) and Tiffany (1930), but its dimensions are smaller. Plants of this species with smaller dimensions are reported by West & West (1903)[1] and Margalef[1] from Angola and Spain respectively.

The writer is grateful to Prof. E. Gonzalves for her valuable suggestions and for going through the manuscript. Thanks are also due to Principal J. G. Chohan for his interest in the work.

BOTANY DEPARTMENT,
SARDAR VALLABHBHAI VIDYAPEETH,
VALLABH VIDYANAGAR, GUJARAT,
February 18, 1966.

R. J. PATEL

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21. NEW PLANT RECORDS FOR SOUTH INDIA—III

The occurrence of three more species of plants so far not recorded in south India is reported in this paper, in continuation of new records I & II (*J. Bombay nat. Hist. Soc.* **53**: 523-26 and **54**: 925-27).

All the three species, viz. *Tournefortia argentea* Linn. f. (Boraginaceae), *Syzygium aqueum* (Burm. f.) Alston (Myrtaceae), and *Dichrostachys muelleri* Benth. (Mimosoideae), reported herein have been recorded by 'Trimen' (1894) in A HANDBOOK TO THE FLORA OF CEYLON while their occurrence has not been recorded by Gamble (1924) in THE FLORA OF THE PRESIDENCY OF MADRAS.

1. **Tournefortia argentea** Linn. f. Suppl. 133. 1781.

A small tree, 3-3·5 m. tall, trunk short, bark deeply furrowed, pale, branchlets thick, marked with scars of the fallen leaves, twigs densely silky-pubescent; leaves large, simple, entire, closely placed at the ends of branches, leaves 11-14×4-6 cm., oval or obovate, much tapering to base with rounded or obtuse apex, fleshy covered with close silky-white adpressed hairs; petiole short 0·6-0·8 mm. and stout, venation prominent with a strong midrib and 4-6 lateral veins. Flowers, numerous, sessile in peduncled cymes, spreading. Sepals 5, ovate densely silky

[1] Information communicated by Prof. E. Gonzalves, St. Xavier's College, Bombay.

hairy; corolla rotate, over 1 cm. in diameter, 5-lobed; stamens 5 included in the tube, filaments short, anthers sessile, large at the throat of the corolla; stigma subsessile obscurely two-lobed. Fruit subglobose, minutely operculate brown pyrenes.

This species was found to occur in the Krusadi Island, Ramanathpuram District, and was collected by S. V. Parthasarathy and S. R. Raju in February, 1947 (Madras Agricultural College Herbarium, No. 4409).

2. **Syzygium aqueum** (Burm. f.) Alston in Ann. Roy. Bot. Gard. Peradeniya **11**: 204. 1929. (Syn. *Eugenia aquea* Burm. f.).

An evergreen tree, all parts glabrous; leaves variable, those of the young shoots often elongate, oblong-linear, thin, the older ones oblong to ovate-oblong, 20-25 cm. long; petiole very short almost obscure or absent. Flowers large, whitish on a short 2-3 cm. long pedicel, solitary or in threes, forming short or compact cymes at the ends of branches, calyx 1-1·5 cm. long, clavate, smooth, 4-lobed, the lobes being persistent, twice as broad as long; petals 4, broader than long, rounded, free; stamens numerous, in many rows, filaments long, slender, anthers small; style filiform, stigma small with many ovules in each cell. Fruit berry crowned by inflexed calyx lobes, 1-4 seeded with many abortive seeds, seeds compressed.

This species has been collected from Manjolai in Singampatti forests of Tirunelveli District by D. Daniel Sundararaj in July, 1958 (Madras Agricultural College Herbarium, No. 4408).

3. **Dichrostachys muelleri** Benth. Fl. Aus. **2**: 299, 1864. (Syn. *Neptunia spicata* F. Muell.)

Much branched thorny rigid shrubs or small trees, 3-5 m. tall, bark grey coloured, furrowed, branchlets glabrous or slightly pubescent and ending in spines. Leaves bipinnate, primary rachis 1-2 cm. long, glabrous with a small gland between each pair of pinnae, pinnae paripinnate, 1-2 pairs, rather distant, 1·5-2 cm. long; leaflets sessile, 6-8 pairs, close to one another, 6-7 × 2-3 mm., oblong-linear, somewhat obtuse at the apex, glabrous on both sides, stipules 1-2 mm. long, subulate from a triangular base. Flowers dense in axillary long pedunculate spikes, 3-4 cm. long, the upper part of the spike not so crowded as the rest and arranged in a lax manner with long pale whitish purple staminodes. Calyx membranous, companulate, shortly five-toothed, 0·2-0·3 mm., petals 5, united to one-third their lengths, 1·5-1·8 mm. long, stamens 10, free, exserted, 2·5 mm. long; ovary subsessile, style filiform, stigma terminal, truncate. Pods linear, compressed, glabrous, 8-10 × 0·9-1·3 cm., twisted up when ripe. Seeds 6-10, each 5 × 4 mm., obovate, compressed, brownish.

D. muelleri Benth. differs from *D. cinerea* W. & A. commonly found in India in having only 1 or 2 pairs of pinnae each with 6-8 pairs of

slightly bigger leaflets compared to *D. cinerea* which has 8-10 pairs of pinnae and 12-20 pairs of leaflets in each pinna. In addition, the flowers in *D. muelleri* are arranged in long (3-4 cm.) pedunculate spikes with the neuter flowers in the lower part of the spike set in a lax manner while the spike in *D. cinerea* is shortly (1·5-2 cm.) pedunculate with the hermaphrodite and neuter flowers arranged evenly.

This species has been collected from the following four places in south India, viz. Kudiraimalai theri, Nazereth, Tirunelveli District, by D. Daniel Sundararaj in December, 1944 (Madras Agricultural College Herbarium, No. 4411); Krusadi Islands, Ramanathapuram District, by D. Daniel Sundararaj in May, 1946 (Madras Agricultural College Herbarium, No. 4410); Rameswaram Island, Ramanathapuram District, by M. Nagarajan in May, 1962 (Madras Agricultural College Herbarium, No. 4412); Puli Island, Ramanathapuram District, by D. Daniel Sundararaj and S. R. Raju in September, 1944 (Madras Agricultural College Herbarium, No. 4413).

The first mentioned place is in the sandy tract in Tirunelveli District about twelve miles from the east Coast and the region is in the southernmost part of the Indian peninsula. The three other habitats are islands n the Gulf of Mannar in Ramanathapuram District.

AGRICULTURAL COLLEGE
& RESEARCH INSTITUTE,
COIMBATORE, S. INDIA,
April 22, 1964.

D. DANIEL SUNDARARAJ
M. NAGARAJAN

Notes and News

An old member, on William the Hornbill

We are glad to publish a letter received from one of our oldest members Lieut.-Colonel M. L. Ferrar, after whom Ferrargunj mentioned by Mr. Humayun Abdulali in his recent paper on the birds of the Andamans and Nicobars is named. He writes: 'It gave me very great pleasure to find in your new issue of the B.N.H.S. Journal so full an account of the opening of Hornbill House, surprise too for I had not been aware of the intention to name the house after old William, the acquaintance, indeed the friend, of so many members of the Society and their friends. How well I remember introducing him to my bride when I brought her out to Bombay in January 1913 and how fitting it is that his memory should have been preserved in this manner.'

Donation of Equipment

Our resources for conducting research in field ornithology have been enriched through the generosity of the executors of the late Dato Loke Wan Tho, who have presented to the Society through Dr. Sálim Ali a Nagra III Bird Call Tape Recorder.

Bird Photograph Negatives of Loke Wan Tho and Lt.-Col. R. S. P. Bates

We are indebted to the executors of the late Dato Loke Wan Tho who have presented to the Society through Dr. Sálim Ali the testator's collection of negatives of bird photographs taken by him and by the late Lt.-Col. R. S. P. Bates.

Recognition of the Society for Ph.D. guidance in Field Ornithology

The University of Bombay has recognized the Society, with Dr. Sálim Ali as guide, for research studies leading to the Ph.D. Degree in Field Ornithology.

International Union for Conservation of Nature

At the 8th General Assembly of the International Union for Conservation of Nature recently held at Lucerne Mr. Zafar Futehally, who attended as the Society's representative and non-official delegate from India, was elected a member of the Executive Board of the IUCN for a period of six years from July 1967.

Bhutan Bird Survey

As reported in the last issue of the *Journal* Dr. Sálim Ali assisted by Mr. J. D. Panday and Mr. M. J. Pereira spent the months of February and March in Bhutan, collecting and studying the avifauna of mainly eastern Bhutan. Among others, noteworthy additions to the Society's Collections are Ward's Trogon (*Harpactes wardii*) and the Slenderbilled Babbler (*Turdoides longirostris*).

Nicobar Bird Survey

Mr. Humayun Abdulali assisted by Mr. B. R. G. Grubh and Mr. P. B. Shekar of the Society's staff spent the period 25th February to 12th April in various islands of the Nicobar group collecting and studying the bird and other fauna of the islands. A report on these collections will be published in a future issue of the *Journal.*

UNESCO-National Institute of Oceanography (CSIR) Training Programme in Oceanography

Twenty-five candidates from various institutions and universities in India and SE. Asia were given a four-weeks course in General Oceanography at Hornbill House in February 1966 and, later, two weeks of specialized training at other centres in India.

Indian Association of Biological Sciences (IABS)

We are glad to announce the foundation in January 1965 of the Indian Association of Biological Sciences. The IABS has the following aims: to unite the various biological societies in India and to promote the advancement of biological knowledge; to participate in the activities of governmental and non-governmental agencies in which biologists need representation; to hold meetings of biologists annually or biennially on a nation-wide basis; and to organize symposia on important biological topics. The Association hopes to start a bimonthly bulletin somewhat on the lines of *Bioscience* to popularize the study of biology. The members will be of two categories:

(*a*) Adhering Societies: Open to biological societies in India. Annual fee, 2% of their total annual membership fee and subscriptions;

(*b*) Individual Members: Annual fee, Rs. 10

Persons interested may write to the Secretary, IABS, Department of Botany, University of Delhi, Delhi-7.

Services of UNESCO Archives, Paris

UNESCO intimates for general information the setting up, at its headquarters in Paris, of the UNESCO Archives, intended for affording service to research workers, students, and other persons who may be interested. The Archives have a collection of about 217,000 pieces of documentation, with inventories, indexes, and lists of various

kinds of materials to facilitate consultation. The Staff regularly compiles a quarterly list of UNESCO documents and publications in English and French, and indexes the records of the UNESCO General Conference and of the UNESCO Executive Board meetings. Enquiries for information may be addressed to: Services of UNESCO Archives, UNESCO, Place de Fentency, Paris 7e.

Lepidopterological Society of Japan Expedition to the Nepal Himalayas and the Malayan Peninsula

While forwarding to us its first Special Bulletin (see book review, at page 188 above) the Lepidopterological Society of Japan, c/o Ogata Hospital, 3-18 Imabashi, Higashi-ku, Osaka, Japan, intimates that it intends to publish in succession the results of its expedition to the Nepal Himalayas and the Malayan Peninsula.

Wild Life Bulletin

We welcome the publication as from June 1965 of *Wild Life Bulletin*, issued by the Indian Board for Wild Life 'with a view to publicize the activities of the Board, its standing Committee and its Bird and Zoo Wings as well as to disseminate useful and up-to-date knowledge on wild life'. For the present the *Bulletin* is to be published half yearly. The Editorial Board has issued an appeal to those who have interesting information on wild life to write either to the Regional Secretaries of the Board or to the Honorary Editor, *Wild Life Bulletin*, Ministry of Food and Agriculture (Department of Agriculture), Krishi Bhavan, New Delhi-1.

Increase in Society Membership Fees

Commencing from 1 January 1967 there will be an increase in Society membership fees as follows:

Ordinary Members. Annual Subscription: Inland Rs. 36 instead of Rs. 30. Foreign £ 3 or its equivalent in US $ 8·50.

Life Members. Contribution: For members of not less than 20 years' standing, Rs. 180 (£ 14) instead of Rs. 150 (£ 11-6-0); for others, Rs. 600 (£ 45-10-0) instead of Rs. 500 (£ 38).

Corporate Bodies. Compounded subscription for 25 years: Rs. 600 (£ 45-10-0) instead of Rs. 500 (£ 38).

Entrance Fee. Rs. 5 (£ 0-7-10) as at present.

The attention of intending life members and of corporate bodies wishing to compound their subscriptions is drawn to the coming increase.

Gleanings

Eighty Years Ago

In May 1888 the Society in its monthly meeting unanimously decided that, as the condition of the animals in the Victoria Gardens was not satisfactory as the Municipality could not reasonably be expected to form a zoological collection at the ratepayers' expense and was prevented by the Government's ruling from charging an entrance fee, the Society would establish and run a zoo. In pursuance of this resolution two letters were issued. One asked the Collector of Bombay for a grant from Government of ' the Chowpatty cliff, extending from the footpath leading up the hill, on the right (formed by the main water pipe) to the Siri Road on the left, including the vacant land at the foot of the hill '— in view of the condition of the land, which was then vacant, the letter described it as of little value for building purposes ! The other letter, addressed to the Municipality, offered to take over the animals then in the Municipal Zoo together with the cages, building materials, etc. and, in exchange for an annual grant equal to what the Municipality was then spending on the Zoo, to bind the Society not to charge on ' all recognized native public holidays ' an entrance fee exceeding 1 anna per adult and ½ anna per child. The project was energetically pursued and by the 6th of September about Rs. 54,000 had been raised, but the scheme fell through as Government refused the Society the use of the proposed site. The efforts of the Society were not wasted however, as they stirred up the Municipality to take up the improvement and enlargement of its collection in consultation with a Sub-committee appointed by the Society.

1888-9, *J. Bombay nat. Hist. Soc.* Vols. 3 and 4

Discarded Bottles collect distribution records of small mammals

In 1961 a milk bottle lying in a hedge was found to contain the remains of eight small mammals. In a deliberate search made in 1963-64 a considerable proportion of discarded bottles were found to contain the bones of small mammals. Now this method of trapping is being extensively used to collect distribution records of such mammals, for example in the London area and Dungeness in Kent.

1965, P. A. Morris and J. F. Harper, in *Proc. zool. Soc. London*, Vol. **145** : 148-153

Bullfrogs as members of an orchestra

' In 1951 the Blue Ridge Mountain Festival was held at Washington, Virginia. When the site of the concert was surveyed by the musical

director, he feared, at first, that Bullfrogs (*Rana catesbeiana*) in a nearby river would be a distraction and would therefore have to be cleared out. However, he was pleased to find that their musical quality was just right for the festival. He said, "I noticed that every time their leader, or leaders, croaked, he or they hit C-sharp right on the nose. The result was so pleasing, we're going to make it part of the programme."'

1958, James A. Oliver: THE NATURAL HISTORY OF NORTH AMERICAN AMPHIBIANS AND REPTILES, p. 29

Goldsmith, on the Joys of the Naturalist

'Some practice, therefore, much instruction, and diligent reading, are requisite to make a ready and expert naturalist, who shall be able even by the help of a system, to find out the name of every object he meets with. But when this tedious, though requisite part of study is attained, nothing but delight and variety attend the rest of his journey. Wherever he travels, like a man in a country where he has many friends, he meets with nothing but acquaintances and allurements in all the stages of his way. The mere uninformed spectator passes on in gloomy solitude; but the naturalist in every plant, in every insect, and every pebble, finds something to entertain his curiosity and excite his speculation.'

1840, Oliver Goldsmith, in the preface to his HISTORY OF THE EARTH AND ANIMATED NATURE

At an Australian Waterhole in a Drought

In an article illustrated with several colour photographs, Vincent Serventy describes a visit paid by him to Queen Victoria Spring in Western Australia, a famous waterhole on the edge of the Nullarbor Plain. There had been no rain for four months and no accessible water was visible. A little spade work repaired this defect. Early next morning small flocks of budgerigars were circling round. As the sun arose they were there in their thousands, undeterred by a falcon plunging down upon them. Frantically they gulped, even as an unfortunate companion was being devoured by a brown hawk. Flock by flock they took off after their drink, leaving tired members of the flock to the mercy of the crows that crowded round the pool. 'Dozens died, but thousands were saved.'

1963, Vincent Serventy, in *Animals* Vol. 2, pp. 470-1

Leopard and Buffaloes

A story comes from Ceylon of a leopard that caught a buffalo calf, about a day or two old, out of a stampeding herd of buffalo. The mother immediately charged and brought calf and leopard to the ground. The latter recovered, however, and carried the calf another 50 feet or so. In the meantime a bull from the herd joined in the fray and between

them the buffaloes succeeded in rescuing the calf, apparently not seriously hurt as it toddled away and was seen alive the next day.

1964, *Loris* Vol. **10** (1) : 27

[Lt.-Col. C. H. Stockley (1936) at page 182 of STALKING IN THE HIMALAYAS AND NORTHERN INDIA mentions that according to the Kashmiris a leopard will lie on a fawn without killing it till its bleatings draw the mother within attacking distance, and adds: 'Two reliable observers have told me of coming on a scene which would bear out this Kashmiri story, and in each case the interruption sent off the leopard and the calf (*sic*) was quite unhurt, although the leopard had been lying on it.'—EDS.]

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THE SOCIETY'S PUBLICATIONS

Mammals

The Book of Indian Animals, by S. H. Prater. 2nd (revised) edition. 28 plates in colour by Paul Barruel and many other illustrations. **Rs. 30**
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Birds

The Book of Indian Birds, by Sálim Ali. 7th (revised) edition. 64 coloured and many monochrome plates. **Rs. 25**
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A Synopsis of the Birds of India and Pakistan, by S. Dillon Ripley II. An up-to-date checklist of all the birds resident and migrant, including those of Nepal, Sikkim, Bhutan, and Ceylon. **Rs. 25**
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Identification of Poisonous Snakes. Wall chart in English, Gujarati, and Marathi. **Rs. 10**
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Butterflies of the Indian Region, by M. A. Wynter-Blyth. With 27 coloured and 45 monochrome plates. **Rs. 28**
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The Society will gratefully accept back numbers of the *Journal*, particularly numbers prior to Vol. 45, from members who may not wish to preserve them.

TERMS OF MEMBERSHIP

Life Members pay an entrance fee of Rs. 5 and a life membership fee of Rs. 500.
Ordinary Members pay an entrance fee of Rs. 5 and an annual subscription of Rs. 30.
The subscription of members elected in October, November, and December covers the period from the date of their election to the end of the following year.

MEMBERS RESIDING OUTSIDE INDIA

The terms are the same for members living outside India. Such members should pay their subscriptions by means of orders on their Bankers to pay the amount of the subscription, plus postal registration (Rs. 2.50) if required—in all Rs. 32.50—to the Society in Bombay on the 1st January in each year. If this cannot be done, then the sum of £2-10-0 should be paid annually to the Society's London Bankers—The National & Grindlays Bank Ltd., 26 Bishopsgate Street, London, E.C. 2.

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Journal of the Bombay Natural History Society

Vol. 63, No. 2

Editors
H. SANTAPAU, S.J.,
ZAFAR FUTEHALLY, & J. C. DANIEL

AUGUST 1966

Rs. 15

NOTICE TO CONTRIBUTORS

Contributors of scientific articles are requested to assist the editors by observing the following instructions:

1. Papers which have at the same time been offered for publication to other journals or periodicals, or have already been published elsewhere, should not be submitted.

2. The MS. should be typed (double spacing) on one side of a sheet only, and the sheets properly numbered.

3. All scientific names to be printed in italics should be underlined. Both in zoological and in botanical references only the initial letter of the genus is capitalized. The specific and subspecific names always begin with a small letter even if they refer to a person or a place, e.g. *Anthus hodgsoni hodgsoni* or *Streptopelia chinensis suratensis* or *Dimeria blatteri.*

4. Trinomials referring to subspecies should only be used where identification has been authentically established by comparison of specimens actually collected. In all other cases, or where identification is based merely on sight, binomials should be used.

5. Photographs for reproduction must be clear and show good contrast. Prints must be of a size not smaller than 8·20×5·60 cm. (No. 2 Brownie) and on glossy glazed paper.

6. Text-figures, line drawings, and maps should be in Indian ink, preferably on Bristol board.

7. References to literature should be placed at the end of the paper, alphabetically arranged under author's name, with the abridged titles of journals or periodicals underlined (italics) and titles of books *not* underlined (roman type), thus:

Banerji, M. L. (1958): Botanical Exploration in East Nepal. *J. Bombay nat. Hist. Soc.* **55** (2): 243-268.

Prater, S. H. (1948): The book of Indian Animals. Bombay. Titles of papers should not be underlined.

8. Reference to literature in the text should be made by quoting the author's name and year of publication, thus: (Banerji 1958).

9. *Synopsis:* Each scientific paper should be accompanied by a concise, clearly written synopsis, normally not exceeding 200 words.

10. *Reprints:* Authors are supplied 25 reprints of their articles free of charge. In the case of joint authorship, 50 copies will be given gratis to be distributed among the two or more authors. Orders for additional reprints should be in multiples of 25 and should be received within two weeks after the author is informed of the acceptance of the manuscript. They will be charged for at cost plus postage and packing.

EDITORS,
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1966 AUGUST Vol. 63 No. 2

An annotated list of the Butterflies of Delhi, India[1]

BY

JULIAN P. DONAHUE[2]

(*With two maps, a text-figure and three plates*)

ABSTRACT

A collection of over 5600 butterflies from Delhi, India, obtained from 1961 to 1965, contained 72 species. An additional five species have been reported in the literature or are represented by specimens in the Indian Agricultural Research Institute, New Delhi.

For each species the following information is given : habitat preference, flying time (seasonal), total number of specimens, number of specimens of each sex, the sex ratio, maximum and minimum sizes observed in the material examined (given as the length of one forewing), variation, and the distribution of the species in India.

Two diverse habitats were heavily collected : the xerophytic Reserved Forest on the Ridge, a low prolongation of the Aravalli Hills ; and the mesophytic Sundar Nagar Nursery. The Nursery, and other parts of the cities of Delhi and New Delhi, have been so heavily irrigated that they differ radically from arid native habitats, such as the Ridge.

The development of the mesophytic urban habitat perhaps accounts for the presence of 14 species found in mesic areas east of Delhi, but not found in the arid land west of Delhi. Conversely, three species of *Colotis* plus the hesperiid *Pelopidas thrax thrax*, which are characteristic of arid land west of Delhi, occur on the Ridge but do not occur

[1] The major part of a thesis submitted to Michigan State University in partial fulfilment of the requirements for the degree of Master of Science. Publication approved by the Department of Entomology.

[2] Department of Entomology, Michigan State University, East Lansing, Michigan 48823, U.S.A.

east of Delhi. Finally, *Pieris canidia indica*, *Colias electo fieldi*, and possibly *Argynnis hyperbius*, appear to be visitors from the Himalaya.

The greatest numbers and variety of butterflies are found during the monsoon season, from July through September, and afterwards through early November. The wet season form, in those species which have seasonal forms, usually occurs during the monsoon. But in at least six species (*Anapheis aurota*, *Cepora nerissa*, *Eurema hecabe*, *Colotis etrida*, *Ypthima inica*, *Precis almana*, and possibly *Precis orithya*) the colour pattern characteristic of the wet season appears as early as mid-April or May, two of the warmest, driest months of the year. This indicates that environmental factors other than humidity may be influencing the seasonal forms of these species.

The two female colour forms of *Colotis fausta faustina* are seasonal : the white form occurs during the monsoon ; the salmon-coloured form occurs at other times of the year.

Gongylus gongylodes (Orthoptera : Mantidae) is reported as a predator of *Colotis fausta*, and *Telenomus* (*Aholcus*) *talaus* (Hymenoptera : Scelionidae) is recorded as an egg-parasite of *Papilio demoleus demoleus* or *P. polytes romulus*.

The 'cyrus' female form of *Papilio polytes*, usually considered rare, is relatively common in Delhi.

The subspecies *minuta* Evans, originally ascribed to *Euchrysops pandava*, is merely the dry season form of *E. parrhasius parrhasius*, and is therefore a new synonym.

A list of 32 species which may occur in Delhi is included.

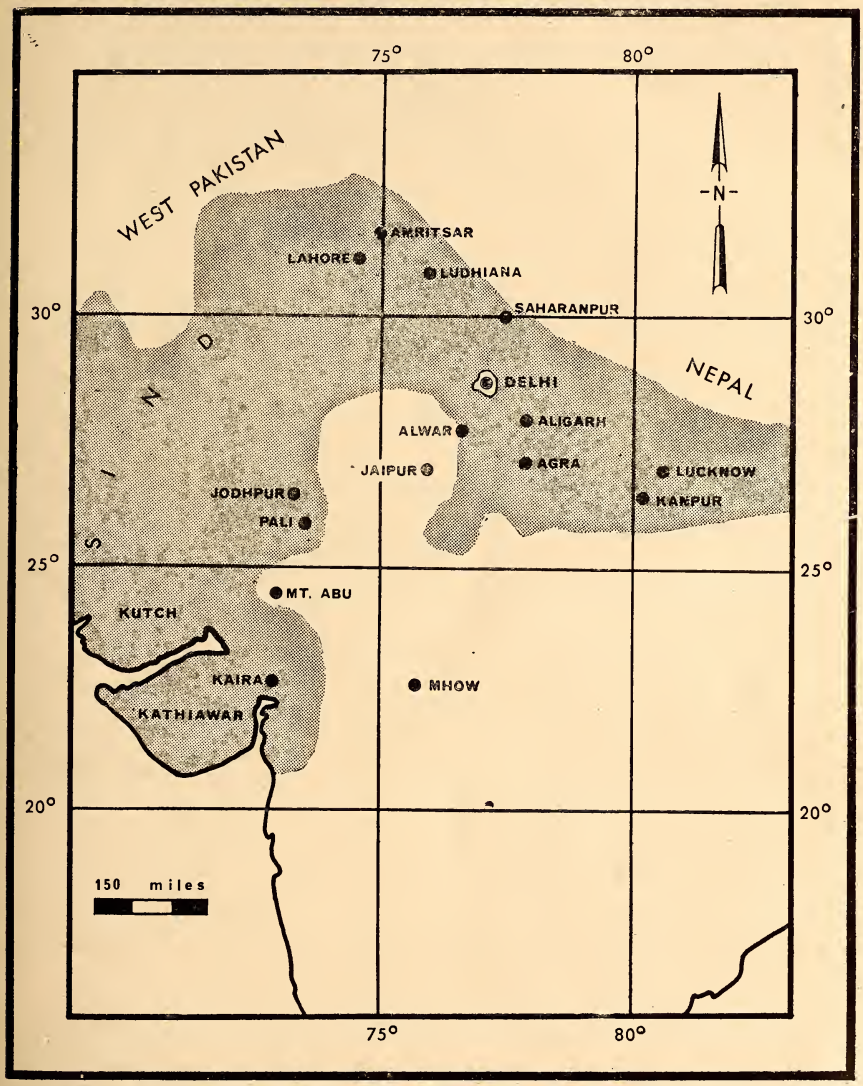
It is indeed surprising that no one has published a list of the butterflies of India's capital city, but the hot, arid climate of the north Indian plains has never been famous for inspiring the pursuit of Lepidoptera. Consequently, the only list of Delhi butterflies is a partial list of 21 species that Longstaff (1912) collected there in November 1903. Otherwise, no complete list is available for any locality nearer to Delhi than 250 miles.

Description of the Study Area

Delhi is a Chief Commissioner's State of 574 square miles, wedged between the States of Punjab and Uttar Pradesh, on the Indo-Gangetic Plain at lat. 28° 40'N., long. 77° 10'E. (Maps 1 & 2).

Although it was not possible to survey the entire State, large collections were made in two diverse habitats: the Sundar Nagar Nursery (Map 2, Plate I, figs. 1 & 2), a lush area between the Zoological Park and Humayun's Tomb, on the south-east side of the State; and the 'Ridge' (Map 2, and Plate II, figs. 3 & 4, Plate III, figs. 5 & 6), a low (200-300 feet) prolongation of the Aravalli Hill Range that gradually disappears as it extends north-east to the Jumna River, which flows from north to south on the east side of Delhi. Unless otherwise stated, specimens collected on the Ridge were obtained in a Reserved

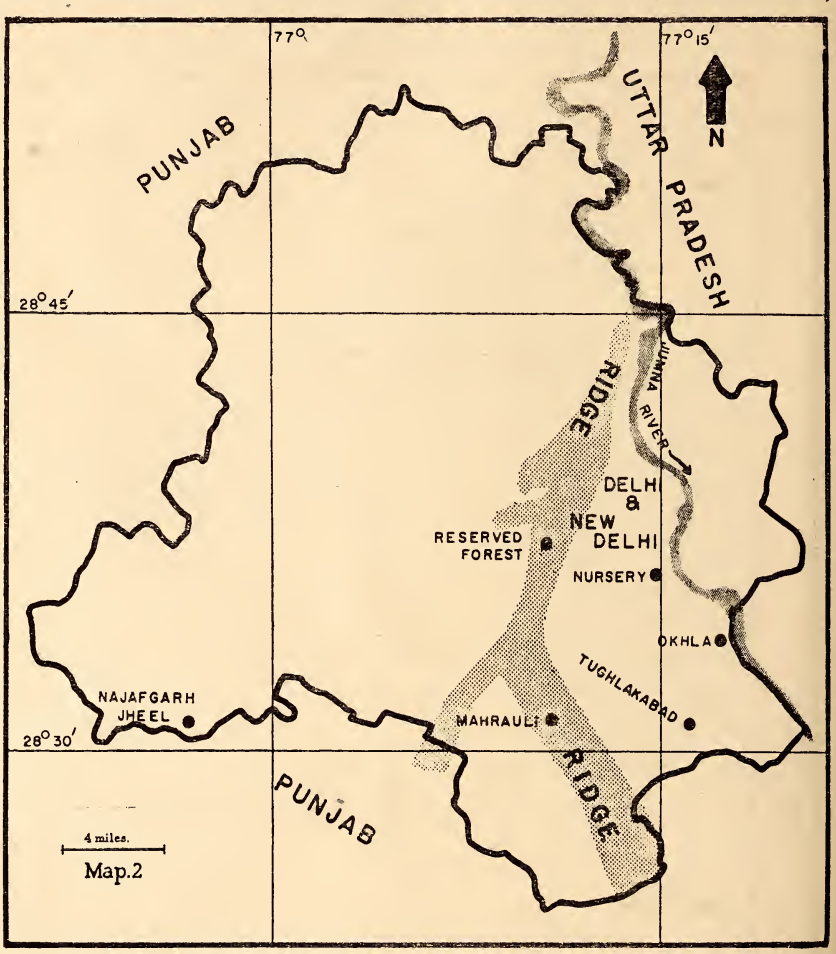
Forest west of the Ashoka Hotel, on either side of Link Road between Sardar Patel Road and Ridge Road (Map 2).



Map 1. Outline map of north-western India and West Pakistan, showing major collecting sites referred to in text. Approximate extent of Indo-Gangetic Plain is shaded.

The Nursery approaches a mesophytic habitat because of extensive irrigation throughout the year. Although flowers and shrubs are cultivated in much of the area, native grasses, shrubs, and trees occur in many parts of the Nursery (Plate I, figs. 1 and 2). Some Delhi butterflies, such as *Leptosia nina*, *Euploea core*, and, to a great extent, *Ypthima inica*, have been found only in restricted parts of this area.

Mukherjee (1953) has classified the essentially native and little-disturbed vegetation of the Ridge (Plate II, figs. 3 & 4, and Plate III,



Map 2. Outline map of Delhi, India

figs. 5 & 6) into two categories: (1) the permanent vegetation, which occurs throughout the year; and (2) the ephemeral vegetation, which consists of annuals growing chiefly during the rainy season. He states: 'The *permanent vegetation* is xerophytic in ecological peculiarities due to the rigorous climatic and edaphic conditions and gives an appearance somewhat like a thorn scrub or bush jungle. But the number of plants is somewhat fewer than in other scrub jungles of India.' According to Mukherjee (1953), the most characteristic trees on the Ridge include *Azadirachta indica*, *Salvadora persica*, *S. oleoides*, *Prosopis spicigera*, *Acacia modesta*, *A. senegal*, *A. leucophloea*, *Cassia fistula*, *Ehretia laevis*, *Tecomella undulata*, *Balanites roxburghii*, and *Butea monosperma*. The

more numerous thorny shrubs on the Ridge include *Zizyphus nummularia*, *Grewia betulaefolia*, *Capparis aphylla*, *C. sepiaria*, *Celastrus senegalensis*, *Calotropis procera*, and *Carissa spinarum*. Mukherjee (1953) lists 178 species of plants, representing 44 families, that occur on the Ridge.

Reference should be made to Maheshwari (1963) for a complete analysis of the flora of Delhi.

In addition to the two major collecting sites above, small collections have been made in xerophytic situations at Tughlakabad Fort, eight miles SSE. of New Delhi, and at Okhla, the origin of the Agra Canal on the Jumna River, five miles south-east of New Delhi. A few specimens have also been collected near the Najafgarh Jheel, a large, shallow-water lake surrounded by open cultivated land 18 miles WSW. of New Delhi. With the few exceptions noted later, these localities have produced nothing unusual.

Climate and Seasonal Abundance

The climate of Delhi can be characterized as semi-arid, but there are marked seasonal changes. It is cool and dry from October to February, hot and dry from March to early June, and hot and humid during the monsoon from mid-June through September. The precipitation and temperature data are given for each month in Table 1, along with the number of species that have been collected in each month.

Table 1

Monthly rainfall and temperatures in Delhi, India (Source : Sohoni 1953), with the number of species of butterflies recorded for each month

Month	Rainfall (inches)	Temperature (°F.)		No. Spp. Collected
		mean daily max.	mean daily min.	
January ..	0·99	70·5	43·3	26
February ..	0·83	74·7	49·2	32
March ..	0·51	85·0	57·1	38
April ..	0·33	96·6	67·7	31
May ..	0·52	104·8	78·8	26
June ..	3·03	102·4	82·5	13*
July ..	7·03	95·3	80·1	41
August ..	7·23	93·0	78·4	53
September ..	4·84	93·5	75·5	47
October ..	0·40	92·5	64·3	31*
November ..	0·10	83·2	51·8	55
December ..	0·43	73·7	45·0	38

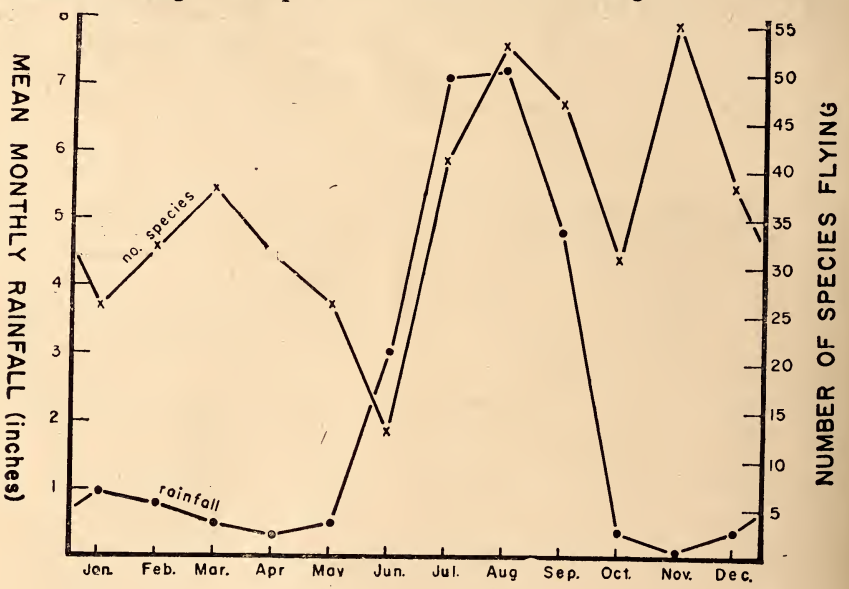
* June and October were relatively poorly collected. A fairly low number of species is expected in June, but over 50 species should be expected in October.

Of the mean annual rainfall of 26·24 inches, 84% occurs during the monsoon from June through September. The dry conditions prevailing

from October to May dictate the arid nature of the native vegetation. During the monsoon, however, the vegetation flourishes. Most plants produce lush new growth at a rapid pace, and almost overnight the land is green where leafless trees and hard bare ground had been but a few weeks earlier (see Plate II, figs. 3 & 4, and Plate III, figs. 5 & 6 for examples of the changes). The pronounced change in the vegetation during the monsoon has been studied in Gujarat by Saxton (1924).

The activity and abundance of the butterflies are strongly correlated with the climatic events in Delhi. Most species occur only during the monsoon, or are most common at that time (Table 1, and text-fig.). Butterfly numbers then decrease from mid-November to February, when specimens are scarce. Some species become extremely abundant during the hot season (*Anapheis aurota* and *Colotis fausta*, for example), but the variety of species on the wing gradually declines to a low point in June. About two weeks after the monsoon breaks (the onset is variable, but is usually in late June) the air is once again filled with butterflies.

The graph of monthly precipitation and the number of species occurring in a given month (text-fig.) demonstrates the time lag between a change in the pattern of rainfall and a change in the number



Text-figure. Number of species of butterflies recorded each month in Delhi, correlated with mean monthly rainfall.

of species flying. No attempt has been made to estimate relative numbers of butterflies during the different months, although the number of species collected was usually directly related to the number of individuals flying.

1. Uncultivated lowland area on north side of Nursery (Zoo in background). *Ypthima inica* most abundant in tall grass in centre of photograph. 1 July 1962. 2. Native grasses and thorn shrubs and trees in Nursery, looking south from the area in 1, towards Humayun's Tomb (right centre background). 1 July 1962.

(*Photos : Julian P. Donahue*)

3. Dry season aspect of vegetation in Reserved Forest on the Ridge. 9 May 1962. 4. Wet season aspect of same area as 3, on 14 Aug. 1962. Note change in the ground cover, in foliage of trees, and in vine in foreground.

(*Photos : Julian P. Donahue*)

Seasonal Variation

Many species of Delhi butterflies have two well-marked seasonal forms, associated with the wet and dry seasons. Wet season specimens are usually larger and more conspicuously patterned than dry season specimens, while the seasonal forms of some species even have different wing shapes. *Eurema hecabe* is an exception, in that the dry season form is heavily marked on the underside, while the wet season form is almost immaculate on the underside.

Previous authors have implied that the wet season form occurs only during the monsoon, but this certainly is not true in Delhi. In at least six species (*Anapheis aurota*, *Cepora nerissa*, *Eurema hecabe*, *Colotis etrida*, *Ypthima inica*, *Precis almana*, and possibly *Precis orithya*), the colour pattern characteristic of the wet season appears in *all* specimens as early as mid-April or May—two of the hottest, driest months of the year—and lasts until sometime after the monsoon, depending on the species. These pre-wet-season forms may be smaller than wet season specimens, but in their facies (and wing shape, in *P. almana*) they are identical to wet season individuals.

The factors responsible for the appearance of the seasonal forms have been the subject of some experimentation and much speculation. Marshall (1901) and Dixey (1902) concluded, after a series of experiments, that the seasonal forms were influenced by both temperature and humidity. Apparently no modern, more sophisticated, research has been conducted into the problem, but Sevastopulo (1944) believes that three factors operate, either separately or in conjunction, to influence the form of a butterfly: (1) condition of the food ; (2) effect of atmospheric humidity on the larva ; and (3) effect of atmospheric humidity on the pupa. He further believes that the nature of the food or relative humidity alone are not the complete explanation of the phenomenon.

The appearance of the 'wet-season' form of some Delhi species in the dry season, mentioned earlier, indicates that some factor other than humidity may affect those species, although the majority of the Delhi wet-season specimens appear to be restricted to the monsoon season. It is quite possible that the factors affecting the form of a butterfly are different for different species.

Methods of Collecting

The butterfly collector in Delhi has poor success with special collecting methods—such as baits, models, or locating butterflies swarming on stream-banks—which are often successful in a moist forest habitat. Collecting butterflies at flowers, stalking them (especially *Precis*), or

chasing the fast-flying species are the only methods which have produced results in Delhi. Some species, such as *Leptosia nina* and *Mycalesis perseus*, must be beaten from the grass, while low-flying species (*Eurema*, *Zizeeria*, etc.) can be obtained by gentle sweeping. During warm weather it is advisable to do the bulk of the collecting before 10 a.m., while the butterflies are attracted to flowers and before they begin flying more rapidly. A warm day on the Ridge can be most exhausting, since the butterflies seldom pause in their headlong flight through the scrub, and many were the times when both collector and net became snagged and torn on the thorns.

No mass movements ('migrations') of butterflies have been observed in Delhi, although this phenomenon has been reported elsewhere in India for species which occur in Delhi. But some species, such as *Colias electo* and *Pieris canidia* probably emigrate to Delhi from the Himalaya, although so few specimens reach Delhi that it would be difficult to detect the movement.

Method of Study

The list which follows is the result of the examination of 5611 mounted specimens, representing 72 species, collected by the author from May 1961 to August 1962, and by Roy L. Donahue and Reed C. Finfrock from 1962 to 1965. A few additional specimens were purchased from Miss Nirmala of Delhi, who provided specimens collected by 'Venu', Leela R. Menon, and herself. All these specimens form a part of the collection of Indian butterflies deposited in the Entomology Museum at Michigan State University (MSU). Five additional species that were not examined have either been reported from Delhi in the literature or are represented by single specimens in the collection of the Indian Agricultural Research Institute (I.A.R.I.), New Delhi.

The total number of specimens examined is given for each species, followed by the number of specimens of each sex and the sex ratio (given as the percentage of males). With only a few exceptions (such as *Hypolimnas misippus*, *Ixias pyrene*, *Papilio polytes*, and *Colotis fausta*), males could not be distinguished from females in the field, so the sex ratio as given should reflect the relative abundance of the two sexes under field conditions at the time of collecting, although it is well known that behaviour and other ecological factors generally make the females of some species very difficult to find. The relationship between the sex ratio observed in the field and the actual sex ratio of a species can only be derived from rearing experiments and studies of predation, parasitism, and behaviour. The sex was determined by

examining the abdomen of all specimens, even of those species which are sexually dichromic.

To simplify the presentation of data on seasonal occurrence, each month has been divided into quarters, designated by Roman numerals as follows: I = 1 - 7; II = 8 - 14; III = 15 - 21; and IV = 22-end of the month. Because of the probability that a given species was not collected during every week it was flying, and because most Delhi butterflies appear to be continuously brooded in all except the winter months, the flying time is assumed to be continuous if the interval between collection records is four quarters or less. For example, if a given species was collected in the first and fourth weeks of October, and again in the third week of November, the flying time will be presented as October I to November III. June, October, and, to some extent, September have been poorly collected, and it is to be expected that additional records from these months may alter the known flying time of a species. The precise date of each capture is given if twelve or fewer specimens of a species have been collected.

The size of specimens, given in millimetres, is the length of one forewing from base to apex.

The species included in this paper were identified according to the following references: Evans (1949)—Hesperiidae; Talbot (1939)—Papilionidae, Pieridae; Cantlie (1962)—Lycaenidae; Evans (1932)—Nymphalidae; and Talbot (1947)—Danaidae, Satyridae. Monographs of certain groups have been referred to whenever possible. The names used in this paper follow the above authors, unless subsequent investigations have shown other names to be more appropriate. The arrangement of species follows the above authors, while the arrangement of families follows dos Passos (1964). The figures in Wynter-Blyth (1957), Seitz (1927), and in various volumes of LEPIDOPTERA INDICA (Moore, 1890-1900; Swinhoe, 1905-1913: volumes V and VI were not consulted) were occasionally consulted for the clarification of a description. Terminology of the genitalia follows Klots (1956).

'Form' names are avoided whenever possible, especially for seasonal forms, since these names have no taxonomic validity. Some species, however, have distinct forms which, for the sake of recognition, are occasionally referred to by name.

Frequent reference is made in this paper to lists of butterflies published for other localities in north-western India and West Pakistan. The nearest localities and their distances from Delhi are as follows (see Map 1): Lucknow, Uttar Pradesh, 250 miles SE. of Delhi (de Rhé-Philipe 1902, 1905); Kanpur, U.P., 240 miles SE. of Delhi (partial list, Sevastopulo 1948); Lahore, West Pakistan, 250 miles NW. of Delhi (de Rhé-Philipe 1917); Amritsar, Punjab, 250 miles NW. of Delhi (partial list, Sevastopulo 1948); Fatehgarh, Punjab, 140 miles

NNW. of Delhi (partial list, Peile 1911); Jodhpur, Rajasthan, 300 miles WSW. of Delhi (MacPherson 1927); and Lyallpur, West Pakistan, 300 miles NW. of Delhi (partial list, Sevastopulo 1948).

Other, more distant localities (Map 1) whose lists have been consulted include Sind (the southern portion of the Indus Valley), West Pakistan, about 400 miles west to about 600 miles WSW. of Delhi (Swinhoe 1887; Menesse 1950); Kutch (region), Gujarat, about 600 miles SW. of Delhi (Nurse 1899); Kathiawar (region), Gujarat, about 600 miles SW. of Delhi (Mosse 1929); Mount Abu, Rajasthan, 380 miles SW. of Delhi (MacPherson 1927); Kaira District, Gujarat (near Ahmedabad), 580 miles SSW. of Delhi (Aldrich 1946); and Mhow, Madhya Pradesh, 420 miles SSW. of Delhi (Swinhoe 1886).

The terms used in this paper for the relative abundance ('common', 'rare', etc.) are the terms used by the above authors to indicate the status of species in their respective areas.

To clarify the range of certain species, occasional reference is made to specimens in the Michigan State University collection from the following localities (Map 1): Saharanpur, Uttar Pradesh, 90 miles NNE. of Delhi; Aligarh, U. P., 70 miles SE. of Delhi; Agra, U. P., 110 miles SSE. of Delhi; Ludhiana, Punjab, 170 miles NNW. of Delhi; Siliserh, Rajasthan (5 miles south of Alwar), 90 miles SSW. of Delhi; Jaipur, Rajasthan, 140 miles SW. of Delhi; and Sumerpur, Rajasthan (45 miles SSW. of Pali), 340 miles SW. of Delhi.

The following abbreviations are used in the text:

Wing surfaces

UPF—upperside (dorsal surface) of the forewing.
UPH— do. do. hindwing.
UNF—underside (ventral surface) of the forewing.
UNH— do. do. hindwing.

Seasonal forms

WSF—wet-season form
DSF—dry-season form

Collectors

JPD—Julian P. Donahue.
RLD—Roy L. Donahue.
RCF—Reed C. Finfrock.

Affinities of the Delhi Butterfly Fauna

The butterfly fauna of Delhi is poor compared to that of the montane, mesophytic habitats of the Western Ghats or the Himalaya. With the exception of *Colias electo*, *Pieris canidia*, and possibly *Argynnis hyperbius*, which are presumably immigrants from the Himalaya, all Delhi butterflies are characteristic of the populations of peninsular India, rather than of the adjacent Himalaya.

On the Indo-Gangetic Plain, a deep alluvial tertiary deposit between the Himalaya and peninsular India, the number of species decreases as

5. Dry season aspect of vegetation in another portion of Reserved Forest on the Ridge. 9 May 1962. 6. Wet season aspect of same area as 5, on 14 Aug. 1962. Note the marked increase in grasses. Large tree on right is *Azadirachta indica.*

(*Photos : Julian P. Donahue*)

one goes west. The annual precipitation also decreases as one goes west to the Great Indian Desert where, in some years, there is no precipitation at all. Conversely, the hill ranges of India generally receive a great amount of precipitation and have a rich butterfly fauna.

The 77 species of Delhi butterflies represent seven families (Table 2). For comparison with other localities on the Indo-Gangetic Plain, 84 species have been recorded south-east of Delhi in Lucknow District, U.P. (de Rhé-Philipe 1902, 1905); 54 species north-west of Delhi in Lahore, West Pakistan (de Rhé-Philipe 1917); and 51 species WSW. of Delhi in Jodhpur, Rajasthan (MacPherson 1927).

TABLE 2

FAMILY REPRESENTATION IN DELHI

FAMILY	NUMBER OF SPECIES
Hesperiidae	.. 11
Papilionidae	.. 4
Pieridae	.. 20
Lycaenidae	.. 22
Nymphalidae	.. 13
Danaidae	.. 4
Satyridae	.. 3
Total	.. 77

Extensive irrigation and the introduction of a multitude of exotic trees and shrubs have apparently altered the environment of the cities of Delhi and New Delhi to the point where the shaded residential areas have a lower temperature and a higher humidity. The cities are verdant oases set in a parched land, and several species of butterflies are virtually restricted to the irrigated city. Were it not for the creation of this mesophytic habitat, there is little doubt that fewer species would occur in Delhi.

The diversity of the two major habitats in Delhi perhaps explains the occurrence in Delhi of 20 species of butterflies which appear to be on the periphery of their known ranges (Table 3). The majority of these are more or less restricted to the mesophytic city habitat and have not been reported west of Delhi, where the climate becomes even more arid. Some of these species may occur in the Great Indian Desert, but collections have apparently not been made there.

Four of the remaining peripheral species are characteristic of the arid land west and south-west of Delhi, but have not been recorded east of Delhi, while two species appear to be stragglers or strays from the Himalaya.

In the Delhi area, as is true wherever man goes, the native vegetation must have been considerably altered when land was cleared, crops

were planted, and livestock were turned loose to overgraze the land (see Donahue 1962c). The vegetation on the Ridge probably represents only a portion of once-extensive thorn forests.

Beirne (1947a, 1947b) has noted that, at least in the British Isles, the net result of the activity of man and his animals is the decline or disappearance of populations of many species of Lepidoptera, while relatively few species become more numerous. Apparently no studies of the population ecology of Indian butterflies have been undertaken, but this list of species could well form the foundation for such an investigation in Delhi itself.

TABLE 3

DELHI BUTTERFLIES THAT APPEAR TO BE ON THE PERIPHERY OF THEIR KNOWN RANGES

Species	Periphery
Spialia galba galba	.. western
Suastus gremius	.. do.
Parnara naso bada	.. do.
Borbo cinnara	.. do.
Graphium nomius nomius	.. do.
Leptosia nina nina	.. do.
Delias eucharis	.. do.
Ixias marianne marianne	.. do.
Ixias pyrene sesia	.. do.
Rapala iarbus ssp.	.. do.
Charaxes fabius fabius	.. do.
Euthalia nais	.. do.
Mycalesis perseus tabitha	.. do.
Ypthima inica	.. do.
Pieris canidia indica	.. south-western
Colias electo fieldi	.. do.
Pelopidas thrax thrax	.. eastern
Colotis calais amata	.. north-eastern
Colotis vestalis vestalis	.. do.
Colotis fausta faustina	.. do.

ACKNOWLEDGEMENTS

Were it not for the munificence of The Ford Foundation, which financed the transportation of the author and his gear to India, this study would not have been possible. My primary debt of gratitude is therefore tendered to this great organization.

To my father Dr. Roy L. Donahue and to my good friend Reed C. Finfrock I am deeply indebted for the several thousand specimens of butterflies they collected in Delhi after my departure. My strict instructions to collect every lycaenid and hesperiid they encountered, to the

neglect of larger species, bore fruit: not only was I swamped with tremendous series of common species, but they found several species which I myself had failed to collect in Delhi. To Mrs. Evelyn Jackson, who had the hideous task of mounting all that exiguous material, I am grateful for a job well done.

I further wish to thank Mr. T. G. Howarth and Mr. G. E. Tite, of the British Museum (Natural History), for assistance with taxonomic problems and for examining some Delhi specimens in their care; and Dr. M. G. Ramdas Menon of the Indian Agricultural Institute, New Delhi, for allowing me to examine some of his Delhi butterflies in that institution's collection.

Sir Keith Cantlie was most generous in allowing me to borrow his copy of the rare first edition of THE IDENTIFICATION OF INDIAN BUTTERFLIES by W. H. Evans, without which it would have been more difficult to properly assign names to the nymphalids.

To Dr. Irving J. Cantrall, of the University of Michigan, and C.F.W. Muesebeck, of the U.S. National Museum, go my thanks for identifying a mantid predator and hymenopterous parasites, respectively, of Delhi butterflies.

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ACCOUNT OF SPECIES

HESPERIIDAE

Several of the 11 known species of skippers from Delhi are very similar in appearance. Although there are many characters to separate the groups, such as tibial spines, genitalia, and antennae, only the salient features of the facies of each species are listed here. Complete keys and figures of male genitalia will be found in Evans (1949).

Gangara thyrsis, *Hasora chromus*, and *Badamia exclamationis* are large species, all of which are figured by Wynter-Blyth (1957). *Spialia galba*, a small species with many white spots, is also figured by Wynter-Blyth. *Telicota colon* is the only orange skipper so far recorded from Delhi (figured in Wynter-Blyth as *Astychus augias*). *Gegenes nostrodamus* is a very pale brown species, whose male has no spots on the upperside, while *Suastus gremius* is the only Delhi species with black spots UNH. Both these latter species are also figured by Wynter-Blyth.

The remaining four species have spotted UPF and are very similar in appearance. *Parnara naso* has no spot in space 1b UPF and no male stigma; *Borbo cinnara* has no spot in the cell UNH, has no male stigma

UPF, and usually does not have two spots in the cell UPF. The two species of *Pelopidas* which can be identified only after genitalic examination, have male stigmas, two spots in the cell UPF, and one spot in the cell UNH. The combinations of these characters will separate the species that have been recorded from Delhi, but additional skippers undoubtedly occur and should be looked for.

Because of recent taxonomic changes and the recognition of new species in this family, published records of the distribution of some species cannot be considered totally reliable.

Hasora chromus chromus (Cramer)

The Common Banded Awl is, as the name implies, the most common and widespread *Hasora* in India, although only five specimens have been collected in Delhi. I collected two males on *Lantana* flowers in the Nursery (26 Aug. and 21 Sept. 1961), while Leela R. Menon collected two males and a female in Delhi (Oct. 1962). These last records indicate that the species may be locally common in suitable habitats. A large skipper, probably this species, was observed on *Lantana* in the Nursery, 4 Nov. 1961, but was not collected.

SIZE: The specimens range in size from 17 mm. to 22 mm.

DISTRIBUTION: This subspecies occurs throughout India (Evans 1949; Wynter-Blyth 1957), and has been recorded as far west as Karachi (Menesse 1950), where it is very rare.

Badamia exclamationis (Fabricius)

Only two males have been examined, both of which were collected by JPD in the Nursery. The first (23 mm.) was taken on 20 July 1962 as it fed on a white-flowered *Lantana* at midday. A second specimen (26 mm.) was collected the following day on *Lantana*, and another was seen but not secured. A few days later RCF obtained three specimens, which remain in his personal collection.

DISTRIBUTION: The Brown Awl occurs rather locally throughout India (Wynter-Blyth 1957), but the British Museum (N.H.) has no specimens west of 'North India' (Evans 1949). It has been recorded from Lucknow (de Rhé-Philipe 1902), where the eggs and larvae were found on *Bignonia gracilis* (de Rhé-Philipe 1905). It has also been recorded from Mount Abu, but not in Jodhpur, by MacPherson (1927); Kutch (Nurse 1899); and Kathiawar (Mosse 1929). It is very rare in Karachi (Swinhoe 1887; Menesse 1950), which is apparently the westernmost record for the species.

Spialia galba galba (Fabricius)

The Indian Skipper, a small but distinctive species, has been collected only sporadically in Delhi. In the Nursery, a female was taken on 15 July 1961 (JPD), and another was collected on 18 November 1962 (RLD). On the Ridge, a male was obtained on 26 Feb. 1963 (RCF), while a female was collected on 9 August 1962 (JPD). In addition, two males and a female were collected in Delhi by Venu, Dec. 1962.

SIZE: Males and females range from 8 mm. to 11 mm.

DISTRIBUTION: This subspecies occurs throughout India, west to Kutch and Sind, east to Assam (Evans 1949). It has not been reported from Jodhpur (MacPherson 1927), is apparently rare in Lahore (de Rhé-Philipe 1917), but is fairly common to common in Lucknow (de Rhé-Philipe 1902), Kutch (Nurse 1899), Kathiawar (Mosse 1929), and Sind (Swinhoe 1887 ; Menesse 1950). This species may be near the western limits of its range at the latitude of Delhi.

Suastus gremius gremius (Fabricius)

Only five males of the Indian Palm Bob have been collected in Delhi. Two came from the Nursery (25 Sept. 1961, JPD ; 17 Nov. 1962, RCF), while Leela R. Menon collected three in Delhi in Nov. 1962. These last records would imply that this species may be more common on the north side of Delhi where the food plants, various species of palm, are more common.

SIZE : The forewings are from 11 mm. to 12 mm. long.

DISTRIBUTION: This distinctive subspecies occurs in south and central India, the north-west Himalaya, and Bengal, Sikkim, and Assam (Evans 1949 ; Wynter-Blyth 1957). It is the most common hesperiid in Lucknow (de Rhé-Philipe 1902), though it is uncommon in Lahore (de Rhe-Philipe 1917), rare in Kutch (Nurse 1899) and Kathiawar (Mosse 1929), very rare in Karachi (Menesse 1950), and apparently absent from Jodhpur (MacPherson 1927). This species appears to be near the western limit of its range at the latitude of Delhi.

Gangara thyrsis thyrsis (Fabricius)

The only Delhi record of this species is a single specimen in the British Museum (N.H.) from the Godman-Salvin collection [B.M. No. 1913-2] (T.G. Howarth, pers. comm.: specimen cited in Evans 1949, p. 325).

This subspecies of the Giant Redeye occurs from south India to Bombay and Calcutta, and again from Kangra (Punjab Himalaya) to Sikkim, Assam, and farther east. The specimen from Delhi, assuming

no labelling error, is apparently the only record from the Indo-Gangetic Plain, and should be substantiated with additional material. This huge skipper is crepuscular, and should be looked for near various species of palms, the food plant. Beating the bushes during the day-time may dislodge a resting specimen.

Telicota colon colon (Fabricius)

The Pale Palm Dart, the only orange skipper so far recorded from Delhi, has been collected from Sept. IV to Nov. IV, a period during which most of the Delhi hesperiids make their appearance. This species reportedly feeds on sugarcane, so it may be locally common in the parts of Delhi where this crop is grown. Miss Nirmala collected three males in Delhi in Nov. 1962, but all the rest of the specimens examined were taken in the Nursery : one male on 25 Sept. 1961 (JPD), one male on 3 Nov. 1962 (RCF), two males on 4 Nov. 1961 (JPD), a male and a female on 17 Nov. 1962 (RCF), and one male on 25 Nov. 1962 (RCF).

The only hesperiid collected in Delhi by Longstaff (1912), 7-12 Nov. 1903, was probably this species.

SIZE : The specimens range in size from 14 mm. to 16 mm.

DISTRIBUTION : Evans (1949) records specimens in the British Museum (N.H.) from south and central India, Kathiawar, Kumaon, and from the U.P. to Sikkim. Two other subspecies occur in Ceylon, the Andaman Islands, and Assam.

Distributional lists published prior to the appearance of Evans's CATALOGUE (1949) are unreliable, since there appears to have been a considerable amount of confusion and misapplication of names in the two similar genera of *Potanthus* and *Telicota*. Specimens on which earlier lists were based should be re-examined in the light of the recent taxonomic changes before they can be included in our present knowledge of the distribution of the species. An examination of the genitalia, which are figured in Evans (1949), is virtually essential for the proper identification of most species.

This species is described and figured as *Astychus augias* (Linnaeus) in Wynter-Blyth (1957), who omits reference to two other species of Indian *Telicota*.

Gegenes nostrodamus (Fabricius)

Only nine males of this arid-land skipper have been collected in Delhi, all from the Nursery : 26 June 1961, 20 July 1962 (3 specimens), 21 and 31 July 1962 (JPD); 3 and 9 Sept. 1962 (RLD); and 4 Nov. 1962 (RCF). Darker specimens occur from late July (when light speci-

mens also occur) to November. The genitalia of all specimens were examined, but *G. pumilio* (Hoffmansegg) was not found, although it has been recorded as far east as the Punjab and Kulu (Evans 1949). This latter species was omitted by Wynter-Blyth (1957).

SIZE: The specimens range from 13 mm. to 14 mm.

DISTRIBUTION The Dingy Swift has been recorded east to Sind; Kutch; Deesa, Gujarat; NW. Frontier Province; and the Punjab, then becomes rare through the U.P. to Bengal (Evans 1949). Longstaff (1912) took it in Lahore, although de Rhé-Philipe (1917) failed to find it there; Aldrich (1946) records it from Kaira District; Menesse (1950) and Swinhoe (1887) have collected it in Sind; and Nurse (1899) took it in Kutch. There are two additional specimens in the Michigan State University collection from Ludhiana, Punjab (12 Sept. 1961).

Parnara naso bada (Moore)

This is the only white-spotted brown skipper so far recorded from Delhi which does not have a spot in space 1b UPF or UNF. Only six specimens have been collected in Delhi, all of which came from the Nursery, Aug. IV to Nov. IV: one male on 26 Aug. 1961 (JPD); one female on 21 Sept. 1961 (JPD); one female on 4 Nov. 1961 (JPD); a male and a female on 4 Nov. 1962 (RCF), and a male on 22 Nov. 1962 (RCF).

SIZE: The forewing is from 14 mm. to 15 mm. long.

DISTRIBUTION: This butterfly occurs in India from Ceylon north to Kashmir and east to Sikkim and Assam (Evans 1949). Wynter-Blyth (1957) apparently included this species with *P. guttatus mangala* (Moore), which is only known to occur in the Himalaya from Chitral to Sikkim and Assam (Evans 1949). *Parnara naso bada* has been recorded from Mount Abu (MacPherson 1927), but other authors have failed to report its occurrence in localities nearer Delhi. There is an additional specimen in the MSU collection from Aligarh, U.P., 17 Nov. 1962 (RLD). Delhi appears to be the westernmost locality recorded for this species at this latitude.

Borbo cinnara (Wallace)

This species is similar to *Pelopidas* females, but can be separated with the characters listed in the introduction to the family. It has been collected only in the Nursery from July III to Nov. IV. 41 specimens: 20 males (49%), 21 females.

SIZE: The forewing length of males and females varies from 14 mm. to 17 mm.

VARIATION: In one female (28 Aug. 1961, JPD) the subapical spots

UPF are almost indiscernible, and the spot in space 1b UPF is absent. The other spots UPF are smaller than usual.

DISTRIBUTION: Although the British Museum (N.H.) has many specimens from India, there appear to be none from west of 'Central India' (Evans 1949). *B. cinnara* has also been recorded from Mount Abu (MacPherson 1927) and Kathiawar (Mosse 1929) as *Baoris colaca* (Moore), a synonym. Previous authors may have confused this species with *Borbo bevani* (Moore) which, though not yet collected in Delhi, has been reported from Lahore (de Rhè-Philipe 1917) and Karachi (Swinhoe 1887). All these records should be re-examined in the light of the revisional work by Evans (1949).

Pelopidas thrax thrax (Hübner)

This species is very similar to *P. mathias*, but it is less common. The males can be distinguished by the position of the stigma UPF: in *P. thrax* the posterior end of the stigma is under the origin of Cu_1, while in *P. mathias* the posterior end of the stigma is well proximal to the origin of Cu_1. The male and female genitalia of all Delhi *Pelopidas* have been examined.

The females of these two species are very similar, and only an examination of the genitalia can separate them.

Among the Delhi *Pelopidas*, two types of female genitalia were found: (*a*) the less common type of female has a lateral, linear, well-defined sclerotized signum on both the right and left sides of the bursa copulatrix; (*b*) the more common type of female has only a diffuse, indistinct signum on the left side of the bursa copulatrix.

Since no copulating pairs of *Pelopidas* have come into my possession, there is still some doubt as to which type of female to associate with which species. I have arbitrarily assumed that the more common female, type (*b*), is associated with the more common male, *P. mathias*. Conversely, the type (*a*) female has been associated with *P. thrax*.

Pelopidas thrax is usually encountered in the Nursery, where it flies with *P. mathias*, but five specimens have been collected on the Ridge. It is probably more frequent on the Ridge than the records indicate, but the dearth of attractive flowers makes this fast-flying species difficult to collect. It has been collected in February IV and March II (Ridge), from July II to November IV (Nursery), and in December IV (Ridge). 35 specimens: 23 males (66%), 12 females.

SIZE: Males and females range from 15 mm. to 17 mm.

DISTRIBUTION: The only Indian record of this western subspecies in the British Museum (N.H.) is a single male from Kutch (Evans 1949), although Evans (1949) and Menesse (1950) report that this species is

common in Sind. Evans (1949) also records two males of a second subspecies, *P. t. masta* Evans from Sikkim. There appear to be no other published records of this species from India, but earlier authors may have confused it with other species. Wynter-Blyth (1957) has omitted it from his book, on which many collectors rely. The author has also collected two males 15 miles south of Saharanpur, U.P., 8 May 1961.

Pelopidas mathias mathias (Fabricius)

The most common Delhi skipper, numerous on *Lantana* during and after the monsoon. It has been collected in most habitats, March I and IV, and from July III to December I, although it is most frequently collected in the Nursery. 100 specimens : 69 males (69%), 31 females.

Although the males can be distinguished from the preceding species by the position of the stigma and by examining the genitalia, the only sure way to separate the females is by examining their genitalia.

SIZE : The males and females range in size from 14 mm. to 16 mm., averaging only about 1 mm. smaller than *P. thrax thrax* from Delhi.

DISTRIBUTION : Evans (1949) records specimens in the British Museum (N.H.) from virtually throughout India, including Punjab, Sind, and U.P. It has also been recorded from Lucknow (de Rhé-Philipe 1902), Jodhpur (MacPherson 1927), Lahore (de Rhé-Philipe 1917), and Sind (Menesse 1950). There is a male in the MSU collection from Aligarh, U.P. (17 Nov. 1962, RLD).

PAPILIONIDAE

Polydorus aristolochiae aristolochiae (Fabricius)

Although the specific name of this species was upheld by Opinion 265 in 1954 (rather than supplanting it with *ascanius* or *diphilus*, see Talbot 1947, p. 491), the generic name is still being debated. Munroe (1961) has placed this species in the genus *Pachlioptera* Reakirt, but Kent H. Wilson (pers. comm.) believes that it will come to rest in *Parides* Hübner. For the time being the arrangement of Talbot (1939) will be followed.

Only four Delhi specimens have been examined : a male collected by JPD in the Nursery on 27 Sept. 1961 (46 mm.), two males collected in Delhi in Oct. 1962 by Leela R. Menon (both 48 mm.), and a male collected in Delhi in Nov. 1962 by Miss Nirmala (48 mm.). The fact that three specimens were collected on the north side of Delhi in a two-month period may indicate that the species is more common there.

Longstaff (1912) reported that he saw 'many' in Delhi, 7-12 Nov. 1903.

DISTRIBUTION: The Common Rose is widespread throughout India (Talbot 1939; Wynter-Blyth 1957), and has been recorded as far west as West Pakistan (Menesse 1950).

Papilio polytes romulus Cramer

This swallowtail, the subject of a great deal of study because of the mimetic colour patterns of the females, is not very common in Delhi. It has been collected on the Ridge only once (Feb. IV), and at scattered times in the Nursery: March I and IV; May I; and July II to Nov. I. 31 specimens: 13 males (42%), 18 females, of which two (11%) are form '*romulus*' Cramer, a mimic of *Polydorus hector* (Linnaeus), which has not been recorded in Delhi; seven (39%) are form '*cyrus*' Fabricius, which has the same facies as the male; and nine (50%) are form '*stichius*' (Hübner), whose model is *Polydorus aristolochiae*; a species which appears to be less common in Delhi than its mimic.

The '*cyrus*' form of the female has been observed ovipositing on lime bushes (*Citrus*) on two occasions: on 21 Aug. 1962; and on 6 Sept. 1961, when one laid nine eggs (one egg to a leaf) on a single lime bush before the specimen was collected.

The larvae of both *P. polytes* and *P. demoleus* may be found on the *Citrus* bushes in the Nursery, but only one male was reared: the larvae pupated on 5 Sept. 1961, and the adult emerged 14 Sept. 1961.

On 27 July 1961 an egg of either *P. polytes* or *P. demoleus* was collected from a lime bush in the Nursery (the egg was about 3 mm. from the edge, on the underside of the leaf). On the evening of 28 July 1961 a hymenopterous parasite was observed emerging from the egg, and by the next day three parasites had emerged. They have been identified as *Telenomus* (*Aholcus*) *talaus* Nixon (Scelionidae) by C.F.W. Muesebeck of the U.S. National Museum, where all three specimens are deposited. The type series of this parasite was described from the eggs of *Graphium agamemnon* (Linnaeus) in Malaya.

SIZE: ♂♂ 38 mm. (7 March 1964, RLD) to 50 mm. (several); ♀ form '*stichius*' 46 mm. (15 July 1961, JPD) to 53 mm. (28 Aug. 1961, JPD); ♀ form '*cyrus*' 44 mm. (26 Aug. 1961, JPD) to 52 mm. (22 July 1961, JPD); ♀ form '*romulus*' 51 mm. (2 May 1963, RLD) and 52 mm. (13 Aug. 1962, JPD).

VARIATION: *Papilio polytes* is one of the classic examples of polychromic mimicry. Goldschmidt (1945) proposes hypothetical genotypes for all forms of this species, and includes a good bibliography on the subject.

Annandale & Dover (1921) have summarized the relative abundance of the three female forms in India. In general, the most common is '*stichius*,' followed by '*romulus*' and '*cyrus*.' The '*cyrus*' form is considered to be absent or rare in many localities. In north India, including Delhi, the '*romulus*' form becomes less common, where its model, *Polydorus hector*, apparently does not occur.

Sevastopulo (1947, 1956) reared 175 *P. polytes* from eggs in Calcutta. Of the 95 females he obtained, 68% were '*stichius*,' 19% were '*cyrus*' and 13% were '*romulus*.' Sanders (1955), however, found that the '*cyrus*' form was only very rarely collected in Calcutta.

The most important point concerning the Delhi female forms is that the male-like '*cyrus*' form is relatively common, perhaps because there is little natural selection for the two mimetic forms when the models are uncommon (*P. aristolochiae*) or absent (*P. hector*) in Delhi.

DISTRIBUTION: The Common Mormon is found throughout India (Talbot 1939; Wynter-Blyth 1957). In Lucknow the '*stichius*' female is most common, '*romulus*' is rare, and '*cyrus*' has not been found (de Rhé-Philipe 1902). In Jodhpur the '*cyrus*' female has not been recorded (MacPherson 1927). It is interesting to note that MacPherson (1927) found *Polydorus hector*, the model for the '*romulus*' form of *P. polytes*, in Jodhpur in 1924, which is apparently the northernmost record for the species.

Papilio demoleus demoleus Linnaeus

The Lime Butterfly is the most common Delhi swallowtail, and is usually found in the Nursery where its foodplant, *Citrus*, is cultivated, although specimens are occasionally encountered on the Ridge. It has been recorded in March II (Ridge) and May IV, from July I to Sept. IV, and Nov. I. The poor representation of some months may be because the species is so common and easily recognized that it is not collected. 48 specimens: 28 males (58%), 20 females. Females have only been collected from July I to Sept. IV.

A copulating pair was collected on 13 July 1961 (JPD), and a female was observed ovipositing on young basal leaves of *Citrus* on 15 July 1961. Several larvae, which are very similar to the larvae of *P. polytes*, were collected from *Citrus*, and four were reared through to adults. The pupation dates were 1 Aug., 2 Sept., 2 Sept., and 3 Sept. 1961. The emergence dates were 16 Aug. (?), 13 Sept., 14 Sept., and 14 Sept. 1961, respectively.

See the comments under *P. polytes* for notes on egg parasites of *P. demoleus* or *P. polytes*.

SIZE: ♂♂ 33 mm. (4 Aug. 1962, JPD) to 47 mm. (15 July 1961, JPD). ♀♀ vary only slightly, from 44 to 50 mm. Assuming that 'expanse' is

twice the length of one forewing, the small male cited here is about the same size as the smallest *P. demoleus* (? sex) cited by Crawford (1930).

DISTRIBUTION: This species is common throughout India (Talbot 1939 : Wynter-Blyth 1957).

Graphium nomius nomius (Esper)

The only known Delhi specimen of the Spot Swordtail was collected at midday in the Nursery on 20 July 1962 as it fed on a white-flowered *Lantana*. The specimen, a female, is virtually perfect (the left tail is missing), and the forewing is 40 mm. long.

DISTRIBUTION: The distribution given by Talbot (1939), 'Ceylon, Southern India to the Sikkim lowlands,' leaves much to be desired. According to Wynter-Blyth (1957) this species occurs in the Himalaya from Simla east, and in peninsular India north to Madhya Pradesh and southern Bihar, west to Saurashtra and Lucknow. At first de Rhé-Philipe (1902) considered it rare in Lucknow, but later he (1905) reported that it was regular in July and August. It was observed at Mahuva, on the west coast of the Gulf of Cambay, Gujarat, by Mosse (1929), and has been taken on Mount Abu (MacPherson 1927). Delhi appears to be the westernmost record of this species in the Indo-Gangetic plain north of Gujarat.

PIERIDAE

Leptosia nina nina (Fabricius)

The Psyche is rare in Delhi : it has been found only in moist, shaded portions of the Nursery, where it may be flushed by beating the grass. Its habitat is essentially the same as that of *Euploea core*. The three specimens were collected on 26 Aug. (♀, 17 mm.), 25 Sept. (♀, 14 mm.), and 4 Nov. 1961 (♂, 18 mm.).

Longstaff (1912) found this species in Delhi, 7-12 Nov. 1903.

DISTRIBUTION: This fragile butterfly occurs more or less throughout India, but the western limits of its range are not well defined (Wynter-Blyth 1957 ; Talbot 1939). It is very local in Lucknow (de Rhé-Philipe 1905), but it has not been reported south-west or west of Delhi. Despite Wynter-Blyth's (1957) statement that it occurs in Sind, Menesse (1950) and Swinhoe (1887) have failed to record it from that region. Delhi, therefore, appears to be the westernmost record of this species in India.

Delias eucharis (Drury)

This species was first observed feeding on *Lantana* in the Nursery on 5 Nov. 1961, and another specimen was observed flying over the Nursery the next day, but the first specimen was not collected until 23 Nov. 1961, when a worn female was caught on *Lantana* in the Nursery. The only other Delhi specimen examined was another worn female collected by RLD in the Nursery on 21 March 1965.

SIZE: The forewing of both specimens is 38 mm. long.

DISTRIBUTION: The Common Jezebel occurs from the lower slopes of the Himalaya south to Ceylon (Talbot 1939), although it is less common in the north-western part of its range. It is seasonally common in Lucknow (de Rhé-Philipe 1902) and Fatehgarh (Peile 1911), but is apparently rare in Jodhpur (MacPherson 1927), Lahore (de Rhé-Philipe 1917), and Kanpur, U.P. (Sevastopulo 1948). Delhi appears to be near the western periphery of the range of this species, since there are no records from West Pakistan.

Cepora nerissa phryne (Fabricius)

The Common Gull occurs from July II to May I in all habitats, although it is more frequently collected in the Nursery. It is uncommon from December through May, a period in which the females are more frequent than males. Longstaff (1912) found only males of this species in Delhi, 7-12 Nov. 1903. 126 specimens: 65 males (52%), 61 females.

SIZE: ♂♂ 20 mm. (25 Dec. 1962, RCF) to 29 mm. (31 July 1962, JPD). ♀♀ 18 mm. (26 Feb. 1963, RCF) to 29 mm. (17 Aug. 1962, JPD).

VARIATION: Males and females from mid-April to mid-November are larger and darker, with the veins UNH prominently blackened, while dry-season specimens are smaller, with the UNH ground colour a paler yellow, with the veins blackened faintly or not at all.

DISTRIBUTION: Throughout peninsular India (Talbot 1939), at least as far west as Jodhpur (MacPherson 1927) and Lahore (de Rhé-Philipe 1917). It has not been recorded from Sind (Menesse 1950).

Anapheis aurota aurota (Fabricius)

The Pioneer is one of the most common Delhi butterflies, occurring in all habitats throughout the year: abundant from March to May, then becoming less frequent until November, when it becomes common again. Uncommon in January. 362 specimens: 205 males (57%), 157 females.

Longstaff (1912) says this species was 'abundant at flowers' 7-12 Nov. 1903, and saw 'countless crowds' at Mahrauli (8 miles SSW. of New Delhi).

The sex ratio of field-collected specimens varies markedly: 46% males April II (20 specimens); 53% males for the month of March (166 specimens); 73% males in a series of 41 specimens collected at Tughlakabad, 10 Nov. 1962 (RCF); and 84% males May I (25 specimens).

Four copulating pairs have been collected: 24 March 1963 (2 pairs, RLD); 10 April 1962 (JPD); and 13 April 1962 (JPD, male very worn). On 2 May 1962 a cluster of four pupae and nine pupal cases was found on a thorny twig on the Ridge. Adults emerged from three of the pupae the next day (the fourth was preserved before emergence). Nurse (1899) has also observed over a dozen pupae on a single twig, in Kutch. Two larvae were also collected on 2 May. One was lost, but the second pupated on 4 May and emerged (♂) on 10 May 1962.

Adults were observed on Neem flowers (*Azadirachta indica*) on 2 May 1962. This species has also been observed attracted to light in Delhi (Donahue, MS. in preparation).

SIZE: ♂♂ 18 mm. (2 May 1962, JPD; 16 June 1964, RCF) to 27 mm. (many specimens throughout the year). ♀♀ 18 mm. (14 Nov. 1963, RLD) to 29 mm. (11 March 1963, RLD; 10 Nov. 1962, RCF).

VARIATION: The seasonal forms are difficult to characterize, but specimens collected from May to August generally have less black suffusion on the veins and a paler ground colour UNH than dry season specimens. Three males collected in March (RCF) and May (JPD) have the spot at the end of the cell UPF detached from the costa, as opposed to most specimens, which have the spot connected to the costa with a dark band.

DISTRIBUTION: The Pioneer is common in India, extending west to Palestine and Africa (Talbot 1939).

Appias libythea libythea (Fabricius)

The Striped Albatross is the least common of the large Delhi 'whites'. It occurs on both the Ridge and in the Nursery, August IV (Nursery only), Nov. I to Dec. III, and Feb. IV (Ridge, one male). The females have only been collected in Aug. IV and again in December. This butterfly may be more frequent in Delhi, but it is possibly overlooked because of its general resemblance to several other pierids (*Cepora nerissa*, *Catopsilia* spp., *Anapheis aurota*). A copulating pair was collected on 28 Aug. 1961 (JPD). 20 specimens: 15 males (75%), 5 females.

SIZE: ♂♂ 22 mm. (1 Dec. 1962, RLD) to 29 mm. (29 Aug. 1961, JPD). ♀♀ 21 mm. (25 Dec. 1962, RCF) to 24 mm. (28 Aug. 1961, JPD).

VARIATION : The August specimens are largest. The four August males have darker markings on the apex and margin UPF than dry season specimens ; the only August female is darker on the upperside than the December females, e.g. UPH with large marginal spots, a discal band, and streaks connecting the spots with the band.

DISTRIBUTION : Peninsular India to the Punjab (Talbot 1939). It is rare in Lucknow (de Rhé-Philipe 1902, 1905, who identified it as *A. paulina*, which does not occur in north India) and on Mount Abu (MacPherson 1927). It has also been recorded from Lahore (de Rhé-Philipe 1917), and southward in peninsular India. There is also a female in the MSU collection from Siliserh, Rajasthan, 19 Nov. 1963 (RLD). This species is apparently uncommon but widely distributed in India.

Pieris canidia indica Evans

The Indian Cabbage White is one of the butterflies whose occurrence in Delhi came as a surprise. Only five specimens have been collected: a male from the Nursery on 28 March 1963 (RLD), 26 mm., and four specimens from the Ridge—a female on 21 Feb. 1963 (RCF), 25 mm.; two females on 12 April 1963 (RCF), 22 and 23 mm. ; and a male on 13 April 1963 (RCF) 23 mm. There is also a single specimen in the I.A.R.I. collection, obtained in Delhi by M. G. Ramdas Menon, 6 March 1958.

DISTRIBUTION : This subspecies is normally confined to the Himalaya, where it is very common (Wynter-Blyth 1957 ; Talbot 1939), but it has been reported south of the hills several times. Sanders (1930) found it 15 miles NE. of Amritsar, Punjab, on 23 Feb., and again in late March, when it was present in 'considerable quantities.' Sevastopulo (1948) also reports that it is 'common at Amritsar before the weather gets hot,' and de Rhé-Philipe (1902) captured a single faded female in Lucknow in April. Although de Rhé-Philipe (1917) failed to record it from Lahore, he did observe *P. brassicae* there in Nov., Jan., and Feb. *Pieris brassicae* is also reportedly common in Fatehgarh in the early spring (Peile 1911).

Delhi is apparently the south-western most record of lhis subspecies.

Ixias marianne marianne (Cramer)

The White Orange Tip, like many other Delhi butterflies, is rare in the cold months of January and February, and again in the hot dry months from April to early July. It is common during the monsoon, but the population tapers off again in December. Although more frequently collected in the Nursery, it also occurs on the Ridge where

it is occasionally numerous. It has been recorded in Delhi from July I to Jan. I, and Feb. II to May II. 210 specimens: 118 males (56%), 92 females. The sex ratio of field-collected specimens appears to remain fairly constant.

Longstaff (1912) collected this species at Mahrauli (10 Nov. 1903) and in Delhi (7-12 Nov. 1903).

SIZE: ♂♂ 19 mm. (23 March 1963, RCF; 21 Feb. 1963, RCF) to 28 mm. (28 Aug. 1961, JPD). ♀♀ 21 mm. (several August specimens) to 27 mm. (29 Aug. 1961, JPD).

VARIATION: Wet season specimens of this variable species tend to be more heavily marked. Three of the females examined had none of the usual black spots in the orange subapical band UPF (13 April 1963, RCF; 25 Sept. 1961, JPD; and 24 Nov. 1962, RCF). In the dry season form of the female, which occurs from early November through May, the dark band bordering the proximal edge of the orange subapical band UPF is absent.

DISTRIBUTION: This handsome species is endemic to India, and occurs from the Punjab, U.P., and Nepal south to Ceylon (Talbot 1939; Gabriel 1943). Wynter-Blyth (1957) adds Saurashtra and Bengal to this range. It is common in Lucknow (de Rhé-Philipe 1902); apparently absent from Jodhpur, although it is common on Mount Abu (MacPherson 1927); and very rare in Lahore (de Rhé-Philipe 1917). It appears to be absent from Kutch, but it is common in adjacent Kathiawar (Mosse 1929). The MSU collection contains specimens from 15 miles south of Saharanpur, U.P. (8-9 May 1961); Aligarh, U.P. (17 Nov. 1962, RLD); and Amber, Rajasthan (7 miles north of Jaipur, 15 Nov. 1963, RLD). Delhi may be near the western periphery of the range of this species, since the specimen from Amber is the only record from northern or central Rajasthan known to the author.

Ixias pyrene sesia (Fabricius)

There is still some doubt surrounding the subspecies to which the Delhi population should belong. According to Talbot (1939), Delhi specimens would belong to *I.p. kausala* Moore, since the female is often white. But Gabriel, who revised the genus in 1943, ascribes white female forms to both *I. p. sesia* and *I. p. kausala*, and only gives Himalayan localities for the distribution of the latter. A careful examination of the descriptions in Talbot (1939) and Gabriel (1943), an examination of the figures in Swinhoe (1905-1910), and a comparison of Delhi specimens with *I. p. sesia* from south India led to the conclusion that the Delhi population is probably referable to *Ixias pyrene sesia* (Fabricius).

The Yellow Orange Tip is less common in Delhi than *I. marianne*, and occurs from Aug. III to Sept. IV, and again from Nov. I to May II. There are no records from June, July, or October, although this may be due to incomplete sampling. This species is common in March, and apparently common from the wet season through December. 86 specimens: 62 males (72%), 24 females.

Longstaff (1912) found the Yellow Orange Tip in Mahrauli (10 Nov. 1903) and in Delhi (7-12 Nov. 1903), when he saw only two specimens.

SIZE: ♂♂ 19 mm. (29 March 1964, RCF) to 27 mm. (3 Sept. 1962, RLD). ♀♀ 19 mm. (26 Feb. 1963, RCF) to 27 mm. (17 Aug. 1962, JPD).

VARIATION: Both seasonal and sexual dichromism are conspicuous in this species. The wet-season form, characterized by its larger size and wide marginal band UPH, occurs in August and September. Wet-season females are further characterized by the wide discal band UPF, which is more or less uniform in width to the tornus. Transitional forms with a macular margin UPH occur in early November, but the dry-season form appears in late November and flies until May. Most dry-season specimens have no trace of the marginal band UPH, and the females have only a narrow line connecting the bar at the end of the cell UPF with the tornus.

Two colour phases of the female occur: ground colour white or greenish white, with a slightly darker subapical band UPF; and ground colour pale yellow or greenish yellow, with the subapical band UPF of the same colour or pale orange. Both forms are about equal in frequency, fly together, and are apparently not associated with a particular season as are the female forms of *Colotis fausta*.

DISTRIBUTION: The Yellow Orange Tip appears to be uncommon in the arid plains of north-western India. The male is common in Lucknow, but the female has not been taken there (de Rhé-Philipe 1902); it is absent from Jodhpur but common on Mount Abu (MacPherson 1927); and apparently rare in Fatehgarh (Peile 1911). Menesse (1950) never observed this species in Sind, so it would appear that Delhi is near the western edge of the range at this latitude.

Colotis calais amata (Fabricius)

This is a small version of *C. fausta* but, unlike that species, it is found almost exclusively in the Nursery—there are only two records, Feb. IV and March II, from the Ridge. It occurs from July III to May IV (no June records). 175 specimens: 113 males (65%), 60 females, 2 unsexed. Infrequent from January to March, and in September and October (insufficient collecting ?).

Longstaff (1912) found this butterfly ' abundant alike in the Kudsia gardens and close to the hotel . . . ', in Delhi, 7-12 Nov. 1903. He also noted that one specimen was ' very small '.

SIZE: ♂♂ 13·5 mm. (22 Nov. 1962, RCF) to 20 mm. (26 Aug. 1962, RLD). ♀♀ 15 mm. (29 May 1962, JPD) to 21 mm. (29 Aug. 1961, JPD).

VARIATION: Specimens collected from July III through March are generally larger and darker than specimens collected in April and May. This is an unusual distribution of seasonal forms, since the forms do not correlate well with precipitation patterns. But April and May are two of the warmest months of the year, so temperature or insolation may be the dominant environmental factors affecting the appearance of the forms. There are no records from June, which is another of the warmest months.

DISTRIBUTION: This subspecies of the small Salmon Arab occurs from Bombay north to Sind, Baluchistan, and U.P., west to Iran and Syria (Talbot 1939). It has not been reported from Lucknow (de Rhé-Philipe 1902), but it is fairly common in Jodhpur (MacPherson 1927), common in Lahore (de Rhé-Philipe 1917), and common in Sind (Fraser 1911 ; Menesse 1950). Two additional specimens are in the MSU collection from Agra, U.P. (21 Nov. 1957). Delhi appears to be near the north-eastern edge of the range of this species.

Colotis vestalis vestalis (Butler)

The White Arab, like its relative *C. calais*, is found exclusively in the Nursery, where it is very common during the monsoon, although it has been collected there every month of the year. 167 specimens : 102 males (61%), 65 females.

SIZE: ♂♂ 15 mm. (29 May 1962, JPD) to 20 mm. (several specimens collected during the monsoon). ♀♀ 14 mm. (30 April 1963, RLD) to 21 mm. (two specimens, 31 July 1962, JPD).

VARIATION: The seasonal forms are not well differentiated, except that specimens flying during the monsoon are brighter yellow on the underside.

DISTRIBUTION: This species occurs from the Persian Gulf east to Sind, Baluchistan, and the U.P. (Talbot 1939). It is common in Sind throughout the year (Fraser 1911 ; Menesse 1950) ; ' exceedingly abundant ' during all months except May and June in Lahore (de Rhé-Philipe 1917) ; common in Lyallpur, W. Pakistan (70 miles west of Lahore : Sevastopulo 1948) ; and common during the fall and winter months in Jodhpur (MacPherson 1927). It has not been recorded from Lucknow (de Rhé-Philipe 1902). The author obtained several specimens in Agra, U.P. (21 Nov. 1957).

Delhi is apparently near the north-eastern edge of the range of this species.

Colotis fausta faustina (C. & R. Felder)

The Large Salmon Arab, the most striking of the Delhi *Colotis*, was not found until the first trip to the Ridge, to which it is restricted and where it is abundant virtually throughout the year, Nov. I to Dec. IV, and Feb. III to Sept. IV. Cold weather may account for its absence in January, but it should occur in October. 214 specimens : 146 males (68%), 68 females.

The sex ratio varies somewhat, although probably not significantly. On 14 Aug. 1962, 27 specimens were collected, of which 22 (81%) were males. On 20 Aug. 1962, 18 specimens were obtained, of which 12 (68%) were males. Only the white form of the female occurs in August and, since they are not frequent, they were collected in preference to the males—hence the actual percentage of males flying was probably greater than indicated by the figures above. On 18 Nov. 1962, when the salmon-coloured females could not be distinguished from the males, 27 specimens were collected (RCF), of which 19 (70%) were males.

VARIATION : The females occur in two forms : a form with a white or salmon-white ground colour on the upper- and undersides, which flies from Aug. II to Nov. I (no October records) ; and a salmon-coloured form, indistinguishable from males, which flies from Nov. I to Dec. IV and from Feb. IV to July I. Previous authors have failed to observe that these two colour phases are seasonal—the white or salmon-white form flying in the wet season, the salmon form flying in the dry season. Both forms fly together in the first week of November, and may also be found to occur together in October.

The dry-season form of both sexes (Nov. I to July I) is also characterized by being smaller and having the black markings on the upperside reduced : the black apical markings UPF are less extensive, and the black margin UPH is reduced to separate spots, a very narrow line, or is entirely absent.

One symmetrically aberrant male (15 Feb. 1964, RCF) has a rounded apex on both forewings, quite unlike the apex of normal specimens. The black apical markings UPF are consequently more reduced than usual for the DSF.

PREDATOR RECORD : On 20 August 1962 a specimen was observed being eaten by a praying mantis, identified as a nymph of *Gongylus gongylodes* (Linnaeus) (Orthoptera : Mantidae) by Dr. Irving J. Cantrall of the University of Michigan.

DISTRIBUTION : This subspecies is reported as 'not rare' from the Punjab to Sind and Karwar, Mysore. The nominate subspecies occurs

as far west as South Arabia, Turkey, and Egypt (Talbot 1939). Published records of this species are sparse, perhaps due to its very local occurrence. The only records near Delhi are a few sight records in Jodhpur (MacPherson 1927), a single specimen collected in Lahore in October (de Rhé-Philipe 1917), a female in the MSU collection from Pali, Rajasthan (4 Oct. 1961), and a male from Siliserh, Rajasthan (19 Nov. 1963, RLD). This species is more common in Kutch (Nurse 1899) and Kathiawar (Mosse 1929), but Aldrich (1946) records it as 'not rare' in Kaira District. It is reportedly rare in Sind (Fraser 1911; Menesse 1950).

Delhi is apparently the north-easternmost record of this species in India.

Colotis etrida etrida (Boisduval)

The Little Orange Tip is the only *Colotis* which is common in all Delhi habitats. It occurs from Nov. I to Sept. I, but appears to be uncommon (or poorly collected) in January, June, September, and October. 322 specimens: 192 males (60%), 130 females.

Longstaff (1912) found it 'in abundance, flying close to the ground' in Mahrauli, 10 Nov. 1903.

SIZE: ♂♂ 13 mm. (3 March 1963, RCF) to 19·5 mm. (9 Aug. 1962, JPD). ♀♀ 11 mm. (9 May 1962, JPD) to 20 mm. (17 Aug. 1962, JPD).

VARIATION: Wet-season specimens are usually larger and darker on the upperside than dry-season specimens. The wet-season form, which flies from April through September, is almost immaculate UNH, but males have marginal black spots UPH. The dry-season form, which occurs from November through March, has a considerable amount of black dusting UNH, while the males have almost no trace of the marginal spots UPH.

Two extreme wet-season females (9 Aug. 1962, JPD) have the apical black UPF so extensive that only a trace of the orange band shows. The underside of these specimens is more yellow than usual.

DISTRIBUTION: This species occurs from peninsular India to the Himalaya (Talbot 1939). It is rare in Lucknow (de Rhé-Philipe 1902); fairly common in Jodhpur (MacPherson 1927); common in the Hardoi District, 190 miles SE. of Delhi (de Rhé-Philipe 1902); common in Lahore (de Rhé-Philipe 1917); and common in Sind (Fraser 1911; Menesse 1950). Additional specimens from Siliserh, Rajasthan (19 Nov. 1963, RLD) and Agra, U.P. (21 Nov. 1957) are in the MSU collection.

Genus **Catopsilia** Hübner

There is a strong belief by many workers that *C. crocale* and *C. pomona* are conspecific, and that *C. florella* and *C. pyranthe* are also

conspecific (see Sevastopulo 1950; and Talbot 1939 and 1947, p. 493, for a summary of current thinking). The four 'species' are treated as entities in this paper merely because they can be easily separated. No endorsement, expressed or implied, is intended concerning the conspecific or distinct status of these four 'species'.

Catopsilia crocale crocale (Cramer)

The Common Emigrant has been collected only in the Nursery, from July II to Nov. I (no October records). 38 specimens: 23 males (61%), 15 females, of which 10 (67%) are form '*jugurtha*' (Cramer), 3 (20%) are form '*crocale*' (Cramer), and 2 (13%) are form '*jugurthina*' (Godart). The '*crocale*' and '*jugurthina*' forms have only been collected in July. The male forms '*alcmeone*' (Cramer) and '*flavescens* Frühstorfer are considered together, since there is some overlap in the colour pattern.

SIZE: ♂♂ 29 mm. (15 July 1961, JPD) to 37 mm. (13 July 1961, JPD). ♀♀ 24 mm. ('*jugurthina*,' 15 July 1961, JPD) to 39 mm. '*crocale*,' 14 July 1961, JPD).

DISTRIBUTION: 'Very common' throughout India (Wynter-Blyth 1957; Talbot 1939). It has been recorded as common in Lucknow (de Rhé-Philipe 1902), Lahore (de Rhé-Philipe 1917), Jodhpur (MacPherson 1927), and Sind (Menesse 1950).

Catopsilia pomona (Fabricius)

The Lemon Emigrant is apparently the rarest of the four 'species' of *Catopsilia* in Delhi. Less than 4% of the *Catopsilia* specimens are referable to this 'species'. The rapid flight of *Catopsilia* makes them difficult to collect, so this 'species' may be more common than the records indicate. All ten specimens are from the Nursery, except for a male collected on the Ridge, 23 April 1963 (RCF), 36 mm. Males were collected in the Nursery on 15 July 1961 (JPD), 37 mm.; 28 Aug. 1961 (JPD), 31 mm.; and 29 Aug. 1961 (JPD) 32 mm. The female form '*hilaria*' (Stoll) has been collected on 5 Jan. 1963 (RLD), 27 mm.; 6 Jan. 1963 (RCF), 31 mm.; and 21 July 1962 (JPD), 28 mm. The female form '*catilla*' (Cramer), usually considered 'not rare', has been collected in the Nursery on 14 July 1961 (JPD), 36 mm.; 31 Aug. 1961 (JPD), 35mm.; and 28 Oct. 1962 (RLD), 29 mm.

DISTRIBUTION: As for *C. crocale*, except that *C. pomona* is uncommon in Jodhpur (MacPherson 1927) and Sind (Menesse 1950).

Catopsilia pyranthe pyranthe (Linnaeus)

The Mottled Emigrant is confined to the Nursery, with the exception of three males from the Ridge in August. It has been collected April IV, May IV, and from July II to Nov. III. Females have only been collected between April IV and Sept. IV. Copulating pairs have been collected on 20 July 1962 (JPD) and 29 Aug. 1961 (JPD). 109 specimens : 64 males (59%), 45 females.

SIZE : ♂♂ 22 mm. (3 Sept.1962, RLD) to 32 mm. (11 Aug. 1962, RLD). ♀♀ 19 mm. (29 May 1962, JPD) to 32 mm. (31 July 1962 and 26 Aug. 1961, JPD).

DISTRIBUTION : As for *C. crocale.*

Catopsilia florella gnoma (Fabricius)

The African Emigrant is less common and more scattered throughout the year than *C. pyranthe.* It has been collected in July III and IV, from Sept. I to Jan. I, and from Feb. III to April IV. Further collecting may produce specimens from May, June, and August, the months for which there are no records. Specimens have been collected on the Ridge only in the last weeks of February, March, and December. Only four specimens have been collected in Delhi during the monsoon season, when *C. pyranthe* is most abundant, thus lending support to Talbot's (1939) belief that *C. florella* is a dry-season form of *C. pyranthe.*

SIZE : ♂♂ 23 mm. (1 Dec. 1962, RLD) to 31 mm. (29 March 1964, RCF). ♀♀ 21 mm. (30 April 1963, RLD) to 31 mm. (3 Sept. 1962, RLD).

DISTRIBUTION : As for *C. crocale.*

Eurema brigitta rubella (Wallace)

The Small Grass Yellow is the least common Delhi *Eurema.* It is found in all habitats from Aug. II to Jan. I, and again in Feb. III and IV (Ridge). It is most frequently collected in August (10 specimens), September (12 specimens), and November (23 specimens). Females have only been collected from Aug. II to Dec. IV. 57 specimens : 39 males (68%), 17 females, 1 unsexed.

SIZE : ♂♂ 14 mm. (several, Nov. & Dec.) to 19 mm. (29 Sept. 1961, JPD). ♀♀ 15 mm. (20 Aug. 1962, JPD ; 18 Nov. 1962, RCF) to 19 mm. (several, late Sept. to early Nov.).

VARIATION : The marginal band UPH is continuous and broad from Aug. II to early November, after which it becomes reduced and macular. Wet season females (Aug. to Oct.) have a considerable amount of black scaling on the upper-and undersides.

DISTRIBUTION : Throughout India, while other subspecies occur west to the Ethiopian Region (Talbot 1939). It is reportedly scarce in Lucknow (de Rhé-Philipe 1902), uncommon in Jodhpur (MacPherson 1927), and occasionally abundant, though usually uncommon, in Lahore (de Rhé-Philipe 1917). There are additional specimens in the MSU collection from Ludhiana, Punjab (11-12 Sept. 1961), Siliserh, Rajasthan (19 Nov. 1963, RLD), and Agra, U.P. (21 Nov. 1957).

Eurema laeta laeta (Boisduval)

The Spotless Grass Yellow is more common on the Ridge, but it occurs in all habitats from Aug. II to April II. 103 specimens : 61 males (59%), 42 females.

SIZE : ♂♂ 13·5 mm. (26 Feb. 1963, RCF) to 18 mm. (18 Nov. 1962, RCF). ♀♀ 14 mm. (20 Aug. 1962, JPD) to 19 mm. (29 Sept. 1961, JPD).

VARIATION : The wet season form '*venata*' (Moore) occurs from Aug. II to Sept. IV. DSF '*laeta*' (Boisduval) occurs from Oct. IV to April II. There are no records from early October, when both forms or a transitional form should occur. The dry season form is so pale that it appears almost white in flight.

DISTRIBUTION : Throughout India (Talbot 1939). A few specimens, of form '*laeta*' only have been reported from Lahore (de Rhé-Philipe 1917), but it is common in Jodhpur (MacPherson 1927). It has not been recorded from Lucknow (de Rhé-Philipe 1902). There are additional specimens in the MSU collection from 15 miles south of Saharanpur, U.P. (8-9 May 1961), Siliserh, Rajasthan (19 Nov. 1963, RLD), and Pali, Rajasthan (9 May 1961).

Eurema hecabe simulata (Moore)

The Common Grass Yellow is, appropriately, the most common *Eurema* in Delhi, flying from June IV to May III in all habitats, although it is more frequently collected in the Nursery. It is apparently rare from January to June. A copulating pair was collected on 25 Sept. 1961 (JPD). 247 specimens : 156 males (63%), 91 females.

The sex ratio of field-collected specimens varies considerably, with the percentage of males increasing from Aug. IV to Sept. I, then decreasing to Nov. IV : 64% males Aug. IV (47 specimens), 88% males Sept. I (16 specimens), 69% males Nov. I (32 specimens), 53% males Nov. III (17 specimens), and 47% males Nov. IV (19 specimens).

SIZE : ♂♂ 15 mm. (26 Feb. 1963, RCF) to 22 mm. (18 Nov. 1962, RCF ; 7 Sept. 1962, RLD). ♀♀ 15 mm. (22 Nov. 1962, RCF) to 22 mm. (2 specimens, 28 Aug. 1961, JPD).

VARIATION : The dry-season form of this species is more heavily marked than the wet-season form. The DSF, which flies from about early November to late April, has conspicuous rusty markings on the underside and a prominent rusty subapical patch UNF. The WSF is poorly marked on the underside, does not have the rusty subapical patch UNF, and usually has no trace of the two cell spots UNF—the often-used key character for the species. The 'dogface' pattern UPF is more pronounced in the WSF than in dry-season specimens, and in dry-season specimens the black margin UPF is occasionally reduced to a narrow border somewhat as in *E. brigitta* (although there are some males from Oct. IV and Nov. I with the reduced margin).

Because many specimens are poorly marked, the genitalia of all males were examined, but no specimens of the similar *E. blanda silhetana* (Wallace) were found. Despite the statements in Talbot (1939) and Wynter-Blyth (1957) that *Eurema blanda* occurs from Ceylon and peninsular India to Sikkim, Assam, and eastward, I have collected it only in Ceylon, the Western Ghats, and north-eastern India. If it does occur on the Deccan Plateau or the Gangetic Plain it must be very local.

Because *Eurema hecabe* is so very variable in both size and coloration, it is my opinion that at least some of the Indian subspecies are not valid, but Talbot (1939) will be followed until more work can be done on the genus.

DISTRIBUTION : *E. hecabe* occurs throughout India, with *E. hecabe simulata* presumably restricted to Ceylon, peninsular India, and the Central Provinces (Talbot 1939). *E. hecabe fimbriata* (Wallace) is said to occur from the Punjab to Chitral and Kumaon (Talbot 1939), but all the records cited indicate that this is a Himalayan subspecies, hence the assignment of the Delhi population to *E. h. simulata*. The species is common throughout the Indo-Gangetic Plain, and extends westward to Africa (Talbot 1939).

Colias electo fieldi Ménétriès

As with *Pieris canidia*, the occurrence of this hill species in Delhi was unexpected. RLD has collected the only five Delhi specimens, which are identical to several large series I have collected in the Himalaya. A female was collected in the Nursery on 3 March 1963, and on 24 March 1963 a male and a female were obtained. A male and a female were also obtained on the North Ridge, near I.A.R.I., on 29 March 1964.

SIZE : The two males measure 19 mm. and 20 mm., while the females are 23 mm. 25 mm., and 25 mm.

DISTRIBUTION : The Dark Clouded Yellow occurs throughout the Himalaya (Talbot 1939), but it has also been recorded from the following localities on the plains, where it is presumably a non-breeding straggler in the winter and spring : 15 miles NE. Amritsar, Punjab, in late March [Sanders 1930, who also found *C. erate erate* (Esper) there in late Feb. and late March] ; Amritsar (Sevastopulo 1948, who also collected *C. erate*) ; Lahore, in the ' early cold weather months ' and again in Feb. and March (de Rhé-Philipe 1917) ; Fatehgarh (Peile 1911) ; and Lucknow, in the winter, and also in Feb. near Goshainganj, 130 miles SE. of Lucknow (de Rhé-Philipe 1902). Delhi appears to be the south-westernmost record of this species.

(*to be continued*)

Aestivation of perianths of *Areca catechu* Linn. fruits

BY

T. A. Davis and Abantika Kundu
Indian Statistical Institute, Calcutta

(*With three figures*)

Introduction

Data are presented in the following pages on the different ways the six perianths of the female flowers/fruits of the areca palm (*Areca catechu* Linn.) are arranged. It is customary to describe the sepals (outer whorl of perianth) as well as the petals of areca flowers as being imbricately arranged (Hooker 1894 ; Murthy & Bavappa 1960a ; Raghavan & Baruah 1956). But critical examination of a large number of fruits reveals that the sepals always imbricate leading to a spiral arrangement. In about half the number of fruits, the spiralling is clockwise, and in the rest, the converse. The petals have four distinct kinds of aestivation. In *c.* 20% of the fruits, all the petals regularly contort. About half of them have clockwise and the rest counter-clockwise contortion. In the remaining *c.* 80%, the petals imbricate like the sepals (both directions). The leaves of areca palm are spirally arranged, and a palm may be considered either a left-hander or a right-hander. The foliar asymmetry is not correlated with the aestivation of either the sepals or petals. Examination of the foliar spirals of seedlings raised from known fruits suggests that there is no correlation existing between the aestivation of the petals of a fruit and the foliar spiral of the seedling which develops out of it.

Material and Methods

A total of 4203 areca palms from four Indian States (Kerala, Mysore, West Bengal, and Assam) were examined for their foliar asymmetry in 1965. About four thousand fruits of 24 palms from Calcutta were examined for the arrangement of the perianths. (some of them including the bracteoles) during 1964 and 1965. As some knowledge on the gross morphology of the flowers/fruits may help

to interpret the results better, a brief account of the areca flowers is given below.

Areca catechu Linn. bears unisexual flowers on the same infrafoliar, highly branched spadix, enclosed by a single glabrous spathe which is covered by the sheathing base of the subtending leaf almost up to the stage of the bursting of the spathe. The main rachis of the spadix is stout and compressed, producing several branches, some of which further branch and re-branch. The ultimate filiform spikes bear more or less distichous minute male flowers. The female flowers are solitary or, less frequently, in pairs at the bases and axils of the branches. Rarely one or two male flowers are seen at the base of a female flower. The spathe, corresponding to the fourth bract (younger to the largest spathe) of the coconut, although absent in most areca spadices, can be made out if very young spadices are examined. Barring the contributions of Blatter (1926), Juliano & Quisumbing (1931), Menon & Pandalai (1958), Patel (1938), and Venkata Rao (1959), the floral biology of palms has not been studied appreciably.

At the base of every female areca flower, a minute bract is visible which is more pronounced just at the time the spathe ruptures and the spadix emerges. Each female flower has two small scaly bracteoles (prophylls) just outside the sepals; of them the outer one sometimes grows almost half the size of a sepal. The outermost sepal, which partially overlaps the remaining two sepals, is located opposite and equidistant from the two bracteoles. When viewed from behind the spike on whose axil a female flower is produced, if the outermost sepal is located to the right of the observer, the bigger prophyll will be on the left. In another, the positions are just interchanged.

The male flowers are small triangular or ovate bodies measuring *c.* 4·5 mm. × 3·0 mm. There are three minute sepals which are largely imbricate (critical large scale examinations not made); they alternate the inner whorl of three valvate petals which enclose six stamens, and the pistillodes in the centre consist mostly of the reduced trifid stigma. The female flowers are much larger, measuring *c.* 18 mm. × 10 mm. at the time of receptivity. The perianths of the outer whorl representing the sepals are always imbricately arranged (one completely out, another partially covered by the outer sepal and partially covering the inner, and the third is completely in). Though the sepals are described as boat-shaped, they are more or less triangular, concave within, and fit tightly on the petals which are also triangular, convex outside, and slightly bigger than the sepals. The perianths being acrescent grow with the fruit. A thin ring of six staminodes is seen between the petals and the ovary. The ovary has a dome-shaped trifid stigma formed by the three stylar projections.

Results and Discussion

100 fruits from a spadix were examined to determine the position of the outer sepal relative to the axis on which the fruit is borne. The fruit is viewed from behind the axis, and the results given under.

Fruits with outer sepal to left of axis	.. 47
Fruits with outer sepal to right of axis	.. 44
Fruits with outer sepal opposite to axis	.. 2
Fruits where positions could not be made out	.. 7
Total	.. 100

Four distinct types of petal-arrangement are observable on areca fruits. All the petals in a flower may regularly rotate, i.e. contort (one half of each petal remaining out and the other half being overlapped by the succeeding or preceding petal) either clockwise or counter-clockwise. When a flower is viewed from the stigmatic end downwards, if the outer free portion of the petal twists clockwise, the flower is considered a left-hander, and vice versa if the petal twists counter-clock-

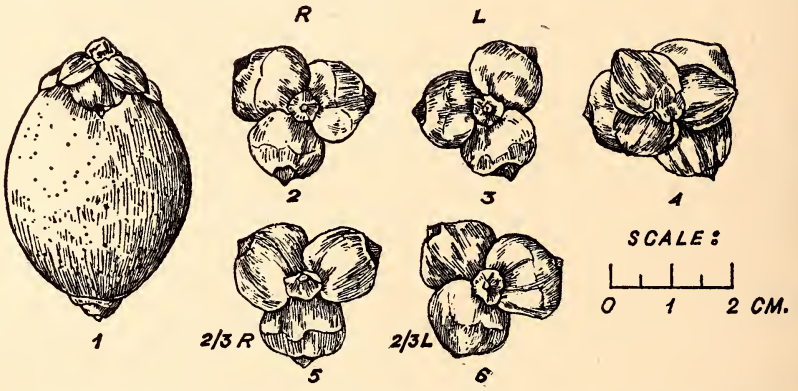

Fig. 1. 1. Areca fruit (side view); 2-3. Corolla regularly twisting to right (2), to the left (3); 4. Six perianths intact (top view); 5-6. Right- and left-handed imbrications of Corolla.

wise. In Fig. 1 the two middle drawings in the upper row represent the two kinds of regular petal-twist, the two lower drawings the two situations when the petals imbricate. In a flower where the petals are imbricately aestivated, depending on the arrangement of the middle petal, a flower is considered $\frac{2}{3}$-left-hander (illustration 6 of Fig. 1) or $\frac{2}{3}$-right-hander. In the $\frac{2}{3}$-left-handed condition, (starting from the outermost one) the three petals spiral clockwisely. The arrangement of the petals is reversed in a $\frac{2}{3}$-right-hander.

The proportion of flowers having their petals regularly contorting

and those with imbricate aestivation was about one to five for a population of 762 fruits examined in 1964 (Davis 1964a). In Table 1 data are given on a little over three thousand fruits from 15 areca palms sampled in Calcutta.

TABLE 1

Areca catechu: AESTIVATION OF PETALS

Petal-twist	No. of fruits	Percentage	
Left	320	10·53	19·58
Right	275	9·05	
⅔-Left	1,225	40·31	80·42
⅔-Right	1,219	40·11	
Total	3,039	100·00	

The proportion of flowers having contorted petals to those with imbricate ones in the new population altered slightly (1 : 4). Since the earlier data were also collected from Calcutta, the variation in the two sets of observations may suggest that the proportions differ with individual palms or seasons, and warrants the need for much larger samples.

The petal arrangement on the fruits of six other palm species was also studied and the data together with those for *Areca catechu* appear in Table 2.

TABLE 2

AESTIVATION OF PETALS ON FRUITS OF 7 PALM SPECIES

Species	Lefts	Rights	⅔-L	⅔-R	Total
Areca catechu	320	275	1,225	1,219	3,039
Areca triandra	9	6	182	206	403
Borassus flabellifer	25	38	143	143	349
Cocos nucifera	25	16	208	186	435
Phoenix paludosa	42	19	62	61	184
Phoenix sylvestris	384	253	1,083	961	2,681
Ptychosperma macarthuri	0	1	1,195	1,128	2,324
Total	805	608	4,098	3,904	9,415

Flowers with contorted corolla in *Areca triandra* constitute only 3·7% of the population sampled. The corresponding figures for *Cocos nucifera*, *Borassus flabellifer*, *Phoenix sylvestris*, and *P. paludosa* are 9·4, 18·0, 23·8, and 33·7 respectively. In *Ptychosperma macarthurii*, however, with the exception of a single flower, a population of 2324 flowers showed only imbricate petals. The mechanism which regulates the aestivation of the corolla varying with species is not yet known. As the number of foliar spirals varies with the species, the foliar arrangement may have some influence on the aestivation.

Calyx-corolla relationship

As already mentioned, the calyx in *Areca catechu* is always imbricate, $\frac{2}{3}$ left or $\frac{2}{3}$ right and, under each situation, the four types of petal-aestivation occur (Fig. 2, L_1-L_4, R_1-R_4). In only a single exceptional flower, the sepals contorted clockwisely. 2277 flowers were examined for the arrangements of sepals and petals, and the data are presented in Table 3.

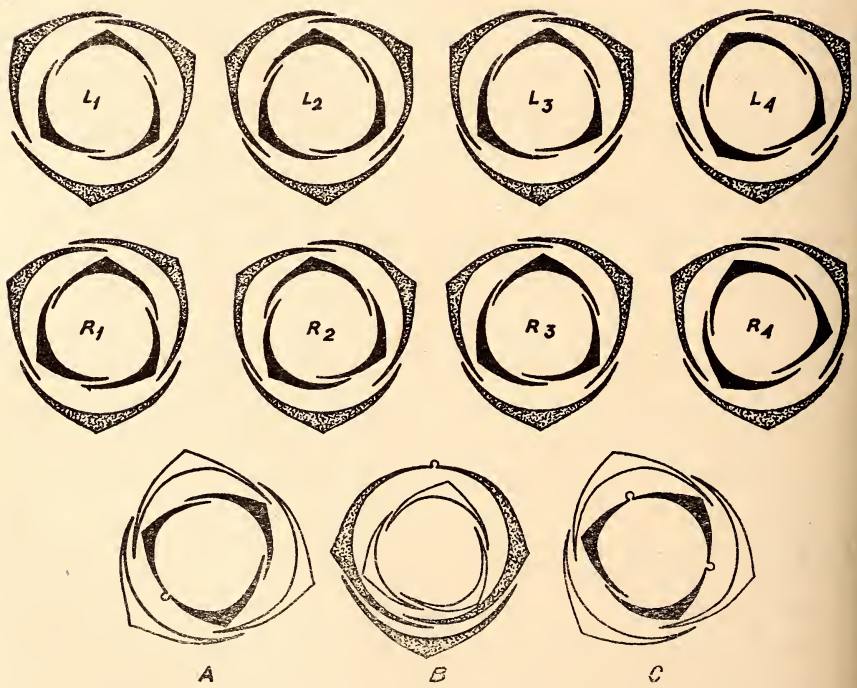

Fig. 2. Aestivation of perianths in *Areca catechu*. *Top row*: The four possible petal-arrangements when sepals imbricate to left. *Middle row*: Petal arrangements same as top row but sepals imbricate to right. *Bottom*: *A*. Flower with a double petal; *B*. Another with a double sepal; *C*. Flower with three petals united.

The number of flowers with left-handed sepal-imbrication does not differ significantly from that of their counterpart. Flowers whose sepals as well as petals are left-handed form slightly over 50% of the population sampled (584 : 526). Among flowers with left-handed sepals, those with left as well as right-spiralled petals are distributed equally. But among flowers with right-handed sepals, those bearing left-handed petals

TABLE 3

Areca catechu : DISTRIBUTION OF FRUITS ACCORDING TO AESTIVATION OF PERIANTHS

Sepals	Petals				Total
	Left	Right	$\frac{2}{3}$-L	$\frac{2}{3}$-R	
Left	—	—	1	—	1
Right	—	—	—	—	—
$\frac{2}{3}$-L	124	124	460	468	1,176
$\frac{2}{3}$-R	116	101	458	425	1,100
Total	240	225	919	893	2,277

are more. The slight excess of left-handedness in the aestivation of *Areca catechu* perianths is in conformity with the situations met with in some species of Malvaceae and Bombacaceae by Davis (1964b ; 1965), Davis & Ghoshal (1966), Davis & Kundu (1965), and Davis & Selvaraj (1964) and in the coconut by Davis (1962).

In order to see whether the proportions of the different groups of flowers vary significantly between individual trees, 1670 young fruits from 12 trees were examined at Calcutta, and the data presented in Table 4.

All the trees bore fruits having the eight different types of perianth arrangement. The aestivation is not influenced by the foliar spirality of a palm. Another point of interest is that 22·14% of the fruits bore twin sepals, and the twins always happened to be the younger two calyx components of a flower (Fig. 2, B). The outermost sepal which is completely exposed is just opposite the twin sepal. This may confirm that all the three members of the calyx whorl are not formed simultaneously, although the time-interval between the second and third sepals is very small when it exists.

Some spikes bore more than two flowers each, and an examination of those flowers suggested that the left- and right-handed flowers are distributed randomly on a spike.

The areca palm has five rows of leaves placed at $\frac{2}{5}$-distances of the circle, giving a phyllotaxy of five-ranked or ' pentastichous ' with an

TABLE 4

Areca catechu: AESTIVATION OF PERIANTHS ON FRUITS OF INDIVIDUAL TREES

Tree and spiral	Sepal-petal combinations								Fruits with twin sepals	Total
	IL/L	IL/R	IL/IL	IL/IR	IR/L	IR/R	IR/IL	IR/IR		
1 R	4	4	19	18	4	5	21	18	6	99
2 L	1	4	18	10	2	1	12	18	10	76
3 L	5	8	10	23	2	4	25	14	3	94
4 R	3	7	15	17	7	6	19	15	5	94
5 R	5	4	20	24	4	6	36	13	20	132
6 L	1	9	14	33	8	3	23	13	6	110
7 R	1	4	9	18	9	1	17	9	105	173
8 L	4	9	38	33	11	5	27	21	33	181
9 R	15	4	25	13	4	3	11	21	5	101
10 L	16	7	42	33	7	15	38	42	12	212
11 R	8	19	20	21	8	4	27	21	17	145
12 L	7	10	20	29	1	3	14	11	158	253
Total	70	89	250	272	67	56	270	216	380	1,670

N.B. L=regularly left-spiralled ; R=regularly right-spiralled ; IL=imbricate left IR=imbricate right.

angular divergence of 144° (Murthy & Bavappa 1960b). Thus, the sixth leaf will stand over the first with a genetic spiral of two circles and the eleventh leaf over sixth with a similar spiral. Since there are only about eight leaves present on the crown of a palm at a time and because of the fairly long internodes, the above details on the leaf-arrangement are not easily observable. As the leaves appear to be 'alternate', it is easier to conceive that they are arranged in a single spiral running clockwise or counter-clockwise. A tree is considered as having a clockwise (left-handed) foliar spiral if the younger of any two consecutive leaves (or inflorescences) is located nearer the vertical drawn from the middle of the older leaf towards the right-hand side of the observer, and as right-handed if it falls on the opposite side. This definition conforms to the coconut spirals (Davis 1962). In a population, the two kinds of trees are distributed in almost equal proportions as may be seen from Table 5.

TABLE 5

Areca catechu: DATA ON FOLIAR SPIRALS

Locality	Lefts	Rights	L+R	L−R
Palode (Kerala)	541	540	1,081	1
Vittal (Mysore)	544	505	1,049	39
Calcutta (W. Bengal)	155	162	317	−7
Jalpaiguri (N. Bengal)	382	323	705	59
Gauhati (Assam)	538	513	1,051	25
Total	2,160	2,043	4,203	+117

As the leaves are arranged spirally, the perianths also show spiral mechanism. The sepals of all the fruits and petals of about 80% fruits are arranged one after another (from the outermost) in spiral form. From data given in Table 3, it is seen that, only in just a little less than half the fruits, both the sepals and petals are arranged along the same direction (left- or right-spiralled). In the rest, the whorls of calyx and corolla are oppositely arranged, and this situation is more difficult to explain in view of the fact that the leaves in a palm always veer either clockwise or anti-clockwise.

Even in fruits where the sepals and petals veer in the same direction, the outermost petal which is to develop in continuation of the last sepal does not always seem to be doing so because of its varying positions as detailed below.

Of the 2277 fruits examined, the sepals imbricate in all except an odd case of contortion. On account of this situation a fruit bears one

sepal which is completely exposed. The sepals in a flower either twist right-handed or left-handed. The three petals can be arranged in four different ways (two types of contortions and two imbrications). Six different types of aestivation are possible when only the two kinds of petal-imbrications are considered in relation to the outermost sepal. Therefore, for the two types of sepal arrangements twelve kinds of imbrications are possible. With the left- and right-handed regular contortions for each calyx type, there are altogether sixteen different arrangements of perianths possible. Fig. 3 depicts 12 such combinations and the four combinations where the petals contort are seen in Fig. 2.

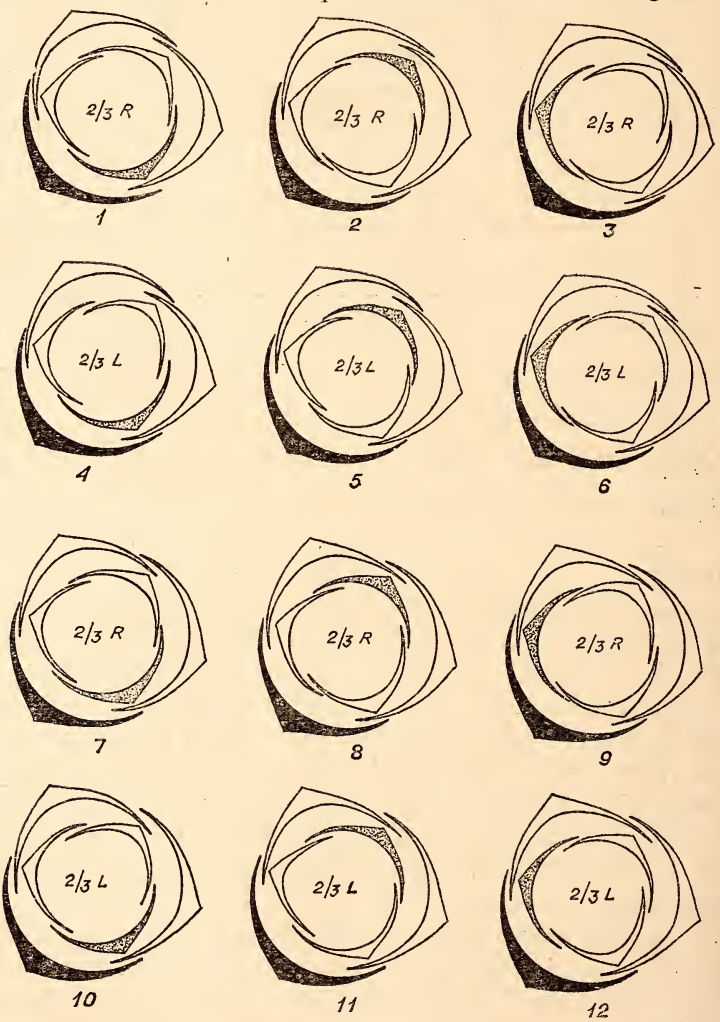

Fig. 3. Drawing to show relative positions of outermost sepal and outermost petal in areca fruits. Sepals in flowers 1-6 imbricate to left, in 7-12 to right. Petals in 1-3 and 7-9 imbricate to right, and in 4-6 and 10-12 to left.

When viewed from the middle of the outermost odd sepal, one petal will be seen just on its opposite side, one to its right and the other left. Any one of these can be the outermost petal. (Where the corolla is contorted, all the petals are similarly arranged.) In flowers where the petals imbricate right-handedly, the outermost petal can be in three positions in relation to the outermost sepal (vide Nos. 1-3 of Fig. 3), and when the petals imbricate left-handedly, a further three combinations are possible (vide Nos. 4-6 of Fig. 3). The six figures in the lower two rows show right-handed rotation of the calyx as opposed to the left-handed rotation of those in the top two rows. The numbers of fruits falling under the 16 sepal-petal combinations collected from three trees are given in Table 6.

In 26·26% of the entire fruits examined, the outermost petal was located opposite the outermost sepal, in 26·27% to its left, and in 23·10% to the right. The proportion of fruits having both the sepals and petals imbricating left-handedly and having the outer petal located to the left of the outer sepal is slightly greater than those of the other perianth-combinations relating to the left-handed sepals. Similarly, flowers having right-spiralled calyx and corolla and the outer petal located to the right of the outer sepal are slightly in excess of the other situations.

Aestivation of fruit and foliar spiral of subsequent seedling

One thousand ripe areca fruits collected from ten palms growing at the premises of the Indian Statistical Institute, Calcutta, were sown in a special nursery in December 1964, after separating them into four groups according to the aestivation of the petals. An examination of the foliar arrangement in the seedlings did not show that a fruit with a particular kind of aestivation gives rise to a seedling having a particular foliar spiral. In each group, left-handed and right-handed seedlings were observed.

Abnormalities

While examining the spadices from many areca palms, the following abnormalities were met with. A single flower having regularly contorted sepals and those bearing twin sepals have already been mentioned. In the two other flowers, the younger two petals fused to about three-fourths of their lengths (Fig. 2, A). In yet another flower, all the three petals remained united, but the corolla was free at one region where the margins overlapped each other clockwisely (Fig. 2, C). The sepals of this flower, however, were free and imbricate. One flower had only 2 sepals and 2 petals as the one already described by Bavappa & Murthy (1961). Hermaphrodite flowers were noticed in five trees, a spadix bearing 2 to 22 such abnormal flowers. The size of the bisexual flowers ranged between the sizes of normal male and female flowers.

TABLE 6

Areca catechu: CALYX-COROLLA RELATIONSHIP

			Tree 1	*Tree* 2	*Tree* 3	*Total*	% *on g. total*
A. Sepals: Imbricate: ⅔-Left-handed							
Petals	Twisting regularly to the Left		4	8	7	19	6·01
	Twisting regularly to the Right		4	19	10	33	10·45
Petals	Imbricate ⅔-Left	*Outer petal to outer sepal*					
		(*a*) Opposite	4	5	8	17	5·38
		(*b*) To the Left	12	9	5	26	8·23
		(*c*) To the Right	3	6	7	16	5·06
	Imbricate ⅔-Right	*Outer petal to outer sepal*					
		(*a*) Opposite	7	8	12	27	8·54
		(*b*) To the Left	7	5	12	24	7·60
		(*c*) To the Right	4	8	5	17	5·38
Total:			45	68	66	179	56·65
B. Sepals: Imbricate: ⅔-Right-handed							
Petals	Twisting regularly to the Left		4	8	1	13	4·11
	Twisting regularly to the Right		5	4	3	12	3·80
Petals	Imbricate ⅔-Left	*Outer petal to outer sepal*					
		(*a*) Opposite	13	7	6	26	8·23
		(*b*) To the Left	5	13	2	20	6·33
		(*c*) To the Right	3	7	6	16	5·06
	Imbricate ⅔-Right	*Outer petal to outer sepal*					
		(*a*) Opposite	6	6	1	13	4·11
		(*b*) To the Left	5	6	2	13	4·11
		(*c*) To the Right	7	9	8	24	7·60
Total:			48	60	29	137	43·35
Grand Total:			93	128	95	316	100·00

Each flower bore six or less fully or partially developed stamens. The ovary developed conspicuously in flowers which resembled the female flowers. Similar condition was recorded in the coconut by Davis *et al* (1954) and Rao (1948) and in the arecanut by Bavappa & Murthy (1961) and Raghavan & Murthy (1954). One young areca fruit bore a single horn-like structure developing from one of the staminodes like the ones described by Davis (*in press*) and Murthy & Bavappa (1959).

Synopsis

Of the six perianths on a fruit of *Areca catechu* Linn., the outer three (sepals) are always imbricately aestivated. The two wings of the innermost sepal are overlapped by the outer sepals while those of the outermost one are exposed. A wing of the middle sepal is overlapped by the outer sepal and, depending on the position of its exposed wing, a fruit may be regarded as left- or right-handed. In a large sample, fruits with the two kinds of sepal-arrangement are distributed in almost equal proportions. The inner whorl of three perianths (petals) either contorts (twists regularly) or imbricates like the sepals. The petals of about 20% of the fruits sampled twist regularly, and in the rest they imbricate. In about 50% of the fruits having either contorted or imbricate aestivation, the petals veer clockwise, and the rest counterclockwise. The data supplied show that the outermost sepal and outermost petal of a fruit are related to each other in sixteen different ways. The aestivation of the petals of a fruit is not correlated with the foliar spiral of either the mother palm or the seedling that develops out of it.

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A report on Ticks collected from Birds and small Mammals in North Arcot and Chittoor Districts, South India

BY

M. J. Rebello and Rachel Reuben

Virus Research Centre, Poona[1]

Early knowledge about ticks in south India was very scanty and based mainly on collections made by veterinarians on domestic animals. Sharif published a key in 1928 and Sen summarised the existing knowledge about tick ectoparasites of wild mammals and birds in 1938. Subsequently the Virus Research Centre (VRC) has built up a large body of information on the subject based on collections made in several parts of India.

The present report is intended to place on record information on ticks collected from an area mainly in North Arcot District, Madras State, not covered by any of the previous surveys made by the VRC. The extensive studies made by the VRC in another part of south India, Mysore State, are being separately reported by the workers concerned (Trapido *et al.* 1964a and 1964b; Rajagopalan, V. R. C. unpublished data).

Methods

During 1963 birds were mist-netted weekly in each of two villages in North Arcot District. Japanese mist-nets, 3 to 4 feet off the ground, were used among bushes and trees near houses. The birds caught were searched for ticks and other ectoparasites, banded, and released. They were also bled for virological studies. During the course of the study many released birds were recaptured and found to have more ticks. The method adopted for searching for ticks was to lift each feather gently and to remove with a pair of forceps any ticks attached beneath. Special attention was paid to the head region, where the great majority of the ticks were found attached. After one of the authors (R. R.) had

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removed as many ticks as she could find, the bird was searched by a second person, and then handed back to her for a final check. The efficiency of this method is discussed later.

Some birds were also brought in by local trappers from forested areas in North Arcot District. These were the Grey Partridge, *Francolinus pondicerianus* (Gmelin), and the Painted Spurfowl, *Galloperdix lunulata* (Valenciennes). They were kept in the laboratory over trays of water and the engorged ticks collected from time to time as they detached and dropped in the water.

The small mammals were collected mainly from the villages where the birds were captured. They were captured in standard Sherman traps, brought to the laboratory, and transferred to cages which were kept over trays of water for the fed ticks to detach. A few collections were made in Ootacamund, Nilgiri District, and some in Chittoor District, Andhra State.

Results

Birds

Over the period of the study 590 birds belonging to 55 species were examined. Of these, 136 birds belonging to 16 species were found to be positive for Ixodid ticks (Table 1). Only three species of ticks were collected, of which *Haemaphysalis intermedia* Warburton & Nuttal, 1909, was the most common species. Its predominance in the collections is a reflection of the fact that birds were almost all netted in and around villages, since *Haemaphysalis intermedia* is a common cattle tick.

The following species of birds were negative for ticks : *Ardeola grayii* (Sykes) (2), *Accipiter badius* (Gmelin) (5), *Turnix suscitator* (Gmelin) (3), *Streptopelia senegalensis* (Linnaeus) (1), *Psittacula krameri* (Scopoli) (20), *Clamator jacobinus* (Boddaert) (2), *Eudynamys scolopacea* (Linnaeus) (2), *Rhopodytes viridirostris* (Jerdon) (3), *Athene brama* (Temminck) (2), *Caprimulgus asiaticus* Latham (2), *Halcyon smyrnensis* (Linnaeus) (20), *Merops orientalis* Latham (21), *Upupa epops* Linnaeus (10), *Megalaima haemacephala* (P.L.S. Müller) (2), *Dinopium benghalense* (Linnaeus) (16), *Lanius vittatus* Valenciennes (3), *Lanius schach* Linnaeus (1), *Dicrurus adsimilis* (Bechstein) (1), *Dendrocitta vagabunda* (Latham) (1), *Corvus splendens* Vieillot (4), *Corvus macrorhynchos* Wagler (6), *Coracina melanoptera* (Rüppell) (6), *Pericrocotus cinnamomeus* (Linnaeus) (3), *Aegithina tiphia* (Linnaeus) (4), *Pycnonotus luteolus* (Lesson) (4), *Muscicapa latirostris* Raffles (1), *Terpsiphone paradisi* (Linnaeus) (1), *Anthus trivialis* (Linnaeus) (2), *Motacilla maderaspatensis* Gmelin (5), *Nectarinia zeylonica* (Linnaeus) (17), *Nectarinia lotenia* (Linnaeus) (1), *Nectarinia asiatica* (Latham) (4), *Passer domesticus* (Linnaeus) (97), *Petronia xanthocollis* (Burton) (30), *Ploceus philippinus* (Linnaeus) (28),

Lonchura striata (Linnaeus) (1), *Lonchura malacca* (Linnaeus) (19). The number in brackets represents the number of birds examined.

The method of removing ticks has already been described. Its efficacy was tested on a few occasions. Two birds were killed after being searched in the field and five birds were kept alive in the laboratory. Thrice a single tick was collected in the laboratory after the original field examination, and on four occasions no more ticks were recovered. The field method was thus reasonably thorough and it seems likely, therefore, that the majority of the ticks collected on recaptured birds represented fresh infestations, and were not merely ticks which were missed by the naked eye the first time the bird was examined. Indian Pittas and Greyheaded Babblers were frequently recaptured infested with ticks after an interval of a week from the original examination.

Small mammals

The collections made from small mammals in Chittoor and North Arcot Districts are summarised in Table 2. It is interesting to find that many rodents harboured the immature stages of the genus *Hyalomma*, the commonest collected in this study being *H. brevipunctata*. The predominant genus, however, was *Rhipicephalus*, particularly *R. haemaphysaloides*. At present three species of *Rhipicephalus* are recognised in India (Sharif 1928; Dhanda, to be published). These are *Rhipicephalus sanguineus* (Latreille), *Rhipicephalus haemaphysaloides* Supino, and *Rhipicephalus ramachandrai* Dhanda. Two species of *Rhipicephalus* showing distinct differences from the known species were collected during this study from rodents and shrews. These species have been designated as *Rhipicephalus* species 4 and 5 for the present. These species require careful study to determine their taxonomic status. Most of these ticks were collected as fed nymphs and subsequently reared in the laboratory.

A few miscellaneous collections made in North Arcot District have been included in Table 3.

Two *Rattus rattus wroughtoni* and four *Suncus murinus* were collected in Ootacamund, Nilgiri District. Two larvae identified as *Ixodes ceylonensis* were collected, one from *Rattus rattus wroughtoni* and the other from *Suncus murinus*. This is of special interest since it is the first record of this species in India outside the Kyasanur Forest disease area in the forests of Shimoga District, Mysore State.

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TABLE 1

TICKS COLLECTED FROM BIRDS EXAMINED IN NORTH ARCOT DISTRICT FROM JANUARY TO DECEMBER, 1963

Host (Species found negative not included)	Total birds examined	Total birds positive for ticks	*Haemaphysalis intermedia*				*Haemaphysalis bispinosa*	*Hyalomma marginatum isaaci*		Total
			L	N	M	F	L	L	N	
1 *Francolinus pondicerianus* (Gmelin) (Grey Partridge) ..	11	6	19	2	3	1	—	—	—	25
2 *Galloperdix lunulata* (Valenciennes) (Painted Spurfowl) ..	2	2	4	6	—	—	—	—	—	10
3 *Cacomantis merulinus* (Scopoli) (Indian Plaintive Cuckoo) ..	1	1	1	—	—	—	—	—	—	1
4 *Pitta brachyura* (Linnaeus) (Indian Pitta) ..	9	7	57	21	—	—	1	—	—	79
5 *Mirafra assamica* Horsfield (Bush Lark) ..	1	1	6	1	—	—	—	—	—	7
6 *Lanius cristatus* Linnaeus (Brown Shrike) ..	4	1	2	6	—	—	—	—	—	8
7 *Dicrurus leucophaeus* Vieillot (Grey Drongo) ..	4	1	1	—	—	—	—	—	—	1
8 *Sturnus pagodarum* (Gmelin) (Brahminy Myna) ..	35	17	35	8	—	—	—	—	1	44
9 *Acridotheres tristis* (Linnaeus) (Common Myna)	11	5	16	4	—	—	—	1	—	21
10 *Tephrodornis pondicerianus* (Gmelin) (Common Wood Shrike) ..	9	5	10	1	—	—	1	—	—	12
11 *Pycnonotus cafer* (Linnaeus) (Redvented Bulbul)	22	1	2	—	—	—	—	—	—	2
12 *Turdoides affinis* (Jerdon) (Whiteheaded Babbler)	66	57	840	114	—	—	3	1	—	958
13 *Orthotomus sutorius* (Pennant) (Tailor Bird) ..	9	2	2	1	—	—	—	—	—	3
14 *Acrocephalus dumetorum* Blyth (Blyth's Reed Warbler) ..	13	5	11	1	—	—	—	—	—	12
15 *Copsychus saularis* (Linnaeus) (Magpie-Robin) ..	4	3	17	11	—	—	—	—	—	28
16 *Saxicoloides fulicata* (Linnaeus) (Indian Robin) ..	26	22	48	31	—	—	—	—	—	79
Total ..	227	136	1071	207	3	1	5	2	1	1290

NOTE—4 nestling Little Cormorants, *Phalacrocorax niger* (Vieillot), and 9 nestling Grey Herons, *Ardea cinerea* Linnaeus, were examined, and 61 *Argas* larvae were collected from one Little Cormoran t and five Grey Herons.

L = larva ; N = nymph ; M = male ; F = female.

TABLE 2

TICKS ON SMALL MAMMALS FROM CHITTOOR DISTRICT, ANDHRA PRADESH, AND NORTH ARCOT DISTRICT, MADRAS STATE (1962-63)

Host	Total No. examined	No. +ve for ticks	*Haemaphysalis or lomma evipunctata*				*Haemaphysalis intermedia*	*Haemaphysalis leachi* group	*Rhipicephalus haemaphysaloides*			*Rhipicephalus* sp. no. 4	*Rhipicephalus* sp. no. 5			*Hyalomma* sp.?	*Rhipicephalus* sp.?	Total
			L	N	M	F	N	N	N	M	F	N	N	M	F	L	L	
Suncus murinus (Linnaeus) ..	56	7	1	2					1		16		16	2	1		11	50
Vandeleuria oleracea (Bennett)	3	1			4	6												10
Mus platythrix Bennett ..	81	46	13	43	9	17		1	93	2	2					1	13	194
Mus booduga (Gray) ..	4	1				2				1								3
Millardia meltada (Gray) ..	24	15	2	5	1	1			56	5	14						1	85
Tatera indica (Hardwicke) ..	42	9							57	2	2	7	1				10	79
Rattus rattus rufescens (Gray)..	109	17	2	6	5	3			11	11	7		7	5	8		7	72
Rattus rattus wroughtoni Hinton ..	19	9		1					4				5		1			11
Rattus rattus subspecies unknown* ..	3	1	6															6
Rattus blanfordi (Thomas) ..	6	1	1															1
Rattus cutchicus (Wroughton)..	3	2							2								1	3
Bandicota bengalensis (Gray & Hardwicke) ..	4	0																0
Funambulus tristriatus tristriatus (Waterhouse) ..	53	12	1	31	4	10	3		1								1	51
TOTAL ..	407	121	26	88	23	39	3	1	225	21	41	7	29	7	10	1	44	565

* This was a white-bellied form with tail too long for inclusion in *R. r. wroughtoni*. Since all three specimens were immature males, subspecific identification could not be made with certainty.

TABLE 3

MISCELLANEOUS ECTOPARASITIC COLLECTIONS

——	Total No. examined	No. +ve for ticks	*Hyalomma brevipunctata*	*Hyalomma a. anatolicum*	*Haemaphysalis intermedia*				*Haemaphysalis leachi* (Group)		*Rhipicephalus haemaphysaloides*			Total
			F	M	L	N	M	F	M	F	N	M	F	
Canis aureus Linnaeus ..	2	2			13	28	8	17			2		1	69
Herpestes edwardsi (Geoffroy)	2	2							5	1				6
Lepus nigricollis Cuvier ..	1	1			30	27	17	25						99
Domestic pig ..	3	2		3								1		4
Bats ..	5	nil												
Ground drag ..	6	6	1		189	49	2	8			1		1	251
Human ..	2	2									3			3
TOTAL ..	21	15	1	3	232	104	27	50	5	1	6	1	2	432

Chilka Lake: A Pilot Survey for Banding Possibilities

BY

K. S. LAVKUMAR

Rajkumar College, Rajkot

The Bombay Natural History Society's Party detailed to survey the Chilka area for banding possibilities was rather hurriedly composed in the month of December 1965 and consisted of Shekar of the Society's staff, Kishore Kadiwar a young and enthusiastic naturalist from Rajkumar College taken along by me, and myself. We assembled a few minutes before departure time of the Secunderabad Express at Victoria Terminus. Somehow, our enterprising travel agents got us the necessary seats and the last of the gear was stowed away just as the train pulled away from the platform. It was Christmas Day and the rush of people considerable at this otherwise normally crowded station.

The train journey from Bombay to Poona has always been my favourite; the clean and efficient electric engines make it a habit of speeding across the low coastal plain to the foot of the Western Ghats. The mountain section is slow but not at all trying as an everchanging panorama of escarpments and deep forested gorges provide a thrilling and everchanging view. It was good to once again see the arrogant curve of the 'Duke's Nose' rising above Khandala and momentarily I was transported to its top as I thought of the time two years previously when I had sat on the very edge of the proud profile.

From Lonavla to Poona the countryside assumes a typically Saurashtrian appearance so characteristic of the Black-cotton soil areas and I listed many of the common birds familiar at Rajkot as we speeded past the small farmsteads and groves of trees. Beyond Poona the ubiquitous steam engine took over and we puffed away into the dusk through well irrigated land bearing wheat, sugarcane, and alfa-alfa. I missed the Deccan as we arrived at Hyderabad early on the 26th morning. A day's stay was necessary as the connecting train for Orissa left in the afternoon. We utilised the time in going over the famous Salarjung Museum and bird watching in the attractively laid out public gardens stretching between the station and the Vidhan Sabha.

The section between Hyderabad and Rajamundry on the north bank of the Godavari was also covered under cloak of night and I was able to see little of the country, though I expect I missed little as much should be

arid and I expect scenically uninteresting. The Godavari Delta region was pleasing country, green, well cultivated and populous. Here there was an obvious demonstration of Man at harmony with Nature. People looked well fed, there were fine cattle and despite the human affluence, the trees and other vegetation around the stands of sugarcane and rice stubble were not mutilated. The fuzzy toddy palms lent a peculiar character to the scene. Around Bombay these palms look depressing, but here they have full crowns and were most attractive. Birdlife was plentiful and I expect there should be many roosts of wagtails in the sugarcane plots.

From Rajamundry upto Vizianagaram, where the night once again overtook us, the entire east coastal plain revealed a beautiful aspect. Sugarcane, golden rice stubble, thick stands of coconuts, rows of toddy palms, and closely ranked casuarinas all made a rich pastoral view, offsetting a distant panorama of high blue and tangled mountains of one of India's last great forests, the Dandakaranya. It was lovely country and birdlife was plentiful as could well be expected.

It was somewhere in the middle of the 27th night that the sleepy station of Balugaon saw us bundle out of the train. The entire platform was deserted except for the three of us and the Forest Range Officer deputed to receive us. I sleepily wondered why ever should the train stop at this place at all; Pilot Survey Parties could not be that frequent. A wet breeze blew through a large banyan tree outside the station and limpid stars were reflected in water alongside the road—dimmed imaginations conjured up a limitless expanse of water crowded with waterfowl and skeins darkening the skies overhead—a Pinkheaded Duck among them . . .

28*th December*. Mr. Rath, the aforestation D.F.O., stowed our luggage and us into two jeeps and we set off for our destination on the SE. edge of the lake. Till Rambha, we travelled along the Madras-Calcutta highway shaded by large trees many of them ancient banyans. The road skirted the sea-like Chilka. The country side had a picture postcard quality and a cool morning breeze blew from the blue mountains to our right. There were few birds apparent, and the lake itself was totally devoid of any waterfowl.

A little beyond Rambha we turned off the road on to a red dirt track and after winding through low scrub-covered hills we came out on to a vast flat expanse of wet grass and salt marshes at the southern end of the lake. There was much water in the roadside ditches, and long muddy inlets of the lake cut across them. The scene now abruptly changed; there were waders and ducks everywhere and, on one large bay of the lake, I was thrilled to see rafts of Pintail and Brahminies unconcernedly drifting close to lines of fish traps. This was fine unspoilt country indeed.

Soon we came onto the sandy flats which continue as a string of dunes to cut off the lake water from the sea. Here were thick stands of casuarinas and cashew trees. This narrow tongue of sand is broken by a single inlet of the sea through which the tide waters enter the lake and the many fish of the Chilka have access to the sea. Between the outer dunes and the body of the lake is a labyrinth of large low-lying islands and water channels. Our hope of coming across large congregations of birds centred on this complex and in this we were disappointed, as the further we proceeded along the dune, the number of birds became less and less and, except for one broad inlet where a great mass of shovellers rose on our arrival, we saw fewer birds in density than might be expected on any winter day on the lakes at Rajkot. Here a duck trapper had a pair of female shovellers and, as they were in good condition, I had them purchased for subsequent ringing and releasing, though other members of our convoy pressed to wring their necks instead. It was suggested we engage him and a few others of his tribe to catch birds for us, but he hardly appeared efficient and the number of birds did not justify making any optimistic arrangements. Despite the paucity of birds, I greatly enjoyed the drive as the freshness of the air and the lovely surroundings were in themselves worth experiencing. It was about 2.00 p.m. when we skirted the last bay and drew up beside two dug-outs with mat sails tied to stakes on the grassy verge. In these we crossed the furlong-wide channel to Barhampur Island which was selected as our headquarters for the survey. The water was crystal clear and nowhere deeper than four feet. The floor was covered by a thick mat of green water plants, but of birdlife there was a singular absence. Two Lesser Egrets and some Ringed Plovers waded along the water margin, and over the grass small flocks of Grey Plovers ran about looking for insects. Two Gadwall swam out in the water to our left. Nothing could have been less exciting. Shekar was disgusted, but I have given up getting disappointed as Dr. Longstaff's advice to Himalayan travellers has long been a part of my general outlook on life, and I make it a point to 'live in the present' and the present in such lovely country was infinitely charming.

The Forest Ranger's hut placed at our disposal was a structure of clean whitewashed adobe walls and thickly thatched roof standing on the northern shore of the island. It was separated from the water by a broad sward of grass, and surrounded by small rice fields, now in stubble, enclosed by earth bunds planted with screwpine hedges and small wind-swept banyans and cashew trees. The bird population was composed of a scattered group of Ringed, and Grey plovers on the ground, a pair of Redvented Bulbuls, and a rabble of Whitethroated Munias in the hedges, while a Pied Bushchat cock and some Pied Mynas inhabited the small compound of the hut. These then were the surroundings and birdlife of

the Headquarters of the Survey Party for possibilities of ringing thousands of waterfowl!

29*th December*. After a late breakfast, Mr. Rath decided to take me in a larger dug-out to have a look at the birds reputed to be in large throngs on the mud surrounding the Barnikuda Island and this would also give us an idea of the congregation of birds, if any, on the main lake. Shekar elected to stay behind to string up a few nets along the water's edge in an attempt to get some of the Grey Plovers running about. The brawny boatmen poled us across the shallow waters nowhere deeper than seven feet and when we were well out in the channel and got the full force of the breeze, they unfurled their mat-sail and at a leisurely pace we headed for a narrow channel between Barnikuda and Noapara islands. The amount of birdlife increased and we passed rafts of Pochards and, closer in to land where they could upturn to reach the weeds, Pintail and Gadwall. On the flats, Brahminy Duck in droves grazed placidly. I have never seen so many of them and at such close quarters except in Tibet. There were many Stints of both species, Lesser Sand Plovers, Grey Plovers, and a large flock of Blacktailed Godwits. The variety of waders one sees on the Saurashtra coasts was lacking. A pair of Whitebellied Sea Eagles soared overhead and they had a huge stick nest in a large banyan on the water-edge of Noapara Island. I was brought a downy eaglet by one of the little boys, who apparently went up to the eyrie frequently and once retrieved a duck brought in by the great birds!

Circling the island to the north, I got a view of large concentrations of duck, and in the distance flocks of flamingos made a pink line above the shimmering water. All this concentration was to the west and I resolved to have a closer look at the islands as soon as possible. Our return to camp was uneventful and a brisk sea breeze carried us to a late lunch and a disappointed Shekar who was just in time to take down the nets as a couple of young water buffalos started taking interest in the quality of material used in the new ' fishing-net '.

It was quite apparent that if we wanted to achieve anything, we would have to abandon our idea of returning to Barhampur each evening and setting off the next morning in the boat, as our pace was too slow and we would not be able to cover much area of the islands. My resolve was finalized to spend nights either in the dug-out, or under the stars wherever we touched land at sundown.

The evening was one of intense beauty as a setting sun shed its golden rays on wide expanses of blue water and distant mountains across the lake. A skein of Pintail headed across the green sky towards the sea.

30*th December*. We accompanied Mr. Rath to the jeeps and saw them off. After the party left, we crossed the dunes through dense

casuarinas to the main sea. The water was clear, and the sand shelved steeply into the green depths. I was struck by the absence of sails along the horizon and it was apparent that coastal traffic was not as well developed as on the western coast.

On return to the rest house, we assembled all our gear and after a hurried lunch, we stowed things into the canoe and set off on our voyage of discovery. It was late afternoon and a stiff sea breeze drove us round the northern edge of Barhampur Island to the entrance of the Noapara channel. This circuit would give us a view into the channel between the islands and the main dune giving us an idea of conditions all the way to Titipo where on our way in we had seen large flocks of shovellers. The main channel and the narrow one into which we turned were devoid of much birdlife and it was again with a sense of nagging doubt that we moored at dusk and settled in for the night, the matting sail spread over the canoe to protect us from night dampness. The pink light of sunset faded to reveal lustrous stars reflected in placid waters and isolated pairs of Brahminy Ducks called to each other in resonant honks, while a few Brownheaded Gulls floated like phantoms on the glassy surface.

31*st December*. The channel further narrowed and at its narrowest, a cane pallisade cut it off with a couple of fish traps at one end. It was a lovely morning and gulls and Brahminy Ducks floating on the water made attractive pictures. Near the gate in the fish corral, we again grounded our boat and while the boatman went into the village to look for a reputed trapper and fetch some milk, we strolled along the waterside turf under curious but friendly gaze of muscular young fisher-lads and watched a medley of common birds ; Common Swallows were in numbers and, from the droppings around a large banyan, it was clear they had been roosting there. In a hedge below were a pair of Dhayal, a male Black Redstart, and flocks of Redvented Bulbul. The banyan was alive with Greyheaded Mynas, White-eyes, and high in its great crown was an immense platform of branches and twigs, the home of a majestic pair of Sea Eagles.

The trapper was away and so we pushed off, helped through the narrow passage by the bronzed youths and waved away by a young teacher from the village school who had joined us in our morning amble.

The muddy shores widened into broad flats and expanses of shallow water. Ahead stretched another corral beyond which lay the lake itself. The binoculars revealed an astonishing sight of throngs of waterfowl. Pintail, Gadwall, Wigeon, Common Pochards, and Brahminy Duck placidly floating on the water. To the south the concourse stretched into the hazy distance where a mass of pink proclaimed the presence of a multitude of flamingos. The entire afternoon was sailed parallel to the coast towards Krishnaprashad, and all along the shore were the

teeming multitudes. The flamingos were breath-takingly spectacular. It was indeed a memorable day worth all the distance of travel and the days of disappointment.

The reason why we had not come to know the great concentration of duck was clear. The birds rested and fed in the same area. In the shallows, an upending duck got all it needed from the lake bottom and further out the diving duck got easy fare. On all sides, the rice stubble was too dry and devoid of food for the duck to be attracted off the water, hence the total absence of feeding flights which are such spectacular and familiar sights at Bharatpur. All the ducks were out in the water, and I doubted the efficiency of the netters in harvesting the throngs for us.

That evening we moored beside two other boats off Krishnaprashad and turned in for the night, having accepted the ranking of Chilka among the waterfowl paradises in the country, and the boatmen promising greater sights on the morrow when we arrived at Nalbano Island in the middle of the lake.

1*st January*. The golden light of the New Year awoke us to a thrilling spectacle of flamingos (Lesser) flying in wavering skeins towards the fabled isle. I was reminded of the early dawn at Nir years ago when we had visited the Flamingo City in the Great Rann of Kutch. A flock of Little Cormorants followed the Flamingos and, among the Brahminy Duck, a group of twelve Shelducks swam past. After an early meal, which was to serve as breakfast and lunch combined, we set course in the direction the flamingos and cormorants had taken, and soon the trees of Krishnaprashad were dimmed in the haze. On the body of the lake itself there were no ducks and the interminable expanses of water and sky and a warm sun overhead induced an amnesia followed by a pleasant drowsiness.

At around noon, I bestirred myself and looked over the gunwale of our 'warship' and what I saw startled me into wakefulness. There ahead of us lay flocks of Pochards and, as we approached a low line of fish corrals which encircled the island, their multitudes became denser and denser. What astonished me more than the number of the birds was the vast pallisade of canes which encircled the entire island like a fortification.

The whole island is submerged under several feet of water in the rains, the fish come to feed and spawn in the shallow, weed-grown place. Before the level of the water falls, this great pallisade is put up by various villages; the island itself is divided into four compartments. As the water level further drops, the weeds are exposed. In fact at the time of our visit there was no dry land. The drying waters expose the fish which are easily captured. This provides, as can be imagined, an ideal feeding ground for duck, geese, flamingos, and Spotted Sandpipers. Great eagles arrive to take the pickings, and on one low em-

bankment I saw an assemblage of 2 Pallas's Fishing Eagles, 3 White-bellied Sea Eagles, 1 Tawny Eagle, a couple of Ospreys, and several Brahminy Kites, while overhead in constant flight were Blackeared Kites, Whiskered Terns, Blackheaded Gulls, and Common Swallows.

Immense flocks of Shoveller, Pintail, Wigeon, and Gadwall fed in the grass and a large flock of Lesser Flamingos rose in a pink haze to the sound of a shot-gun as some shikaris entered the defences of the island in a dug-out. A small flock of 15 Greylags took flight with much gaggling. The afternoon was memorable as we waded through the squelching plants, mud, and black ooze. The site was indeed ideal for future ringing operations. That night we slept in the boat after moving out into the lake out of reach of an odious stench set free by the rotting material and bird droppings. We planned a further foray next morning into the marsh.

2nd January. During the night a strong easterly wind began to blow, and in the pale light of dawn I was horrified to see a pale film of cloud overhead, and thick clouds banked the horizon out to sea. 'We end our work on the lake, Shekar', I said and told the men to get us as fast as the gusty wind would take us across the lake to Balugaon. Quite obviously this was a cyclone and I did not fancy getting involved in high wind, waves, and heavy rain under inadequate shelter, rations in their last doles, and valuable cameras and books getting a soaking. So, we hoisted our picturesque but inefficient rattan sail and headed for a steep promontory near which was Balugaon landing. The gales grew intense and the high waves transformed the Chilka into a miniature sea. The dug-out raced forward and by 11·30 a.m. we reached Balugaon. That evening the storm struck with violent intensity. The grey clouds lowered and a deluge poured violently through the night. I was thankful I had abandoned the venture and talking things over with Shekar, I felt it would be correct to start operations in a planned way next season, and as he was to accompany Dr. Sàlim Ali to Bhutan in the summer, he should return to Bombay with me.

3rd January. Dawned weak and wet. The rain continued well into the afternoon and it was only at sundown that the storm clouds receded in a glory of gold and orange skies above the fine blue hills. On the way back, we saw ample testimony of the cyclone's velocity in flattened sugarcane and jute; the great winds, the papers told us, had struck the entire east coast from Orissa to the Krishna Delta.

In conclusion I would like to recommend a ringing project centred at Noapara, with tents to live in. Two boats, one large which could be used for spending nights at the island and a smaller one with an outboard motor for quick transport of personnel and equipment from one halting centre to another. The trappers could

operate from the large dug-out stationed at the island, the smaller craft bringing in the nightly catches each morning to the central camp. In this manner, a 15-day camp should yield fine bags. The ringing party should travel together from Bombay to Balugaon where prior arrangement of hiring boats etc. should be made through the Forest Department. Apart from the help in hiring craft and engaging men, the Society's party should be self-reliant.

There was a suggestion we engage local trappers, but I consider this unsound policy as our work should not encourage netting which subsequently might provide a lucrative occupation at the expense of the birds. There appears to be a good market for trapped duck around Chilka, now one of the sought-after tourist attractions, accessible overnight from Calcutta.

The Nalbano Island could well be declared a sanctuary for ducks. Its pallisades provide easy protection from marauding guns. Supervision would be easy. Shooting around the lake should not be restricted, however. Chilka properly managed is not only ideal for ringing operations, but could well be one of India's star tourist attractions.

Our deepest gratitude is due to Shri Rath, the D.F.O., the Forest Staff at Balugaon, and Shri Mahanty of Bird Heigler & Co., of Calcutta, for all the kind help and encouragement they extended us during our stay in the Chilka area.

Transport of the Fry and Fingerlings of the Milk Fish *Chanos chanos* (Forskål)[1]

BY

T. A. MAMMEN[2]

Fisheries Extension Unit, Mandapam Camp

1. INTRODUCTION

Chanos culture is very popular in several SE. Asian countries, and extensive brackish water fish farms are exclusively devoted to its culture. The main points in favour of chanos culture are: (1) Ready availability of fish seed in creeks, lagoons, and salt pans connected to the sea; (2) Capacity of the fry and fingerlings to rapidly acclimatize to freshwater conditions; and (3) Good growth in fresh water, particularly hard water and highly alkaline water, in which the growth of major carp is poor.

From 1931 onwards the culture of chanos was attempted, particularly by the Department of Fisheries, Madras, but no appreciable progress was achieved. Ganapathi *et al.* (1950), Panikkar *et al.* (1952, 1958) and Viswanathan *et al.* (1952) worked out certain interesting aspects of the adaptability and acclimatization of chanos to low salinities. In the wake of this interest several chanos collection centres were located on the east and west coasts of India but, with the advent of improved technique and the shift of emphasis to major carp culture, chanos culture in India has been almost given up. The present production of major carp seed is only about 1% of the total requirements and the culture of chanos admirably fits into some of the places considered unfit for fish culture. The main difficulties in utilizing chanos seed resources are the inefficiency of the methods hitherto used for transporting chanos, the disappointing results of direct stocking of chanos fry, the equally disappointing growth of fry in nurseries, and the very great difficulty of transporting chanos fingerlings.

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[2] Present address: Ministry of Food and Agriculture, (Department of Food), New Delhi.

In view of the extensive resources of chanos fry and fingerlings in and around Mandapam, the present author undertook a study of the transport of chanos fry and fingerlings during 1959-62. Although, owing to the winding up of the Fisheries Extension Unit at Mandapam Camp and the transfer of the author to Hyderabad, it was not possible to complete the work, some observations were made, which would help towards the economic utilization of the chanos fry and fingerling resources.

2. Transport of Chanos Fry

2.1. *Chanos fry collection and transport*

The material for the present study was collected from Chinnapalem creek near Pamban. Fry were collected by dragging with a piece of cloth, usually early in the morning. Collection was easy, from a hundred to a thousand fry being collected with each haul. The fry were then taken by head-load in milk-can type containers to Pamban, where they were acclimatized to low salinities, by periodically replacing $\frac{1}{4}$th water with Well water, this process being repeated till a salinity of 5‰ or so was obtained. The fry were then transported by rail in 40-gallon milk-can type containers, each filled with 25 gallons of water holding 250 to 400 numbers of fry. A mortality varying from 10 to 30% was usually reported after about 6 hours of train journey. As this mortality was considered excessive, alternate modes of transport were attempted.

2.2. Preliminary experiments were conducted, using small plastic bags filled with 175 c.c. of sea-water holding varying numbers of fry, to determine optimum concentrations. The bags were then filled with oxygen and kept for observation on the incidence of mortality. The results are given in Table 1.

It may be seen that, even at a very high concentration of 200 fry of 1·3 to 1·5 cm. size per 175 c.c. of sea-water, no significant mortality was noticed up to 36 hours. At a concentration of 100 fry, mortality was negligible even at 72 hours. With the latter concentration, trial consignments were sent to Madurai, a distance of 90 miles by road and rail. The procedure was as follows.

Chanos fry were obtained from Chinnapalem creek and transported to the Fisheries Extension Unit, Mandapam Camp, by milk-can type container each with 1000 fry, filled to capacity with water from the collection ground. The mouth of the container was plugged with a laboratory towel to avoid splashing during transport. The journey was performed partly by head-load (3 km.), partly by train (6 km.), and partly by Jeep (3 km.). No appreciable mortality was noticed. The fry were then transferred to enamelled trays and gradually acclimatized to low salinity conditions as described above. The entire process of trans-

TABLE 1

MORTALITY OF CHANOS FRY (OF 1·3-1·5 CM. SIZE) AT DIFFERENT CONCENTRATIONS IN 175 C.C. OF SEA-WATER PACKED IN SMALL PLASTIC BAGS WITH OXYGEN UNDER SLIGHT PRESSURE

Sl. no. of experiment	Quantity of water	No. of fry introduced	Mortality at the end of						Remarks
			12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	
1	175 c.c.	25	nil	nil	nil	nil	nil	nil	
2	do.	25	1	1	1	1	1	1	Those dying early are probably injured fry
3	do.	50	nil	nil	nil	nil	nil	nil	
4	do.	50	nil	nil	nil	nil	nil	nil	
5	do.	75	1	1	1	2	2	2	
6	do.	75	2	2	2	2	2	2	
7	do.	100	nil	nil	nil	nil	nil	nil	
8	do.	100	nil	nil	nil	nil	nil	nil	
9	do.	150	1	1	2	14	55	95	
10	do.	150	1	2	4	20	78	100	
11	do.	200	1	1	15	47	200	..	
12	do.	200	nil	1	16	73	172	200	
13	do.	300	2	12	300	..	..	..	
14	do.	300	6	27	300	..	..	..	

NOTE.—The fry were packed in approximately 4 hours after reaching headquarters and 8 hours after collection.

port, and acclimatization, took 6-10 hours. The conditioned fry were counted and removed by petri-dish to finger-bowls, each receiving 100 in number. The water in each finger-bowl was renewed and made up to 175 c.c. and was transferred to plastic bags specially made for the purpose from 200 gauge lay-flat tubing; oxygen from an oxygen cylinder was passed into the plastic bag till it filled up and exerted a reasonable pressure. The free end of the plastic bag was twisted and double knotted. A deal-wood box, 54·5 cm. × 31·5 cm. × 33 cm. could hold 40 such bags in four rows in two tiers. The weight of the consignment was 10·2 kg., of which 7·4 accounted for the dead weight of the box. A few trial consignments were despatched to Madurai, where they were opened 20 to 48 hours after packing. In most of the cases the mortality was nil, in a few it ranged from 1 to 4%. One interesting feature was that the results from the transport tests did not appreciably vary from the standing tests. Hence the bulk of the remaining tests were standing tests. In some cases, for example where optimum surface area had to be determined, the jolting effect of the rail transport was simulated by stacking the bags on a weak table and running off and on an old table fan placed on this table.

2.3. *Causes of mortality of chanos fry*

2.3.1. *Handling mortality*

Chanos in all stages was extremely delicate and highly susceptible to injury. A good number were accidentally killed during collection, partly due to injury and partly to the clogging of the gills as a result of the stirring of the silty bottom during dragging. Rough handling invariably resulted in mortality. Thus, if after impounding the fry in the cloth used for collection, the water was drained with the object of measuring the collection, a high mortality would result. To avoid this mortality the fry were transferred with water using a petri-dish for the purpose.

2.3.2. *Medium of transport*

Despite their delicateness, chanos fry showed extreme powers of osmoregulation and could even stand direct transfer from sea-water to fresh water. The question for consideration was which of the salinity concentrations would be most conducive to maximum efficiency. To elucidate this point, fry of 1·7 to 1·9 cm. size were packed with oxygen in lots of 200 in bags, each containing 380 c.c. of water, some lots in collection-ground water, some in well water, some in a mixture of the two, and some in tap water. Where changes in salinity were involved, they were gradually acclimatized. The packed bags were left undisturbed and the occurrence of mortality noted at definite intervals. The physical properties of water were noted before and after the experiment. The results are presented in Table 2. It may be seen that the incidence of mortality was early in tap water, followed by well water, then in the mixture of well water and collection-ground water. Analysis of water

TABLE 2

EFFECT OF MEDIUM OF TRANSPORT ON THE SURVIVAL OF 200 FRY OF 1·3-1·5 CM. LENGTH IN 380 C.C. OF WATER WITH A SURFACE AREA OF 22·84 SQ. CM. IN SMALL PLASTIC BAGS

Sl. No. of expt.	Type of water used	Physical properties of water before expt.		Progressive Mortality at the end of								Physical properties of water after expt.	
		Salinity	pH	24 hrs.	40 hrs.	70 hrs.	90 hrs.	96 hrs.	112 hrs.	118 hrs.	136 hrs.	pH	Oxygen content
15	Collection ground sea water	38‰	8·4	0	1	1	2	4	24	35	135	7·5	1·14 ml/L
16	do.	do.	do.	0	0	0	0	31	35	40	140	do.	1·88 ml/L
17	do.	do.	do.	0	0	1	2	3	15	25	145	do.	2·36 ml/L
18	Well Water	1·5‰	8·0	2	2	2	10	15	105	discontinued		7·5	2·05 ml/L
19	do.	do.	do.	0	0	1	6	30	160	discontinued		do.	2·34 ml/L
20	do.	do.	do.	6	8	10	35	150		discontinued		do.	2·68 ml/L
21	Ordinary sea-water and well water	20‰	8·2	0	1	1	2	12	55	75	180	7·5	1·5 ml/L
22	do.	do.	do.	1	2	3	5	7	40	60	175	do.	1·25 ml/L
23	do.	do.	do.	0	0	0	6	6	31	32	165	do.	2·05 ml/L
24	Tap Water	3·5‰	8·2	5	5	8	30	190				7·5	..
25	do.	do.	do.	4	6	9	198					do.	1·71 ml/L
26	do.	do.	do.	5	6	26	200					do.	..

Mean Temperature 31°C.

at the end of the experiment showed a pH of 7·5 and sufficient dissolved oxygen in all cases.

The reason for mortality in the low salinities could be either (1) after-effect of acclimatization or (2) effect of accumulation of metabolic waste products. From published accounts (Panikkar *et al.* 1952) it appears unlikely that the former was the reason. This view is supported by the fact that, when larger quantities of water were provided, mortality was delayed. The limiting factor therefore appears to be the accumulation of waste products, whose ill effects are experienced early in the absence of buffer action of the saline medium. The actual physiological break-down responsible for the high degree of mortality between 118 hours and 136 hours, even under high salinity conditions, appears to have been starvation, as is revealed in a subsequent experiment. As the mortality up to 30-hour period is low in all cases and the duration of transport under field conditions was well within this period, all these media could be adopted, although the saline medium ensured a greater margin of safety. The final arrangement was as follows. After the collection of fry, about 6 hours were allowed for the emptying of the stomach—this period was conveniently used for gradually acclimatizing the fry to a salinity of say 20‰. The fry were then packed in saline medium and transported. At the salinity concentration of 20‰, the osmotic pressure was more or less similar to that of the body fluid of the fry, and this would facilitate the removal of the waste products and offer a certain amount of buffering action against the accumulation of carbon dioxide. The final acclimatization to fresh water was done after the completion of the transport.

2.3.3. *Transportation mortality*

This was due to one or more of the following reasons.

2.3.3.1. *Injury sustained.* As already mentioned any injury sustained by the fry ended in mortality. During transportation in milk-can type containers the fry were very liable to get injured by violent splashing. When these metal containers were used, say for short distance journey, splashing was avoided by filling the container to the very top and closing the mouth. The higher percentage of survival reported with the small plastic bag was essentially due to the resilience of the plastic bag cushioning out the splashing to a great extent; also the small surface area of water reduced the amplitude of the splashing.

2.3.3.2. *Lack of proper conditioning.* Conditioning of chanos fry prior to transport involved both acclimatization and physical conditioning. Since final culture was intended in fresh water, acclimatization to it at some stage was necessary. The physical conditioning was to prepare for a crowded journey so that the fry in transport would not suffer from crowding and pollute the medium by vomiting and defaecation. However, prolonged physical conditioning was unnecessary, for chanos fry

occur crowded in the natural environment. The alimentary canal at this sage is short and the contents are quickly voided. So conditioning for 6 hours was sufficient. However, the medium had to be periodically replaced, because the fry would otherwise reinjest the faecal matter.

2.3.3.3. *Lack of sufficient oxygen.* The oxygen intake of chanos fry being of the order of 0·0002 c.c./fry/hour, the concentration of 100 fry per 175 c.c. arrived at was quite satisfactory for normal duration of transport. In actual transport, besides the oxygen contained in the medium, oxygen was replenished from the atmosphere and the exact quantity going into solution depended on (1) water surface area, (2) the pressure and the percentage of oxygen contained in the atmosphere.

2.3.3.3.1. *Water surface area.* Increased surface area favoured absorption of oxygen, but caused violent splashing and therefore more mortality. To determine optimum surface area, experiments were conducted with 4 distinct surface areas, keeping 200 fry of 1·7 to 1·9 cm. length in 350 c.c. sea-water as constant in all cases. These plastic bags were packed with oxygen and left in plastic (pickle) jars of appropriate surface area and the jolting effect was artificially simulated. Table 3 shows the optimum surface area for this particular volume and size of fry to be 25 sq. cm. The mortality with larger surface area was considerable, and was caused by injury sustained during splashing. With a limited surface area of 14 sq. cm. the splashing was negligible and the fry were not injured, but mortality set in at 48 to 60 hours and was quite evident at 72 hours. This appeared to be due to oxygen deficiency in the absence of adequate oxygen dissolution on acount of the limited surface area.

2.3.3.3.2. *Pressure and percentage of oxygen contained in the atmosphere* determines the extent of oxygen dissolution (Dalton's law and Henry's law). In an open system the rate of dissolution was the least as there was only 20% oxygen and no extra pressure. This could be improved by providing an atmosphere of oxygen (i.e. 100% oxygen) and maintaining it under pressure, as in oxygen packing. Experiments were conducted to find out the relative merits of different packings. Some lots of bags were kept open. In the second lot the bags enclosed a certain amount of atmospheric air, and the free end of the bag was twisted once or twice and knotted so that the air was compressed and exerted a mild pressure on the water below. The third lot was packed with oxygen in the usual way, also maintaining a slight oxygen pressure.

The results presented in Table 4 show that, for short distance transport taking up to 24 hours, even open transport in plastic bags was possible, although not recommended because of the chance of accidental spilling. Merely keeping air under mild pressure prolonged the period of safe transport to 36 hours, and oxygen transport was necessary in cases requiring longer duration of transport.

TABLE 3

EFFECT OF SURFACE AREA ON THE SURVIVAL OF 200 CHANOS FRY OF 1·7-1·9 CM. SIZE IN 350 C.C. OF DILUTED SEA-WATER OF SALINITY 20‰, pH 8·2, AND MEAN TEMPERATURE 30·5°C.

Sl. No. of expt.	Surface area of water in plastic bag, in sq. cm.	Mortality at the end of						Remarks
		12 hrs.	20 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	
27	14	nil	nil	nil	1	6	28	
28	14	nil	nil	nil	nil	1	22	
29	25	nil	nil	nil	nil	nil	2	
30	25	nil	nil	nil	nil	nil	nil	
31	38·5	16	18	28	48	60	80	
32	38·5	14	14	18	27	40	53	
33	75·5	24	68	154	200			Water was slightly turbid at the end of experiment.
34	75·5	48	124	190	200			do.

NOTE.—The jolting effect of transport was artificially simulated in this experiment.

TABLE 4

EFFECT OF MILD PRESSURE AND OXYGEN ON THE SURVIVAL IN TRANSPORT OF 100 FRY (OF 1·3 TO 1·5 CM.) IN 175 C.C. OF WATER MADE UP OF EQUAL QUANTITIES OF SEA-WATER AND WELL WATER, SURFACE AREA APPROXIMATELY 25 SQ. CM.

Sl. No. of expt.	Mode of packing	Mortality at the end of							Dissolved Oxygen concentration at the end of expt.
		12 hrs.	24 hrs.	36 hrs.	48 hrs.	60 hrs.	72 hrs.	96 hrs.	
35	Bags kept open (air without pressure)	1	4	81	100				1·0%
36	do.	1	3	95	100				nil
37	Bags packed with Oxygen under slight pressure	nil	nil	nil	nil	nil	nil	6	94·33%
38	do.	2*	2	2	2	2	3	9	83·48%
39	Bags packed with air under slight pressure	1	1	5	58	100			2·2%
40	do.	2*	2	2	42	95	100		1·8%

Mean Temperature—30·5°C.; pH=8·2; S=20‰.

* Presumably weak or injured fry.

2.3.4. *Starvation mortality*

From the Tables 1, 2, and 3 it was seen that even under the best conditions mortality of chanos fry occurred after the 5th day. This was suspected to be due to starvation, as provision of larger quantities of water did not improve the situation. In a large basin of 400 sq. cm. surface area, filled with 5 litres of sea-water 200 healthy fry were kept and the incidence of mortality noted at intervals. The dead fry when noticed were promptly removed to avoid fouling of the water. No mortality was observed until after the 5th day, 8% mortality occurred on the 6th day, 26% mortality (progressive) on the 7th day, 61% on the 8th day, and complete mortality on the 10th day. These deaths were evidently due to starvation. The natural endurance being thus limited, it was necessary that acclimatization, conditioning, and transport were completed and the fry were planted in nurseries within this short period. It is therefore necessary to restrict the combined period of acclimatization and conditioning prior to transport to a short period, say six hours.

2.3.5. *Post-planting mortality*

Growth of chanos fry in the natural environment is very rapid. They attain 5-8 cm. length (3 to 7·5 gm. weight) in one month and 8 to 16 cm. length (7·5-38 gm.) in the second month. As against this, growth in nurseries was negligible and was associated with a very high incidence of mortality. As direct stocking of fry was a failure, it was felt that naturally-occurring chanos fingerlings should be utilized for stocking.

3. Transport of Chanos Fingerlings

Chanos fingerlings occurred in the shallow lagoons in and around Mandapam, including those of the adjoining islands, in such large numbers that, during the late summer months, a fishery of chanos fingerlings existed in this area. Preliminary attempts to stock these large-sized fingerlings yielded good results in Ramanathapuram area. Similar good results were recorded from Vellore Moat farms (1953). The extreme difficulties in transport might have been the main reason for chanos fingerlings not being taken up for large scale stocking.

3.1. *Collection of chanos fingerlings*

At Pamban chanos fingerlings were caught mostly by scare line fishing. At Mandapam, *kondavalai* (an inshore drag net with wooden sticks at regular intervals keeping the head rope and foot rope at a fixed distance) was used. The *kondavalai* was dragged by 6 to 10 fishermen in the shallow regions of the lagoon. During low tide the fingerlings got stranded in the pools and collection was particularly easy, anything up to 2500 fingerlings being collected per hour per net.

The freshly collected fingerlings being over-active, hand picking led to loss of scales and consequent fungal attack and injury to the internal organs. The excited fingerlings knocked about in the container, bruising their body and polluting the water medium by the fallen scales and vomited and defaecated matter. The mortality was so great that in one instance the entire collection of about 2000 fingerlings died in the short period between collection and actual transport.

3.2. *Oxygen consumption of freshly caught chanos fingerlings*

Viswanathan & Tampi (1952) and Job (1957) worked out the oxygen consumption of chanos in relation to size. But the oxygen consumption reported appeared to be that of routine metabolism of conditioned fish as the figures did not amply reflect the oxygen requirements of freshly caught fingerlings. In actual practice it was necessary to know of the optimum quantity of water required per fingerling to keep them alive. With this object a series of trials were made using small cement cisterns having a surface area of approximately 0·8 square metres. Each cistern was filled with 35 gallons of water made up of equal quantities of fresh water and sea-water. Concentrations varying from 5-500 freshly caught fingerlings of size 7 to 9 cm. were kept in the cisterns. Mortality, except in the lower concentrations, was so rapid that it was not possible to keep a record. Having got an idea that the optimum number was between 10 and 20 fingerlings per cistern, the experiments were repeated to arrive at the optimum number. Fingerlings that died shortly after the experiment began were replaced, their mortality being considered due to injuries sustained during collection. The optimum number was found to be about 17. This indicated that about 2 gallons (9 litres) of water were required to sustain a single fingerling — a requirement inconsistent with economical transport. The solution was one of reducing the rate of oxygen uptake. Of the two methods available, (1) use of anaesthetics and (2) physical conditioning, the latter alone was tried.

3.3. *Conditioning of chanos fingerlings.*

The fingerlings, immediately after impoundment in *kondavalai*, were transferred with minimum handling to conditioning boxes with velon screen sides, kept immersed in water. The conditioning boxes were then transported, where possible, through water and, where overland transport was necessary, in water-proofed jeep trailers filled with salt water. Spilling of water from the trailer was minimised by firmly tying a thin tarpaulin over the trailer mouth. To begin with, the conditioning boxes with the fingerlings were kept immersed in the channel leading to the Marine Fish Farm at Mandapam. In due course the screen meshes got plugged with silt and not more than 150 fingerlings could be kept alive in a 105-gallon conditioning box. By periodical cleaning of the mesh, it was possible to keep alive 200 fingerlings. The conditioning

box was then moored to an anchor in the open sea, a little beyond the zone of turbulence. In these conditions a concentration of 250 fingerlings not only did not result in appreciable mortality but the fingerlings continued to be active, even after 4 days. Dissection revealed that they were getting sufficient food ; starvation was evidently necessary to reduce the activity. For this purpose a 6000-gallon cemented tank at the Fisheries Campus was filled with water, partly salt and partly fresh, and the fingerlings in the conditioning box were left to starve in the tank. This procedure worked, the fingerlings became progressively less active, and several batches of 200 to 250 fingerlings were successfully conditioned.

Whereas freshly captured chanos fingerlings knocked about in frenzied excitement at the sound of an approaching foot-step the same fingerling of size 6-10 cm. did not respond to the sound of foot-steps after about a week's conditioning, though it could be excited by the beam of a flash light. After another week flashing a light merely induced a scattering of the shoal, and after 3 weeks of conditioning even this response was hard to detect. Conditioning time increased with the size of the fingerlings.

3·4. *Starvation mortality*

Unlike chanos fry, chanos fingerlings were hardy and, in a test case, survived 56 days of starvation. Though they appeared emaciated with somewhat disproportionately large heads, some of them grew very well when stocked in tanks near Chittarakottai—apparently the prolonged starvation did not impair their capacity for growth.

3·5. *Effect of starvation on the efficiency of chanos fingerling transport*

An experiment was conducted to determine the optimum number of 56 days conditioned chanos fingerlings. In standard plastic bags each containing 6 litres of water, 5, 10, 20, 30, 40, 50 and 60 fingerlings respectively were introduced and packed with oxygen. No mortality was seen in any lot in a standing test of 6 days' duration. The maximum efficiency in this case worked out to 10 fingerlings per litre as against 1 fingerling per 9 litres for unconditioned fingerlings. In actual practice such prolonged conditioning would be difficult, and the observation reported merely illustrates the possibility of economic transport by starving the fingerlings.

In order to arrive at the concentrations of fingerlings at various levels of starvation a few further experiments were conducted. The results obtained are presented in Table 6.

Since the season expired soon after and the author was transferred, by the next season these experiments could not be repeated on a statistical design.

TABLE 5

EFFECT OF CONDITIONING ON THE LIMITS OF CONCENTRATION OF CHANOS FINGERLINGS AS REVEALED IN STANDING TESTS IN STANDARD SIZE PLASTIC BAGS PACKED WITH OXYGEN UNDER SLIGHT PRESSURE, USING WATER OF LOW SALINITY (5‰)

Serial No. of expt.	Length of fingerling in cm.	No. of fingerlings.	Qty. of water in litres.	Qty. of water per fingerling in c.c.	Period of conditioning before packing.	Mortality recorded at the end of							Remarks on concentration for the conditioning given.
						6 hrs.	12 hrs.	18 hrs.	24 hrs.	30 hrs.	36 hrs.	48 hrs.	
41	4-6	60	9	150	12 days	nil	nil	7	—	—	—	—	
42	4-6	49	9	180	8 do.	nil	nil	nil	nil	nil	nil	6	Safe.
43	4-6	60	9	150	12 do.	nil	nil	nil	nil	nil	nil	nil	do.
44	7 (av.)	25	6	240	1½ do.	nil	2	2	2	3	5		Slightly excessive.
45	7 (av.)	60	9	150	7 do.	nil	nil	6	discontinued				Excessive.
46	7 (av.)	70	9	129	7 do.	nil	6	11	discontinued				do.
47	7 (av.)	40	9	225	12 do.	nil	nil	nil	nil	nil	nil	nil	Safe.
48	7·5 (av.)	60	9	150	7 do.	nil	nil	3	7	discontinued			Excessive.
49	7·5 (av.)	75	9	120	7 do.	nil	nil	6	11	discontinued.			
50	8 (av.)	25	9	360	3 hrs.	15	23	discontinued					Obviously in excess.
51	8 (av.)	20	9	450	3 do.	20	20	discontinued					do.
52	8 (av.)	25	9	360	1 day	2	4	discontinued					Obviously in excess.
53	8 (av.)	50	9	180	7 days	nil	nil	nil	1	15			Slightly in excess.
54	8 (av.)	50	9	180	7 do.	nil	nil	23					Excessive.

55	8 (av.)	40	9	180	12 do.	nil	nil	nil	nil	nil	22	49	Slightly in excess.
56	8·5 (av.)	60	9	150	7 do.	nil	nil	1	15	discontinued			Excessive.
57	9 (av.)	20	9	450	1 day	1	1	discontinued					do.
58	9 (av.)	20	6	306	1½ days	nil	1	1	2	7			do.
59	9·5 (av.)	35	9	257	7 do.	nil	nil	9					do.
60	9·5 (av.)	40	9	225	7 do.	nil	nil	nil	nil	nil	2		Optimum.
61	9·5 (av.)	50	9	180	7 do.	nil	nil	12	41				Excessive.
62	10 (av.)	20	9	450	1 day	2	6	discontinued					do.
63	10 (av.)	20	9	450	1½ days	2	6	14	discontinued				do.
64	10 (av.)	35	9	257	7 do.	nil	nil	9	discontinued				do.
65	10·5 (av.)	35	9	257	7 do.	nil	nil	3	25	discontinued			do.
66	10·5 (av.)	20	9	450	7 do.	nil	nil	nil	discontinued				Optimum.
67	11 (av.)	10	9	900	7 do.	nil	2	2	5	8			Excessive.
68	11·5 (av.)	25	9	360	8 do.	nil	nil	1	14	18	24	25	do.
69	12 (av.)	10	9	900	1½ do.	nil	1	1	4	discontinued			do.
70	12 (av.)	10	9	900	7 do.	nil	1	1	4	10			do.
71	12 (av.)	18	9	500	12 do.	nil	nil	nil	nil	nil	nil	1	Optimum.
72	12·5 (av.)	25	9	360	7 do.	nil	nil	2	16				
73	13·5 (av.)	10	9	900	8 do.	nil	nil	nil	nil	nil	nil	nil	Safe.
74	10 (av.)	4	9	2112	8 do.	nil	nil	nil	nil	nil	nil	nil	Safe.

TABLE 5

EFFECT OF CONDITIONING ON THE LIMITS OF CONCENTRATION OF CHANOS FINGERLINGS AS REVEALED IN STANDING TESTS IN STANDARD SIZE PLASTIC BAGS PACKED WITH OXYGEN UNDER SLIGHT PRESSURE, USING WATER OF LOW SALINITY (5‰)

Serial No. of expt.	Length of fingerling in cm.	No. of fingerlings.	Qty. of water in litres.	Qty. of water per fingerling in c.c.	Period of conditioning before packing.	Mortality recorded at the end of							Remarks on concentration for the conditioning given.
						6 hrs.	12 hrs.	18 hrs.	24 hrs.	30 hrs.	36 hrs.	48 hrs.	
41	4-6	60	9	150	12 days	nil	nil	7	—	—	—	—	
42	4-6	49	9	180	8 do.	nil	nil	nil	nil	nil	nil	6	Safe.
43	4-6	60	9	150	12 do.	nil	nil	nil	nil	nil	nil	nil	do.
44	7 (av.)	25	6	240	1½ do.	nil	2	2	2	3	5		Slightly excessive.
45	7 (av.)	60	9	150	7 do.	nil	nil	6	discontinued				Excessive.
46	7 (av.)	70	9	129	7 do.	nil	6	11	discontinued				do.
47	7 (av.)	40	9	225	12 do.	nil	nil	nil	nil	nil	nil	nil	Safe.
48	7·5 (av.)	60	9	150	7 do.	nil	nil	3	7	discontinued			Excessive.
49	7·5 (av.)	75	9	120	7 do.	nil	nil	6	11	discontinued.			
50	8 (av.)	25	9	360	3 hrs.	15	23	discontinued					Obviously in excess.
51	8 (av.)	20	9	450	3 do.	20	20	discontinued					do.
52	8 (av.)	25	9	360	1 day	2	4	discontinued					Obviously in excess.
53	8 (av.)	50	9	180	7 days	nil	nil	nil	1	15			Slightly in excess.
54	8 (av.)	50	9	180	7 do.	nil	nil	23					Excessive.
55	8 (av.)	40	9	180	12 do.	nil	nil	nil	nil	nil	22	49	Slightly in excess.
56	8·5 (av.)	60	9	150	7 do.	nil	nil	1	15	discontinued			Excessive.
57	9 (av.)	20	9	450	1 day	1	1	discontinued					do.
58	9 (av.)	20	6	306	1½ days	nil	1	1	2	7			do.
59	9·5 (av.)	35	9	257	7 do.	nil	nil	9					do.
60	9·5 (av.)	40	9	225	7 do.	nil	nil	nil	nil	nil	2		Optimum.
61	9·5 (av.)	50	9	180	7 do.	nil	nil	12	41				Excessive.
62	10 (av.)	20	9	450	1 day	2	6	discontinued					do.
63	10 (av.)	20	9	450	1½ days	2	6	14	discontinued				do.
64	10 (av.)	35	9	257	7 do.	nil	nil	9	discontinued				do.
65	10·5 (av.)	35	9	257	7 do.	nil	nil	3	25	discontinued			do.
66	10·5 (av.)	20	9	450	7 do.	nil	nil	nil	discontinued				Optimum.
67	11 (av.)	10	9	900	7 do.	nil	2	2	5	8			Excessive.
68	11·5 (av.)	25	9	360	8 do.	nil	nil	1	14	18	24	25	do.
69	12 (av.)	10	9	900	1½ do.	nil	1	1	4	discontinued			do.
70	12 (av.)	10	9	900	7 do.	nil	1	1	4	10			do.
71	12 (av.)	18	9	500	12 do.	nil	nil	nil	nil	nil	nil	1	Optimum.
72	12·5 (av.)	25	9	360	7 do.	nil	nil	2	16				
73	13·5 (av.)	10	9	900	8 do.	nil	nil	nil	nil	nil	nil	nil	Safe.
74	10 (av.)	4	9	2112	8 do.	nil	nil	nil	nil	nil	nil	nil	Safe.

TABLE 6

RESULTS OF CHANOS FINGERLING TRANSPORT USING JEEP TRAILER WITH FINGERLINGS PACKED WITH OXYGEN IN STANDARD PLASTIC BAGS SUPPORTED IN CONVERTED KEROSINE TINS—DISTANCE 100 MILES; DURATION OF ACTUAL JOURNEY 5 HRS.

Serial No.	Length of fingerling in cm.	No. of fingerlings	Quantity of water in litres	Quantity of water per fingerling (in c.c.)	No. of days of conditioning before packing	Actual duration between time of packing and time of release	Mortality at the time of release
75	4–7	70	9	129	10	13 hrs.	1
76	4–8	54	9	167	14	13 ,,	nil
77	4–8	70	9	129	5	13 ,,	1
78	4–8	60	12	200	4	9 ,,	2
79	5–8	50	12	240	14	12 ,,	nil
80	5–9	55	12	218	5	10 ,,	2
81	5–9	45	12	267	5	10 ,,	3
82	5–9	50	12	240	5	11 ,,	2
83	5–9	50	12	240	5	9 ,,	2
84	6–10	46	12	267	5	11 ,,	nil
85	6–10	45	12	267	5	12 ,,	4

86	6–10	42	12	286	5	12 ,,	1
87	6–10	40	12	300	5	12 ,,	4
88	6–8	35	12	343	4	10 ,,	3
89	6–8	35	12	343	4	9 ,,	4
90	6–8	35	12	343	4	8½ ,,	3
91	7–9	40	12	300	4	9 ,,	4
92	8–10	40	12	300	4	9 ,,	3
93	8–12	28	12	429	10	13 ,,	nil
94	7–13	32	12	375	14	13 ,,	nil
95	9–12	20	12	600	4	9½ ,,	5
96	10–12	20	12	600	4	10 ,,	8
97	8–11	25	12	480	4	9 ,,	6
98	9–12	20	12	600	4	10 ,,	6
99	9–13	18	12	667	4	10 ,,	5

TABLE 6

RESULTS OF CHANOS FINGERLING TRANSPORT USING JEEP TRAILER WITH FINGERLINGS PACKED WITH OXYGEN IN STANDARD PLASTIC BAGS SUPPORTED IN CONVERTED KEROSINE TINS—DISTANCE 100 MILES; DURATION OF ACTUAL JOURNEY 5 HRS.

Serial No.	Length of fingerling in cm.	No. of fingerlings	Quantity of water in litres	Quantity of water per fingerling (in c.c.)	No. of days of conditioning before packing	Actual duration between time of packing and time of release	Mortality at the time of release
75	4–7	70	9	129	10	13 hrs.	1
76	4–8	54	9	167	14	13 ,,	nil
77	4–8	70	9	129	5	13 ,,	1
78	4–8	60	12	200	4	9 ,,	2
79	5–8	50	12	240	14	12 ,,	nil
80	5–9	55	12	218	5	10 ,,	2
81	5–9	45	12	267	5	10 ,,	3
82	5–9	50	12	240	5	11 ,,	2
83	5–9	50	12	240	5	9 ,,	2
84	6–10	46	12	267	5	11 ,,	nil
85	6–10	45	12	267	5	12 ,,	4
86	6–10	42	12	286	5	12 ,,	1
87	6–10	40	12	300	5	12 ,,	4
88	6–8	35	12	343	4	10 ,,	3
89	6–8	35	12	343	4	9 ,,	4
90	6–8	35	12	343	4	8½ ,,	3
91	7–9	40	12	300	4	9 ,,	4
92	8–10	40	12	300	4	9 ,,	3
93	8–12	28	12	429	10	13 ,,	nil
94	7–13	32	12	375	14	13 ,,	nil
95	9–12	20	12	600	4	9½ ,,	5
96	10–12	20	12	600	4	10 ,,	8
97	8–11	25	12	480	4	9 ,,	6
98	9–12	20	12	600	4	10 ,,	6
99	9–13	18	12	667	4	10 ,,	5

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Synopsis

Transport is the main difficulty in utilising the extensive chanos seed resources.

It was found that chanos fry can be transported in small plastic bags very economically and with almost no mortality. Delicate handling and gradual acclimatization over 6 hours to about half salinity concentration prepare the fry for transport. The fry can be transported without any packing in small plastic bags upto 24 hours, with air under mild pressure upto 36 hours, and in oxygen under mild pressure upto 96 hours without appreciable mortality. Large water surface area caused mortality by splashing. Optimum area was found to be about 25 sq. cm., for 350 c.c. of water.

The lack of sufficient knowledge on the technique of rearing chanos fry to fingerling size limits the applicability of the above method of transport.

Chanos fingerlings are available in large quantities in the natural environment. By a simple technique of starvation it was possible to reduce their extreme excitability and high oxygen demand and thus improve the transport efficiency by 90 times, a level at which it is economically feasible to undertake their long distance transport for stocking purposes.

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Studies on the Insect Pollinators of *olitorius* and *capsularis* Jute

BY

S. K. Ghose

Jute Agricultural Research Institute, Barrackpore, West Bengal

(*With two figures*)

Introduction

In the course of study on natural crossing in two cultivated species of jute, *Corchorus olitorius* Linn. and *C. capsularis* Linn. (Family: Tiliaceae), Ghose & Das Gupta (1945) found that, among flower-visiting insects, bees are the most numerous and frequent of the visitors effecting cross-pollination. But they did not mention the species of the bees. Ray (1960) assumed that insects, wind, gravitation, etc. were the possible agents of natural crossing in *olitorius* Jute. Dutt & Ghose (1962) ascertained that insects and not wind are the agents of cross-pollination in both the species. Ghose & Das Gupta (1945) hypothetically deduced that the higher frequency of natural crossing in *olitorius* was due to the bigger size of its flowers being preferred by the insects. None of the previous workers examined the population of pollinating insects. So the present investigations were carried out to study the insect pollinators of both these species of jute.

Material and Methods

Two field experiments, one with *olitorius* (JRO-632) and the other with *capsularis* (JRC-212), were conducted in 1962 season. Crops were raised in lines, 30·48 cm. (1 ft.) apart, in two separate but adjacent plots. Each plot was 21·34 m.×17·07 m. (70 ft.×56 ft.). The plant to plant distance along the lines was 7·62-10·16 cm. (3-4 in.).

The flower-visiting insects were caught simultaneously from both the *olitorius* and the *capsularis* trials for 11 days during the flowering stage and their records were maintained. Insects were caught at six fixed periods each day, namely 6.30-7.00, 8.00-8.30, 9.30-10.00, 11.00-11.30, 12.30-13.00, and 13.30-14.00 hours.

The number of flowers on three plants taken at random from every alternate row, i.e. 81 plants from each trial, were recorded on the days

of capturing the insects. In the case of both the species, correlation between the total numbers of hymenopterous insects and *Apis dorsata* Fabricius caught and the average number of flowers per plant on the respective dates have been calculated.

In order to assess the activities of *A. dorsata*, observations were made to find out the average number of flowers and plants visited per minute and also the time spent in a flower and in between two flowers by a single bee in both the species of jute.

Observations

Orders of insects visiting flowers :

(a) *olitorius :* Insects belonging to three orders, namely Hymenoptera, Diptera, and Lepidoptera were found to visit *olitorius* flowers in the proportions 80·00, 18·3, and 1·7% respectively. The average total catch of insects was 30 per day (Fig. 1).

(*b*) *capsularis : capsularis* flowers were also visited by these three orders of insects. The average capture of flower-visiting insects per day was 52 (Fig. 1). The percentages of hymenopterous, dipterous, and lepidopterous insects were 80·7, 18·3, and 1·0 respectively.

The ratio between the average daily catches of insects in *olitorius* and *capsularis* fields was 1 : 1·8. Therefore, the density of insect population in *capsularis* was nearly double that in *olitorius*.

Hymenopterous insects visiting flowers :

(i) *olitorius :* Three oriental species of honey bees, namely *Apis dorsata* Fabricius, *A. florea* Fabricius, and *A. indica* Fabricius, were found to visit *olitorius* flowers. Their respective daily average number of captures were 18·0, 1·0, and 0·5 (Fig. 1), representing 75·3, 5·3, and 2·3 % respectively of the hymenopterous insects. The remaining 17·1 % hymenopterous insects consisted of bees other than honey bees, wasps, etc., none of them in considerable number.

(ii) *capsularis :* In *capsularis*, the corresponding average number of daily captures of *A. dorsata*, *A. florea*, and *A. indica* were 28·0, 6·0, and 0·5 respectively (Fig. 1), constituting 66·4, 14·8, and 1·3 % respectively of the hymenopterous insects. Like *olitorius*, among the remaining 17·5 % hymenopterous insects, none of the species of other bees, wasps, etc., was worth mentioning.

The average daily captures of *A. dorsata*, *A. florea*, and the remaining hymenopterous insects in *capsularis* were 1·55, 6·0, and 1·75 times respectively more than in *olitorius*. The populations of *A. indica* were negligible and equal in both the fields.

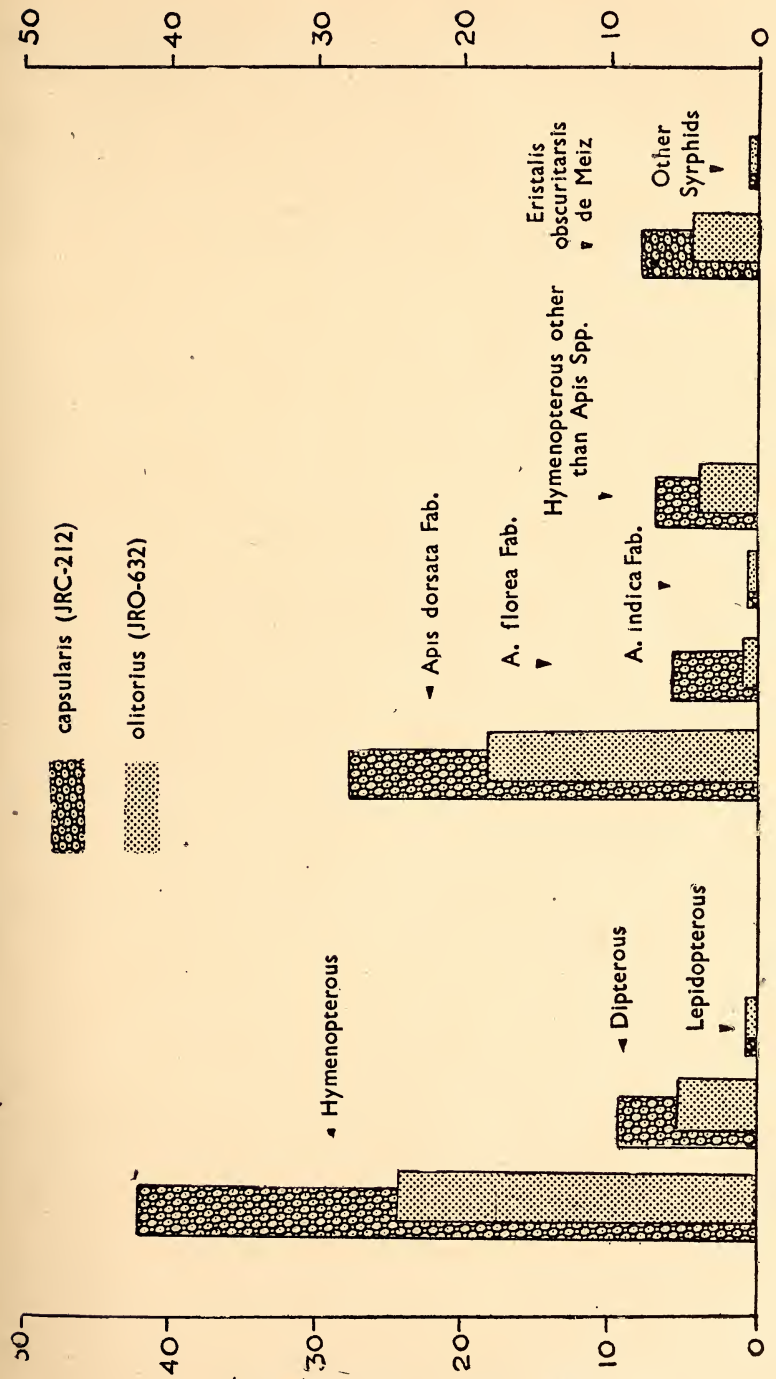

Fig. 1. Activities of flower-visiting insects in *capsularis* and *olitorius* jute.

Dipterous insects visiting flowers :

(a) *olitorius :* The dipterous insects were all syrphids, but *Eristalis obscuritarsis* de Meiz. was very predominant and consisted of 81·97 % of the dipterous insects.

(b) *capsularis : E. obscuritarsis* was 86·91 % of the total syrphids caught.

The captures of syrphids and of *E. obscuritarsis* were 1·75 times and 1·84 times more in *capsularis* than in *olitorius* (Fig. 1).

Periods of activity of insects :

A. Hymenopterous insects :

(i) *olitorius :* The hymenopterous insects were found in large numbers during the period from 8·00 to 8·30 hours (Table 1). But as *A. dorsata* was 60% of the total insect pollinators and none of the remaining species of hymenopterous insects was more than 3·3%, the activities of *A. dorsata* alone and of the others collectively were taken into account (Fig. 2). The peak period of activity of *A. dorsata* was from 8·00 to 8·30 hours, but there was no marked peak period in the activities of the remaining hymenopterous insects. They were found to be active during 8·00 to 14·00 hours (Table 2a).

(ii) *capsularis :* The maximum activity of the hymenopterous insects was found during the period from 9·30 to 10·00 hours (Table 1). It is evident from Table 2b that *A. dorsata* and *A. florea*, which constituted 53·8 and 11·5 % respectively of the total capture of insects had the same peak period of activity. But hymenopterous insects other than *Apis* spp. were found to be active from 8·00 to 14·00 hours, without showing any appreciable peak in their activities (Table 2b).

The difference in the peak periods of activity of *A. dorsata* (Fig. 2) in *olitorius* and *capsularis* was obviously due to the different times of opening of flowers in the two species.

B. Dipterous insects :

In both *olitorius* and *capsularis* jute, dipterous insects were present in maximum numbers during the period from 6·30 to 7·00 hours, though *capsularis* flowers had not opened at that time. During that period, they were found to sit on the closed *capsularis* and *olitorius* flowers which had bloomed on the previous day and also to visit fresh *olitorius* flowers.

Correlations between the population densities of flowers and hymenopterous insects and A. dorsata

(a) *olitorius :* No significant correlations between the average numbers of flowers per plant and of daily capture of hymenopterous insects and *A. dorsata* (Table 3) have been found.

TABLE 1

ACTIVITIES OF HYMENOPTEROUS AND DIPTEROUS INSECTS DURING DIFFERENT PERIODS

Insect Orders	Species of jute	Average no. of captures in half-hours beginning :						
		6·30 hrs.	8 hrs.	9·30 hrs.	11 hrs.	12·30 hrs.	13·30 hrs.	Total
Hymenoptera	*olitorius*	1·18	11·82	5·18	3·18	1·45	1·09	23·90
	capsularis	0·27	5·18	20·45	8·00	5·09	3·27	42·26
Diptera	*olitorius*	2·09	0·36	0·36	1·09	1·09	0·54	5·53
	capsularis	4·64	1·54	0·64	0·73	1·36	0·82	9·73

TABLE 2a

ACTIVITIES OF HYMENOPTEROUS INSECTS IN *olitorius* DURING DIFFERENT PERIODS

Insects	Average no. of captures in half-hours beginning :						
	6·30 hrs.	8 hrs.	9·30 hrs.	11 hrs.	12·30 hrs.	13·30 hrs.	Total
Apis dorsata ..	1·00	10·73	3·91	1·54	0·73	0·09	18·00
A. florea ..	0·09	0·18	0·45	0·18	0·18	0·18	1·26
A. indica ..	0·00	0·00	0·18	0·18	0·09	0·09	0·54
Insects other than *Apis* spp. ..	0·09	0·91	0·64	1·28	0·46	0·73	4·11

TABLE 2b

ACTIVITIES OF HYMENOPTEROUS INSECTS DURING DIFFERENT PERIODS IN *capsularis*

Insects	Average no. of captures in half-hours beginning :						
	6·30 hrs.	8 hrs.	9·30 hrs.	11 hrs.	12·30 hrs.	13·30 hrs.	Total
Apis dorsata ..	0·00	3·27	15·73	5·09	3·17	0·82	28·08
A. florea ..	0·00	0·45	3·91	1·09	0·26	0·54	6·25
A. indica ..	0·00	0·00	0·18	0·09	0·18	0·09	0·54
Insects other than *Apis* spp. ..	0·27	1·55	0·64	1·71	1·47	1·82	7·46

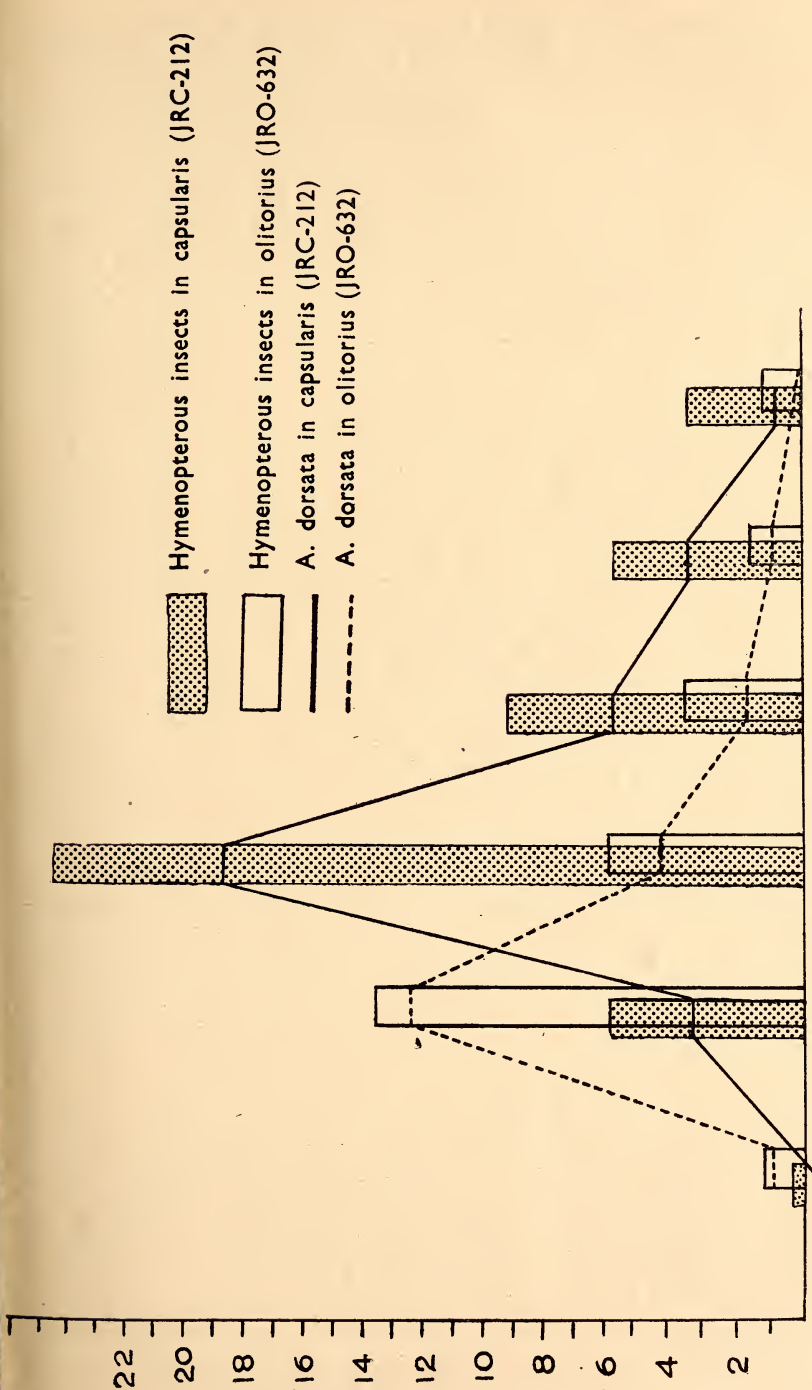

Fig. 2. Activities of Hymenopterous insects and *Apis dorsata* Fabricius during different periods in the day.

(b) *capsularis :* The number of daily captures of hymenopterous insects collectively and of *A. dorsata* in particular showed highly signi-

TABLE 3

POPULATION DENSITIES OF FLOWERS AND INSECTS IN *olitorius*

Date of observation	Av. no. of flowers	Number of hymenopterous insects			No. of lepidopterous insects	No. of dipterous insects	Total
		A. dorsata	Others	Total			
25-9-62	3·54	20	9	29	—	5	34
27-9-62	2·67	5	5	10	3	8	21
29-9-62	3·22	11	7	18	2	13	33
3-10-62	1·84	23	8	31	1	14	46
4-10-62	1·96	22	7	29	0	4	33
5-10-62	2·64	43	1	44	0	5	49
9-10-62	2·68	44	3	47	0	4	51
11-10-62	2·13	15	9	24	0	3	27
12-10-62	2·28	5	9	14	0	2	16
16-10-62	1·54	9	4	13	0	3	16
18-10-62	0·84	1	3	4	0	0	4

Correlations : r_{12} 0·345, r_{13} 0·418 — The correlations are not significant.

1=average number of flowers per plant
2=number of *A. dorsata*
3=total number of hymenopterous insects

ficant correlations (at 1% level) with the average number of flowers per plant per day (Table 4).

TABLE 4

POPULATION DENSITIES OF FLOWERS AND INSECTS IN *capsularis*

Date of observation	Av. no. of flowers	Number of hymenopterous insects			No. of lepidopterous insects	No. of dipterous insects	Total
		A. dorsata	Others	Total			
25-9-62	6·85	25	6	31	4	7	42
27-9-62	6·53	25	20	45	1	10	56
29-9-62	10·64	54	25	79	—	12	91
3-10-62	3·34	34	23	57	—	12	69
4-10-62	4·49	32	11	43	—	29	72
5-10-62	7·30	56	4	60	—	9	69
9-10-62	5·36	56	10	66	—	14	80
11-10-62	3·42	17	13	30	—	4	34
12-10-62	2·13	7	22	29	1	5	35
16-10-62	1·22	3	19	22	—	4	26
18-10-62	0·39	0	3	3	3	1	7

Correlations : r_{12} 0.800, r_{13} 0.796 — 1=average number of flowers per plant; 2=number of *A. dorsata*; 3=total number of hymenopterous insects

The correlations are highly significant.

Effects of climatic conditions on the activities of pollinating insects :

Dutt & Ghose (1962) assumed that the activities of pollinating insects are affected by rainfall ; in the present experiments, their activities were observed to be greatly reduced in cloudy weather.

Behaviour of A. dorsata *in* olitorius *and* capsularis *fields :*

(a) *olitorius : A. dorsata* was found to visit on an average 9·93 flowers and 8·85 plants per minute. Rarely, was it found to visit two flowers of the same plant consecutively. It spent on an average 4·37 and 3·63 seconds in a flower and in between two flowers respectively (Table 5).

TABLE 5

BEHAVIOUR* OF *A. dorsata* IN *olitorius* AND *capsularis* FIELDS

Species of jute	Av. no. of flower per plant	No. of plants visited per minute	No. of flowers visited per minute	Time (in secs.) spent in a flower	Time (in secs.) spent between two flowers
olitorius	2·65	6·06-11·35 av. 8·85	4·61-19·45 av. 9·93	2·23-10·38 av. 4·37	1·92-7·16 av. 3·63
capsularis	6·91	6·95-12·63 av. 8·38	6·40-17·14 av. 11.18	1·50-3·75 av. 2·40	1·35-3·62 av. 2·36

*Observations on different aspects were made separately.

(b) *capsularis :* It visited on an average 11·18 flowers and 8·38 plants per minute (Table 5). Frequently, the flowers of the same plant were visited consecutively by a single bee. It spent less time in a flower (average 2·40 seconds) and in between two flowers (average 2·36 seconds) than in *olitorius*. The difference in behaviour was probably due to the smaller size and greater number of *capsularis* flowers.

DISCUSSION

In order to justify their view on the cause of higher percentage of natural crossing in *olitorius* jute, Ghose & Das Gupta (1945) stated that *olitorius* flowers, owing to their larger size, were preferred by the flower-visiting insects. Dutt & Ghose (1962) were of the opinion that the lower percentage of natural crossing in *capsularis* was due to the larger number of flowers per plant, i.e. all the flowers were not visited by the insects. Neither explanation seems satisfactory to the present author, since the proportion of flowers to insects in the *olitorius* field was virtually the same as that in *capsularis*. For example, while the number of flowers in

capsularis was double that of *olitorius*, the number of insect visitors to the former was also nearly double, i.e. 1·8 times. Moreover *Apis dorsata*, the most important species, was found to visit *capsularis* flowers more frequently and as such there is little chance of any *capsularis* flower remaining unvisited as assumed by the above workers. In the opinion of the present author, the higher percentage of natural crossing in *olitorius* is due to a much larger number of ovules in its flowers than in *capsularis* and less chance of close-pollination than in the latter as ascertained from the behaviour of *A. dorsata*. According to Ghose & Das Gupta (1945), the average number of ovules per ovary of *olitorius* is 200 against 50 in *capsularis*. It is, therefore, likely that the number of unfertilised ovules after anthesis will be higher in *olitorius*, thereby enhancing chances of natural crossing by the insects.

The variations in the extent of natural crossing in *olitorius* jute in the observations of Ghose & Das Gupta (1945) and of Ray (1960) were slight, although they followed quite different techniques. The former authors thought that, if the number of dominant plants be increased, the chances of a flower of a recessive plant being out-pollinated by the pollen of another recessive plant would be less. Accordingly, they raised four recessive plants in a field of dominant plants and recorded on the average 12·8% natural crossing per plant, with a maximum of 17.0%. Ray (1960), on the other hand, raised both the strains of *olitorius* in alternate rows and registered on an average 10·5% natural crossing per plant, the highest being 17·7%, the figures differing little with those of Ghose & Das Gupta (1945). Considering the proportion of dominant and recessive plants, the percentages of natural crossing should have been higher in the former experiment. The present author considers that the lack of any significant variation is most probably due to differences in the population and activities of pollinating insects. The findings of Dutt & Ghose (1962) tend to support this view, since they recorded much less natural crossing in *olitorius*, though following the same technique as Ray (1960). They attributed this phenomenon to the reduced activity of the pollinating insects due to frequent rainfall. Likewise, the same factor seems to be responsible for the variations in the percentages of natural crossing in *capsularis*, as observed by Ghose & Das Gupta (1945), in different years or in the same year and in the same or different localities.

The part played by insects in the pollination of *olitorius* and *capsularis* jute is further realised from the work of Dutt & Ghose (1962), who observed that the setting of seeds per pod was about 46% and 12% more in non-caged *olitorius* and *capsularis* plants respectively in comparison with caged plants and expressed the opinion that 16-mesh wire-net cages were satisfactory from the point of view of aeration, light, and humidity. It was, therefore, quite likely that visits of the insects

increased the intensity of self-pollination, leaving aside the question of close- and cross-pollination, and thereby increased the production of seeds in non-caged plants.

It is evident from the above observations that *A. dorsata* is the most important insect pollinator of both the cultivated species of jute. Unfortunately, this species cannot be maintained in hives, which is however possible for *A. indica*. It may be worth while to place colonies of this species in jute fields during the flowering season for the increase in the production of seeds.

Summary

Hymenopterous and dipterous insects represented about 80 and 18% respectively of the pollinating insects both in *olitorius* and in *capsularis* jute ; lepidopterous insects were negligible. The total capture of insect pollinators in *capsularis* was 1·8 times more than in *olitorius*.

The percentages of *Apis dorsata* among the hymenopterous insects were about 75 and 66 in *olitorius* and *capsularis* respectively. The corresponding percentages of *A. florea* were about 5 and 15. No other species of hymenopterous insect was important.

Eristalis obscuritarsis was about 82 and 87% of the total syrphids captured in *olitorius* and *capsularis* respectively.

The peak period of activity of *A. dorsata* was from 8·00 to 8·30 hours in *olitorius* ; in *capsularis*, this species and *A. florea* showed highest activity from 9·30 to 10·00 hours. This was due to the different times of opening of flowers in the two species of jute.

The number of daily captures in *capsularis* of total hymenopterous insects and of *A. dorsata* showed highly significant correlations with the average number of flowers per plant. But no such correlation has been found in *olitorius*.

Cloudy weather affected greatly the activity of the insects.

Owing to the smaller size and greater number of the flower in *capsularis*, *A. dorsata* visited more plants and flowers per minute and spent less time in a flower and in between two flowers of this species than in *olitorius*.

The higher percentage of natural crossing in *olitorius* was probably due to its larger number of ovules which increase the chances of natural crossing as compared with *capsularis*.

For production of seed, colonies of *A. indica* might usefully be placed in jute fields during flowering.

Acknowledgement

Thanks are due to Sri P. Dutta, Statistician, Central Inland Fisheries Research Institute, Barrackpore, for helping in the analysis of the data.

References

Dutt, N. & Ghose, S. K. (1962) : Measurement of natural crossing as effected by insects in *olitorius* and *capsularis* jute. *Indian J. of agric. Sci.* **32** : 242-250.

Ghose, R. L. M. & Das Gupta, B. (1945) : Floral biology, antheses and natural crossing in jute. *Indian J. Genet.* **4** : 80-84.

Ray, B. (1960) : Natural crossing in *Corchorus olitorius* L. *Indian Agrist.* **4**: 1-4.

Nomenclatural Notes on some Flowering Plants

BY

N. P. Balakrishnan

Botanical Survey of India, Shillong

The following notes involving nomenclatural changes were compiled by the author during the course of his work in the large Central National Herbarium at Calcutta. The names are arranged family-wise. In addition to the citation of original publication, indication of type specimens wherever located, and important floras, a brief explanation to the required name change is included.

Aquifoliaceae

Ilex tavoyensis Balak. nom. nov. *I. wallichii* Hook. f. Fl. Brit. Ind. 1 : 605, 1875 (non Steudel 1840) ; Kurz, Fl. Brit. Burma 1 : 246, 1877. *Type :* Tavoy, *Gomez* s.n. Herb. Maingay 1774 (CAL).

Anacardiaceae

Holigarna wightii Balak. nom. nov. *H. grahamii* Hook. f. Fl. Brit. Ind. 2 : 37, 1876 (non Kurz 1872) ; Woodr. in J. Bombay nat. Hist. Soc. 5 : 273, 1897 ; Talbot, Trees Bombay 63, 1902 ; Gamble, Fl. Pres. Madras, Reprint ed. 191, 1957 ; Cooke, Fl. Pres. Bombay, Reprint ed. 1 : 298, 1958. *Semecarpus grahamii* Wight, Ic. Pl. Ind. Or. 1 : t. 235, 1839 ; Dalz. & Gibs. Bombay Fl. 52, 1861.

Wight's Icon 235 is based on specimens from peninsular India which he named *Semecarpus grahamii.* Later Kurz (1872) wrongly referred certain specimens from Pegu to this species and described them under the name *Holigarna grahamii,* indicating *Semecarpus grahamii* Wight in parentheses as synonym. J. D. Hooker (1876) found the specimens on which Wight's name is based are different from those described by Kurz, and he gave a new name, *Holigarna albicans,* to the specimens of Kurz and applied *H. grahamii* to Wight's specimens, thus creating a later homonym. This is clearly against the provisions of Art. 64 of the Code. The combination *H. grahamii* Hook. f. (1876) is based on a type different from that on which the combination *H. grahamii* Kurz (1872) is based,

and is therefore a later homonym. A new name *H. wightii* is proposed here for the peninsular Indian species.

Holigarna grahamii Kurz in J. As. Soc. Beng. 41 : 395, 1872, pro parte. *Holigarna albicans* Hook. f. Fl. Brit. Ind. 2 : 38, 1876.

Holigarna grahamii Kurz, excluding the synonym *Semecarpus grahamii* Wight, is validly published; Kurz has given a detailed description which is entirely based on his Burmese specimens. The inappropriate indication of a synonym does not invalidate a name otherwise validly published. *H. albicans* Hook. f. is a superfluous name and should be rejected in favour of *H. grahamii* Kurz.

Papilionaceae

Astragalus ladakensis Balak. nom. nov. *A. strictus* Grah. ex Benth. in Royle, Illustr. Bot. Himal. 198, 1835 (non Siev. ex Fisch. 1825) ; Hook. f. Fl. Brit. Ind. 2 : 124, 1876.

Desmodium benthamii Balak. nom. nov. *D. brachystachyum* Grah. ex Benth. in Miq. Pl. Jungh. 223, 1852 (non Schlecht. 1838) ; Baker in Hook. f. Fl. Brit. Ind. 2 : 171, 1876 ; Gamble, Fl. Pres. Madras, Reprint ed. 245, 1957 ; Haines, Bot. Bih. Or. 265, 1922.

Desmodium bakeri Balak. nom. nov. *D. rottleri* Baker in Hook. f. Fl. Brit. Ind. 2 : 174, 1876 pro parte (non G. Don, 1832) ; Gamble, Fl. Pres. Madras, Reprint ed. 245, 1957. *Eleiotis rottleri* Wight & Arn. Prodr. 231, 1834.

D. rottleri Baker is a later homonym of *D. rottleri* G. Don (Gen. Syst. 2 : 297, 1832). A new name, *D. bakeri*, is chosen for this species. The Burmese specimens cited by Baker *loc. cit.* belong to *Neocollettia wallichii* (Kurz) Schindl. in Fedde Rep. 21 : 16, 1925.

Umbelliferae

Bupleurum hamiltonii Balak. nom. nov. *B. tenue* Buch.-Ham. ex D. Don, Prodr. Fl. Nep. 182, 1825 (non Salisbury, 1796) ; DC. Prodr. 4 : 128, 1830 ; Clarke in Hook. f. Fl. Brit. Ind. 2 : 677, 1882 ; Duthie, Fl. U. Gang. Pl. 392, 1903 ; Wolff in Engler, Pflanzenr. 43 : 145, 1910.

Bupleurum hamiltonii Balak. var. **khasianum** (Clarke) Balak. comb. nov. *B. tenue* D. Don var. *khasianum* Clarke in Hook. f. Fl. Brit. Ind. 2 : 677, 1882 ; Wolff, l.c. 145.

Apiaceae (Rubiaceae)

Ixora arborea Roxb. ex Seem. var. **zeylanica** (Hook. f.) Balak. comb. nov. *I. parviflora* Vahl var. *zeylanica* Hook. f. Fl. Brit. Ind. 3 : 143, 1880. *Type* : *Thwaites* C.P. 2, ' Ixora jucunda Thw. var. r.' (CAL).

Bremekamp (in *J. Bot.* **75** : 324, 1937) changed the name *Ixora parviflora* Vahl to *I. arborea* Roxb. ex Seem., the former being a later homonym. J. D. Hooker *loc. cit.* described a variety *zeylanica* under *I. parviflora* Vahl, which differs from the typical form in having broadly elliptic, obovate, acute, acuminate leaves, which are cuneate at base, more membranous, less reticulate ; the petioles are longer and the stipules longer cuspidate.

Asteraceae (Compositae)

Artemisia edgeworthii Balak. nom. nov. *A. stricta* Edgew. in Trans. Linn. Soc. 20 : 73, 1846 (non Heyne ex DC. 1838) ; Hook. f. Fl. Brit. Ind. 3 : 323, 1881.

Acanthaceae

Rhinacanthus nasuta (L.) Kurz var. **montana** (Clarke) Balak. comb. nov. *R. communis* Nees var. *montana* Clarke in Hook. f. Fl. Brit. Ind. 4 : 451, 1885 ; Gamble, Fl. Pres. Madras, Reprint ed. 759, 1957.

Lauraceae

Actinodaphne malabarica Balak. nom. nov. *A. hirsuta* Hook. f. Fl. Brit. Ind. 5 : 152, 1886 (non Blume 1851) ; Gamble, Fl. Pres. Madras, Reprint ed. 862, 1957. *Actinomorphe hirsuta* (Hook. f.) O. Kuntze, Rev. Gen. 570, 1891.

Litsea cuipala (D. Don) Balak. comb. nov. *Tetranthera cuipala* D. Don, Prodr. Fl. Nep. 65, 1825. *T. lanuginosa* Wall. ex Nees in Wall. Pl. As. Rar. 2 : 64, 1831. *Litsea lanuginosa* Nees in Syst. Laurin. 634, 1831 ; Meissn. in DC. Prodr. 15(1) : 221, 1864 ; Brandis, For. Fl. 382, 1874 ; Gamble, Man. Ind. Timb. 312, 1881 ; Hook. f. Fl. Brit. Ind. 5 : 178, 1886.

Litsea saligna (Nees) Balak. comb. nov. *Tetranthera saligna* Nees in Wall. Pl. As. Rar. 2 : 67, 1831. *T. angustifolia* Wall. ex Meissn. in DC. Prodr. 15(1) : 183, 1864, pro parte. *Litsea angustifolia* (Wall. ex Meissn.) Hook. f. Fl. Brit. Ind. 5 : 169, 1886 (non Blume 1826, nec Kurz 1875) ; Prain, Beng. Pl. 903, 1903 ; Kanjilal et al. Fl. Assam 4 : 87, 1940

The oldest name for this species is *Tetranthera angustifolia* Wall. (1830), but this is a *nomen nudum* and cannot be taken into consideration for purposes of priority. This name was validated only in 1864 by Meissner, when he furnished a description. There was already an earlier validly published name for this species, *Tetranthera saligna* Nees (1831) ; J. D. Hooker on transferring this species to *Litsea*, chose the

epithet of Wallich, *angustifolia*, and this is against the rule of priority of the Code. Further, *L. angustifolia* Hook. f. (1886) is a later homonym of *L. angustifolia* Blume (1826) and *L. angustifolia* Kurz (1875).

Litsea thwaitesii Balak. nom. nov. *L. undulata* Hook. f. Fl. Brit. Ind. 5 : 158, 1886 (non Zipp. ex Blume 1851). *Tetranthera lingustrina* Thw. Enum. Pl. Zeyl. 254, 1861 (non Nees 1831).

Orchidaceae

Anoectochilus Blume : The genus *Anoectochilus* was founded by Blume in 1825. In 1858 he described the genus *Odontochilus*, differentiating it from the former by the shorter sac of its lip, which is concealed by the bases of the sepals and also because of the more developed columnar processes. These distinctions seem to be insufficient to justify generic rank, an opinion first expressed by J. D. Hooker in Icones Plantarum 2 : t. 2168, 1893, and later supported by King & Pantling in Ann. R. Bot. Gard. Calc. 8 : 293, 1898, and recently by Holttum in Rev. Fl. Mal. 1 : 124, 1953. To quote Holttum : ' As construed here, this includes two genera *Anoectochilus* and *Odontochilus*. The former has coloured leaves and distinct spur, the latter genus green leaves and a saccate base to the lip. The species *A. calcaratus*, however, is intermediate between the two ; and the essential flower structure of both is very similar ; so that the union of the two genera is not unnatural.'

The following new combination is proposed.

Anoectochilus rotundifolius (Blatt.) Balak. comb. nov. *Odontochilus rotundifolius* Blatter in J. Bombay nat. Hist. Soc. 32 : 521, 1928 ; Fischer in Gamble, Fl. Pres. Madras, Reprint ed. 1016, 1957.

Amaryllidaceae

Molineria trichocarpa (Wight) Balak. comb. nov. *Curculigo finlaysoniana* Wall. ex Hook. f. Fl. Brit. Ind. 6 : 279, 1892. *Hypoxis trichocarpa* Wight, Ic. Pl. 6 : t. 2045, 1853 (sinistra fig. tant.) ; Thwaites, Enum. Pl. Zeyl. 323, 1864 ; Kurz in Miquel, Ann. Mus. Lugd.-Bat. 4 : 178, 1869. *H. latifolia* Wight, l.c. t. 2044, 1853. *H. leptostachya* Wight, l.c. t. 2045 (dextra fig. tant.). *H. pauciflora* Wight, l.c. t. 2046 (sinistra fig. tant.). *H. brachystachya* Wight, l.c. t. 2046 (dextra fig. tant.). *Molineria finlaysoniana* Baker in J. Linn. Soc. 17 : 121, 1878 ; Fischer in Gamble, Fl. Pres. Madras, Reprint ed. 1049, 1957.

Curculigo finlaysoniana is the oldest name given to this species by Wallich in 1832 as a *nomen nudum*, which was validated only in 1892 by J. D. Hooker. Next in order of priority follow five names described by Wight in 1853 under *Hypoxis*. All these are synonymous with the

present species and have equal status, having been published on the same date, March 1853. Of these, *H. trichocarpa* has been later adopted by Thwaites & Kurz, who treat the other binomials of Wight as synonyms and hence chosen here as the basionym.

The genus *Molineria* has been segregated from *Curculigo* by all recent authors and can be distinguished as follows :

Perianth tube produced above the ovary ; stamens perigynous *Curculigo*

Perianth tube not produced above the ovary ; stamens epigynous *Molineria*

Studies on Indian Copepods—8. Observations on the diurnal vertical movements of Planktonic Copepods in the Gulf of Mannar[1]

BY

A. N. P. UMMERKUTTY[2]

Central Marine Fisheries Research Institute, Mandapam Camp

(*With a map and seven text-figures*)

INTRODUCTION

Both Russell (1927) and Cushing (1951) have reviewed this problem and have shown that the majority of zooplankton species make extensive vertical movements in the waters they inhabit. Their massive movement, up and down every 24 hours is an impressive phenomenon which must be fully studied for a closer understanding of the biological and ecological conditions characteristic of a given species. The patterns of vertical movements may differ not only between different species, but also between different developmental stages and sexes of the same species. It may also vary in different latitudes, under different physico-chemical environments of the same latitude, and also in various seasons. It results from a combination of several physical and physiological factors which, acting together, produce a unique rhythm more or less steady in a species under a particular set of conditions.

The vertical movements of copepods have been the subject of extensive investigations in Polar and Temperate waters (Bogorov 1946; Ussing 1938; Wiborg 1954; Russell 1925, 1926, 1928 a & b; Nicholls 1933; Clarke 1933; 1934a, b, & c; Farran 1947; Bainbridge 1952). The information on this subject in tropical and subtropical waters is, however, very meagre, particularly of the Indian region where little work has been done in this field. The studies reported here aim at establishing the nature of the vertical migration of planktonic copepods in our waters. As the investigations have been carried out at a depth of about six

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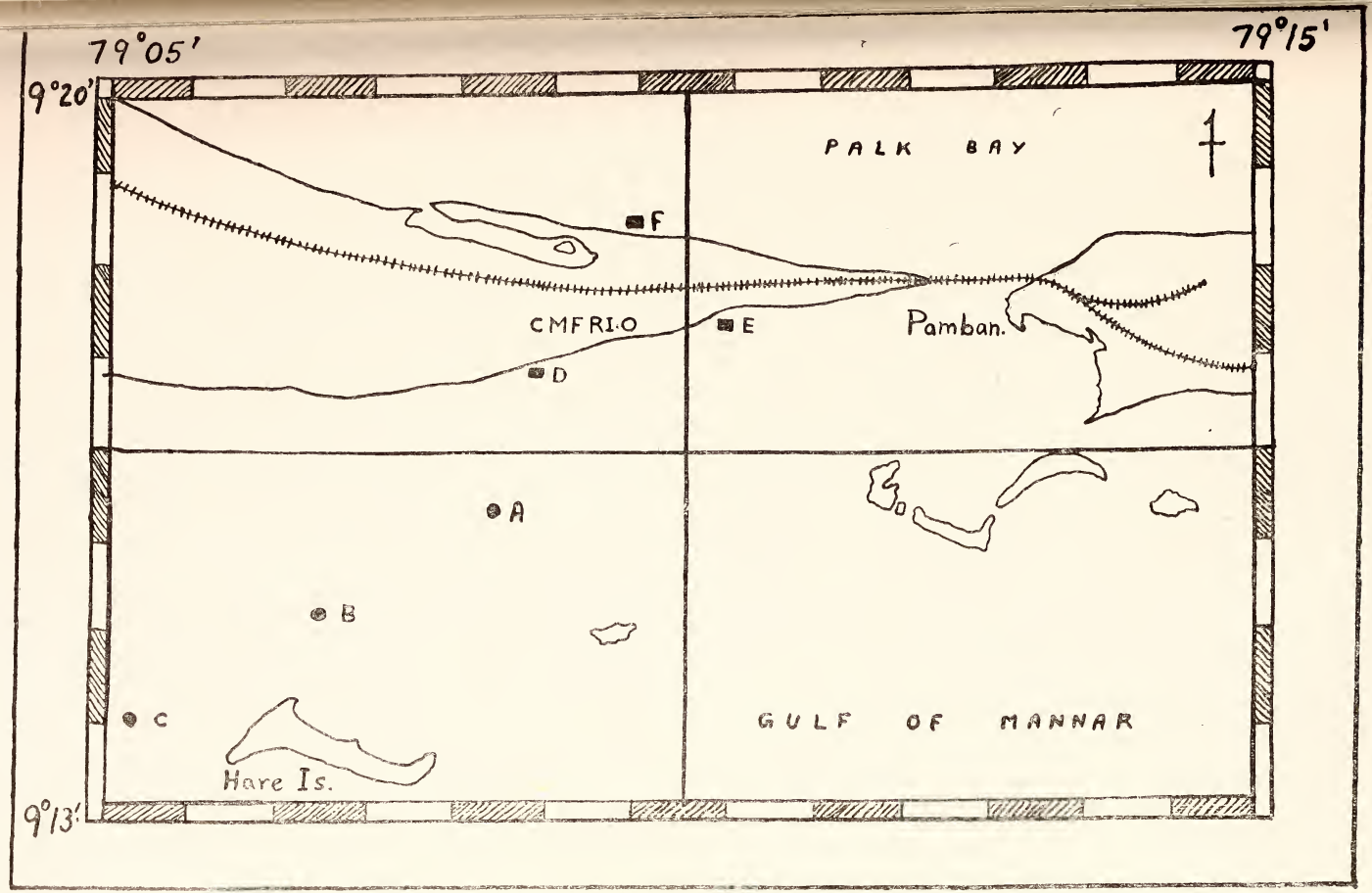
[2] Present address: Zoological Survey of India, 27, Jawaharlal Nehru Road, Calcutta 13.



Map of Mandapam area showing the various centres of collection. Samples for studies on the vertical movements were taken at Station C.

fathoms, the data on which the present conclusions are based refer to shallow waters only.

The results obtained indicate that diurnal vertical migration occurs in tropical waters also, at least in some species of copepods. This statement is based on two types of evidence. Firstly, the number of individuals of a species, especially adults and late copepodite stages, vary considerably in surface hauls made at 4-hourly intervals. During the dark hours there is a great increase in their number, and a considerable reduction during the bright daylight hours. This indicates that the general population withdraws from the brightly lit zones, although stray individuals remain in all the layers irrespective of changing light intensities. Secondly, simultaneous collections made with Clarke-Bumpus apparatus at surface and at depth indicate that during daytime adults and late copepodites concentrate in the deeper areas, and extend their distribution to the upper waters only when darkness sets in. This alteration in distribution of populations in the two layers, coinciding with changes in light intensity, is consistent with the idea of diurnal vertical movements.

Material and Methods

The material for the present study was collected at Station C in the Gulf of Mannar (Map), situated about six miles from the Central Marine Fisheries Research Institute and about one mile from Hare Island. Three series of collections were made. (1) Using organdie nets, 4-hourly surface hauls were made on 12 and 13 January 1960 commencing at 6 a.m. on the first day and ending at 6 a.m. on the second day. Temperature of the water both at surface and at depth was noted along with each collection and water samples were taken for determining the salinity from both hauls. (2) Attempts to make similar collections throughout day and night did not succeed on 20 February 1960. After 6 p.m. the sea became rough, with a strong wind blowing towards the mainland, and it was found difficult to continue the work. In this second series of collections therefore, data are available only for the day. (3) Four-hourly collections were made for 24 hours on 8 and 9 March 1960. The Clarke-Bumpus apparatus was employed for making collections both at the surface and down below. Organdie half-metre nets were used for surface hauls.

All the collections were preserved in 5% formalin immediately after the haul. Subsampling for laboratory analysis was done as follows. All samples were raised to 250 cc. by adding properly diluted formalin and a subsample of 10 cc. pipetted out. In the case of collections obtained by Clarke-Bumpus apparatus the entire subsample was examined. However, as the half-metre net collections invariably contained a much

higher amount of organisms, it was difficult to make a detailed study of the entire subsample. Subsequently, further subsampling had to be done of collections made by organdie nets and only a sample of 2 cc. of the original 250 cc. was examined in detail.

Volumetric Composition

The volumetric composition of copepod and non-copepod items was determined in wet condition using the principle of displacement and is presented in Table 1. Copepod and non-copepod items of each subsample were sorted out separately and were introduced into graduated capillary tubes which contained known quantities of sea-water. The volumetric value of the introduced item was then directly found from the difference between the initial and final water-level readings.

Table 1

Actual volumes of copepod (C) and non-copepod (NC) items and their percentages in surface hauls in January 1960

Date & Time	Total volume in cc.	Relative volumes in cc.		Percentage	
		C	NC	C	NC
12.1.1960					
5.45 a.m.	2·2	1·2	1·0	54·5	45·5
9.45 a.m.	1·2	0·6	0·6	50·0	50·0
1.45 p.m.	1·15	0·6	0·55	53·0	47·0
5.45 p.m.	1·3	0·7	0·6	53·8	46·2
9.45 p.m.	2·0	1·15	0·85	57·5	42·5
13.1.1960					
1.45 a.m.	2·2	1·18	1·02	53·6	46·4
5.45 a.m.	2·8	1·5	1·3	53·4	46·6

The maximum concentration of copepods at the surface was found at 9.45 p.m. The distribution of a certain percentage of copepods in the surface waters persists because early larval forms are relatively less rapid in changing the site than adults and late copepodites. Some non-copepod items of plankton show as much migratory behaviour as copepods. *Sagitta* spp. and *Lucifer* spp., both well known to display pronounced vertical movements, have been found making day and night journeys in response to light.

Gravimetric Estimation

To give a clearer picture of the whole series of changes in diurnal migration a gravimetric estimation is more important. A subsample of copepods in 2 cc. of the surface hauls by organdie net was dried in a watch glass and weighed. Similarly, a subsample of 10 cc. of each of

the collections taken by Clarke-Bumpus apparatus at surface and at 5-metre depth was dried and weighed. The data obtained are presented

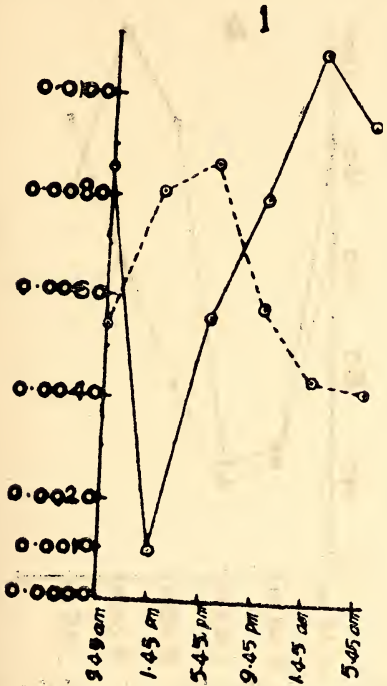


Fig. 1. Actual dry weights of copepods in 10 cc.-subsamples at surface (———) at 5-metre depth (.....), collected with Clarke-Bumpus apparatus during March 1960.

Fig. 2. The same collections expressed as percentages of the total catch from the two layers of the water column.

in Text-figs. 1 and 2, in which copepod populations are expressed as a whole and include adults and copepodites of both sexes. The figures show that, though the population as a whole goes up and down, a certain percentage of plankton retain their respective levels. These include not only early copepodites of several species but also adults of such species as *Acrocalanus monachus*, *Paracalanus parvus*, and *Oithona* spp. which are composed of small-sized individuals. However, there is clearly a conspicuous reduction in the abundance of copepods at the surface about midday, followed by a high concentration in surface waters about midnight.

Numerical Composition of Species

Pseudodiaptomus aurivilli Cleve

Text-figs. 3 and 4 show the distributional pattern of this species at 5 metre level and at surface as sampled by Clarke-Bumpus apparatus in March 1960 ; the actual numbers of copepodites and adults caught in

surface hauls by organdie net during the 24-hour period are presented in Table 2. The two figures and the table show that the adult population

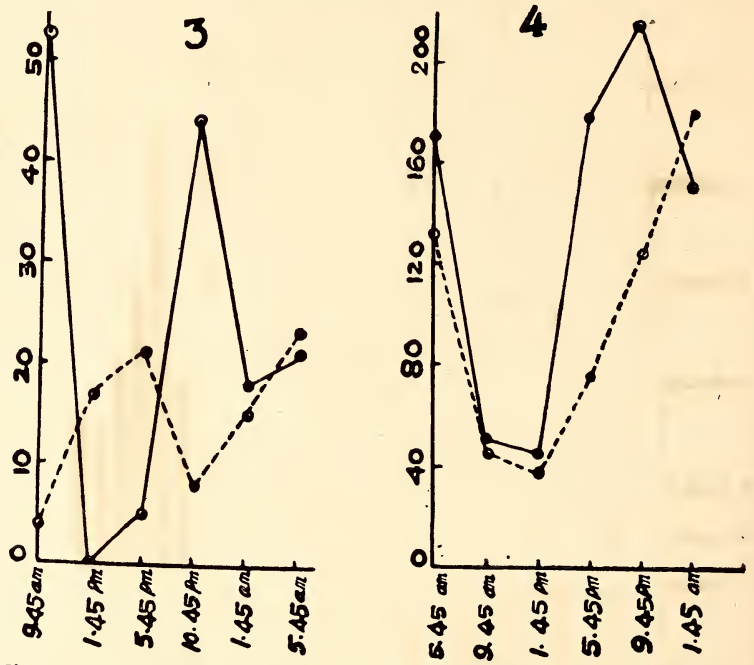


Fig. 3. *Pseudodiaptomus aurivilli*: Distribution of adults at surface (———) and at 5-metre depth (.....) on 12-13 January 1960, collected by Clarke-Bumpus apparatus.

Fig. 4. *Pseudodiaptomus aurivilli*: Distribution of adults at surface on 8-9 March 1960 (———) and 12-13 January 1960 (.....).

of this species displays great variation in its numbers in surface waters. After sunset five times more adults are caught in surface waters than at noon. There seems to be little change in the distributional pattern of copepodites except, to some extent, in the case of the fifth stage, which shows a higher concentration at surface during late hours of the evening.

A sex-wise analysis of adults does not show any difference in the pattern of response to light. The males dominate most of the time except during the dusk and early morning. This dominance of the male may be due to the greater percentage distribution of that sex in the population during breeding months (December-March). The apparent dominance of females during dusk and early morning is probably attributable to the transient condition of the population, the animals being in an active state of migration thus disturbing the normal stability.

TABLE 2

Pseudodiaptomus aurivilli : ACTUAL NUMBERS OF ADULTS AND COPEPODITES (Cop.) CAUGHT IN SURFACE HAULS WITH ORGANDIE NETS DURING 24-HOUR PERIOD ON 12-13 JANUARY 1960

Date & Time	Cop. I	Cop. II	Cop. III	Cop. IV ♂	Cop. IV ♀	Cop. V ♂	Cop. V ♀	Adults ♂	Adults ♀
12.1.1960									
5.45 a.m.	0	1	4	26	22	73	38	121	50
9.45 a.m.	0	2	5	22	16	32	32	34	17
1.45 p.m.	0	0	8	13	12	20	15	33	14
5.45 p.m.	0	3	11	12	20	24	49	71	106
9.45 p.m.	0	0	6	12	19	44	42	115	100
13.1.1960									
1.45 a.m.	0	0	2	10	11	24	27	68	82

Centropages furcatus (Dana)

This species is composed of fairly large-sized individuals, but it occurs only in small numbers. The members of this species appear to react strongly to day and night changes. During noon not a single adult was observed at surface in any of the three subsamples analysed, but in samples taken at 10 p.m. and at 2 a.m. twelve and sixteen individuals respectively were caught. During the intervening hours the increase or decrease showed graduations (Text-fig. 5). The species being scarce in plankton could not be sampled properly by the Clarke-Bumpus apparatus and a thorough observation could not be made on its distribution in different vertical levels.

Calanopia elliptica Dana

In this species also substantial evidence of migratory movements was obtained. At dawn the species is represented by a few adults in the plankton ; as the day advances it gradually disappears from surface waters and is not seen throughout the brightly-lit hours. At night at about 10 p.m. large numbers become available at surface. However, a decline in abundance is seen in the early hours that follow (by 2 a.m.). This may be due to what Cushing (1951) termed a departure from the surface at midnight. According to this view, copepods migrate upwards as darkness intensifies and reach their maximum surface distribution by about 10 p.m. In complete darkness they stop swimming and sink passively. Thus, being unable to maintain their topmost level, they get distributed in layers down below. This phenomenon which could be termed positive geotaxis gets combined with photokinesis. It is parti-

cularly notable in the present species probably because of its larger size (Text-fig. 6).

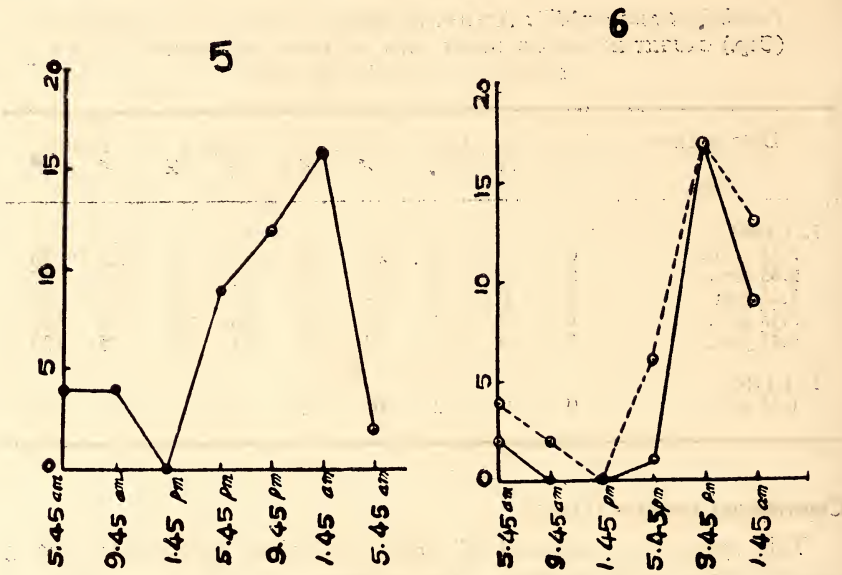


Fig. 5. *Centropages furcatus*: Distribution of adults at surface on 12-13 January 1960, collected by organdie net.

Fig. 6. *Calanopia elliptica*: Distribution of adults at surface on 12-13 January (.....) and 8-9 March 1960 (———), collected by organdie net.

Acartia erythraea Giesbrecht

This is one of the commonest species of this area and seems to prefer upper water layers during the dark hours. Minimum numbers are found at surface during noon while maximum concentration occurs eight hours later and persists till the early hours. The data obtained for the months of January and March by organdie net are plotted in Text-fig. 7. In March only the adults and the fifth copepodites were found. This suggests that at this time of year the species reaches the end of its breeding season. As in *C. furcatus*, in this species maximum concentration in surface waters occurs at about 10 p.m. and is followed by a slight declination.

Probably in this species, as in several others, diurnal migration is not obligatory. They tend to avoid the brightly-lit surface layer during the day and in doing so get distributed at lower layers. The chief notable features are the low number of adults captured at surface during the noon and the gradually higher concentrations appearing at deeper levels. After sunset there is no appreciable decrease in their numbers in areas near the bottom. This signifies that the population remains fairly well-distributed at all levels above the bottom. In the

surface layer, however, there occurs a progressive increase as the darkness prevails.

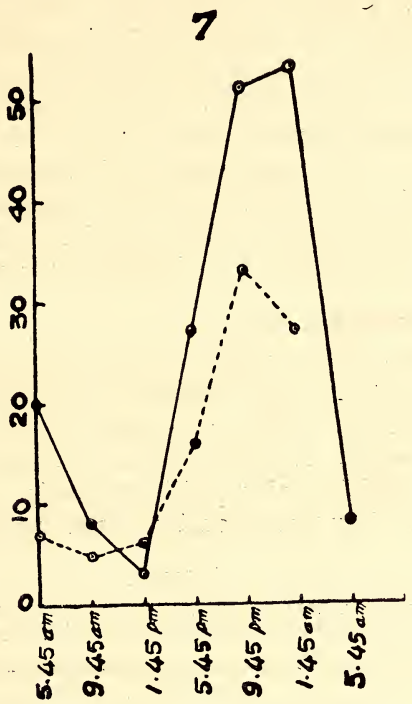


Fig. 7. *Acartia erythraea*: Distribution of adults at surface on 12-13 January (.....) and on 8-9 March 1960 (———), collected by organdie net.

Centropages dorsispinatus Thompson & Scott

This species showed a very irregular distribution. Though there was an apparent withdrawal of the population from the surface during the sunlit hours, the population did not return to its original density in the surface waters even during the darkest hours (Table 3). Cushing

TABLE 3

Centropages dorsispinatus: DISTRIBUTION OF ADULTS AND COPEPODITES (COP.) IN SURFACE LAYER ON 12 AND 13 JANUARY 1960

Date & Time	Cop. I	Cop. II	Cop. III	Cop. IV ♂	Cop. IV ♀	Cop. V ♂	Cop. V ♀	Adult ♂	Adult ♀
12.1.1960									
5.45 a.m.	0	7	19	36	33	50	27	36	31
9.45 a.m.	1	2	5	5	9	3	1	5	2
1.45 p.m.	0	5	7	36	39	18	16	8	5
5.45 p.m.	0	4	6	7	12	4	2	2	2
9.45 p.m.	2	3	7	5	5	5	6	2	3
13.1.1960									
1.45 a.m.	1	2	7	9	7	6	5	2	1
5.45 a.m.	0	2	5	10	12	13	18	16	11

(1951) and other earlier workers have rightly pointed out the inadequacies of the studies of selected horizontal stations in the investigations on vertical migration. Cushing has shown that neither the vessel making the collections nor the water mass in which the collections are made remain static even for short intervals. There is always an exchange of fauna with the surrounding waters. This changing pattern becomes all the more complicated by the patchy nature of the distribution of copepods in the sea. An area where there is a swarming of a particular species of copepod in the morning could be replaced in the evening by a mass of water containing few of them, specially so if the patch noticed is a small one. The example of *C. dorsispinatus* may be such a case.

Schmackeria serricaudata T. Scott

Within the limits of the available data for this species, it appears that there is an inherent, positive, migratory behaviour. The maximum number is found in the surface layer during the dawn, and then there is a decline in numbers. A slight increase is noticed at dusk which is maintained up to midnight after which the species records appreciable increase (Table 4). Why there should be a concentration on the surface

TABLE 4

Schmackeria serricaudata: DISTRIBUTION OF ADULTS AND COPEPODITES (COP.) IN SURFACE WATERS ON 12 AND 13 JANUARY 1960

Date & Time	Cop. I	Cop. II	Cop. III	Cop. IV ♂	Cop. IV ♀	Cop. V ♂	Cop. V ♀	Adult ♂	Adult ♀
12.1.1960									
5.45 a.m.	0	0	0	0	0	6	4	28	25
9.45 a.m.	0	0	0	0	1	5	0	5	4
1.45 p.m.	0	0	1	3	2	4	7	5	7
5.45 p.m.	0	0	0	0	0	8	8	7	8
9.45 p.m.	0	0	0	1	2	4	7	8	7
13.1.1960									
1.45 a.m.	0	0	0	2	2	4	7	14	12
5.45 a.m.	0	0	0	0	0	3	1	3	1

in early morning hours, rather than during darkness, immediately after dusk is hard to explain. It is likely that there is an error in the data because of their patchy distribution in plankton, a feature common in copepods as has been already noted earlier.

GENERAL REMARKS

Russell (1927) and Cushing (1951) have discussed the various factors which influence the behaviour pattern of the migrating species. These factors include sunlight, weather, water temperature, presence and

abundance of phytoplankton, age of the animal concerned, etc. In addition to these, physiological factors have also been held responsible for the hazardous vertical sojourns that these tiny creatures undertake during the course of a day.

The effect of weather is rather indirect. During a cloudy day, the penetration of light into the water is poor. It thus creates artificially a situation which is comparable to dawn or dusk. Windy weather will make the surface turbulent thus making this layer physically uninhabitable. Both these factors seem to be insignificant in the present studies. Both in January and in March when the studies were carried out the weather was fair.

The effect of temperature appears to act chiefly in the regions of thermoclines : ' It is a possibility that a homogeneous group of animals (stage, sex or brood of a species) has a temperature range beyond the extremes of which the animal does not appear; a thermocline near the limits of this range will be obviously more effective in modifying migration than one in the centre of the range. As a mediator of migration temperature was shown by Esterley (1912) to be without effect as the diurnal differences in temperature at any depth was only a small fraction of the temperature range through which the animals moved ' (Cushing 1951, p. 165). This view is substantiated by the present series of observations. The change in temperature between the surface and 5-metre depth during the 24 hours was negligible (Table 5).

TABLE 5

TEMPERATURE OF WATER MASS AT STATION C IN THE GULF OF MANNAR DURING JANUARY AND MARCH 1960

Date	Time	*Temperature in* °C. Surface	Five-metre depth
12.1.1960 ..	5.45 a.m.	26·1	26·0
	8.45 a.m.	26·2	26·0
	1.45 p.m.	26·6	26·3
	5.45 p.m.	26·8	26·4
	9.45 p.m.	26·4	26·3
13.1.1960 ..	1.45 a.m.	26·2	26·1
	5.45 a.m.	26·0	26·0
8.3.1960 ..	5.45 a.m.	26·5	26·4
	9.45 a.m.	27·0	26·8
	1.45 p.m.	27·3	27·2
	5.45 p.m.	27·5	27·3
	9.45 p.m.	27·1	27·0
9.3.1960 ..	1.45 a.m.	26·6	26·5
	5.45 a.m.	26·6	26·5

The importance of phytoplankton in the migratory activities of planktonic copepods has recently been discounted as these animals are filter feeders and are incapable of discriminating between food-abundant areas and others. Age and inner physiological rhythm certainly play important roles in deciding the migratory pattern of individual species. But the most important factor appears to be light. The large amount of work that has been done in boreal and austral waters on this subject demonstrates beyond doubt that changes in the intensity of light that penetrates into the water during different hours of the day have direct bearing on the diurnal vertical movements of copepods. 'It is now generally agreed that the immediate stimulus to diurnal migration is light, perhaps modified in extreme cases by temperature. The conception of an optimum light intensity inside which the copepods keep, each stage and each population having perhaps its own optimum, has proved the most fruitful explanation of their movements' (Marshall & Orr 1955). Why and how the changes in light intensity come to exert such strong influence on the movements of these organisms is not clear.

The fact that in the present studies all species avoided the bright light of the sun to a great extent is in full agreement with the conclusions arrived at by earlier workers. But why the adult population does not withdraw completely from the surface during the day and why some species are quite indifferent to changing light intensities are not clearly understood. Fuller and comprehensive studies on these lines are needed in our waters.

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Summary

The diurnal vertical movements of the following species of planktonic copepods are studied : *Pseudodiaptomus aurivilli, Centropages furcatus,*

Calanopia elliptica, *Acartia erythraea*, *Centropages dorsispinatus*, and *Schmackeria serricaudata*.

It is found that all these species are fairly well distributed in the surface waters from dusk to dawn, but they avoid the top layer during the brightly lit hours of the day. The salient features of these migratory movements and the probable causes that influence them are briefly discussed.

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An Account of the Weeds of Central Research Farm, Jodhpur, Rajasthan

BY

Y. Satyanarayan and S. K. Saxena

Central Arid Zone Research Institute, Jodhpur

Weeds constitute a serious problem to agricultural production in western Rajasthan. Most of these weeds can be controlled by simple agronomic practices like clean cultivation. Apart from perennial weeds such as *Zizyphus nummularia*, *Saccharum spontaneum*, *Pluchea lanceolata*, *Cyperus rotundus*, and *Cynodon dactylon*, some of which provide either useful top-feed or fodder, it is the annual weeds which severely compete with the growing crop for moisture and nutrients.

A preliminary study of the weeds of Central Research Farm, Jodhpur, was conducted during 1963. Weeds were collected from all over the 700-acre farm during June to December. Some of the weeds had both a normal life form and a habitat form and could be considered as ecotypes. The soil of the Farm is sandy loam in texture, with a hard kankar pan occurring at a depth of 2 metres from the surface. The topography is flat with less than one per cent slope. The soil reaction is alkaline but the total soluble salts are low. The majority of weeds come up during the monsoon season (July to September) and disappear at the end of the season. Biennial and perennial weeds, however, continue to thrive for a longer duration. Winter weeds are few.

Analysis of the weed flora showed that there are 25 families with 58 genera and 79 species among the dicots and 2 families, 16 genera and 29 species, among the monocots. Families with the largest number of species are :

1. Dicots : Compositae—9 genera and 9 species ;
   Papilionaceae—5 genera and 10 species ;
   Amaranthaceae—5 genera and 7 species.
2. Monocots : Gramineae—15 genera and 26 species.

Eight families are represented by a single genus and species, viz. Papaveraceae, Polygalaceae, Caryophyllaceae, Malvaceae, Cucurbitaceae, Pedaliaceae, Chenopodiaceae, and Portulacaceae. There are altogether 73 annuals, 2 biennials, and 33 perennials, of which the dicots consist of 60 annuals, 2 biennials, and 17 perennials. The monocots contain 13 annual and 16 perennial species.

Systematic enumeration

Dicotyledons

Papaveraceae

Argemone mexicana Linn. Vern.[1] *Satyanasi.* Tall annual herb. Common throughout the Farm.

Capparaceae

Cleome papillosa Steud. Small, branched, semi-erect annual. Occasionally found near fencing of Farm boundary.

Cleome viscosa Linn. Vern. *Pilli-hulhul* ; Hindi *Gandhia* and *Kalo.* Common on roadsides, botanical garden, fallow, ploughed, and *bajra* fields.

Gynandropsis gynandra Brig. Vern. *Bagra.* Erect, unbranched annual. Common on roadsides, and in botanical garden and fallow fields.

Polygalaceae

Polygala erioptera Lamk. Vern. *Chota bhekaria.* Small erect annual. Occasional in fallow, *bajra*, and castor fields.

Caryophyllaceae

Polycarpaea corymbosa Lamk. Vern. *Zutaniakad.* Small erect annual herb. Abundant in fallow, *bajra*, and legume fields, and nursery.

Portulacaceae

Portulaca oleracea Linn. Vern. *Bara-noonia, Lunki.* Succulent annual herb. Occasional in fallow fields, botanical garden, and nursery.

Malvaceae

Abutilon indicum Sw. Vern. *Dabi, Jhili, Tarakanchi.* Perennial undershrub. Occasional in botanical garden.

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[1] The vernacular names are local Marwari names except where otherwise specified.

TILIACEAE

Corchorus antichorus Raensch. Vern. *Hadeka Khot.* Prostrate, perennial herb. Very common in fallow fields, along roadsides, and in nursery.

Corchorus tridens Linn. Vern. *Chuchki* (Gujarati). Semi-procumbent annual herb. Occasional in legume fields and nursery.

Corchorus trilocularis Linn. Vern. *Hardikekat, Kagle-ki-tamaku.* Erect annual. Occasional in ploughed and fallow fields and along roadsides.

ZYGOPHYLLACEAE

Fagonia cretica Linn. Vern. *Damasha.* Small spiny annual herb. Occasional in fallow and harvested fields.

Tribulus terrestris Linn. Vern. *Gokro, Konti.* Prostrate annual. Very common and abundant in fields and on unmetalled roads.

PAPILIONACEAE

Crotalaria burhia Ham. Vern. *Sannai.* Perennial undershrub. Very common in fallow and *bajra* fields.

Crotalaria medicaginea Lamk. Vern. *Ghagri.* Annual herb. Occasional in fallow fields.

Heylandia latebrosa DC. Vern. *Gorakbutti, Sonda.* Prostrate annual. Rarely found, in botanical garden.

Indigofera anabaptista Steud. Vern. *Bekrioneel.* Annual herb. Rarely found in fallow and ploughed fields ; and in legume crop.

Indigofera cordifolia Heyne. Vern. *Bechka, Godadi, Panbekrio.* Prostrate annual. Very common and abundant in fields of *bajra,* legumes, and castor ; also in nursery and on roadsides.

Indigofera enneaphylla Linn. Prostrate annual. Common in fallow fields, near nursery, and on roadsides.

Indigofera linifolia Retz. Vern. *Bekar, Bakri.* Prostrate annual. Common in fallow and *bajra* fields ; nursery.

Indigofera trigonelloides Jaub. & Spach. Trailing annual. Common in fallow fields and legume crops, near nursery.

Phaseolus trilobus Ait. Vern. *Jungli Moth.* Trailing annual. Occasional in fallow and ploughed fields.

Tephrosia purpurea Pers. Vern. *Sarphunka, Dhamasa.* Erect biennial. Very common and abundant in all fields, fallow lands, and along roadsides.

Cucurbitaceae

Citrullus colocynthis Schrad. Vern. *Tastumba, Tumba.* Prostrate annual. Common on roadsides and in fallow fields.

Ficoideae

Gisekia pharnaceoides Linn. Vern. *Morang, Sareli.* Succulent annual herb. Very common and abundant throughout the Farm.

Limeum indicum Stocks. Vern. *Shapari.* Prostrate annual herb. Found rarely in fallow lands, ploughed fields, and in botanical garden.

Mollugo cerviana Seringe. Vern. *Pada, Pata, Ragatia, Khar, Chiruo-ro-khel.* Small erect annual. Very common in botanical garden, *bajra,* castor, and cotton fields.

Mollugo nudicaulis Lamk. Vern. *Ragatia khar.* Small annual herb. Common in botanical garden and in nursery.

Trianthema pentandra Linn. Vern. *Santa, Sarta.* Succulent annual. Occasional in botanical garden ; fallow and ploughed fields.

Trianthema portulacastrum Linn. Vern. *Safed santar, Sarta.* Annual, slightly succulent. Occasional near nursery and agronomy block.

Rubiaceae

Borreria stricta Schum. Small annual herb. Rarely found in fallow and ploughed fields ; in nursery.

Oldenlandia aspera DC. Vern. *Danakar.* Erect annual. Occasionally found in botanical garden, irrigated fields, and agrostology block.

Compositae

Blainvillea rhomboidea Cass. Annual herb. Rarely found in agronomy block ; near nursery and building area.

Blumea amplectens DC. Vern. *Kukronda.* Woolly annual herb. Occasional in agronomy block.

Dicoma tomentosa Cass. Vern. *Vajradanti.* Erect annual. Common on roadsides, botanical garden, fallow and *bajra* fields.

Eclipta erecta Linn. Vern. *Jalbangra.* Prostrate annual. Rarely found, in irrigated fields and in botanical garden.

Launaea chondrilloides Hook. Vern. *Dhudphad.* Perennial herb. Occasionally found in botanical garden, nursery, and on boundaries of irrigated fields.

Pulicaria wightiana C. B. Clark. Vern. *Sonela.* Erect annual. Very common and abundant throughout the Farm ; more on roadsides.

Tridax procumbens Linn. Vern. *Tunki* (Hindi). Perennial herb. Occasional in botanical garden, and near new buildings.

Vernonia cinerea Less. Vern. *Sahadavi, Phulni.* Erect annual. Rarely found near agronomy block, nullah, and nursery.

Volutarella divaricata Benth. & Hook. Vern. *Lin-Katmanda.* Small erect annual. Common in fallow, ploughed fields, in *bajra* and pasture fields ; near building site.

Asclepiadaceae

Calotropis procera R. Br. Vern. *Ak, Akra, Akda.* Erect shrub. Common along Farm boundary and in fallow and pasture fields.

Pergularia daemia Wight. Vern. *Gadaria kavel.* A large, twining shrub. Rarely found along Farm fencing.

Boraginaceae

Arnebia hispidissima DC. Vern. *Rambas.* Annual or biennial herb. Very common in fallow fields, on roadsides, in *bajra* and pasture fields.

Heliotropium strigosum Willd. Vern. *Chotisantri.* Prostrate annual. Very common throughout the Farm.

Heliotropium zeylanicum Lamk. Vern. *Khalibui.* Erect annual. Very common throughout the Farm.

Sericostoma pauciflorum Stocks. Vern. *Kharsan, Kharhani.* Small perennial undershrub. Occasional in fallow fields, roadsides, and *bajra* fields.

Trichodesma indicum R. Br. Vern. *Salkonta, Phuldar.* Erect annual. Rarely found in botanical garden, fallow and *bajra* fields.

Convolvulaceae

Convolvulus glomeratus Choisy. Vern. *Rhota Bhel.* Perennial. Occasional in botanical garden ; *bajra* and fallow fields.

Convolvulus microphyllus Sieb. Vern. *Santari, Sanowri, Phulwati.* Procumbent perennial. Very common throughout the Farm.

Cressa cretica Linn. Vern. *Lona, Oyindo.* Prostrate annual. Rarely found, in a temporary pond.

Evolvulus alsinoides Linn. Vern. *Sanka-Huli.* Small perennial herb. Common in botanical garden and in *bajra* fields.

Ipomoea pes-tigridis Linn. Twining annual. Common in botanical garden, *bajra* fields, and nursery.

Solanaceae

Solanum indicum Linn. Vern. *Mothi-ring.* Tall undershrub. Rarely found in botanical garden, roadsides, fallow and ploughed fields.

Solanum xanthocarpum Schrad. & Wendl. Vern. *Baringni, Adkuntali.* Perennial herb. Common on roadsides, irrigated plots, botanical garden.

Scrophulariaceae

Anticharis linearis Hochst. Erect annual. Common in botanical garden, roadsides, and fallow fields.

Lindenbergia urticaefolia Link & Otto. Vern. *Pindra.* Annual herb. Rarely found near Farm boundary.

Pedaliaceae

Pedalium murex Linn. Vern. *Mothegokhru.* Erect annual. Rarely found, in botanical garden.

Acanthaceae

Justicia procumbens Linn. Vern. *Gungi bunti, Kagner, Mokra ghas.* Erect annual herb. Common in botanical garden, legume, *bajra,* and castor fields.

Justicia simplex D. Don. Small annual herb. Occasional in fallow fields, *bajra* fields, and nursery.

Peristrophe bicalyculata Nees. Vern. *Kagner*. Prostrate or procumbent perennial. Common on roadsides, below *Prosopis* trees in botanical garden.

Labiateae

Leucas aspera Spreng. Vern. *Goama, Mund* (Hindi). Erect annual. Common in botanical garden, roadsides, castor, cotton, and fallow fields.

Salvia aegyptiaca var. **pumila** Hook. Vern. *Tukam*. Small undershrub. Rare, along Farm fencing.

Nyctaginaceae

Boerhavia diffusa Linn. Vern. *Chelavri, Sata*. Perennial trailing herb. Very common throughout the Farm.

Boerhavia repanda Willd. Annual herb. Common on roadsides, pasture fields, below trees in botanical garden.

Amaranthaceae

Achyranthes aspera Linn. Vern. *Unda kanta, Khutia bharutia*. Erect annual. Rarely found, in Silvatum, nursery, botanical garden.

Aerua persica Merrill. Vern. *Bari bui*. Tall undershrub. Common on roadsides, ploughed and cultivated fields.

Aerua pseudo-tomentosa Blatt. & Hall. Vern. *Chotti bui*. Small perennial herb. Common on roadsides, ploughed and cultivated fields.

Amaranthus blitum var. **oleracea** Hook. Vern. *Jangli Cholai, Tanduladge* (Hindi). Erect, succulent herb. Occasional on irrigation bunds of the agronomy block.

Amaranthus viridis Linn. Vern. *Chonlai* (Hindi). Erect annual. Rarely found, in botanical garden and agronomy block.

Celosia argentea Linn. Vern. *Mokhmal, Pramarti*. Annual herb. Occasional, along roadsides and in *bajra* fields.

Digera muricata Forsk. Vern. *Lahsua*, *Lulero*. Annual which occurs in erect, procumbent, and prostrate forms. Very common in fallow, ploughed, *bajra*, and legume fields.

Chenopodiaceae

Chenopodium album Linn. Vern. *Goela*, *Chill* and *Bathua* (Hindi). Succulent annual. Rare in fallow, cotton, and castor fields.

Euphorbiaceae

Euphorbia granulata Forsk. Vern. *Dudeli*. Prostrate annual. Occasional, in fallow *bajra* fields, and botanical garden.

Euphorbia hirta Linn. Vern. *Dudhdi* (Hindi). Decumbent or prostrate annual. Very common in nursery, near building site, botanical garden, and irrigated plots.

Euphorbia microphylla Heyne. Vern. *Chotti-Dudhi*. Prostrate annual. Common in botanical garden, nursery, building site and in castor fields.

Euphorbia thymifolia Linn. Vern. *Duddi*. Small annual herb. Very common in botanical garden, roadsides, and in legume fields.

Phyllanthus niruri Linn. Vern. *Hasardana* (Hindi), *Bawal* (Gujarati). Erect annual. Very common throughout the Farm.

Monocotyledons

Cyperaceae

Cyperus arenarius Retz. Vern. *Motha*. Erect perennial. Occasional in botanical garden and on roadsides.

Cyperus conglomeratus Rottb. Vern. *Motha*. Erect perennial. Occasional on roadsides, fallow or ploughed fields.

Cyperus rotundus Linn. Vern. *Motha* (Hindi). Erect perennial with stolons. Very common throughout the Farm.

Gramineae

Aristida adscenionis Linn. Vern. *Lomp*, *Lompri*. Slender perennial. Very common in fallow fields and silvatum plots.

Aristida funiculata Trin. & Rupr. Vern. *Lambda*. Small annual. Common in botanical garden, and in fallow fields.

Aristida hirtigluma Steud. Vern. *Lomp, Lompri, Lompla.* Semi-erect perennial. Occasional in fallow fields, along Farm boundary.

Aristida mutabilis Trin. & Rupr. Vern. *Lounp.* Erect annual. Occasional on roadsides, silvatum plots.

Aristida setacea Retz. Erect perennial. Common in botanical garden, fallow fields, and silvatum plots.

Cenchrus biflorus Roxb. Vern. *Bhurut.* Erect annual. Very common throughout the Farm ; more on fallow fields.

Cenchrus ciliaris Linn. Vern. *Anjan, Dhaman.* Annual and perennial forms. Common throughout the Farm.

Cenchrus pennisetiformis Hochst. & Steud. Vern. *Dhaman, Kala-Dhaman.* Decumbent perennial. Occasional in fallow fields and Farm boundary.

Cenchrus setigerus Vahl. Vern. *Kala Dhaman.* Perennial. Common in fallow fields, botanical garden, and silvatum plots.

Chloris barbata Sw. Vern. *Gharania-ghas.* Tufted perennial. Occasional near nursery and botanical garden.

Cynodon dactylon (Linn.) Pers. Vern. *Dubhi, Dobh.* Slender perennial. Very common in cultivated fields, roadsides, nullah of agronomy block, and botanical garden.

Dactyloctenium aegyptium (Linn.) Beauv. Vern. *Makra.* Prostrate annual. Frequent on roadsides, cultivated fields, and silvatum plots.

Dactyloctenium sindicum Boiss. Vern. *Ganthil, Ganthia.* Perennial. Common in botanical garden.

Dichanthium annulatum Stapf. Vern. *Karad, Jharnia-ghas.* Perennial. Common in fields, botanical garden, nursery, and building site.

Digitaria adscendens Henr. Vern. *Tara, Kuri.* Annual. Occasional in fallow and uncultivated fields, botanical garden, and silvatum plots.

Echinochloa crus-galli Beauv. Vern. *Soma.* Annual. Occasional in silvatum plots ; botanical garden.

Eleusine compressa Aschers. & Schweinf. Vern. *Tantia, Gandil.* Perennial. Common in fields outside botanical garden.

Eragrostis ciliaris R. Br. Vern. *Chirioroghas.* Small annual. Common on roadsides and in fallow fields.

Eragrostis pilosa Beauv. Erect annual. Common on roadsides and in fallow fields.

Eragrostis tenella (Linn.) P. Beauv ex R. & S. var. **plumosa** (Retz.) Stapf. Slender annual. Common along roadsides, near observatory, and Farm boundary.

Eragrostis tremula Hochst. Vern. *Kiriya.* Small annual. Occasional in fallow fields, on roadsides near agrostology block.

Lasiurus ecaudatus Satya. & Shank. Vern. *Sehwan.* Woody perennial. Occasional near nursery, building site, and botanical garden.

Panicum antidotale Retz. Vern. *Girona, Gramna.* Perennial. Occasional, in legume plots and botanical garden.

Perotis indica (Linn.) Ktze. Vern. *Undra-Poonch.* Small annual. Occasional in botanical garden, on roadsides, and near nursery.

Tragus biflorus Schult. Vern. *Sita ghas.* Tufted grass. Occasional near building site and silvatum plots.

Urochloa panicoides Beauv. Vern. *Kuri.* Decumbent annual. Common in nursery, building site, and Farm fencing under shade.

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Indian wood-destroying termites

BY

M. L. ROONWAL, SC.D. (Cantab.), F.N.I.

AND

O. B. CHHOTANI, M.SC. (Hons.)
Zoological Survey of India, Calcutta

(*With two plates and an Appendix*)

I. INTRODUCTION

While all species of termites feed on cellulosic materials including wood, some have a more direct and intimate association with wood. Out of approximately 180 species occurring in the Indian Region (India, Pakistan, Ceylon, and Burma), nearly 58 may be termed wood-destroying. These species may be conveniently divided into two categories, viz. (i) those which are wood-inhabiting and spend either the whole or a part of their life in wood, where they breed (42 species) ; and (ii) those which do not habitually inhabit wood, but are nevertheless its important destroyers whenever opportunity occurs (16 species).

These species (vide Appendix for a list) belong to four families, namely the Kalotermitidae (27 species), Hodotermitidae (1 species), Rhinotermitidae (14 species), all wood-inhabiting ; and the Termitidae (16 species, mostly soil-inhabiting but also wood-destroying).

Brief particulars of the more important wood-destroying species are given here. Several of the wood-inhabiting species prefer relatively moist wood (*Archotermopsis wroughtoni* and some species of the genera *Kalotermes*, *Neotermes*, *Glyptotermes*, and *Stylotermes*), while others prefer dry and seasoned wood (all members of the genera *Cryptotermes*, *Coptotermes*, and *Heterotermes*, and some species of the genera *Kalotermes* and *Neotermes*). Of the latter category, *Coptotermes* and *Heterotermes* have also close connections with the ground, where they live in subterranean colonies. It is fortunate and rather curious that *Neotermes tectonae* (Dammermann), a serious pest of teak trees in Java, is not found in India and Burma, where also teak is grown in abundance.

All the non-wood-inhabiting species concerning us here belong to the family Termitidae and are largely subterranean, although a few of them build earthen mounds above ground such as some species of the genus *Odontotermes*.

Some species destroy woodwork in buildings. Such species may conveniently be divided into two groups, namely : (i) dry-wood species (species which live entirely in dry wood, e.g. beams, pillars, doors, windows, furniture, etc.) ; and (ii) subterranean species (which, while attacking woodwork in buildings, railway carriages, etc., are also subterranean, often breeding underground in the soil). The more important species damaging buildings in the Indian Region are :

Dry-wood species :

1. *Cryptotermes domesticus* (Haviland)—South India and Ceylon.
2. *Cryptotermes dudleyi* Banks—India, Ceylon, and E. Pakistan.

Note.—Ahmad (*Spol. Zylan.* 27(1), p. 35, 1953) has recorded *Cryptotermes cyanocephalus* Light as having been introduced into Ceylon. We have examined these specimens, kindly sent by the Colombo Museum, and find that they are *C. perforans* Kemner.

Subterranean species :

3. *Heterotermes ceylonicus* (Holmgren)—Ceylon.
4. *Heterotermes indicola* (Wasmann)—India and Pakistan.
5. *Heterotermes malabaricus* Snyder—India.
6. *Coptotermes ceylonicus* Holmgren—Ceylon, India.
7. *Coptotermes formosanus* Shiraki—Ceylon.
8. *Coptotermes gaurii* Roonwal & Krishna (*exiguus*[1] auct.)—Ceylon.
9. *Coptotermes heimi* (Wasmann) (syn. *C. parvulus* Holmgren)—India and W. Pakistan.
10. *Odontotermes ceylonicus* (Wasmann)—Ceylon.
11. *Odontotermes feae* (Wasmann)—India, E. Pakistan, and Burma.
12. *Odontotermes redemanni* (Wasmann)—Ceylon.
13. *Hypotermes obscuriceps* (Wasmann)—Ceylon.
14. *Nasutitermes ceylonicus* (Holmgren)—Ceylon.

No precise estimates, in financial terms, of the damage caused by termites to buildings in India are available, but there is no doubt that the damage is very heavy. The principal species in India which damage buildings are : *Heterotermes indicola*, *Coptotermes heimi*, and *Odontotermes feae*. Instances where almost an entire township was thus destroyed by *Heterotermes indicola* have been reported (Roonwal 1955).

II. Particulars of some wood-destroying species

Brief particulars of the more important wood-destroying species, especially with reference to recent work, are given below.

[1] '*Coptotermes exiguus* (Holmgren)', as given by Harris (1961, pp. 156 and 159) is most probably *C. gaurii* R. & K. No valid name '*exiguus* Holmgren' seems to exist (vide also discussion in Roonwal & Krishna 1955, p. 143 ; and Roonwal & Chhotani, 1962, p. 30).

(*a*) *The wood-inhabiting species*

1. **Kalotermes beesoni** Gardner (Plate II)

Occurs in northern India (Uttar Pradesh) and W. Pakistan (Punjab). Some aspects of its biology have been studied by Chhotani (1962*a*, *b*). Emergence of winged imagines occurred in June-August. The proportion of the castes, viz. imagines, soldiers and pseudoworkers, was 1 : 5 : 94. Alates collected in the field, as well as those obtained in laboratory emergences, consisted only of females, the males being entirely wanting, thus suggesting that the colony was breeding by means of parthenogenesis. For a detailed taxonomic description and illustrations of the species vide Roonwal & Sen-Sarma 1960.

2. **Neotermes bosei** Snyder (syn. *N. gardneri* Snyder, vide Roonwal & Sen-Sarma 1960, p. 153).

Occurs in northern and eastern India (Uttar Pradesh and Bengal). Generally attacks dead wood of several species of trees, but infestation may pass on to the living portions of trunks and branches. Some aspects of its biology have been studied by Roonwal & Sen-Sarma (1955). Alates emerge from February to July but mostly in May. Faecal pellets are small (length *c.* 0·9-1·14 mm. ; diameter *c.* 0·5-0·7 mm.), reddish brown and longish, with a hexagonal cross-section. In the galleries, these pellets are often lumped together in masses which are covered with wood-dust. These masses are sometimes as large as 3×4·5 cm. and, being hygroscopic, may serve to condition the humidity inside the galleries. For a detailed taxonomic description and illustrations of the various castes vide Roonwal & Sen-Sarma 1960.

3. **Neotermes greeni** (Desneux)

Widely distributed in Ceylon where it is a serious pest of tea and rubber plants, but less so than *N. militaris*. It also infests a number of other trees. For its taxonomic description and illustrations vide Roonwal & Sen-Sarma 1960.

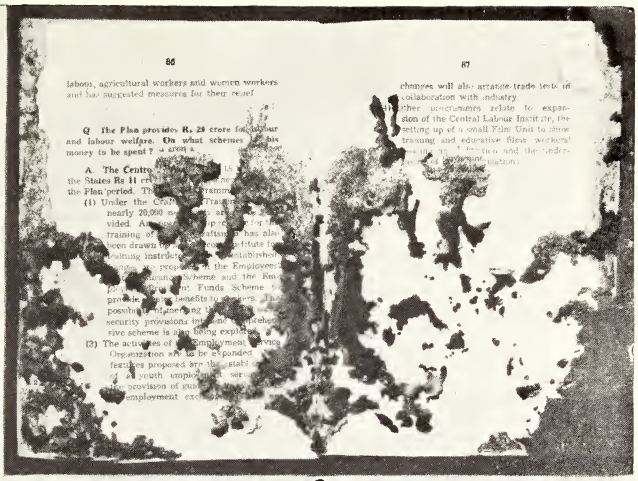
4. **Neotermes militaris** (Desneux)

Widely distributed in Ceylon. Is a serious pest of tea plants whose heartwood it generally hollows out. A single tea bush may harbour a colony of as many as 3000-4000 individuals. Also infests other trees. For its taxonomic description and illustrations vide Roonwal & Sen-Sarma 1960.

5. **Cryptotermes cyanocephalus** Light

A dry-wood species widely distributed in SE Asia (Java and the Philippines). Recorded as a major destroyer of woodwork in buildings in Ceylon (Harris 1961, p. 158), but see Note under ' Dry-wood species ' at page 355 above.

1



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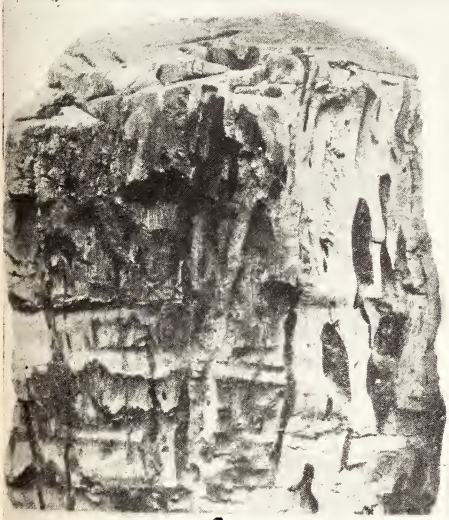

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Photographs showing damage to wood and other cellulosic materials by termites.

Fig. 1. Part of a soft-wood (pine) door-piece, showing damage by *Heterotermes indicola* (Wasmann); Fig. 2. A book damaged by termites; Fig. 3. A piece of wood of *bar* (*Ficus bengalensis* Linn.), showing galleries made by *Cryptotermes havilandi* (Sjöstedt); Fig. 4. Pieces of wood from a log of unknown species almost completely eaten up by *Odontotermes feae* (Washman), and covered by it with earth coverings and fillings.

Upper figure: *Kalotermes beesoni* Gardner. Imagos (alates) soldiers and pseudoworkers.

Lower figure: *Coptotermes heimi* (Wasmann). Imagos (alates), soldiers and workers.

6. **Cryptotermes domesticus** (Haviland)

A dry-wood termite, widely distributed in south east Asia (India and Ceylon to Indonesia and Formosa, etc.). Is a serious pest of woodwork in houses in Ceylon and Malaya.

7. **Cryptotermes dudleyi** Banks

A most widely distributed dry-wood species—India to New Guinea ; and Central and South America. Is a serious pest of woodwork in houses, etc.

8. **Cryptotermes havilandi** (Sjöstedt) [syn. *C. bengalensis* (Snyder)] (Plate I)

A dry-wood termite widely distributed from India to Africa and the West Indies. Species of *Cryptotermes* are generally distributed in coastal areas, many being introductions. But Chhotani (1963) has recently recorded *C. havilandi* from the interior of India (Madhya Pradesh).

9. **Glyptotermes dilatatus** (Bugnion & Popoff)

Occurs widely in Ceylon. Is a serious pest of two economic plants, tea and rubber.

10. **Archotermopsis wroughtoni** (Desneux)

Western Himalayas (Hazara and Kashmir to Kumaon) at altitudes of 2800-9000 ft. above sea-level. Attacks and lives in dead logs and stumps of conifers (pines and deodar). Its morphology and biology was studied long ago by Imms (1919).

11. **Heterotermes** spp. (Plate I)

Members of this genus are subterranean, but attack dry wood above ground in houses and elsewhere, being able to reach such wood by means of long surface-galleries which they construct. Four species of *Heterotermes* are known in the Indian Region, all of them pests of woodwork in houses. The most important species are *H. ceylonicus* (Holmgren) in Ceylon, and *H. indicola* (Wasmann) and *H. malabaricus* Snyder in India. Roonwal (1955) records an instance in which the township of Sri Hargobindpur in the Punjab was partially abandoned a few years ago due to the serious infestation of beams and other woodwork in houses by *H. indicola*.

12. **Coptotermes** spp. (Plate II)

Like *Heterotermes*, the genus *Coptotermes* is a subterranean termite which reaches dry wood above ground, as in houses, railway carriages, etc., and does serious damage. Eight species are known from the Indian Region (vide the recent revision by Roonwal & Chhotani 1962*a*, where

taxonomic descriptions and illustrations are given). The more important species are discussed below briefly.

(i) *Coptotermes ceylonicus* (Holmgren) : Southern India and Ceylon. A pest of tea and rubber and also attacks dry wood.

(ii) *Coptotermes gaurii* Roonwal & Krishna (*exiguus* auct.) : Ceylon. A serious pest of tea plants.

(iii) *Coptotermes formosanus* Shiraki : A species which is widespread (Ceylon, Formosa, S. China, Japan, Hawaiian Is., U.S.A., and S. Africa). A pest of tea and rubber, and also attacks dry wood.

(iv) *Coptotermes heimi* (Wasmann) (syn. *C. parvulus* Holmgren) (Plate II) : All over India and West Pakistan where it is very common. Is a serious pest of woodwork, furniture, etc. in houses and elsewhere. Also known to destroy electric-wire casing, railway coaches, etc. Our knowledge of its biology has been summarised by Roonwal (1959). It is known to attack the dead wood of a large number of trees. Swarming of winged imagines generally occurs at dusk and early night (*c.* 6-10 p.m.). The season of swarming is spring and early summer (March-May) in the more humid areas (W. Bengal, Orissa, and Bombay) and during the monsoon (June-August) in the drier parts (Uttar Pradesh). The nest is made of semi-porous material in dead wood, sometimes even in railway carriages.

(b) The non-wood-inhabiting species

1. **Globitermes audax** Silvestri (syn. *G. birmanicus* Snyder)
Burma. Attacks forest trees. Little is known about its biology.

2. **Microcerotermes heimi** Wasmann

Species of *Microcerotermes* are characterized by the inner margin of the mandibles being serrated like a saw instead of toothed. Nearly 20 species are known from the Indian Region. The most common one is *M. heimi*, occurring in Assam, south India, and Ceylon ; it lives chiefly in logs etc. in forests and makes large globular carton-nests.

3. **Odontotermes** spp.

Species of this genus are among the most common termites in the Indian Region, a few species building earthen mounds. The more important species are discussed below.

(i) *Odontotermes ceylonicus* (Wasmann) : Ceylon. A major pest of woodwork in buildings in Ceylon (Harris 1961, p. 159).

(ii) *Odontotermes feae* (Wasmann) (Plate I) : India, E. Pakistan, and Burma. One of the most destructive termites for woodwork in buildings. Also attacks and kills *Eucalyptus* seedlings in nurseries. No mound is formed as a rule but this happens occasionally (vide Roonwal &

Chhotani 1962*b*). Winged adults swarm out at the beginning of the monsoon.

(iii) *Odontotermes obesus* (Rambur) : The most common mound-building termite in the greater part of India except the south. Attacks moist woodwork and other cellulosic materials (books, textiles, etc.) in houses particularly during the rainy season. But as a pest of dry wood in buildings does not seem to be important. Builds earthen mounds which may rise as high as 2·6 m. (*c.* 8·7 ft.) high. For its mound-structure, vide Roonwal (1958*a*, 1962*b*). For destruction of mound-colonies, vide Roonwal (1951) and Roonwal & Chatterjee (1962).

(iv) *Odontotermes parvidens* Holmgren & Holmgren : All over India. A large species commonly attacking the bark of trees. Was responsible for the killing of plantation teak in Uttar Pradesh (Roonwal 1954) by eating the bark and producing a sort of girdling effect. No mound is built ; nesting occurs underground. Swarming of winged alates occurs in March from small holes in the ground.

(v) *Odontotermes redemanni* (Wasmann) : Peninsular India, Bengal, and Ceylon. Builds earthen mounds as high as those of *Odontotermes obesus*. Is destructive to woodwork in houses, especially in the wet season.

4. **Microtermes obesi** Holmgren (syn. *M. anandi* Holmgren)

A small, widely spread species in India and Ceylon. Often occurs in association with *Odontotermes obesus* in the mound of the latter and in nest-areas of *O. feae*. Does not occur in buildings but attacks logs and dead wood in forests, as well as growing crops such as sugarcane, wheat, millets, etc. (vide Roonwal 1958).

5. **Nasutitermes ceylonicus** (Holmgren)

Ceylon. Is a major pest of woodwork in buildings in Ceylon (Harris 1961, p. 159).

6. **Hospitalitermes birmanicus** (Snyder)

Burma. Attacks saplings. Like other members of the subfamily Nasutitermitinae, the soldiers are characterized by a nasute process in the front part of the subglobular head-capsule and by minute, non-functional mandibles.

III. Control

The destruction and control of wood-destroying termites is a difficult task, mainly because of the difficulty of reaching the population inside the affected timber. The best course is to build houses according to anti-termite designs and to use chemically treated wood (coaltar creosote is very effective). The use of naturally resistant timbers, e.g. heartwood

of teak, is also helpful. Some of the effective control methods devised in recent years in India against subterranean termites may be mentioned briefly.

Control in mounds. Pouring suitable quantities of water-emulsions of some of the chlorinated hydrocarbons (benzene hexachloride, aldrin, and dieldrin) completely destroys mound-colonies in less than a week (Roonwal 1951 ; Roonwal & Chatterjee 1962).

Control by soil treatments (mud-wall poisoning). Laboratory experiments indicate that, if the mud used to plaster huts in villages is mixed with small quantities of benzene hexachloride, effective protection to the super-structure (roof etc.) of bamboo and wood is obtained up to about two years (Roonwal, Chatterjee & Thapa 1962).

IV. Summary

Out of nearly 180 termite species occurring in the Indian Region about 58 destroy wood. Of these, 42 commonly inhabit wood ; the remainder, while not commonly inhabiting wood, nevertheless are important destroyers of wood. They belong to the families Kalotermitidae (27 species), Hodotermitidae (1 species), Rhinotermitidae (14 species), all wood-inhabiting ; and Termitidae (16 species), soil-inhabiting.

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Appendix

List of Indian wood-destroying termites

(a) Species which commonly inhabit wood

Family I. Kalotermitidae

Subfamily Kalotermitinae

1. *Kalotermes beesoni* Gardner
2. *Kalotermes jepsoni* Kemner
3. *Kalotermes pintoi* Kemner
4. *Neotermes andamanensis* Snyder
5. *Neotermes artocarpi* (Haviland)
6. *Neotermes assmuthi* Holmgren
7. *Neotermes bosei* Snyder (syn. *N. gardneri* Snyder)
8. *Neotermes buxensis* Roonwal & Sen-Sarma
9. *Neotermes fletcheri* Holmgren & Holmgren
10. *Neotermes greeni* (Desneux)
11. *Neotermes kemneri* Roonwal & Sen-Sarma
12. *Neotermes magniferae* Roonwal & Sen-Sarma
13. *Neotermes megaoculatus megaoculatus* Roonwal & Sen-Sarma
14. *Neotermes megaoculatus lakhimpuri* Roonwal & Sen-Sarma
15. *Neotermes microculatus* Roonwal & Sen-Sarma
16. *Neotermes militaris* (Desneux)
17. *Neotermes pishinensis* Ahmad
18. *Cryptotermes cyanocephalus* Light
19. *Cryptotermes domesticus* (Haviland)
20. *Cryptotermes dudleyi* Banks
21. *Cryptotermes havilandi* (Sjöstedt) (syn. *C. bengalensis* Snyder)
22. *Cryptotermes perforans* Kemner
23. *Glyptotermes almorensis* Gardner
24. *Glyptotermes ceylonicus* (Holmgren)
25. *Glyptotermes coorgensis* Holmgren & Holmgren
26. *Glyptotermes dilatatus* (Bugnion & Popoff)
27. *Glyptotermes minutus* Kemner

Family II. Hodotermitidae

Subfamily Termopsinae

28. *Archotermopsis wroughtoni* (Desneux)

Family III. RHINOTERMITIDAE

Subfamily (i) Heterotermitinae

29. *Heterotermes ceylonicus* (Holmgren)
30. *Heterotermes gertrudae* Roonwal
31. *Heterotermes indicola* (Wasmann)
32. *Heterotermes malabaricus* Snyder
33. *Reticulitermes chinensis* Snyder

Subfamily (ii) Stylotermitinae

34. *Stylotermes fletcheri* Holmgren & Holmgren

Subfamily (iii) Coptotermitinae

35. *Coptotermes ceylonicus* Holmgren
36. *Coptotermes emersoni* Ahmad
37. *Coptotermes formosanus* Shiraki (*nec* Holmgren)
38. *Coptotermes gaurii* Roonwal & Krishna (*exiguus* auct.)
39. *Coptotermes gestroi* Wasmann
40. *Coptotermes heimi* (Wasmann) (syn. *C. parvulus* Holmgren)
41. *Coptotermes kishori* Roonwal & Chhotani
42. *Coptotermes travians* Haviland

(b) Species which do not commonly inhabit wood but attack and destroy it

Family IV. TERMITIDAE

Subfamily (i) Amitermitinae

43. *Globitermes audax* Silvestri (syn. *G. birmanicus* Snyder)
44. *Microcerotermes annandalei* Silvestri
45. *Microcerotermes heimi* Wasmann

Subfamily (ii) Macrotermitinae

46. *Odontotermes bangalorensis* Holmgren
47. *Odontotermes brunneus* Holmgren
48. *Odontotermes ceylonicus* (Wasmann)
49. *Odontotermes feae* (Wasmann)
50. *Odontotermes horni* (Wasmann)
51. *Odontotermes obesus* (Rambur)
52. *Odontotermes parvidens* Holmgren & Holmgren

53. *Odontotermes redemanni* (Wasmann)
54. *Hypotermes obscuriceps* (Wasmann)
55. *Microtermes mycophagus* (Desneux)
56. *Microtermes obesi* Holmgren (syn. *M. anandi* Holmgren)

Subfamily (iii) Nasutitermitinae

57. *Nasutitermes ceylonicus* (Holmgren)
58. *Hospitalitermes birmanicus* (Snyder)

The Birds of Nepal

PART 12

BY

BISWAMOY BISWAS
Zoological Survey of India, Indian Museum, Calcutta

(*With four plates and five figures*)

[*Continued from Vol.* **60** (3) : 654]

PHYSIOGRAPHY, VEGETATION, etc. OF NEPAL

Nepal exhibits two general surface features, the lowland in the south, and the Himalaya mountains in the north (Figs. 4 and 5).

LOWLAND

The lowland consists of the plain, tarai and bhabar. The former is, in fact, a part of the highly cultivated and densely populated Gangetic plain as seen in Uttar Pradesh and Bihar of India, and is indistinguishable from it.

The **tarai** (altitude *c.* 140-150 m.) is the slightly sunken tract of land lying immediately to the north of the plain. It has come into being by 'filling up by long-continued alluviation of a tectonic basin formed when the strata of the Tethys Sea were folded and raised into the Himalaya Mountains' (Karan 1960, p. 22). Typically, the tarai is a tract where the meandering rivers which are open to annual flooding, flow through alluvium, and give rise to a number of swamps and supports a thick tropical moist deciduous forest consisting chiefly of Sisoo (*Dalbergia sisoo*), Silk-cotton (*Salmalia malabarica*), Khair (*Acacia catechu*), Siris (*Albizia lebbek*), Figs (*Ficus religiosa*, *F. bengalensis*), Palas or the Flame-of-the-Forest (*Butea frondosa*), Tund (*Cedrela toona*), Haldu (*Adina cordifolia*), Jarul (*Lagerstroemia*), a few Palm (*Phoenix*), and large stretches of various grasses, such as Kharaul (*Saccharum narenga*) *Cymbopogon*, *Andropogon*, *Setaria*, etc. Large portions of the tarai have, however, been cleared off for the purpose of cultivation. Such areas are indistinguishable in appearance from the Gangetic plain on the south.

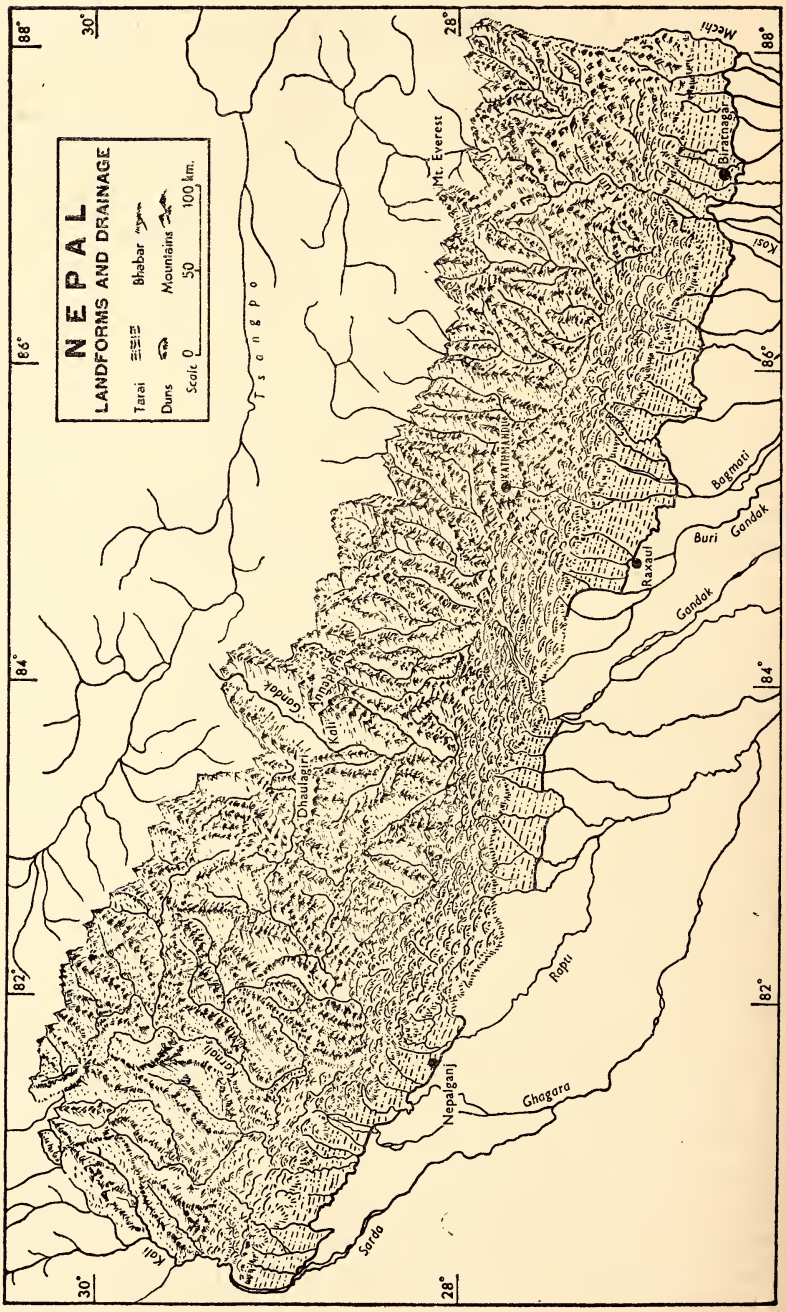


Fig. 4. Land-forms and drainage in Nepal (Adapted from Karan's 'Nepal', 1960)
(By the courtesy of the University of Kentucky Press, Lexington, U.S.A.)

The **bhabar** (altitude *c.* 150-300 m.) comprises a belt of 'hill wash and of alluvial fans composed of highly porous gravels' (Karan 1960, p. 22), immediately on the north of the tarai. It has a low gradient from north to south. All the streams originating from the southern face of the Siwalik Hills on the north, traverse the bhabar. However, because of the nature of its soil and the gradient, water does not accumulate in this zone, although the silt brought about by the streams is deposited. This makes it possible to sustain a luxuriant moist deciduous forest consisting mainly of Sál (*Shorea robusta*), with some Sisoo (*Dalbergia sisoo*), Silk-cotton (*Salmalia malabarica*), *Bauhinia malabarica*, Sinduré (*Mallotus philippensis*), Haldu (*Adina cordifolia*), Tund (*Cedrela toona*), Asan (*Terminalia tomentosa*), *Phyllanthus*, creepers (*Spatholobus*, *Dioscorea*, *Zehneria*), a thick undercover of grasses (*Oplismenus*, *Setaria*, *Pollinia*, *Andropogon*, etc.) and occasional scrub of *Elephantopus*, *Mimosa*, *Crotalaria*, *Sida*, etc.

HIMALAYA MOUNTAINS

The Himalaya mountains in Nepal may be conveniently divided into four zones from south to north, viz. the Subhimalaya, the Lesser Himalaya, the Great Himalaya and the Tibetan zone.

The **Subhimalaya** or the **Siwalik Range** (altitude *c.* 300-1220 m.) : The low range of hills running east-west throughout the length of Nepal immediately on the north of the bhabar, and consisting mainly of sandstone, sandy limestones and gravel beds, is the Siwalik range. It is known as the Churia hills in Nepal, and is in fact, a continuation of the Siwalik system of the Punjab and Uttar Pradesh of India. Its maximum elevation is about 1220 m., and its ridges and spurs are narrow and sharply edged. It supports thick tropical moist deciduous vegetation composed chiefly of Sál (*Shorea robusta*), with some Sisoo (*Dalbergia sisoo*), Asan (*Terminalia tomentosa*), *Reinwardtia trigyna*, *Lindenbergia*, *Inula*, *Leucas*, and in the upper reaches, *Pinus roxburghii*, *Swertia angustifolia* var. *wallichii*, *Aechmanthera*, *Indigofera*, *Blumea*, *Strobilanthes*, *Scutellaria*, etc., and climbers like *Dioscorea*, and *Sabia*. The undergrowth consists of Sabai grass (*Eulaliopsis binata*) and a few other grasses and scrub.

A large number of streams originate from the Siwalik range. Those taking off from its southern slopes flow into India or form tributaries of other rivers, while those from the northern slopes join several rivers coming down from the Lesser or the Great Himalayan ranges. Those rivers flow south through a number of deep gorges across the Siwaliks into India.

Between the Siwalik range and the Lesser Himalaya on the north are a series of canoe-shaped longitudinal valleys running northwest-southeast

and separated by narrow ridges. These valleys which are more or less wide, are called '**duns**' (altitude *c.* 300-1370 m.). They are thickly clothed with deciduous forest of mainly Sàl (*Shorea robusta*) in the lower elevations and Pine (*Pinus roxburghii*) at the upper reaches, with Sinduré (*Mallotus philippensis*), *Millettia auriculata*, Chilone (*Schima wallichii*), Champa (*Michelia champaca*), Haldu (*Adina cordifolia*), *Callicarpa macrophylla*, Bankar (*Clerodendrum colebrookianum*), wild Raspberry (*Rubus rosaefolia*), *Vallaris solanacea*, *Inula indica*, *Indigofera dosua*, patches of *Phragmitis karka*, *Anthistiria gigantea*, and other grasses and scrub like *Mimosa*, *Phyllanthus*, *Drymaria*, etc.

The **Lesser** or **Middle Himalaya** lying on the north of the duns, is an intricate array of high ranges (altitude *c.* 1370-4570 m.) sprawling east-west throughout the length of the country. These are cut into deep ravines and precipitous defiles which fan out into irregularly directed ridges with repeated ramifications. The southern slopes of its ridges, except in protected valleys, are generally too steep to maintain a soil-cap for the growth of forests, but the northern slopes are gentler and clad with dense vegetation.

Depending on the location and altitude, the forests of the Lesser Himalaya consist mainly of Katus (*Castanopsis*), Ash (*Engelhardtia*), Pines (*Pinus* spp.), Oaks (*Quercus* spp.), Rhododendrons (*Rhododendron* spp.), Poplar (*Populus*), Walnut (*Jugllans*), Alder (*Ainus*), *Magnolia*, Deodar (*Cedrus*), Larch (*Larix*), Fir (*Abies*), Birch (*Betula*), Maple (*Acer*), thin Bamboo (*Pleioblastus*), etc.

The well-defined mountain-range called the 'Mahabharat Lekh', extending throughout the length of Nepal from west to east, lies in the Lesser Himalaya.

The **Great Himalaya** : North of the Lesser Himalaya lies the single range of the Great Himalaya with its lofty mountainous wall rising above the limits of perpetual snow. It completely shields the north. A number of the greatest peaks of the world stand in clusters and rows in this range. Numerous rivers of Nepal, which originate in the north of the axis of the Great Himalaya, cut deep gorges across it to flow southward. The average altitude of the crest of the Great Himalaya in Nepal is more than 6000 metres.

In the lower regions of the Great Himalaya, from about 2450 m. up to the tree limits (*c.* 3960-4264 m.), there are good temperate coniferous forests of Blue Pine (*Pinus excelsa*), Spruce (*Picea*), Oak (*Quercus*), Fir (*Abies*), Cypress (*Cupressus*), Tree Juniper (*Juniperus*), Birch (*Betula*), with Hemlock-Spruce (*Tsuga*), Yew (*Taxus*), some deciduous Maples (*Acer*) and Cherries (*Prunus*), thin Bamboo (*Pleioblastus*), *Lyonia*, Jasmin (*Jasminum*), *Syringa*, *Rosa*, *Berberis*, *Rhododendron*, Larch (*Larix*), Asáré (*Viburnum*), *Spiraea*, *Sorbus*, and some alpine plants, like the Primrose (*Primula*), *Pedicularis*, *Potentilla*, *Androsace*, *Saxifraga*, Gentian

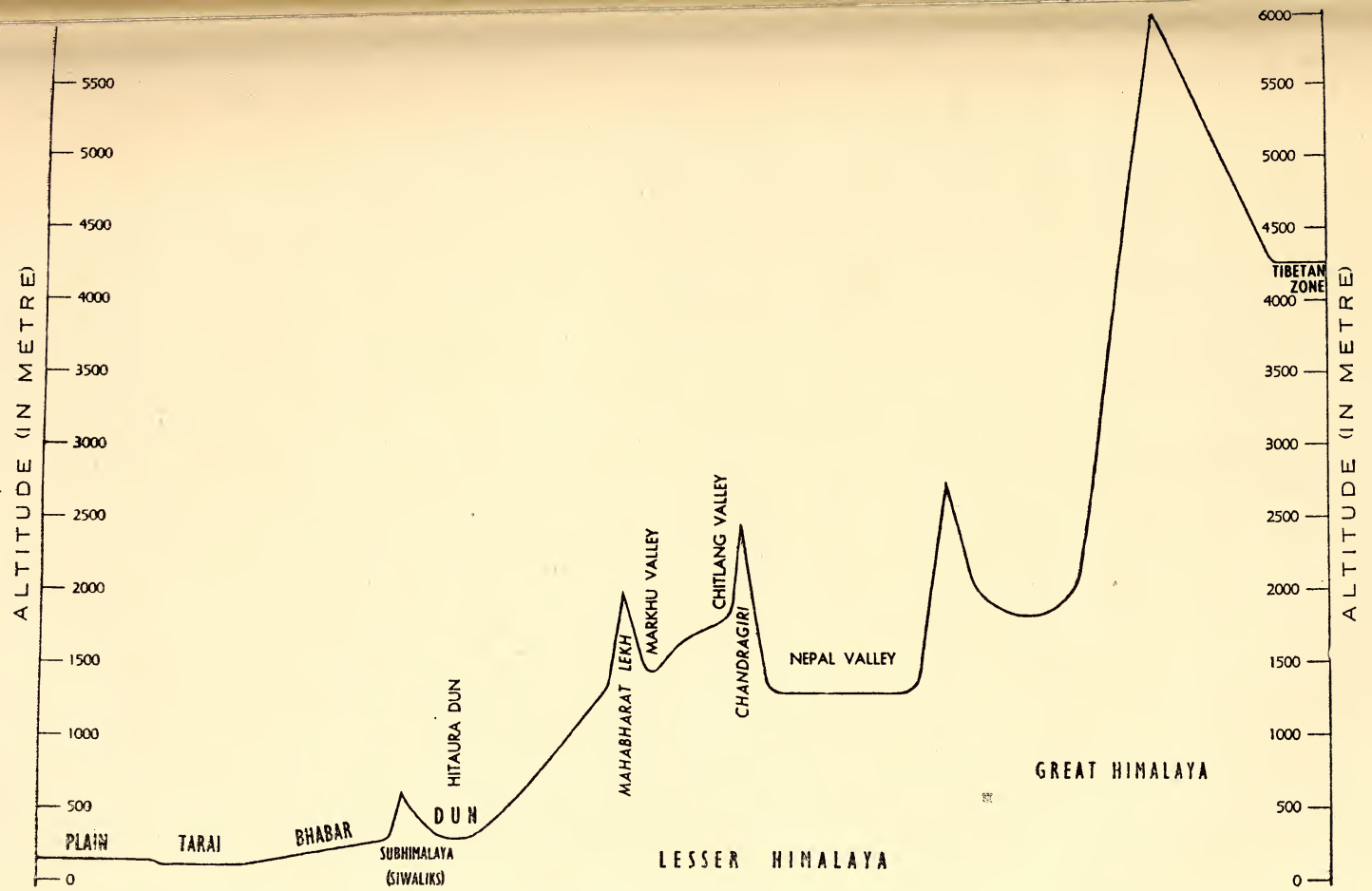


Fig. 5. Hypothetical cross-section of the Himalaya, passing through the Nepal and Chitlang Valleys.

(*Gentiana*), *Iris*, *Meconopsis*, etc., depending on elevation and location. Above the tree limits, the vegetation consists of low bushes of dwarf Rhododendrons (*R. setosum*, *R. anthopogon*), creeping or scaly Juniper (*Juniperus squamata*), Primrose (*Primula*), *Iris*, *Meconopsis*, *Potentilla*, *Pedicularis*, Sedge (*Cyperus*), grass (*Helichotrichon*), etc. Immediately below the snowline, the vegetation consists largely of the grass *Helichotrichon*.

As one goes higher, the number of plants becomes scarce, till on the moraines of glaciers at about 5000 m. or thereabouts, they stand singly or in small clusters.

The **Tibetan Zone** : North of the axis of the Great Himalayan range is the Tibetan zone. Here the mountain slopes gently from south to north up to about 3660 m. The area is largely devoid of vegetation, except for little patches of xerophytic thorny bushes such as of *Caragana*, and grass here and there.

Physiography, Vegetation, &c., of the collecting areas in Central Nepal

The following notes briefly deal with the conditions obtaining in various localities in central Nepal where our collections were made in March-August 1947. Since then, however, conditions there have greatly changed through the interference of man, mainly by large-scale destruction of forests for reclamation of land for agriculture, communications, hydroelectric projects and human settlements.

TARAI

Simra (27°10′N., 84°58′E.) : This is a small village situated near the northern edge of the central tarai, close to the bhabar. There are cultivations about the village, especially in the south, and thick moist deciduous forest in the west, north and east. Two rivers have joined together in the vicinity of Simra to form the Sariswa River, one of which was almost dry during our visit in March. There are also one or two streams with fairly wide beds in the neighbourhood. Altitude : *c.* 140 m.

BHABAR

Amlekhganj (27°17′ N., 85°E.) : This is a large village, the terminus of the Raxaul-Amlekhganj section of the Nepal Government Railway, and situated at the foot of the Siwalik range. There are small plots of cultivation around the village amidst thick forest. A number of hill-streams flow in the vicinity of this village. Altitude : *c.* 300 m.

DUN

Hitaura (27°26′ N., 85°2′ E.) area (with **Suparitar**, 27°28′ N., 85°2′E., **Kusumtar**, 27°27′ N., 85°5′ E., **Paharé Ghat**, 27°26′ N., 85° E., **Karra**,

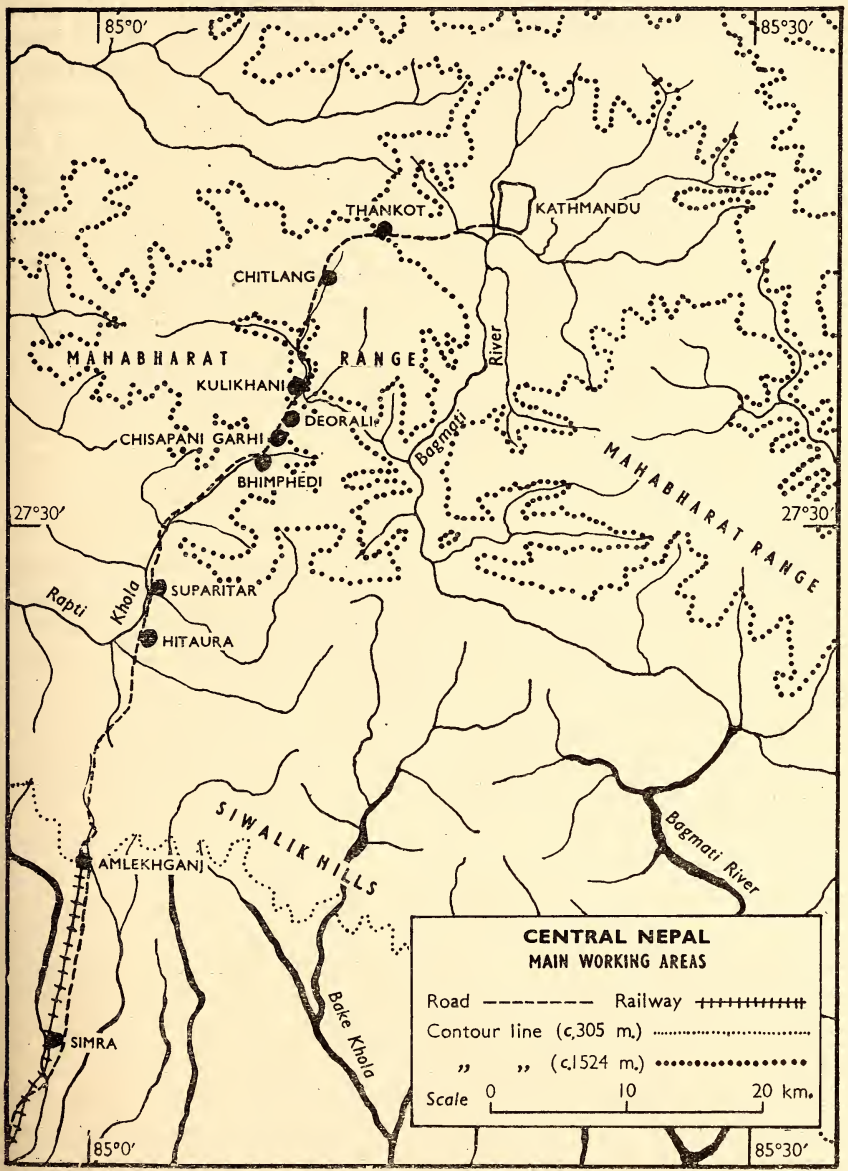


Fig. 6. Map of central Nepal showing main working areas of Koelz-Biswas team.

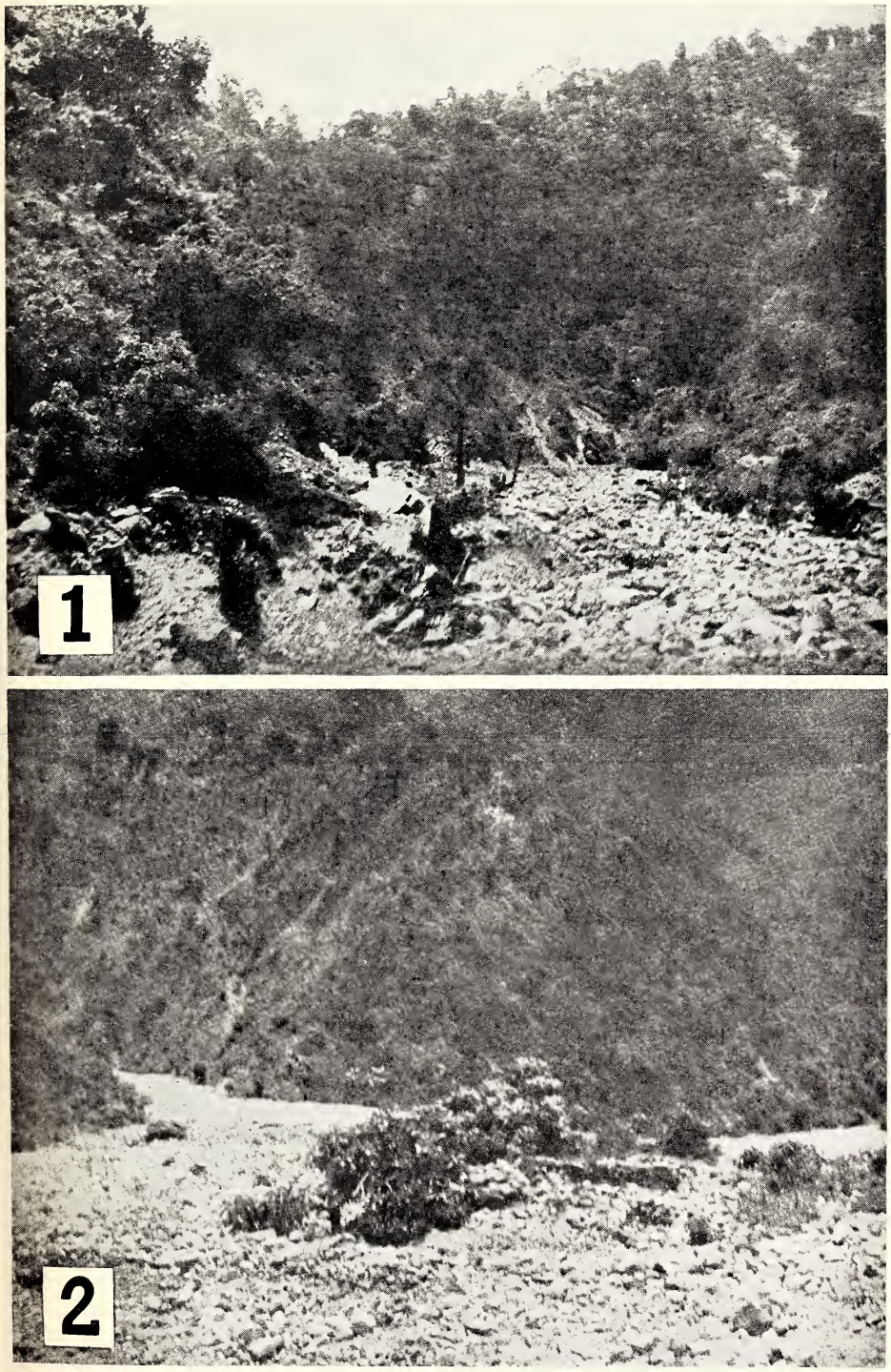
27°25′ N., 85°2′ E. as collecting localities) : This area (Figs. 6, 7) lies in the valleys of the Rapti, Samri, and Karra Kholas. The principal

river of the area, namely the Rapti, flows north to south. North of the Hitaura village, it receives the Samri Khola flowing east to west, and south of the village it receives the Karra Khola coming from east, and a small tributary from the south. The Rapti River then turns sharply westward. Moreover, there are many hill-streams in this area, some of which flow through dark, narrow ravines. The rivers have shingle beds in this area. Apart from a narrow strip of cultivated land along the Rapti and cultivated plots between the villages of Hitaura and Karra, the entire area is well forested. The east-west ridge between the Samri and Karra Kholas, and Paharé Ghat across the Rapti, have thick forests of Sal (*Shorea robusta*), some Lampati (*Duabanga*), Asan (*Terminalia tomentosa*), *Bauhinia*, Kadamba (*Anthocephalus cadamba*), a few Silk-cotton (*Salmalia malabarica*), Amaltas (*Cassia*), *Clematis*, *Drymaria*, and shrubs and weeds like *Mimosa*, *Sida*, etc. Patches of tall grass, like *Saccharum*, *Phragmitis*, *Anthistiria*, occur here and there. The river beds are fringed with thickets of thorny plants and creepers like *Rhaphidophora glauca*. Altitude : *c.* 420-610 m.

Bhimphedi (27°33′ N., 85°9′E.) : Further to the north-east of Hitaura (about 16 km. in a straight line) lies the small town of Bhimphedi, the terminus of the motor route from Raxaul and Amlekhganj. It is situated at the upper limit of the dun on the left bank of the Rapti River at the foot of the Mahabharat Lekh. A number of tributaries of the Rapti, rising from the Mahabharat, flow around the town. The western, northern and eastern sides of Bhimphedi are surrounded by mountains densely clothed with Pine with a mixture of deciduous and evergreen vegetation (Plate I). On the south-west, south, and south-east of Bhimphedi there are some patches of cultivation. There are a number of hill-streams in the vicinity, some of which at places run through deep ravines. The banks of the larger rivers sustain tall grasses and scrub. Altitude : *c.* 1220-1370 m.

MARKHU VALLEY

Deorali (27°34′N., 85°9′E.) : This is a place in name only situated on the northern side of the pass on the Mahabharat Lekh above Chisapani Garhi (= Sissagarhi) on the Bhimphedi-Kathmandu trail. In this area, there is a thin forest of Rhododendron (*R. arboreum*), with some Cheer Pine (*Pinus roxburghii*), Kharsu Oak (*Quercus semecarpifolia*), and bushes of *Luculia*, *Viburnum*, *Rhus*, *Rubus*, *Prunus*, etc. The undergrowth consists of *Clematis*, *Galium*, *Hypericum*, *Valeriana*, *Dipsacus*, *Strobilanthes*, etc., and *Anaphalis*. There are also some orchids, like *Otochilus*, and epiphytes (*Peperomia*). Abundant mosses festoon the trees. A few small hill-streams are present in the area. Altitude : *c.* 1980 m.



1, 2. Forests on the Mahabharat Lekh, east of Bhimphedi, Central Nepal. 19 June 1947.

(*Photos : B. Biswas*)

3. Looking north from Chandragiri Pass, above Thankot. 18 March 1947.
4. Vegetation on northern edge of Thankot Village, Nepal Valley. 18 March 1947.

(*Photos : B. Biswas*)

Kulikhani (27°35′N., 85°9′E.): This is a small village situated on the right bank of the Markhu River below Deorali, and on the trail to

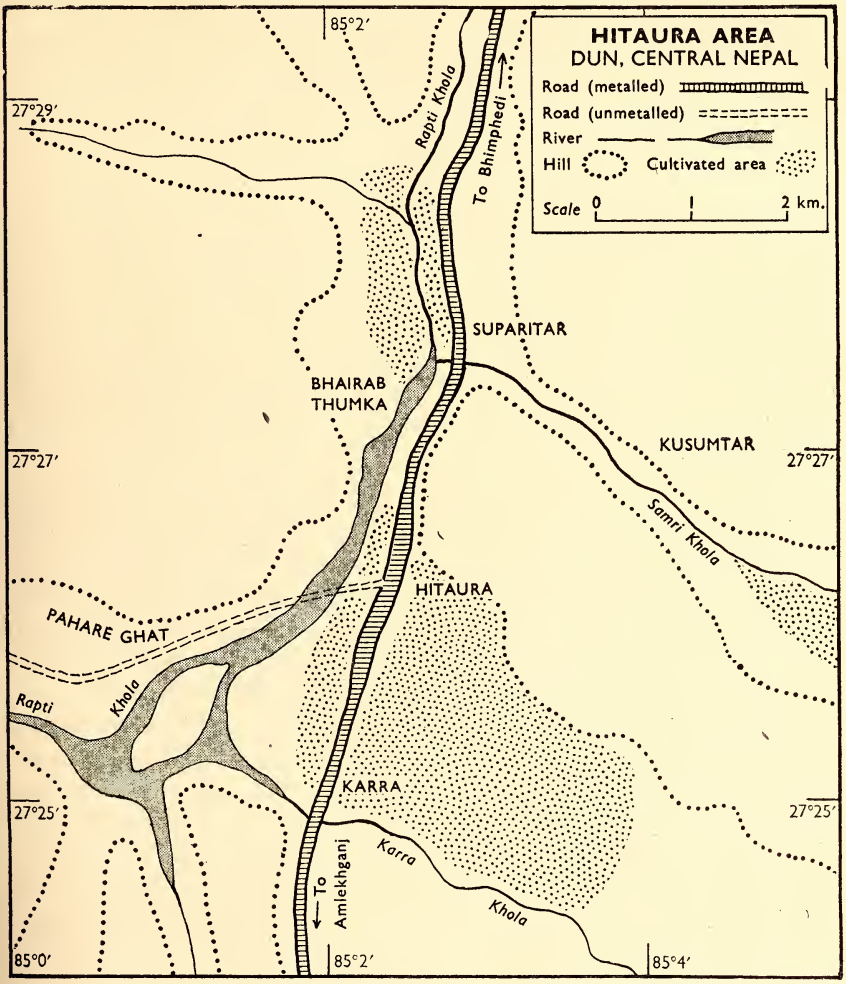


Fig. 7. Map of the Hitaura area, central Dun, Nepal.

Kathmandu. There is extensive cultivation along the river, but to the south and west on the mountain slopes, there are mixed deciduous and evergreen forests. Altitude : *c.* 1400 m.

CHITLANG VALLEY

Chitlang (27°39′N., 85°11′ E.): This is a village lying at the southern foot of the Chandragiri below the pass on the Kathmandu trail, and near the head of the Chitlang Valley. There is extensive cultivation on the south of the village, with patches of scrub and grass here and there.

Such vegetation consists of *Potentilla*, *Teucrium*, *Artemisia*, *Swertia*, *Micromeria*, *Lotus*, *Viola*, *Gentiana*, *Arenaria*, *Oldenlandia*, *Stellaria*, *Pollinia*, *Anthistiria*, etc. A number of small hill-streams flow through this area to join the Chitlang River which takes off from the Chandragiri. On the north of Chitlang, is the thick forest on the Chandragiri. Altitude : *c.* 1830 m.

CHANDRAGIRI

The **Chandragiri** range bounds the Nepal Valley on its western and south-western sides (Fig. 8). It is well covered with forests from its base to the crest, except about the villages situated at its foot. On the outer side, its base lies at about *c.* 1830 m., but inside the Nepal Valley, at about *c.* 1525 m. Collections were made between Chitlang (outside the Valley) and Thankot (inside the Valley) on both faces of the Chandragiri, as well as on the crest in the region of the Pass (27°41′ N., 85°12′E., alt. *c.* 2285-2440 m.).

The forests on the Chandragiri, specially in its upper reaches, are largely of the type which Champion (1936, p. 231) classified as ' Ban oak '. The vegetation consists largely of Oaks (*Quercus semecarpifolia* and *Q. glauca*), Rhododendron (*R. arboreum*), Aru (*Pyrus pashia*), Cherry (*Prunus puddum*), Asaré (*Viburnum*), Angeri (*Pieris*), with shrubs and herbs like *Jasminum*, *Rubus*, *Berberis*, *Randia*, *Ranunculus*, *Artemisia*, *Valeriana*, Fern (*Pteris*), *Lindenbergia*, *Thalictrum*, climbers like *Vitis*, *Smilax*, etc. and grasses (*Andropogon* and others). There are a number of patches where the undergrowth is very scanty, as well as much cut-out treeless areas having thick secondary shrubby growths. The trees are thickly covered with mosses and lichens. In the steeper parts of the slopes, there are thick herbaceous growths with but few trees. Several hill-streams, medium-sized and small, flow down the slopes of the Chandragiri. Some of them have cut deep gorges, dark and damp, overgrown with ferns and mosses.

NEPAL VALLEY

Almost completely enclosed by a series of ridges, the irregularly oval-shaped Nepal Valley (Fig. 8) is situated in the Lesser Himalayan mountain system. The more important of these ridges are the Sheopuri Lekh on the north, Phulchauki Danda on the south-east and south, Chandragiri on the south and south-west, and the Nagar Jong on the north-west. The floor of the valley is more or less level and about *c.* 1220 m. in elevation, but the surrounding ridges range from *c.* 1830 m. to almost *c.* 3000 m. in height (Plate II, fig. 3, and Plate III, fig. 5). The floor of the valley is densely populated and extensively cultivated, even

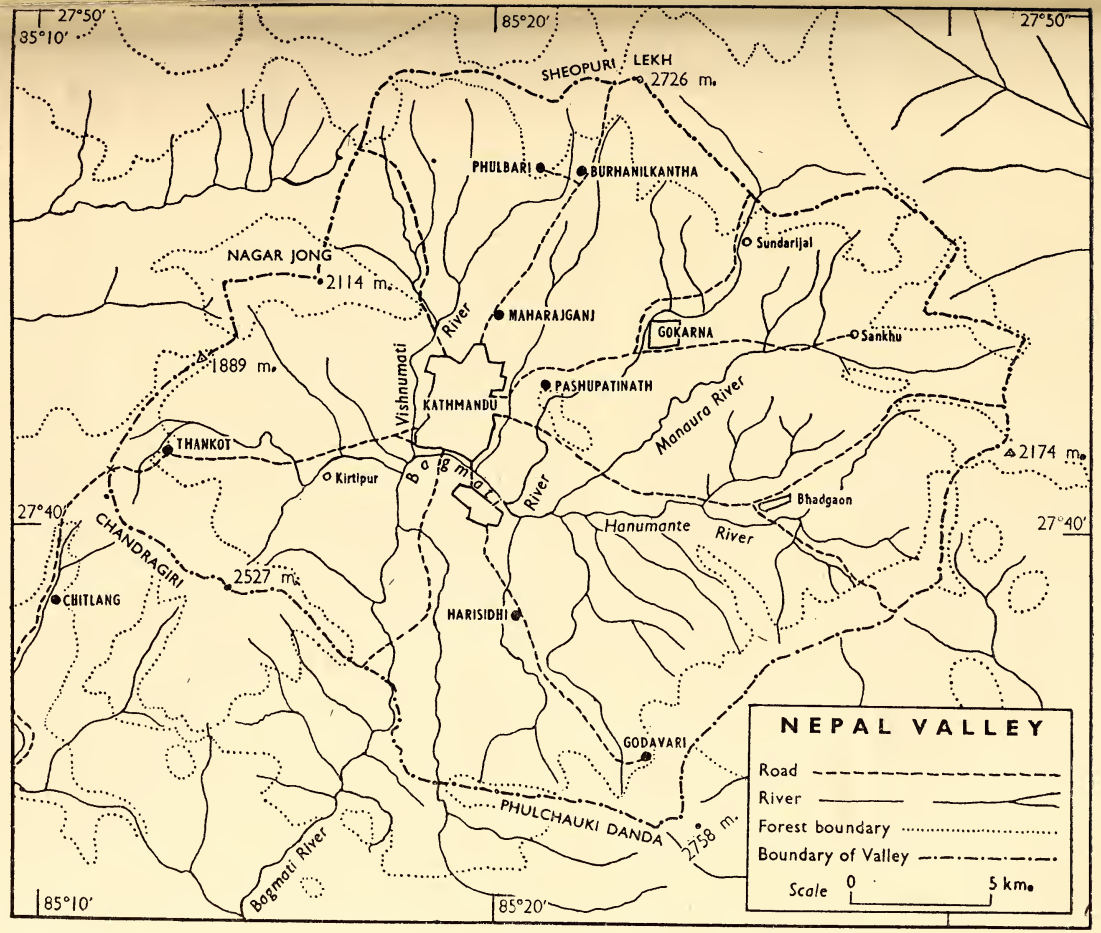


Fig. 8. Map of the Nepal Valley, Nepal.

up to the foothills in many areas. Barring some small patches of woods here and there, there is no forest in the floor of the valley. The surrounding ridges are, however, well forested in most parts. They are chiefly mixed forests of Oaks, Rhododendrons, Pines, Walnuts, Poplars, Alders, and different shrubs, herbs and grasses, depending on the elevation and location. The patches of woods on the floor of the valley are generally located on isolated ' tilas ' (little hillocks), and consist of pine and other trees. They represent the ' central woods ' of Scully (1879).

A large number of streams, big and small, originate from the surrounding ridges and flow into the valley. All of them form tributaries of the Bagmati—the only river that leaves the Nepal Valley through a narrow gorge on the south-west.

Kathmandu (27°42'N., 85°19'E.) : The capital city of the Kingdom of Nepal, Kathmandu is located a little to the west of the centre of the Valley. The principal rivers of the Valley, viz. the Vishnumati and the Bagmati, flow adjacent to the city, the former flowing north-south along its western edge, while the latter which has first a north-south course along its eastern edge, flows east-west along its southern border. The two join at the south-western corner of the city. The area all around Kathmandu is well cultivated.

Collections were made in and around a number of villages in the outskirts of Kathmandu, as well as on the Vishnumati and Bagmati rivers. Altitude : *c.* 1300 m.

Burhanilkantha (27°48' N., 85°22' E.): This is a small village situated at the foot of the Sheopuri Lekh, about 13 km. north of Kathmandu. A hill-stream named Rudramati (a tributary of the Bagmati), flows north-south through the village. Another hill-stream flowing north-south along the eastern edge of the village, joins the Rudramati after turning west to pass through the southern part of the village. There is a small reservoir on the Rudramati above the village. To the east of the village, there is a narrow spur of the Sheopuri, which is covered with thick secondary scrub (Plate III, fig. 6). A little to the west, on a larger spur, lie the villages Phulbari and Jhar. There are cultivations about the villages and on the south, but the mountainside is forested. The vegetation is similar to that of the Chandragiri.

Collections were made in Burhanilkantha-Phulbari and surrounding areas and some way up the Sheopuri. Altitude : *c.* 1830-2155 m.

Godavari (27°36' N., 85°23'E.) is a small village situated at the south-eastern corner of the Nepal Valley between two spurs of the Phulchauki Danda coming out of it. The extensive forest around is a preserve of the ruling Prime Minister. There is a spring and a number of hill-streams in this area, and barring small patches of cultivation the whole area and the mountain are thickly clad with evergreen forest (Plate IV).

5. Looking towards Kathmandu from Thankot, Nepal Valley. 18 March 1947.
6. Vegetation on a spur of the Sheopuri Lekh, east of Burhanilkantha, Nepal Valley. 4 May 1947.

(*Photos : B. Biswas*)

7. Forest on a spur of the Phulchauki Danda, east of Godavari, Nepal Valley. 13 May 1947. 8. Looking north-west from Godavari, Nepal Valley. 16 May 1947.

(*Photos : B. Biswas*)

The vegetation is similar to that of the Chandragiri. There are also some grassy patches in this area. Altitude : *c.* 1675-2135 m.

Thankot (27°41′N., 85° 13′E.) : Located at the foot of the Chandragiri on the main trail from Bhimphedi to Kathmandu, this little village has some cultivation and a few grassy meadows. The area around Thankot is well forested, specially on the spurs of the Chandragiri about the village, except on the eastern side where the extensive cultivated area of the Valley begins (Plate II, fig. 4, and Plate III, fig. 5). In the immediate vicinity of the village, however, the forest is much cut down (for firewood, etc.), and as a result, large treeless patches overgrown with shrubs and grasses are not uncommon. A few hill-streams flow through the forest bed. The nature of the vegetation has already been mentioned under ' Chandragiri ' (p. 374). Altitude : *c.* 1525-2135 m.

In addition to the above mentioned places in the Nepal Valley, collections were made at various spots along Kathmandu-Thankot, Kathmandu-Sundarijal, Kathmandu-Sankhu and Kathmandu-Godavari roads. All these localities were in the cultivated areas with no forests in the vicinity, and in altitudes of *c.* 1285-1525 m. Opportunity was availed of for making collections in a few of the ' central woods ' on tilas.

(*to be continued*)

Re-use of Cells and Brother-Sister Mating in the Indian species *Stenodynerus miniatus* (Sauss.) (Vespidae : Eumeninae)

BY

S. D. JAYAKAR AND H. SPURWAY

Genetics and Biometry Laboratory, Government of Orissa, Bhubaneswar

(*With a plate*)

INTRODUCTION

During the first period of colony formation, before any workers have emerged, the behaviour of queens of the social non-swarming haplometrotic species of Vespidae is comparable with the behaviour of females of solitary species (Yoshikawa 1962). At the foundation of her nest a queen builds cells and lays in them. When her first eggs hatch, food gathering begins and this alternates with continued building and oviposition. A cell is not finished once and for all, but loads are added after it contains a larva, both to accommodate this as it grows and to elaborate the architecture of the nest under various internal and external stimuli (Deleurance 1957, Olberg 1959). A queen wasp can also clean out a previously used cell and re-use it. She does this after she has removed an egg, larva, or pupa, which she has part eaten herself, and part fed to her other offspring. This destruction of some part of the brood is characteristic of this early stage in the formation of the nest (Deleurance 1955). The queen re-uses a cell after a normal imago has emerged only during the few days before the first daughter returns from her first foraging flight, after which the queen abruptly ceases all building and provisioning activities. The cleaning and structural reconditioning of previously used cells is however repeatedly performed by workers and forms an essential part of the economy of such colonies. All social wasps build their cells of paper, or other plant fragments.

The solitary vespoids (eumenines) that build for their offspring not only use mud (not paper) for this purpose, but lack the versatility of the social species. They are usually divided into two behavioural groups : (1) the potters who build individual cells for each egg, usually in

clusters; and (2) the renters (Iwata 1942) or squatters (Jayakar & Spurway 1965a) who lay their eggs in various holes and cavities including the deserted mud cells of the potter species. Squatters not only seal these cavities with mud, but also show considerable architectural skill in filling chinks, partitioning cavities, and rebuilding walls.

This paper describes a species which combines both the capacity to build individual cells and therefore qualifying as a potter wasp, and the capacity to service and re-use these cells repeatedly after her first offspring have emerged from them, and hence functioning as a squatter in her own cells. Thus, though a mud builder and solitary, this species shares a cell economy with the social species, and may mirror a condition which some ancestor of theirs exhibited. As would be expected on the previously hypotheticated phylogeny of the social habit (Roubaud 1916, Wheeler 1923, Iwata 1942, Richards & Richards 1951) this species also performs progressive, though not simultaneous, provisioning.

The Material

The species concerned is *Stenodynerus miniatus* (Sauss.), the cells of which have been described and figured by Horne and Smith (quoted by Bingham 1897) under the name *Pterochilus pulchellus* Smith. This mainly black species is variable, individuals within the same sibship differing both in the number and extent of the yellow spots on the head and thorax and their appendages, and in the extent of red on the petiole and anterior region of the gaster. The main body of this paper describes the fourth nest and mother in our files and they are both numbered *Stenodynerus miniatus* 4 or *St. m.* 4 (Fig. 1). The histories of *St. m.* 1, 2, and 3 begun on 18/v/63, 12/xi/64, and 20/vii/65 respectively all confirm in some way that here reported, and will be further referred to below. These four nests are all that we have observed in our house (Unit 5, Type VIII, No. 2) in New Bhubaneswar (20° 15′ N.; 85° 50′ E.; altitude 45 m.), which is built on laterite originally covered with wet semi-evergreen forest which was cleared in 1947.

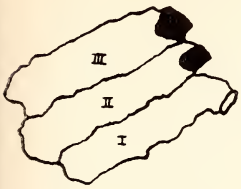
Nests 5-18 and A-T were dissected soon after discovery, only a few observations of the mothers' behaviour being sometimes made. Their contents were either preserved in alcohol or kept alive. Nests 5 and 6 were collected on 14/iv/66 from a house from the village of Balakati which, though only 8 km. from the Bhubaneswar house, is on the delta of the Mahanadi and surrounded by rice fields. The mother of nest 5 was also collected. Many other nests were present in this house. The remaining nests were collected on 2/v/66 from a single

house in Barabil (22° 05′ N.; 85° 25′ E.; altitude 520 m.). This is a mining town associated with iron and manganese mines in the midst of wet deciduous forest in which the dominant species is *Shorea robusta.*

At Barabil, all nests found on the house and judged to have been made this season were collected. Of these nine (nos. 7, 9-11, 14-18) were collected with the mothers working in them, three (nos. 8, 12, and 13) were identified by the young developing in their cells and seventeen (A to F and J to T) are associated with this species of *Stenodynerus* on the nest architecture alone.

Nest Structure and Siting

These nests consisted of one or more granular mud vaults about 4 mm. in diameter and 18-20 mm. long. These were usually attached to a single surface, there being only three exceptions (9, 15, and E) (Figs. 2 and 3). These apparent tubes are numbered with Roman figures, in the order of building when this was watched (in nests 1-4) or could be discovered from the architecture. They were usually built parallel and touching throughout their length, and when on a vertical surface might be at any angle between 0° and 90° to the horizontal. *St. m.* 1 built tube II and tube III so that tube I was between them; the other three individuals watched built their later tubes in a series above tube I. The open vault was usually but not always completed with a chimney, i.e. a complete tube about 3 mm. in diameter and 5 mm. long curved slightly away from the substrate and with its opening bent slightly downwards. The outer walls of these chimneys were smoother than those of the vaults. Usually the tubes of a nest opened in the same direction but in four (8, 14, Q, and S) one of the tubes had been built opening in a different direction to the rest. In 8 and S (Plate, fig. 4) the opening of this exceptional cell was at the opposite end of the construct, the vaults of the tubes being parallel. In 14, the only nest with 4 completed tubes, though the openings of the chimneys were opposite but parallel, the vault of one (called I) was curved round and under the mouths of the other three (Plate, fig. 5). In Q two cells were found in the usual parallel relationship, then an unused but sealed half vault at right angles to them at their open ends, and finally, on the other side of this, another normal tube parallel to the other two (Plate, fig. 6). This partial tandem arrangement of tubes was also present in nest 15 (Plate, fig. 3). The most curious structure, which we have only seen in derelict nests, was for a tube to be curved more or less into a ring built round the shaft of a stout nail and in a plane perpendicular to it (Plate, fig. 7).



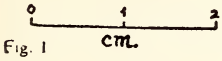


Fig. 1

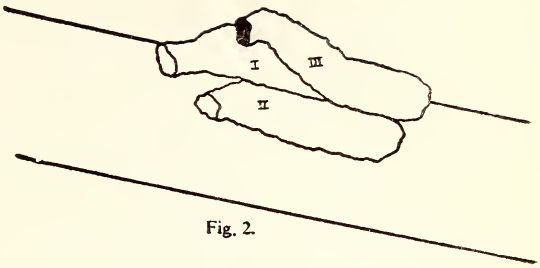


Fig. 2.

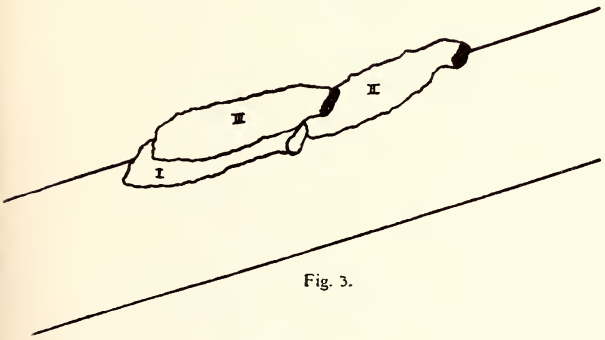


Fig. 3.

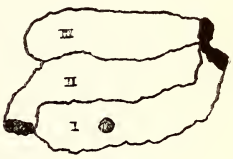


Fig. 4.

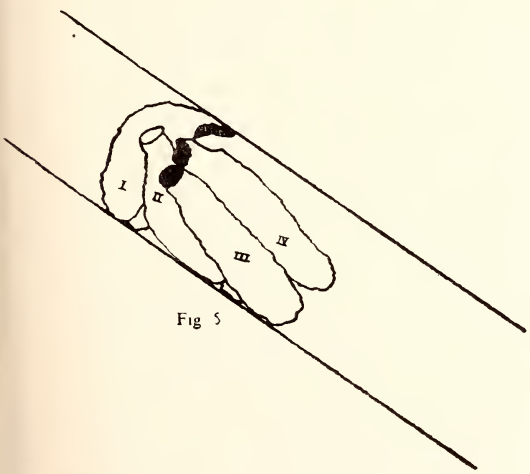


Fig 5

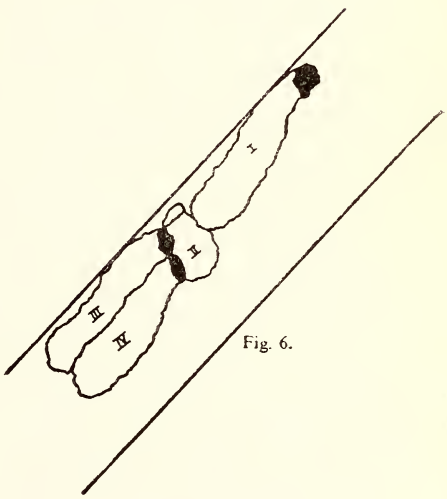


Fig. 6.

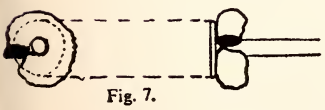


Fig. 7.

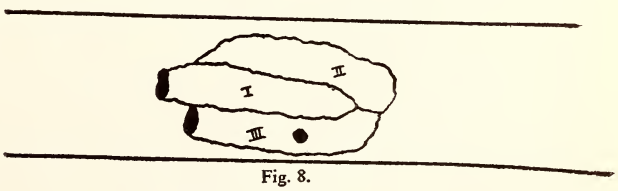


Fig. 8.

Nests of *Stenodynerus miniatus* (Sauss.)
Note : All figures drawn to same scale

Considering the 35 nests studied :

1 nest (14)	contained	4 tubes
1 ,, (Q)	,,	3½ ,,
17 nests (1, 3-5, 7-10, 15-17, C, F, O, P, R, S)	,,	3 ,,
3 ,, (13, 18, B)	,,	2 ,,
2 ,, (2, K)	,,	1½ ,,
8 ,, (6, 12, A, D, E, L, M, T)	,,	1 tube
3 ,, (11, N, J)	,,	½ ,,

Thus three was the commonest number of tubes and the behaviour of *St. m.* 4 suggests that a nest of three may be regarded as the typical ' completed ' nest.

All nests were built on the outer surface of ground floor rooms or on verandah pillars, and all except T were sheltered by a roof or eaves. Their height above the nearest soil ranged from 1·0 to 3·64 metres. Nest 2 was built on a vertical pane of glass and nests 1, 3, 4, 5 and 6, i.e. all the others observed in the plains, were built on vertical white-washed brick walls, as was nest 18. Nest R was built on the lower surface of a masonry lintel on a surface at an angle of 45°. Nest P was built on a vertical wooden component of a wall, and T was built on the wooden vertical surface above a window lintel. The remaining nests at Barabil were all on the ceiling of a large verandah of a complicated shape. This was edged by stout beams. Nest 13 was on the outer or garden side of one of these. The remaining twenty-four nests were on and under the verandah ceiling. Nests C, F, and S were on the lower horizontal surface of these edging beams and, while remains of derelict nests were found on their inner vertical surfaces, no nest included in the sample was so situated. Similar beams attached the verandah roof to the house and nest L was on a vertical surface and nests 8 and 17 on their horizontal surfaces.

The ceiling itself is higher nearer the house than at its garden edge, the surface sloping upwards at an angle of about 15°. This ceiling is made of many rectangular and triangular sheets of asbestos painted white and held together with thin strips of wood, which like all the other wooden structures is painted blackish brown to resemble European oak. The ½ tube of nest 11 was built entirely on this asbestos and, even if construction had not been interrupted, could not have extended on to any wood. The remaining twenty-one nests were built mainly or entirely on these strips of wood. Five nests (10, 12, A, B, D) were built on the lower surfaces 3-4 cm. in width and either completely horizontal or sloping at a small angle. The long axis of the cells might

be parallel or at right angles to the long axis of the strip. The greater number (7, 9, 14, 15, 16, E, J, K, M, N, O, Q) were on the more or less vertical surface of these strips and as these were usually less than 2 cm. in width the long axes of the nests were parallel to the strips. In nests 9 and 15 (Figs. 2 and 3) most of the wall of one tube touched the asbestos, and the single tube of E was built more or less vertically on the wood and then bent over so as to be continued at right angles away from the strip on the nearly horizontal asbestos. An angle between two surfaces seemed rarely to be sought as a foundation for the first tube, as it usually is by the sphecoid tube builder *Sceliphron madraspatanum* (Fabr.).

The openings of the tubes were never directed towards the nearest point in the garden. Usually they pointed towards the house walls but sometimes towards a large area of roofed verandah.

The Evidence for Progressive Non-simultaneous Provisioning

The dissections of nests 5-18 were made much later than the diary of nest 4, but they were made to answer questions raised by that diary. Therefore it is convenient to consider some of the results obtained from these dissections before considering the behaviour of *St. m.* 4, as this will permit certainty in the interpretation of some of her actions.

Table 1 shows the contents of all nests seen worked on by or containing individuals of *Stenodynerus miniatus* or other wasps, including those concerning which diaries had previously been kept. If known, the sex of the cell contents has been given, and also the dates of pupation (*p*) and eclosion (*i*) if these occurred. The presence or absence of a eumenine cocoon was not systematically recorded. Only during the collection was it realized that these are not removed by the mother before a cell is re-used, as they are by the social vespoids.

In all tubes that contained two early stages of the wasp these were separated by a mud partition, i.e. the tube was divided into two cells the lower of which is called 1 and the upper 2, and in any given tube the contents of cell 1 were at a more advanced stage of development than those in cell 2 (e.g. pupa 4·I·1 having black eyes while those of 4·I·2 were brown, and 5·III·1 eclosing 1 day before 5·III·2).

Cells 7·II·1, 10·I·1, and 14·I·1 were not sealed but contained larvae that were fully grown or nearly so. The prey in 10·I·1 was seen inserted by the mother who immediately came out, re-entered the cell abdomen first, and was collected. This observation together with the contents of the cells makes it certain that members of this species practise progressive provisioning, i.e. continue to bring food for their larvae throughout the larval life, only sealing them in at, or towards, the end of this.

TABLE I

CONTENTS OF NESTS BEING WORKED ON BY OR CONTAINING *Stenodynerus miniatus* OR OTHER WASPS

nest and date of dissection	Cell	Tubes in decreasing order of development of contents			
14 2/v/66	2 1	IIss pupa *a* pupa *b*	IV♀ prey remains + large larva	III	I
3 2/x/65	2 1	II *T.p.* 16 diapausing larva ♂	Is *T.p.* 16 diapausing larva ♂	IIIs lepidopteran remnants	
4 29/xi/65	2 1	Is pupa *b i* 9/xii ♂ pupa *b* ♀	II minute larva	III	
5 14/iv/66	2 1	IIIs pupa *d i* 18/iv ♂ pupa *d i* 17/iv ♀	Is large larva *p* 17/iv *i*24/iv ♂ pupa *a i* 23/iv ♀	II♀	
7 2/v/66	2 1	Is pupa *d i* 4/v ♂ *c. i.* pupa *d i* 4/v ♀	II♀ 1 prey + large larva	III	
8 2/v/66	2 1	IIs pupa *d i* 4/v ♂ debris	I	III	
9	2	IIs pupa *d i* 3/v ♂	Is prepupa *p* 4/v ♂ pupa *b* ♀	III♀ 2 prey + minute larva	

10		IIss	I♀	IIIss
2/v/66	1	imago ♀	1 prey + large larva	
15		Iss	II♀	III
	2	pupa *b i* 5/v ♂	3 prey + small larva	
2/v/66	1	pupa *c* ♀	full grown larva *p* 4/v *i* 13/v ♀	

TABLE I

CONTENTS OF NESTS BEING WORKED ON BY OR CONTAINING *Stenodyncrus tilinlatus* OR OTHER WASPS

nest and date of dissection	Cell	Tubes in decreasing order of development of contents .			
14 2/v/66	2 1	IIss pupa *a* pupa *b*	IV♀ prey remains + large larva	III	I
3 2/x/65	2 1	II *T.p.* 16 diapausing larva ♂	Is *T.p.* 16 diapausing larva ♂	IIIs lepidopteran remnants	
4 29/xi/65	2 1	Is pupa *b i* 9/xii ♂ pupa *b* ♀	II minute larva	III	
5 14/iv/66	2 1	IIIs pupa *d i* 18/iv ♂ pupa *d i* 17/iv ♀	Is large larva *p* 17/iv *i* 24/iv ♂ pupa *a i* 23/iv ♀	II♀	
7 2/v/66	2 1	Is pupa *d i* 4/v ♂ *c. i.* pupa *d i* 4/v ♀	II♀ 1 prey + large larva	III	
8 2/v/66	2 1	IIs pupa *d i* 4/v ♂ debris	I	III	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
10 2/v/66	2 1	IIss imago ♂ imago ♀	I♀ 1 prey + large larva	IIIss	
15 2/v/66	2 1	Iss pupa *b i* 5/v ♂ pupa *c* ♀	II♀ 3 prey + small larva full grown larva *p* 4/v *i* 13/v ♀	III	
16 2/v/66	2 1	II *S.* sp. dead imago ♂	I♀	III	
17 2/v/66	2 1	IIIss pupa *a i* 9/v ♂ pupa *b i* 7/v ♀	I♀ large glassy larva	II	
18 2/v/66	2 1	Iss pupa *a i* 9/v ♂	II♀ 6 prey + half grown larva		
13 2/v/66	2 1	Is dead imago ♂ imaginal fragments	IIs		
2 8/xii/64	2 1	I pupa *c i* 12/xii ♂ pupa *d i* 9/xii ♀	II not built		
6 14/iv/66	2 1	I♀ 2 prey + small larva			
11 2/v/66	2 1	I not built ♀ egg			
12 2/v/66	2 1	I pupa *b i* 7/v ♀			
F 2/v/66	2 1	IIs *C. i.* imago ♀ *C. i.* pupa *d i* 4/v ♀	I	III	
O 2/v/66	2 1	Is *chrysidid* pupa *a*	II imaginal fragments	III	
P 2/v/66	2 1	III imaginal fragments	I	II	
J 2/v/66	2 1	I not built dead egg			

KEY TO TABLE I

Roman numerals	tubes
s	sealed
ss	sealed (double lid)
a	butter-coloured pupa
b	ditto with coloured eyes
c	pupa with black on body
d	fully coloured pupa
p	pupated
i	eclosed
———	partition - tube 18 I was not divided
- - - - -	doubtful partition because of injury to outer wall.
♀	cell in which mother was resting or working when captured
♂♀	sex of wasp contents
T.p. 16.	*Trypoxylon pileatum* No. 16
*S.*sp.	*Subancistrocerus* species
C.i.	*Chrysis ionophris* Mocsary

However the contents of cell 18·II·2 showed that the prey is not brought 1 or 2 at a time. The six prey in this cell were collected at 11.42 and were foolishly kept with the wasp larva; four were consumed before alcohol could be added at 17.34. Therefore these may reasonably be regarded as half a day's provisions.

Cell 17·I·1 is particularly important. It was sealed and contained a larva which was full grown, though it had not yet defaecated and become butter-coloured and opaque, as aculeate larvae do before pupation. As cell 17·I·2 did not yet contain an egg this demonstrates that the provisioning of one cell is completed before that of another begins, i.e. simultaneous provisioning does not occur.

The 15 prey recorded in Table 1 were, with one exception, lepidopteran larvae, those in 18·II·1 having only one pair of pro-legs in addition to the anal claspers. The exception is grossly unexpected for a vespoid (Iwata, 1942) and may not have been inserted by the mother wasp. The cell 9·III·1 contained 1 lepidopteran larva but the newly hatched wasp larva was attached near the waist of the empty cuticle of a *spider*. Alcohol was added at 17.34, and the spider remains were sufficient to confirm under a stereoscopic microscope that the facts were as stated. As the mother had been captured from tube 9·III only 17 minutes before dissection of the nest, it is difficult to dismiss the spider as an intruder. Though Bingham (1897) quoted Horne and Smith as interpreting spiders to be the prey of *Pterochilus pulchellus* Smith [= *Stenodynerus miniatus* (Saussure)], it would seem more likely that their cells were being squatted, like our nest 3, by some spider provisioning squatter. The larva in 9·III·1 could not belong to *Trypoxylon pileatum* Smith because we have seen this species lay its egg only after all prey have been inserted into the cavity. Nest 16 reveals that *St. miniatus* may return to a construct after it has been used by a squatter species. If so cell 9·III·1 may have been in the process of being provisioned by two species at the time we dissected the nest! We have never seen a sphecoid and a vespoid performing this, but we have a record of a *Rhynchium brunneum* (Fabr.) and a *Pareumenes brevirostratus* (Sauss.) working alternately on the same tunnel in our nest boxes. Though each removed many prey brought by the other, an egg with adequate provisions was finally sealed, both females contributing mud to the lid.

The slightly crescentic egg in cell 11·I was about 3 mm. long, and lying at the bottom of the vault, at right angles to its long axis, touching and fitting the curvature of the wall. This confirms Roubaud's (1916) discovery that the typical eumenine egg suspension may be lost in species that practise progressive provisioning.

The Behaviour of the Mother St. m. 4

At 09.09 on 13/viii/65, tube I of nest 3 was found newly opened and a pair of wasps, the male mounted on the female, was standing on the nest and, at least qualitatively, performing the rhythmic alternation of courtship + display previously described (Jayakar *in press*). This was not timed but the female was captured, etherised, painted red on the thorax, and released. As she was the only female present on the construct at the time it was hoped that her further behaviour would reveal whether she was the mother wasp, i.e. *St. m.* 3 herself, or a daughter. As there is no evidence that any wasp ever returned to nest *St. m.* 3 the results are equivocal, for it would be a coincidence if the mother should have chosen that moment to desert since, being absent at the time, she could not have been disturbed by the capture of an offspring. *St. m.* 2, the only mother similarly painted, did not complete the tube she was building before capture, and is not known to have returned to her construct.

On 15/viii/65 the red-marked individual was observed having just begun tube I of nest *St. m.* 4 on another outside wall of the same house. While building, like other wasps of this species, she was at right angles to the edge to which she was adding mud. Each load was rolled out by side to side movements of increasing range first of the head only and then of the whole body. Thus her building movements resembled those made by members of the related genus *Eumenes* who however build round pots, and did not resemble those of the sphecoid genus *Sceliphron* who also build tubular vaults; however, like a *Sceliphron* and unlike a *Eumenes*, a *Stenodynerus* of this species can and does enter her cells both head first and abdomen first.

In the tube 4·I the egg 4·I·1 was laid when the vault was just over half-made. This had been noted also in the tube 3·I. In both, the vault was immediately extended and the chimney completed within twenty-four hours, and as long as the contents of the tube were visible no prey was brought during this post-ovipositional construction, i.e. this species has, at this phase of its life cycle, the relatively rare sequence 11 of Iwata (1942), ' Preparation—Oviposition—Preparation—Hunting—Closing '. The dissections have revealed that sequence 12, i.e. an egg being laid in the second cell before the provisioning, or hunting, for both begins (i.e. simultaneous provisioning) does not occur in this species.

The dates of building activity for *St. m.* 4 are given in Table 2. She was last seen on the morning of 27/xi after spending the night (*pernoctating*) in tube II and the red mark on her thorax was last checked on 20/xi while she was sealing tube I for the third time. Therefore this individual, if, as we must assume, the daughter of *St. m.* 3, lived as an imago for 106 days, during which period 14 of her offspring completed

their metamorphoses. The dates (Table 2) between the commencement of a tube, or between the return to an empty tube, and its subsequent sealing, delimit periods of between 8-20 days. Periods of such lengths are to be expected if provisioning is progressive (Roubaud 1916).

TABLE 2

DATES OF BUILDING ACTIVITY AND EMERGENCE FOR NEST *Stenodynerus miniatus* 4

Date	Tube	Cell	sealed	emerged	Sex	Ref. no. of wasp
POTTER PHASE						
begun						
15/viii	I	1		10/ix	?	
17/viii		2	27/viii	11/ix	♂	4·I·2·(1)
27/viii	II	1		20/ix	♀	4·II·1·(1)
28/viii		2	6/ix	20/ix	♂	4·II·2·(1)
6/ix	III	1		29/ix	♀	4·III·1·(1)
7/ix		2	14/ix	29/ix	♂	4·III·2·(1)
SQUATTER PHASE						
1st						
re-pernoctation						
	I	1		7/x	♀ ♂	4·I·1 & 2·(2)
14/ix		2	25/ix	7/x		
	II	1		16/x	♀	4·II·1·(2)
25/ix		2	3/x	16/x	♂	4·II·2·(2)
	III	1		6/xi	♀	4·III·1·(2)
3/x		2	23/x	6/xi	♂	4·III·2·(2)
	II	1		18/xi	♀	4·II·1·(3)
23/x		2	1/xi	18/xi	♂	4·II·2·(3)
	I	1	pupa	29/xi	♀	4·I·1·(3)
1/xi		2	20/xi pupa	29/xi	♂	4·I·2·(3)
	II	1	small larva	29/xi		4·II·1·(4)
20/xi		2				

The mother wasp *St. m.* 4 was almost continuously present in the nest inside the second or outer cell of the tube in which she was working

at the time, facing outwards. Whether or not she was pernoctating was systematically checked on and after 31/viii. She was absent on only one night (21/xi) from the nest. During the hours of daylight, she seemed to leave the nest at least daily, sometimes apparently only once, sometimes once in the morning and once in the afternoon. As she was not watched continuously, we can only guess at the duration of the periods she was away but these seemed at first to be of the duration of about 1 hour but later in the season this lengthened to over four. There is some suggestion in the notes, strengthened by the examination of nest contents (Table 1), that these periods of apparent absence were a series of absences of short duration during which she brought several prey only remaining long enough on the nest to insert each into the current cell. Such behaviour is what would be expected were she provisioning progressively. At night she was completely withdrawn within the cell but during the day her antennae were protruding.

Her loads being small, these were not seen as frequently as could be wished. Mud was seen being brought on 15/xi, five days before the final closure of I for the third time on 20/xi. This load can be interpreted as for the partition in the tube closing the lower cell, i.e. I·1·(3). If so the mother took 14 days to provision 4·I·1·(3) and only 5 days to provision 4·I·2·(3). Considering the completed tubes in the dissected nests, omitting 4 known to have been deserted, only 1 outer tube contained a larva but was not yet sealed, whereas 6 inner tubes were in a comparable condition (Table 1). The difference is not yet significant (probability $\frac{1}{16}$), but again suggests that more time is occupied provisioning the inner cell than the outer cell of a pair. The periods of intense work deep within a cell alternating with many short absences, which were recorded on several occasions during the twenty-four hours before final closure, must be concerned with this rapid provisioning. After these periods of work the mother could not enter so deeply into the tube. The dissections have demonstrated that this internal working cannot be interpreted as the closure of the inner cell which had previously been open and provisioned simultaneously with the outer.

Mud was brought to seal the tube, but material from the chimney was always incorporated, so that this was also drastically shortened. The architecture was variable; usually the tube was closed with a more or less flat lid at right angles to the longitudinal axis of the chimney. Sometimes this lid was within the remnants of the chimney which formed a ittle crenellation round it, and sometimes the mud was worked so that the tube was sealed with a convex knob. There was no daubing such as is seen in the more typical potter wasps, and immediately after sealing a tube the wasp either built another or worked deep inside one previously used. This resembled the cleaning activity performed both by the soli-

tary squatter wasps and by the comb-building social wasps but, confirming the dissections, no mention of removal of cocoon tissue can be found in the notes. If the cell wall contained an emergence hole (see below), it was repaired at this time, and perhaps part of the chimney was rebuilt, but this latter building was usually done gradually during the subsequent provisioning period. Table 2 shows that the three cells were not always re-used in the order in which they were originally built. Only once (see below) did the wasp attend to both the empty cells then available alternately before finally confining her attention to one of them.

The nest dissections have supplied architectural details not obtainable from watching the females. Firstly the partitions between the two cells in a tube which divide the vault into two more or less equal parts are thin, less than 1 mm. in thickness, and fragile. Secondly several chimneys appeared not to have been shortened during sealing. Seven of these chimneys (10·II, 10·III, 14·II, 15·I, 17·III, 18·I, B·I) contained two lids, one at the mouth and the second 2-3 mm. within it. The remaining fourteen sealed tubes contained only single lids. We have not yet found single and double closures in the same nest. Such variation in the number of layers with which a cavity is sealed is characteristic of squatters, e.g. *Subancistrocerus sichelii* (Sauss.) and *Antodynerus flavescens* (Fabr.).

The Emergences from Nest 4 and Their Matings

Table 2 shows the dates on which the offspring of *St. m.* 4 emerged from the cells. With one exception, the two offspring from a single tube emerged on the same day. The wasp I·1·(1) was not seen—only the hole through which it had emerged was found in the cell wall in the lower part of the tube. There had been a longer delay after the laying of egg I·1·(1) before the laying of egg I·2·(1) than for the other pairs of eggs for which the dates of laying were known. Such an emergence hole through the belly of the pot (not the mouth) is typical of the pot-building vespoids, e.g. *Eumenes* spp.

All other offspring emerged by walking out through a hole which they had bitten in the lid with which their mother had sealed the original mouth of the tube. Such an egression or emergence is performed by the sphecoid potters of the genus *Sceliphron*, and by vespoid squatters when the walls of the cavities in which they have built are harder than their mud lids. All other offspring of *St. m.* 4 were seen, and except for I·1·(2) and I·2·(2) the process of emergence was first noticed when the lid had been opened and the head of the occupant of the upper cell (called 2) was visible inside it. From then, watching was continuous until the two offspring were captured. These observations are summarised in Table 3.

TABLE 3

OBSERVATIONS ON NEST *Stenodynerus miniatus* 4 FROM THE COMMENCEMENT OF EMERGENCE

Pair	Date	Last time lid unopened	Lid open ♂ facing out	Behaviour of *St. m.* 4 (m) to face of ♂	♂ walks out of tube	Behaviour after ♂ walks out	♀ visible	♀ begins to come out	Behaviour of ♂ and ♀, m ignored in all	♀ out cop.	captured
I (1)	11/ix	07.10	08.53	in III	09.14	♂ feels m, taps chimney III, flies 09·53, m in III					09.53
II (1)	20/ix	p.m. 19/ix	07.21	in I, comes out, re-enters I 12 times including once leaving nest, feels and bites ♂ repeatedly	08.58	♂ quiet	08.58	09.01	♀ bites ♂ from below repeatedly	09.02	09.27
III (1)	29/ix	07.45	09.06	walking, feels ♂, enters II	09.08	feeling m in II; stands over mouths II and III, quiet	09.08	09.12	♀ pushing	09.13	09.18
II (2)	16/x	09.25	09.40	in III, out and in 5 times, ignores ♂	12.07	quiet m in III	12.18	12.20	♂ grabs ♀, ♀ retires	12.20	12.22
III (2)	6/xi	09.20	10.10	in I, out and in 4 times including once leaving nest, ignores ♂	11.01	quiet m in I	11.01	11.06	♀ pushes ♂	11.06	11.06
II (3)	18/xi	p.m. 17/xi	08.22	in I, out and in 4 times leaves twice	09.23	♂ quiet m returns (prey), out, feeling ♂, once in out, leaves	09.27	09.32	♂ grabs ♀, ♀ retires	09.37	09.37

From this table it is seen that these emergences occurred relatively early in the morning. The complete period between the opening of the cell and the emergence of the male has not yet been accurately timed, but that part of it that has been attended has usually been of the order of an hour. The male has always been visible in the open cell but has been characteristically farther within it than the usual position of the mother wasp when she is resting during the day within the chimney of the tube which she is provisioning. The mother has always been present for some period at least while the emergence was in this stage, and on five occasions she spent some time walking on, and therefore feeling, the construct. The mother's behaviour to her sons' faces has been variable. Sometimes she ignored the male so that there was no evidence that she was aware of his presence, sometimes she made feeling movements with her antennae, and on 20/ix she behaved in an aggressive manner to II·2·(1).

With one exception, the mother was resting in the currently worked-in tube while the male finally walked out, and she showed no further reaction to him. On the exceptional occasion (on 18/xi) when she was away, she returned carrying prey. She ignored the male and inserted this prey, came out, felt him once and returned into the worked-on cell abdomen first, and remained facing out in her usual position. During the short period before the emergence of the second inner wasp the male only once (on 29/ix) felt his mother. He usually remained quietly over the open tube from which he had just emerged and reacted immediately to the behaviour of the second wasp within the tube, which became visible almost immediately. However, on 11/ix, when there was no second wasp to emerge, the male I·2·(1) spent 39 minutes assiduously feeling his mother and tapping the chimney of the tube in which she was resting. It is difficult not to conclude that he was attempting to stimulate her to come out. He was not disturbed, and was captured only after he had flown from the nest of his own accord.

In the other tubes considered in Table 3, another wasp appeared within the tube very soon after the emergence of the first. In all examples, this second wasp was a female. She stimulated the male either with her mandibles or by pushing him from below. As soon as her thorax had emerged, the male seized it, before her abdomen was out of the tube. Twice a female slipped from the male's grip and retired into the tube, but immediately re-emerged to be seized again.

All these pairs (the male standing upon the female's thorax and facing in the same direction) entered into a rhythmic series of copulations qualitatively indistinguishable from those previously observed, probably in this species, and certainly in *Subancistrocerus sichelii*, and

described elsewhere (Jayakar *in press*). To summarise, and in part add to, this previous description, after the mounting immediately upon the emergence of the females, both fluttered occasionally for about a minute before the first copulation, which lasted less than 10 seconds. Immediately after this, the male began tapping the female's head with his antennae, fluttering his wings and swinging his abdomen in an arc of about 60° over hers so that he was repeatedly stroking the tip of hers with it, with a rhythm of about 3 strokes a second. After about 1 minute, the wing movements alone stopped, after another 4-5 the antennal movements stopped, and after another 2-5 the abdominal movements stopped. Then the female might walk on the nest carrying the male and both might flutter occasionally, and in usually less than 10 minutes, another copulation occurred, to be immediately followed by the recommencement of the rhythmic abdominal movements accompanied by the antennal and wing movements.

The mating behaviour of offspring of *St. m.* 4 was not timed in any detail, but they were captured and, with one exception, preserved. The exception, III·1·(1), was painted and released. She was not seen again.

The pair I·1·(2) and I·2·(2) were discovered on 7/x mounted on the cell. Therefore we know that this tube also produced a male and a female simultaneously, but we do not know whether the male emerged from the upper cell and the female from the lower.

The pupae removed from tube I after the desertion of the nest lived long enough to be sexed. I·1·(3) (which died as a pupa) was a female and 1·2·(3) a male. (These are entered in both Tables 1 and 2.)

Therefore *St. m.* 4 laid 17 eggs in this nest, and 14 of her offspring emerged as imagines while she was still feeding their younger sibs. Of the offspring, 7 of the possible 8 from the upper cell, built later than the other and continuous with the chimney, are known to have been males, and 6 of the possible 9 from the lower cell built first and forming the belly of the tube are known to have been females. Of the unscored individuals one tube produced a male and a female but the order of emergence is unknown, one wasp emerged abnormally and was not observed, and one was only obtained as a larva without provisions. Thus, in this nest no exception was observed to the generalization that the eggs are laid in pairs of unlike sex, and so arranged by the mother that the male leaves the tube before the female.

Other Data on Emergences, Sex Determination, Development, and Behaviour

In the Bhubaneswar sample, previous to 4·I·(1) on 10/ix/65, emergences through the wall of the tube had twice been observed in 1·II·1·(1)

on 14/vi/63 and in 1·I·1·(?) on 19/viii/63. In the dissected sample, holes made by ten such flank emergences were found. Seven of these were from cells that contained remains of chrysidid cocoons ; of these six (16·III·1, B·I·1, B·II·1, K·I·1, O·III·1, and S·I·1) were in the inner cell of a tube, but one (K·I·2) was in the outer cell, the typical chimney opening of which remained sealed. Empty chrysidid cocoons were also found in 16·III·2, A·I·1, B·II·2, O·III·2, Q·III·1, and S·I·2. In these cells the mouth of the chimney was open and in Q·III the partition between the two cells was broken down.

However lateral emergence holes were observed in three cells in which no chrysidid vestiges were found. All these three were otherwise exceptional. Considering the hole in 13·II·1, the upper cell of the tube, 13·II·2, though sealed, contained no vestiges of a eumenid cocoon and therefore is presumed to have been sealed empty. It is interesting to speculate as to what stimuli prevented its occupant from waiting indefinitely for its absent tube-mate to make way for it. Two of its sibs, 13·I·1 and 13·I·2 were found dead in their cells.

Both the other wall emergence holes occurred in the same tube. Tube 10·III carried a large hole at about the centre of its length. Excavation revealed that this opened into both cells III·1 and III·2 and that the partition between these had been destroyed. If, as this suggests, both occupants of the tube came out of this single large hole, the wasp in 10·III·2 must have pupated facing in the wrong direction. Spurway *et al.* (1964) have recorded an example of this in the vault building sphecoid *Sceliphron madraspatanum*. As in both these species the egg is laid very early in the filling of the vault, it is difficult to suggest causes for such inversions.

Therefore though an individual of *Stenodynerus miniatus* can emerge through a hole in the wall, more commonly these holes are made by chrysidid parasites. Nest 7 reveals that the *Stenodynerus miniatus* mother need not react to parasitism by ceasing oviposition, as a mother of a *Eumenes* species usually does (Jayakar and Spurway 1965b, and in press, and unpublished observations). A *Chrysis* (*Trichrysis*) *mendicalis* Cam. was seen on nest 4, unfortunately while the female was absent, and this was captured before any oviposition was performed. However as this occurred on 15/x/65, this chrysidid was probably not the mother of the unknown wasp that left I·1 on 10/ix/65.

Considering nests other than 4, eleven outer cells (cell·2) contained males and none contained females, and ten inner cells (cell·1) contained females. The offspring of the only tube found which was not divided into two cells (18·I) was male. This latter tube was not architecturally abnormal, but it contained only one cocoon occupying its inner two-thirds, which contained the male pupa.

However, the laying of eggs in pairs, the female being older than the male, is confirmed as the rule in this species. The dissections have revealed that these females have completed most of their larval lives before the corresponding male egg of a pair is laid. The female of a pair was visibly more advanced in development at every stage until the pupae become fully coloured just before eclosion.

Four pairs have eclosed under observation. There was 3 days' difference between 2·I·1 and 2·I·2 in December, 1 day's difference in April for both the pairs from nest 5, and two days' difference for the pair from 17·III, which was surprising as May was hotter than April. Thus the synchronisation of the emergence from the mouth of the tube opened by the male is not due to synchronisation of eclosion due to different developmental rates, though there is evidence that the males develop more rapidly than the females, as is common among eumenines. In this species, the female, after eclosion, waits until the male leaves his cell and thus makes way for her. It is interesting to speculate what stimuli cause her to become active, and the circumstances in which wasps are found dead in tubes may provide evidence. Such waiting by the imagines developed from the inner, and therefore older, eggs for their younger siblings to eclose and emerge is again common among tunnel filling aculeates. In *Stenodynerus miniatus* it is exploited to almost ensure brother-sister mating.

Two other examples of pairing on the nest other than those described on nests 3 and 4 have been seen. Both were on nest 1 and both support the generalization that these synchronised emergences and pairings occur in the morning. One was observed on 23/viii/63 and timed from 09.24, when the pair was discovered mounted, until 11.15 when the male dismounted and flew away. The female also flew during the next minute. This has been referred to previously, and is described elsewhere (Jayakar *in press*). The second was on the same nest at 08.58 on 16/ix/63.

The ♂ of a species of *Subancistrocerus*, which may be an atypical member of *S. sichelii*, found dead in cell 16·II·1, provides evidence that *Stenodynerus miniatus* may re-use a nest after a period of desertion. This male was found in a lower cell and the upper was closed by curving round so that the mouth of this vault was occluded by the wall of the centre tube called I (because as in nest 1, it was apparently built first) (Plate, fig. 8). This abnormal closure may be the work of the *Subancistrocerus* mother and the space which table 1 schematizes as cell 16· II·2 may represent the space which, as we have mentioned, *S. sichelii* often leaves between the closure of the last cell and the plug in the mouth of the tube. This *Subancistrocerus* mother may have removed any *St. miniatus* or chrysidid silk which may once have been present. Both 16·III·2 and 16·III·1 contained chrysidid cocoons.

Cell 16·I·1 contained a eumenid cocoon but cell 16·I·2 did not. There was no partition between them. No egg was present in 16·I·1. Therefore the female *St. miniatus* captured facing out of cell 16·I·2 seems only to have entered the nest recently after a period in which it was squatted by a *Subancistrocerus* sp. It is not impossiblethat this female originally built these tubes and returned to them after they had been squatted by the other species, and after at least one generation of inhabitants had been parasitized. However, it is perhaps more likely that the female *St. miniatus* numbered 16 did not build the tubes with which she was found associated. If individuals of *St. miniatus* can utilize cells which they did not build themselves, this species resembles the African *Rhynchium anceps* Gribodo, which uses tunnels excavated by the same species, including the same individual, not removing the previous occupant's cocoon. In this digger vespoid the ovipositional rhythm observed suggests that such re-use is the rule (Roubaud 1916). Finally it is possible that *St. miniatus* may be found behaving as a typical squatter nesting in deserted cells of other species or even hollow stems and man-made cavities, i.e., having an ecology similar to that of the mass provisioning species *S. sichelii* but differing in that it practises progressive provisioning.

Desertion and Dissection of Nest 4

On 20/xi, after 11.50, when she sealed I, *St. m.* 4 was seen working in III repeatedly during the afternoon. However, she pernoctated in II and did so also during the nights beginning on 21, 24, 25 and 26/xi. She was apparently absent from the construct on the night beginning on 22/xi, and spent the night beginning on 23/xi in III. She was not otherwise seen in III. She had not been seen previously to work on two tubes simultaneously, nor had she been previously recorded as spending a night away from the construct. Both these behaviour patterns suggest that she did not lay in II until 24/xi, and this is confirmed by the stage of development of the larva observed on 29/xi. These changes in behaviour pattern can also be described by saying that she was becoming disorganized, and we were not surprised when we did not see her again after 07.34 on the morning of 27/xi. On 29/xi at 12.05, the construct was dissected (Table 1).

Discussion

The only references to similar species we have been able to find are to the larger *Ancistrocerus fukaianus* Schulthess referred to several times under the genus *Odynerus* by Iwata (1942) and a smaller Thai species reported as "*Odynerus* sp. No. 1 (van der Vecht)" in Iwata (1964,

p. 339) and in Yoshikawa's companion paper (1964, p. 398, Plate 12). This latter species, which Dr. van der Vecht informs us is closely related but not identical to *St. miniatus*, also builds on the wood work of outdoor roofs. The slightly larger vaults of these tubes seem more gourd-shaped and less cylindrical than in the Orissa species. In all the nests found, they were vertical. The contents of the tubes of the Thai species compared with the condition of the ovaries of the only working female dissected revealed that it performed progressive provisioning. Iwata uses the adjective 'subsocial'. He only watched provisioning of these tubes on one day, so he inferred from the maximum number of tubes in an aggregate that the species must produce on an average only 6 offspring, an apparent infecundity on which he commented. If the Thai species, like the Orissa species, re-uses her own tubes, she could also raise considerably more offspring than 6. Iwata (1964, p. 340) also reared specimens of the squatter species *Subancistrocerus sichelii* from tubes made by this species. The *Subancistrocerus* that uses tubes of *Stenodynerus miniatus*, though not certainly *S. sichelii*, is very similar and we consider that the parallelism in courtship, the brother-sister mating, the ecological interaction and superficial morphological resemblances between these at most three species which still makes us confuse them macroscopically (Jayakar *in press*), may be examples of convergence, and at least require explanation. The sphecoid *Trypoxylon pileatum* that competes with *S. sichelii* for the same size range of tunnels in our nest boxes was also found squatting in the deserted nest of *St. m.* 3 (Table 1).

Stenodynerus miniatus shows two unexpected features. The first, the re-use of cells built by herself, is harmonious with contemporary phylogenetic hypotheses. It is a mirroring of a behaviour that it is reasonable to hypothesise could have occurred in some ancestors of the social vespoids and, as would be expected, is associated with the intermediate condition of progressive provisioning.

In parenthesis, we would like to emphasise with Roubaud (1916) that the evolution of the capacity for *progressive* provisioning should be considered a separate step which necessarily preceded the evolution of the capacity for *simultaneous* progressive provisioning, and which, in the species discussed in this paper and many others, can occur alone. We are convinced by Roubaud's inductions that progressive provisioning, at first facultative, could evolve as an adaptation to inclement conditions which caused provisioning to be delayed. On its first appearance, any further eggs laid before the open cell was closed would presumably not receive the environmental requirements to develop, as observed and emphasised by Roubaud, and which we have described (*in press*) in *Eumenes campaniformis esuriens* (Fabr.) delayed by rain. Any

wastage of gametes seems itself to create a selection pressure to minimise such wastage, i.e. either the ovarian cycle would be brought under the control of external factors so that egg maturation would be delayed until a cell was prepared for it, or some behavioural capacity would be evolved to care for each egg as it was produced, the re-use of cells being one such adaptation. Such selection pressures would become more powerful once a population with compulsory progressive provisioning returned to a favourable environment. There must also be very general selection pressures favouring the supervision of any process at every stage, so that in the event of a catastrophe, correction may be made, or no further work need be wasted on it (Roubaud 1916). If progressive provisioning, and consequent wastage of gametes, initiated the evolution of simultaneous provisioning, this removes the difficulty expressed by Richards & Richards (1951) in explaining the evolution of simultaneous provisioning which they see merely as a *redeployment* of effort, and not providing any *economy* of effort. They suggest that some unexplained alternation of the ovarian cycle may have made it necessary.

The important consequence of the evolution of progressive provisioning for the evolution of societies is that the mother was still present on the construct when her offspring emerged, as we have described for *Stenodynerus miniatus*.

The second peculiar feature of *Stenodynerus miniatus* is, on the contrary, unharmonious with contemporary evolutionary theory. This species seems to have evolved the combination of three behaviour patterns to virtually ensure brother-sister mating, and, failing this, perhaps son-mother mating. The first is shown by the mother, who lays a female and then a male egg so that the male will walk out first. (This behaviour pattern is the rule among tunnel nesting eumenines.) The second is that this male offspring does not fly as soon as he has emerged as, for example, is the practice of members of the species of *Eumenes* (Jayakar & Spurway *in press*), but remains on the nest as do the social vespoids. However, unlike these, he stays for a fraction of an hour if necessary but, while present, actively stimulates any other wasp (his mother or his sister) who may be in any open cell and copulates immediately this becomes mechanically possible. Courtship performed by a male social wasp on the comb from which he developed is both rare and unsuccessful (Yoshikawa 1963). The third pattern is shown by the female offspring who, like many other eumenines, waits within her cell for 1 to 3 days after eclosion for her brother to make way for her, instead of emerging through the cell wall, which we know to be physically and behaviourally possible for this species. It will be important, but arduous, to discover the sex of the exceptional individuals who make these flank emergences.

We wish to emphasise that this compulsory brother-sister mating or adelphogamy seems effected entirely by these specializations, which are all exploitations or modifications of widely distributed capacities and which seem to have no other biological role for this species.

In several species of parasitic hymenoptera, not closely related, e.g. *Telenomus fariae* (Lima), Scelionidae (Dreyfus & Breuer 1944), and *Melittobia* spp., Eulophidae (Schmieder & Whiting 1947, Whiting 1947), son-mother and/or brother-sister matings are the rule. These take place in the confined space in which the imagines eclose, and in which another generation may be produced. Therefore the close inbreeding in these forms seems a secondary consequence of the parasitic habit. *Stenodynerus miniatus* and the morphologically similar, perhaps ecologically associated, *Subancistrocerus sichelii* are both common around human habitations, at least in some areas, so there is no reason to suggest that the behaviour patterns here described are adaptations to a difficulty in encountering a conspecific partner once the maternal nest has been deserted. Their evolution remains at present inexplicable.

In addition to the general disadvantages of close inbreeding which hold widely in the organic world, there are special reasons which make it unexpected in the hymenoptera. Whiting (1943) demonstrated in the braconid *Habrobracon juglandis* (Ashmead) that a diploid was female only if it was heterozygous at a precise locus, at which at least nine different alleles existed. If, by inbreeding, a diploid was produced homozygous for any one of these alleles, this diploid was a male, though non-functional and subviable. The haploid is apparently male because it cannot be heterozygous. The discovery of various mosaics confirmed the hypothesis. If this system were universal in the hymenoptera, some vestiges of the homozygous diploid zygotes would be found in broods of the species with intense inbreeding, probably as sterile eggs. These have been sought and are absent in the species of *Melittobia* studied. However Machensen's (1951) demonstration, that in *Apis mellifera* L. such sterile eggs in expected proportion are produced by inbreeding, once more makes it likely (Whiting 1947) that sex-determination based on complementary allelic systems, though not universal in the hymenoptera, may be generally distributed. It may perhaps be primitive, or a later specialization now characteristic of at least a large section of the group. If this is so, the discovery of any specialization which so far has no discernible biological role but to produce inbreeding in common free-living species with equality of the sexes (Jayakar & Spurway, 1966 and unpublished, for data on *S. sichelii*) becomes even more disquieting.

Summary

Data obtained from thirty-five nests of *Stenodynerus miniatus* are described and discussed.

A female (*St. m.* 4) was disturbed while mounted by a male on a nest of that species, captured, marked, and released on 13/viii/65. She was observed for 106 days and during this period built a nest containing three tubes of mud, each of which was divided into two cells. By the time she had sealed the third tube, the offspring of her first tube had emerged. She then re-used the first tube, and for the rest of the period during which she was observed, she re-used these six cells, laying 17 eggs, 14 of which emerged as imagines while she was attending to the nest. At each use of a tube, whenever we were able to observe the emergences, she laid a female egg in the lower cell and a male egg in the upper, i.e. the cell nearer the mouth of the tube, and the two offspring of these cells typically emerged from the tube together. The male walked out of the tube first and, as the female walked out, he immediately mounted her and copulation occurred, before they had left the construct.

The species is typically eumenine in its building movements and practises progressive provisioning with lepidopteran larvae and perhaps spiders. The laying of the eggs in pairs is the rule, but one exception has been found. *St. miniatus* may re-use a nest after this has been squatted in by another species.

Solitary species which possessed a similar habit of re-using cells while performing progressive provisioning may have formed a stage in the evolution of the social groups. The occurrence of virtually compulsory brother-sister mating is puzzling.

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Life History of the Indian Cuckoo, *Cuculus micropterus micropterus* Gould, in the Soviet Union[1]

BY

I. NEUFELDT

Zoological Institute of the Academy of Sciences of the U.S.S.R., Leningrad

(*With four plates*)

The Indian Cuckoo was described in 1837 by J. Gould from a specimen from the Himalaya. Twenty years later it was for the first time collected in Russia near Blagoveshchensk on the Amur by G. Radde. It was wrongly identified and recorded as *C. optatus* (Radde 1863), and was kept under this name in the collection of the Zoological Museum of the Academy of Sciences in Leningrad for many years. In 1928 Stegmann collected an adult male of the Indian Cuckoo in Amurland as the first record of the species. Later, working with the Museum collection, he 'discovered' Radde's specimen, and included this species in the bird-list of the U.S.S.R. (Stegmann 1930). It is to Stegmann and Radde that we are indebted for our first information on the habits, voice, and habitats of the Indian Cuckoo. Though rather scanty, these data were till now nearly the only source of information for authors of Russian ornithological handbooks and species keys. Very little was known of the breeding biology of the bird, and up to 1957 the eggs and nestlings of the Indian Cuckoo from the USSR were not described, its fosterers remained unknown, and even museum skins were rare in collections.

In the summer of 1957, 1958, 1959, 1961, and 1962 the authoress collected in Amurland new and interesting data which form the basis for the present paper on the life history of this bird.

DISTRIBUTION

Ignoring the incorrect views of Caldwell & Caldwell (1931), Buturlin & Dementiev (1936), and Belopolsky (1950) on the distribution of the Indian Cuckoo, its breeding range in the Soviet Union may be confined

[1] Following the majority of modern authors I accept the existence of only two geographical forms of the Indian Cuckoo: *C. m. micropterus* and *C. m. concretus*. Comparison of 30 adult birds from the USSR and China with Indian ones has shown that *C. m. ognevi* (Vorobiev 1951) is a synonym of the nominate form.

to Amurland from the valley of Burinda River in the west (Radde 1863) to at least the city of Komsomolsk in the east (Kistjakovsky 1959; Kistjakovsky *et al.* 1962). Within the limits of Amurland, where this cuckoo is recorded as a common and even numerous bird, its distribution at the breeding period coincides nearly exactly with areas having two zonal botanical-geographical complexes: broadleaved-coniferous taiga and broadleaved forest (Sochava 1957). The most northerly points of distribution of this bird in Amurland [the basins of Burinda, Olga, Ushumun, and Tu Rivers, the mouth of Selemdzha River, and Bureja River (Radde 1863); Stegmann 1930; Vorobiev 1951; Kistjakovsky & Smogorzhevsky 1964] nearly reach the northern limit of the most typical oak-larch, and oak-pine forests. In Ussuriland, the Indian Cuckoo is distributed sporadically and in small numbers, predominating in the west of the region. Some records come from the regions of the middle reach of Ussuri River and the lower reach of Bikin River (Vorobiev 1951; Leonovich, *in litt.*) and is also recorded from the lower reaches of Iman River eastward to Kartun village (Spangenberg 1965).

The main breeding area of this species is outside the limits of the U.S.S.R and embraces NE. China (Manchuria), the forest regions of the provinces Hopeh, Shansi, etc. extending southward up to Kwantung and Kwangsi (Vaughan & Jones 1913; Stresemann 1923, 1930; La Touche 1931; Meise 1934; Shaw 1936; Hoffmann 1950). The Indian Cuckoo is also known from Korea but its status there is not clear. Austin (1948) considers it to be an uncommon spring transient, but a few known records of this species (Kuroda 1918; Yamashina 1932) are consistent with its breeding irregularly in Korea. The Indian Cuckoo inhabits India (except the north-western arid regions), eastward to Assam, West and East Pakistan, and Nepal. It is widely distributed in Burma, Ceylon, and apparently in northern Thailand, and is found further south up to the Malay peninsula (Robinson & Chasen 1939; Deignan 1945; Phillips 1948, 1952; Smythies 1953; Ripley 1961).

Nearly everywhere within its breeding range the Indian Cuckoo is a typical migratory species, though in Ceylon and in some parts of India a part of the population is resident. In winter, apart from Ceylon, it is common in small islands in the Strait of Malacca, in the Philippines, Banka, and the Thousand Islands; it winters also in Sumatra, Java, and Borneo where *C. m. micropterus* occurs together with the smaller resident form, *C. m. concretus* (Peters 1940).

ARRIVAL IN BREEDING AREA

The Indian Cuckoo leaves its winter quarters very early. In Burma one may hear its characteristic call from the end of January or middle of February (Bingham 1880; Smythies 1953). In Thailand Deignan

(1945) recorded their song on 12 March. In Ceylon the Indian Cuckoo becomes active in March to early April; later, when all winter migrants have left the island for their breeding ranges further north, the summer resident Indian Cuckoos become inconspicuous. According to Hewetson (1956), in India in southern Madhya Pradesh the birds were recorded in March and in northern Madhya Pradesh in May. At the end of March their arrival was noticed in the north-East of the country, in Bhutan (O'Donel 1936); from the beginning of April, in northern Bengal (Storrs 1944; Lister 1954) and southern Bihar (Lowther 1949). In Punjab the earliest arrivals were recorded on 23 April (Whistler 1926). In Nepal the birds are common in April-May (Rand & Fleming 1957; Ripley 1950; Biswas 1960). In China in the second half of April these birds were noticed during their migration in Yunnan (specimens preserved in the collection of the Institute of Zoology, Academia Sinica). In Kwangtung these cuckoos were recorded in the first week of May (Vaughan & Jones 1913); in Fukien, in April; northwards in the provinces Hupeh, Kiangsu, Hopeh, Liaoning, and in north-eastern China, in May (Caldwell & Caldwell 1931; Shaw 1936). According to observations made by A. Hoffmann (1950) the first Indian Cuckoos in Nanking were noticed 28-29 April and in Peking nearly two weeks later, 11-12 May. In the vicinities of these cities these cuckoos were recorded somewhat earlier. Their arrival in 1944-1947 coincided with the appearance of the Blacknaped Orioles in the parks and gardens of Nanking and Peking and preceded by some days the arrival of Common Cuckoos. According to Piechocki (1958) in the suburbs of Peking at the beginning of May the voice of the Indian Cuckoo was not heard. Meise (1934) mentions a male shot in Manchuria near Dshalantun on 29 May. In Korea, in the west of Pyongan Pukto province, these birds were collected during 24-31 May (Kuroda 1918; Yamashina 1932). In Ussuriland (U.S.S.R) along the lower reaches of Iman River, Spangenberg (1965) recorded the earliest song during 27-29 May.

Males commence singing in winter and continue calling on their way to their breeding places. Among palaearctic birds no other species possesses a similar voice; that is why the arrival of the Indian Cuckoo cannot remain unnoticed and the date of the arrival of this bird can be recorded accurately to a day.

According to my records the species arrived on the Amur-Zeya plateau at the same time during five years. Thus, the first male call was recorded near Klimautzy village (NW. of Blagoveshchensk) in 1957, 1958, and 1962 on May 23 and in 1959-1961 on May 24, i.e. 4 days later than the date of arrival of the Common Cuckoo and 2-3 days later than that of the Himalayan Cuckoo. In 1957-1959 in May the weather was rather warm but cloudy, and drizzled occasionally. On the contrary in

1961-1962 the end of May was dry and sunny, and the night temperature fell to −5° C. The forest started to turn green : larch was covered with young needles, small green leaves began to come out on *Betula platyphylla* growing on the plateau along the sunny hill slopes ; oaks and rhododendrons broke into leaf; Dahurian Birch (*Betula dahurica*) burst into blossom and its buds swelled. On the first few days of their arrival the Indian Cuckoo males sing little. A strong wind and incessant rain, or a sharp fall of temperature or heat, exerted a negative influence upon their activity. Owing to the lack of food (caterpillars are few and small in size) in spring the Cuckoos had to spend much time in search of food. Single individuals were repeatedly observed awkwardly hopping on the ground in the most sparse and warmed parts of the forest, picking up insects on the leaves of the previous year, in grass, or on the surface of the ground. Apparently, on May 23-24 only the first males arrived ; females were absent till 25–26 May. From May 27 to 28 the number of males and females increased and the rise in their activity became noticeable.

Voice and Habits

In Chinese one of the names of this bird means ' four-syllabled cuckoo '. In fact, the very peculiar ringing song of the Indian Cuckoo consists of four sibilant, flute notes repeated one after another, a kind of *fju-fju-fju-fu*. The song is rather melodious and easily memorized. In the far east of the U.S.S.R, in China, India, Burma, and in other countries of south-eastern Asia where the Indian Cuckoo is met with during its breeding or non-breeding time, the local people know this song very well and readily recognise it. Without going into particulars since it was done in detail by A. Hoffmann (1950), I would like to repeat that in the majority of the Asiatic languages the name of this bird has an onomatopoeic etymology (Whistler 1926; Baker 1927 ; La Touche 1931 ; Burton 1935 ; Shaw 1936; Ali 1953 ; Smythies 1953 ; etc.). Abdulali (Ali & Abdulali 1938) likens the song of *C. micropterus* to the voice of *Pomatorhinus horsfieldi*.

As in the Common Cuckoo, males of the Indian Cuckoo have individual differences in the key and timbre of the call. Being always four-syllabic, the song may be dull and rough, or clear and ringing. In Amurland the voices of individual males in the majority of cases differed so much that it was rather easy to recognise them and to trace the movements of individual birds all over the territory.

In the south of the Amur-Zeya plateau Indian Cuckoos could be heard all day in the breeding season. In June and the beginning of July the birds did not cease singing even at night. According to my observations, at the end of May and the middle of June males began to

sing before dawn, at 2-2·30 a.m. They sang at intervals which apparently coincided with the feeding times. At 18-18·35 p.m. the birds were active again. Many individuals did not cease singing after sunset. Within the breeding season even prolonged rain accompanied by strong wind did not affect the time and intensity of the singing. It seemed to me that on warm rainy days they called more readily. On the contrary, the long summer drought of 1962, so unusual in Amurland, rather oppressed the birds : some males nearly stopped singing in June, others were heard only early in the morning, at dawn when the air was more humid. However, the recession and rise of activity of Indian Cuckoos depends to a greater extent on their breeding cycle than on the weather. On days preceding copulation and on the days when it takes place males and females are very excited and call often. With the beginning of egg-laying Indian Cuckoos are nearly always silent in their breeding territory.

A male usually sings perched at the very top or on a lateral branch of a high larch or pine tree; sometimes it settles in the crown not far from the main trunk of the tree. Each individual has a favourite place for singing, usually a tall tree. Some other birds living in the neighbourhood (Common Cuckoo, Indian Jungle Nightjar, Eastern Turtle Dove, Whitethroated Rock Thrush, Chinese Greenfinch, migratory Chinese Grosbeak, etc.) show a preference for the same trees. Thus, on 7 June a male of the Indian Cuckoo sang at the top of an old pine three times, from 4 a.m. to 7 a.m. (once with a female), and a male of the Common Cuckoo was heard on the same tree twice. Loud calls of the Indian Cuckoo are audible more than one kilometre away. As distinct from the Common and Himalayan Cuckoos, which before and after cuckooing utter some additional sound, the Indian Cuckoo has no other sound but the main song. While singing the male slightly hangs its wings. When displaying before a female, at the moment of highest excitement, the male spreads his tail in an erect position, slightly moves it from side to side, and begins to call louder and rapidly. Often a male calls even on the wing when chasing the female.

The nuptial call of females is composed of an interrupted warble greatly resembling that of the Common Cuckoo female, but some tones higher. Unlike the male the female is very seldom seen. Usually she hides in a tree crown or perches rather often on a bough like a nightjar and is very difficult to notice. Whereas the male prefers to keep to the very tops of tall trees, usually coniferous ones, a female shows a definite preference for the middle and the thickest part of a tree crown and does not avoid leaf-bearing trees. A cuckoo-hen calls in full measure only when flying; when perching it utters a short and muffled warble.

When frightened or disturbed, Indian Cuckoos instantly fly a long

way off, never to the nearest tree as many other forest birds do. On the wing, the Indian Cuckoo can be easily distinguished from the Common and Himalayan Cuckoos by its fuscous-brown purple-glossed mantle plumage, broad widely-spaced transverse bars on the breast, and short rounded wings (hence its name *micropterus*). Its flight resembles much that of *C. canorus*, but is more swift, with frequent flapping of wings.

Nearly all ornithologists who have had an opportunity to watch the Indian Cuckoo in the Far East have noted its extreme shyness. In my first expedition to Amurland I had the same experience (Neufeldt 1959), in the summer of 1957 I was lucky to shoot one female, and in 1958 with equally great effort two males. In the years that followed, when collection was not so keen and attention was directed to the study of the biology of the bird, we found that it is no more shy than the well-known Common Cuckoo but considerably more mobile. The fact is that the female Indian Cuckoo is constantly moving over its territory, and so accompanying males continually change their singing places. Besides, the male-cuckoo regularly visits every part of its territory singing by turns at set perches. The intervals between such flights are short, usually less than the time the observer must spend for concealment and subsequent watch for the bird. In the meantime the male (the main partner is meant), after flying round the territory, returns again to its original place. Thus, if you know the routes and favourite trees of an individual bird you can judge beforehand where it can be met. It is of interest that males of this species choose the same trees not only within one season but during several years. Keeping this in mind, in the summer of 1962, without any reconnoitring I installed the microphone on the top of an old high pine which was often used by Indian Cuckoos in 1957 and 1958 for singing, and in 40-50 minutes I made a rare tape-recording at short distance of this wonderful bird's voice. We found ourselves misled at times because a male that is not very excited has the habit of interrupting his song without leaving the tree. During such a pause another bird may start singing not far away and when he stops the first starts afresh. Thus, males do not sing in chorus but call to one another. Only when a female appears do the males call all together.

As mentioned earlier Indian Cuckoos begin to sing as early as January in their winter quarters and stop when the breeding season is over. In the south of the Amur-Zeya plateau at the beginning of July their singing was not so intensive and was confined in general to early morning and late evening. In the limits of the territory under study solitary males could be heard up to 8 July in 1957, 10 July in 1958, 6 July in 1959, 11 July in 1961, and 12 July in 1962. In those years Common Cuckoos sang somewhat later, up to 23-25 July. According to Hoffmann's observations in Peking and its environs also, the Indian Cuckoo sings

seldom and one at a time, in mid-July. In India, according to Baker (1927) their calls were recorded before July. Storrs (1944) registered their last song in Bengal on 31 June. In Thailand these birds whistle up to 7 June (Deignan 1945); in Burma up to June (Smythies 1953); in Ceylon, where the breeding takes place during the winter-spring months, the Indian Cuckoos sing before May (Phillips 1948). The cessation of singing does not mean that the birds have left the breeding area.

Breeding Habitats and Numbers

The distribution of the Indian Cuckoo during the breeding season depends, as in other parasitic birds, on the distribution of its main fosterers. All Passeres, supposed or known to be foster-parents of the young cuckoos, inhabit sparse portions of forests or old parks. The Indian Cuckoo is also a typical forest inhabitant. In Thailand, for instance, the birds keep to both evergreen and pine forests (Deignan 1945). In India at the breeding period this cuckoo is common in forests at elevations about 1500 m. above m. s. l.; in the Himalayas it occurs sometimes up to 2700 m. (Baker 1927; Brooks 1875; Whistler 1926; Hewetson 1956). In China in Hopeh province the Indian Cuckoo lives in forest regions (Shaw 1936). According to Hoffman's (1950) information, in Peking and Nanking it is very abundant in gardens and parks as well as in neighbouring hill forests. In Manchuria it prefers leaf-bearing and mixed forests. Favourite habitats of the Indian Cuckoo are mentioned by Spangenberg (1965) to be sparse plantings of old birches, oaks, and maples, and other leaved trees covering hills. Vorobiev found this bird in Ussuriland in oak-groves on small hills; Kistjakovsky (1959, 1962) met them not far from Komsomolsk on the Amur in larch taiga. In the western part of Amurland the main biotope of these birds is old pineries with an undergrowth of dwarf oak, growing on hills and along the Amur River bank (Stegmann 1930). At a distance of 40 km. from the Amur River Stegmann met this cuckoo in oak-groves together with the migratory Chinese Grosbeak and the Grey Minivet. Radde (1863) writes that he observed the bird on high pines in the plains between Burinda and Olga Rivers.[1]

According to my observations near the town of Svobodny where larch trees are very abundant in neighbouring forests, Indian Cuckoos at breeding time are confined to stunted oak-larch forests, influenced by fire and cutting. Such forests usually occupy the plateau and its slopes of various steepness and exposure. The Dahurian Larch (*Larix dahuricus*) forming the upper canopy is represented here by very high solitary trees

[1] All Radde's observations on this species are described under his review of *C. optatus*.

usually with dead tops. Occasionally, generally on southern slopes, there are old pine trees. In the second canopy Mongolian Oaks and Birches (*Betula platyphylla* and *B. dahurica*) dominate. The undergrowth is well developed and comprises in general the Hazel, Lespedeza, and Dahurian Rhododendron. In more humid places the admixture of alders and willows is rather significant. Brush and grass cover is rich and variable. On the ground there is plenty of wind-fallen wood and dead twigs. Such parts of the forests represent in general, clearings at different stages of secondary growth and are favoured breeding places of the Amur Brown Shrike, the density of whose population here is 0·5-1·0 and even 2·0 pairs per hectare. In the Shimanovsky district (environs of Simonovo village) the larch is nearly absent. Here the Indian Cuckoos inhabit oak-pine forests with Rhododendron and Lespedeza. Such forests cover terraces of narrow forested valleys and flat elevations. The upper canopy is composed of solitary old pines, in the second canopy oaks and birches prevail. The undergrowth is dense and composed of undersized oak trees, Rhododendron, and Lespedeza. Oak-groves without admixture of high coniferous trees, and very dense deciduous and pine forests without clearings are avoided by this bird. The abundance of Amur Brown Shrikes (*Lanius cristatus confusus* Stegm.), the regular fosterers of the Indian Cuckoo in the Amur-Zeya plateau (Neufeldt 1963), and the presence in both the above mentioned biotopes of the high pine and larch trees, on which male cuckoos perch for singing, make the conditions favourable for the breeding of the cuckoos.

The arrival of Indian Cuckoos at their breeding places in Amurland coincided with the time of pair-formation and occupation of nest sites among the Shrikes. On returning from winter quarters male cuckoos kept to biotopes situated immediately near the nesting ones. By the end of May territories of the cuckoo-hens were distinctly demarcated. One female controlled an area inhabited by 25-30 pairs of shrikes; thus the range of the individual cuckoo's area depended on the population density of the host species. In years when numerous areas of secondary growth provided a high concentration of shrikes, an area of 100-125 hectares in the environs of Klimautzy village (Amurland) was constantly inhabited by Indian Cuckoos: 1957—2 ♀♀, 4 ♂♂; 1958—2 ♀♀, 3 ♂♂; 1961—1 ♀, 2 ♂♂; and 1962—2 ♀♀, 3 ♂♂. (Cases in which territories occupied by the females overlapped have not been taken into account). Very often, due to rugged terrain with complicated network of forest valleys and diversity of plant associations, the territory occupied by one cuckoo-female was considerable and separated into isolated parts situated as much as 100-300 metres from each other.

The associates of Indian Cuckoos and Amur Brown Shrikes inhabiting the same biotopes were Gray's Grasshopper-Warbler, Thickbilled Warbler, Rubythroat, all rather common and numerous in the under-

growth, and the scarcer but still typical forest dwellers, such as Radde's Bush-Warbler, Indian Tree Pipit, and Masked Bunting. Occasionally nesting migratory Chinese Grosbeaks could be seen. The abundance of open-nesting songbirds attracted Common Cuckoos to these biotopes. All the forest valleys were occupied by the Great Spotted Woodpecker, Whitebacked Woodpecker, and Tits.

Long-term observations on Indian Cuckoos undertaken at one territory have shown that these birds are confined to definite parts of the forest and even to individual trees. Unfortunately, I was not able to ring Cuckoos and so to establish individual identity. The return of Common Cuckoos to the same area over a number of years has been proved beyond doubt (Makatsch 1955).

Breeding

As stated above, in the territory under observation a preponderance of males over females was noticed every year. The literature shows that this phenomenon, characteristic also of the Common Cuckoo, has contributed to the widespread opinion that the parasitic cuckoo is polyandrous and female mates with several males visiting her territory. On the contrary, some authors (e.g. Harbϕ & Moebert, cit. Makatsch 1955), on their own long-term observations, have concluded that in the breeding period Common Cuckoos live in pairs. Now we have data indicating that the excess of males over females is not invariable. Thus, Malchevsky (1954) records an equal correlation between sexes or even an excess of females over males. So polyandry seems unlikely. This problem can be solved only by ringing or otherwise marking the birds and making a special study on the composition of their population.

I give below some results of my stationary visual observations on the Indian Cuckoo and state my opinion on its breeding habits. I would premise that, as regards males with distinctive voices, I was dealing with 'marked' individuals.

At the height of the breeding season one female is fo owed bv 1 or 2, sometimes 3, males who frequently visit her territory. But only one male is believed to impregnate her. This male is most often seen near her. On the day of copulation the female's 'chuckle' is heard very often and she repeatedly changes her place flying from one end of the territory to another. It is very significant that in this period the hen's call is a reciprocal reaction to the song of the 'favoured' male, who judging by his activity is considerably more excited than other males in the vicinity. I saw repeatedly the 'favoured' male try to drive out the other males, who apparently took no part in breeding. When laying eggs the cuckoo-hen is especially cautious and silent. But the male is sometimes heard or seen nearby. He flies openly and diverts to some

extent the attention of host-species, thus making the female's task easier. It thus appears that during the breeding season Indian Cuckoos live in pairs. Brood parasitism involves an escape from the chief duties of raising a family : building the nest, incubating the eggs, and rearing the young. Thus the duties of mates become minimal, being limited to the selection of the breeding biotope and its protection, to a timely search for fosterers' nests, and egg-laying. The relation between mates is not so stable as in non-parasitic species of cuckoos, but the female always shows a preference for a definite male and he becomes her partner for the breeding season.

The ' superfluous ' males who occur in the territory are, seemingly, one-year old birds come from their winter quarters to the area where they hatched and grew up. Nearly half of the singing Indian Cuckoo males collected in Amurland had, in varying number, unmoulted juvenile secondaries and greater coverts, a fact that indicates a considerable proportion of young males in the population. Owing to the generally unequal correlation of the sexes that is observed in nature, not only in cuckoos but also in many other birds, a number of males (particularly young and less experienced birds) remain unmated in their first year. In regions with great density of population, where several females' territories are contiguous, unmated males in moments of great excitement pursue more than one female. Such a pursuit is common even in birds living in constant pairs. In many perching birds, woodpeckers, and birds of prey, not only unmated but also paired males are lured from their territories by the voice or the display of a female from another pair. Several times I observed the nuptial call of the Indian Cuckoo female attract Common Cuckoo males, but this fact does not prove that Indian Cuckoo females mate with males of another cuckoo species. The idea of polyandry in these birds is, I think, groundless. Finally, I would like to note that the impression of a numerical excess of males over females among cuckoos is probably due to the impossibility of observing all the female cuckoos in an area during a short trip.

The Indian Cuckoo is a typical nest parasite, like the other eleven species of the genus *Cuculus*. Though about two hundred host species of the Common Cuckoo are known, for the Indian Cuckoo only isolated trustworthy records are available. For example, the Azure-winged Magpie, *Cyanopica cyana*, is one of the commonest hosts of the Indian Cuckoo in Peking and its environs (Shaw 1938, 1940; Hoffmann 1950). In northern Bengal this cuckoo's eggs were found in the nests of the Drongo, *Dicrurus macrocercus* (O'Donel 1936; Storrs 1944), and in Sikkim in those of the Spider hunter *Arachnothera magna* (Gammie 1877). In Ceylon the Ceylon Blackheaded Oriole, *Oriolus xanthornus ceylonensis*, is probably a foster-parent of this cuckoo (Phillips 1952). The majority of the data, however, is based on guess-

work and supposition and needs confirmation by observed fact. Sometimes having found an egg ready for laying in the oviduct of a dead bird, ornithologists have tried to determine the host species by matching the colour of the egg's shell. Sometimes an abnormal egg in the nest of a songbird, which differed from the others in shape, size, or colour has been referred to some species of cuckoo. Lastly, some authors have listed as host species of the Indian Cuckoo birds among whom the appearance of the cuckoo near their nest caused anxiety (Rattray 1905; Vaughan & Jones 1913; Nehrkorn 1910 *cit.* Makatsch 1955; Hoogerwerf 1949, *cit.* Makatsch 1955, Spangenberg 1965). In the above mentioned works Drongos (*Dicrurus* and *Buchanga*) are mentioned most often as the host-parents of the Indian Cuckoo.

In the U.S.S.R., in Amurland, the egg of the Indian Cuckoo was first found by me in the nest of the Amur Brown Shrike in 1957. The astonishing similarity in the coloration of the eggs of the two species, as well as an obvious adaptation of Indian Cuckoos to the nesting-biotopes of the shrikes in the investigated territory, had long since suggested that the connection between these two species is not accidental. The additional material collected by me in the same region of Amurland now enables me to state quite definitely that this species of shrike is the main, and apparently the single, host of the Indian Cuckoo in this part of its range. Further avifaunistic investigations in our Far East will possibly add to the list of birds fostering Indian Cuckoos. It is not impossible that in the Amur flood-land, as in China, these birds parasitize the Azurewinged Magpies, and that, south of this river, there are nests of the Amur Brown Shrike with eggs of Indian Cuckoos in them. Hoffmann (1950) has mentioned this shrike as a possible foster-parent of the Indian Cuckoo in the parks of Peking.

The breeding period of this cuckoo is correlated with that of its main fosterers. At the end of December, near the southern borders of the breeding range, in Ceylon, Phillips (1948, 1952) found in the nest of the Blackheaded Oriole an egg which is supposed to have been laid by an Indian Cuckoo, and at the beginning of May he obtained a fledgling of this cuckoo. In different regions of India the egg-laying takes place from March-April till May-June (Baker 1927; Jones 1941; Storrs 1944; Ali 1953). Northward, in Peking and its environs, the breeding takes place in general in June. Shaw (1938) reports, for instance, the finding of a week-old cuckoo in the nest on 25 June. Hoffmann (1950) observed young Indian Cuckoos able to fly well in 1946 from 31 July to 16 August, in 1947 from 19 July to end of the month.

In the south of the Amur-Zeya plateau fresh eggs were found in 50 nests of Amur Brown Shrikes from 6 June to 30 June. Some individuals were building their nests till the middle of July. In all the cases known to me Indian Cuckoo eggs were laid also in June at the time of

the intensive breeding of the shrikes. Thus, on 8 June 1957 a cuckoo-female was obtained just after she had laid the second egg of that season (apparently the first egg was laid on 5 or 6 June); on 12 June 1962 a shrike's nest was found containing a fresh cuckoo egg, the nestling hatched on June 22 (the clutch was apparently laid on June 11); on 12 June 1961 I watched for a long time a female Indian Cuckoo try, though unsuccessfully, to enter the nest of a shrike; on 4 August 1959 I obtained a 40-day old Indian Cuckoo, and on 26 July a fledgling whose age was estimated as about 30 days (both could have hatched from eggs laid in the middle of June); on 28 June 1962 a nest was found with a fresh cuckoo egg, the nestling hatched on June 9. The gonads of all male Indian Cuckoos shot at the height of the breeding period (7-27 June) were of equal size, measuring in mm.: 4·0×4·0-6·0×4·0, and 4·0×3·7-5·0×4·0.

Nearly 75% of the Amur Brown Shrikes nests observed in Amurland were built on the ground, the rest at a height of 0·5-1·9 m. above the ground in bushes and trees. The Indian Cuckoo parasitized nests of both types. Its eggs were twice discovered in nests situated on the ground in dense grass and once in a nest built in the crutch of a willow bush. When looking for the nests of shrikes, females of the Indian Cuckoo as well as those of other parasitic species are guided in the first instance by the behaviour of the fosterers. The singing of male shrikes, which is usually accompanied by typical displays, as well as the loud call notes of these birds attracted the Indian Cuckoos to their nest. Later, cuckoo-hens watch the birds in the process of nest-building or discover their nests by the alarm-calls or behaviour of the host. To begin with, cuckoos apparently discover the less disguised nests and the nests of those individuals who by their high excitability and carelessness attract the cuckoo's attention.

On 12 June 1961 I watched a female Indian Cuckoo, perched in the low branches of an old larch on the outskirts of the forest, looking very attentively at a thicket near which a male shrike frightened by me was flying. For a long time she remained unnoticed, but the moment she made a careless movement the shrike noticed her. With a loud call he attacked her and pressed the attack till she left the territory. So the nest built in a heap of dead branches and containing a fresh clutch was not discovered by the cuckoo.

When laying in a nest found beforehand the cuckoo-hen acts with confidence and most persistently. Thus on 8 June 1957 during a trip my attention was attracted by a male shrike flying in agitation near his nest containing fresh eggs. Through binoculars I could make out that he was trying to drive away a rather large bird, an Indian Cuckoo female, perched on the branch of a dry willow bush. In 15-20 minutes the cuckoo flew on to a fragment of a larch branch lying on the ground at

Neufeldt : Indian Cuckoo

Above : Nest with complete clutch of Amur Brown Shrike eggs and one Indian Cuckoo egg ; *Below :* Two-day old nestling of Indian Cuckoo in the nest.

(*Photos : I. Neufeldt*)

Neufeldt : Indian Cuckoo

Above : Amur Brown Shrike female brooding 7-day old Indian Cuckoo ; *Below :* Same bird with food for young cuckoo.

(*Photos : I. Neufeldt*)

1·5 m. distance from the nest. The frightened female shrike immediately left the nest and joined her mate. Looking round but paying no attention to her attacking hosts the cuckoo reached the nest. In 20-30 seconds she flew away from the nest leaving her egg there.

Complete clutches of the Amur Brown Shrike consist usually of 6-7 and sometimes 4-5 eggs, in some nests we found only 3 eggs—the last apparently a case of second laying. In one nest containing 6 eggs, an Indian Cuckoo laid her egg, leaving host's clutch untouched. In two other nests used by these cuckoos we found only 3-5 eggs. It is difficult to say whether cuckoos were to blame or they had laid their eggs in nests with incomplete clutches. It is of interest that, analyzing the stomach contents of Indian Cuckoos collected in China, Shaw & Liu (1940) found the shells and inner shell membranes of a bird's egg. Apparently, this cuckoo as well as the Common Cuckoo sometimes carry off and swallow eggs from their fosterers' nests. In all cases known to me Indian Cuckoos laid their eggs in nest which contained full fresh clutches. Judging by the behaviour of the cuckoos in their territory and by the changes in the activity of males and females during the breeding season the eggs are normally laid at intervals of 1·5-2 days. I do not know the number of eggs laid by one female in one summer, but I think this species lacks the high fertility usually attributed to Common Cuckoo females. If one Indian Cuckoo female could lay 25-20 or even 15 eggs in a summer, at least every second shrike nest examined by me should have contained a cuckoo egg, but actually it was otherwise.

The Indian Cuckoo eggs found in the nests of Amur Brown Shrikes are mimetic. In two cases they practically did not differ in pattern, coloration, and shape from fosterers' eggs. They had a dirty-white, slightly greenish ground colour with beige surface and deeper grey spots and speckles concentrated near the blunt end of the egg thus forming a nimbus-like thickening (Plate I, *above*). The third egg found in the shrike's nest had a pink background mottled with darker greyish brown spots and somewhat different in coloration from the two preceding eggs. Thus, in Amurland according to the coloration of the eggs Indian Cuckoos may be arranged in two groups corresponding to the two types of pigmentation of their fosterers' eggs. In general, the eggs of these cuckoo parasites of the shrikes resemble by coloration the eggs of Azurewinged Magpies, Drongos, and even Streaked Spiderhunters, birds known as Indian Cuckoo host-species in other parts of the area. The eggs of the Indian Cuckoo are larger than those of the Amur Brown Shrike, the measurements (in mm.) being:

Nest No. 1—*Shrike*: 20·0 × 17·0 (2), 21·5 × 16·7, 21·6 × 17·0, 22·0 × 17·2, 23·0 × 17·0, average 21·4 × 16·98; *Cuckoo*: 25·0 × 19·0.

Nest No. 2—*Shrike*: 23·0×17·0, 23·5×17·0, 23·5×17·5, average 23·3×17·1; *Cuckoo*: 26·0×20·0.

Nest No. 3—*Shrike*: 20·5 × 16·5 (3), 21·0 × 16·5 (2), average 20·7×16·5; *Cuckoo*: 25·0×19·5.

The shell surface of fresh Indian Cuckoo eggs is matt but on hatching it acquires a faint lustre.

In all cases known to me shrikes did not notice the increase of the number of eggs in the nest and readily accepted the larger and roundish cuckoo eggs.

Indian Cuckoo eggs hatch in about 12 days, whereas the shrike eggs require 14 days. The cuckoo nestlings always hatch before the fosterers'. The hatching sometimes lasts long. Thus, in one nest cracks on the cuckoo-egg were recorded on 8 July at 18 hrs. and the chick emerged only between 9 and 10 hrs. on 9 July. Whenever cuckoo-females laid their eggs before midday, usually in the morning, the hatching also took place in the morning.

The newly-hatched Indian Cuckoo chick is blind and naked, with closed acoustic ducts; skin on the body, bill, nostrils, and legs yellowish pink; tongue (except the very tip) and inside mouth orange-red; commissures of the jaw and tip of the tongue yellow—even at this age the chicks differ from Common and Himalayan Cuckoos' chicks in having a lighter tip to the tongue. Immediately on hatching, the chick weighs 4·7-4·9 gm.

In the one-day old chick the acoustic ducts are open and the skin on the dorsal part of the body and on the legs is darker. The two-day old is very limp and lies cheeping quietly at the bottom of the nest (Plate I, *below*). Only on strong tactile irritation of the rump skin does the blind nestling strike a rather typical ejection attitude: stands up with legs wide apart, throws its wings well back, and bends its neck down setting the top of the head against the nest bottom. Contact with eggs or newly-hatched fosterers' chicks does not cause this reaction. The actual ejection takes place on the third and partly on the fourth day; after this period the 'overboard' instinct gradually disappears.

On the third day in the region of the future remiges and rectrices there appear hardly visible 'hairs', which may be regarded as rudiments of ancestral nestling 'down'. It is known that only non-parasitic cuckoo-chicks (*Centropus*, *Geococcyx*, *Coccyzus*, etc.) have 'down'. Shelford's (1900) investigations have shown that these thread-like structures (trichoptiles) are not down, but abnormally elongated apexes of horny sheaths enveloping growing feathers. With the growth of a feather papilla trichoptilia lengthen as well. When feathers begin to unfold the trichoptilia break off. I think that the degeneration of the thread-like structures in parasitic cuckoo nestlings is of an adaptive nature, tactile receptors in a naked skin being more sensitive and easily provok-

ing a reflex act of ejection. On the fourth or fifth day appear the first feathers on the nape and shoulders, and then on the forehead, ulnar, carpal, and femur regions; the eyes half open; the skin of the dorsal surface of the head, body, and wings as well as the bill and tip of the tongue grow darker and become dark-grey with a violet shade. Now the Indian Cuckoo chick differs very well from those of the Common and Himalayan Cuckoos, not only in tongue colour but also in the colour of the feather sheaths, the tapering apexes of the undeveloped feathers being beige or pale-yellow in colour in the Indian Cuckoo while in the two other species they have white or slightly greyish distal poles.

In the 7-day old Indian Cuckoo the eyes are entirely open, feather papillae grow over all the pterylae except the dorsal one, the caudal portion of the ventral one, and some parts of the head (Plate II, *above*). The week-old juvenile weighs eight times the newly hatched one. It is still poikilothermal and is constantly brooded by the host-hen. While sitting in the nest the cuckoo cheeps quietly and even when hungry does not utter loud calls. Sometimes it tries, though rather clumsily, to preen.

On 8th day the feathers on the nape, shoulders, thighs, and greater wing-coverts begin to unfold; the eyes are entirely open, though in the nest the chick prefers to keep them closed; the bill flanges, nostrils, and the tip of the tongue become black. The nestling weighs 40-45 gm., i.e. more than an adult Amur Brown Shrike. The length of the second primary is 13-15 mm. and the second rectrix 5-6 mm.

By 9-10 days of age nearly all the feathers emerge from their sheaths; there remain in papillae only the feathers on the crown, the forehead, and the rump, corresponding to the parts of the body with high sensitivity in the 2- to 3-day old nestling. The wing-coverts as well as the first feathers on the nape and thigh have rather large vanes. The skin on the dorsal, the most exposed side of the body is dark, whereas abdominally it is a pale pinkish yellow.

At the approach of a man the 10- to 11-day old cuckoo produces some threat gestures: ruffles its feathers on the head, opens its wings, raises the tail, and tries to peck. The foster parents still continue to brood the nestling.

12-day old chick weighs 73-75 gm., the second primary is 41 mm. the second rectrix 24 mm. All feathers unfold; only the lores and feathers near the orbital ring remain in sheaths. From the age of 12 days regular brooding of the nestling ceases. When its shrike-hosts are absent the young cuckoo sits very quietly in the nest, sometimes preening, raising, and stretching itself. It constantly cheeps without opening its bill. When hungry it screams out its shrill *tu-fju*. On hearing or seeing its foster-parents approaching with food the nestling calls louder, opens its bill, and shakes its wings (Plate III, *above*). At the moment of

taking the food the cuckoo-chick cheeps and trembles all over. In general, all vocal reactions of the young Indian Cuckoo are very similar to those of the young Common Cuckoo but somewhat muffled and low. The female shrike for some unknown reason fed the chick of the Indian Cuckoo less willingly than the males did. Sometimes they did not feed them at all. In such cases young cuckoos readily recognized the male bird and responded only to its calls. Usually, in the nestlings of the Indian Cuckoo and of many passerine birds, each discharge of excrement is enclosed in a gelatinous capsule (faecal sac) so that it can be removed by the parents. It is of interest that the droppings of nestlings of the non-parasitic cuckoos are not encapsuled. However, you have only to touch the Indian Cuckoo chick or take it in the hand for it instantly splashes you over with a large excretion of brown stinking liquid. Thus, at this age the young cuckoo is capable of actively protecting itself from enemies.

When 14 days old the Indian Cuckoo is rather well feathered (Plate III, *below*) though the bases of all the feathers are more or less concealed in feather sheaths. When in the nest the young cuckoo closely watches its foster parents bringing food and actively gets the food from them. It was quite indifferent to calls of the male and female Indian Cuckoos. When the shrikes are out of the nest it raises, stretches, and cleans itself.

On the 18th day the young cuckoo tried to perch on the edge of the nest. When three weeks old it left the nest and perched on a high stump (Plate IV); the remiges, rectrices, and the majority of the small feathers had not reached normal length and the cuckoo was not capable of active flight. Its weight after leaving the nest was 90 gm.

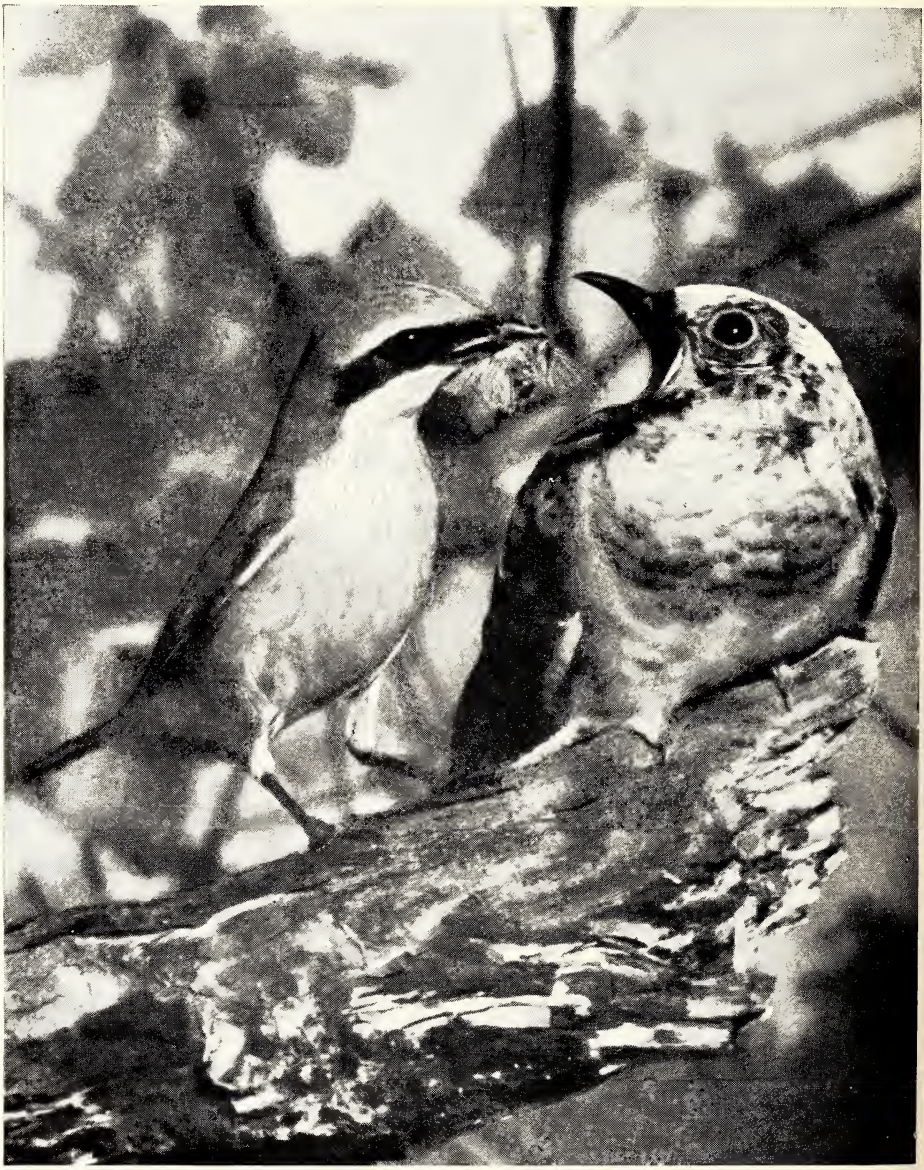
In captivity the Indian Cuckoo chick grows to adult size and acquires the complete juvenile plumage at the age of 45 days (Shaw 1940). According to my data the 30-to 40-day old cuckoo is airborne and does not differ from adults in size, but still continues to beg for food from the foster parents. From shrubs growing on the edge of the forest or from the glade where it hatched and grew up, the chick now moves into the heart of the forest. The shrikes follow it rather unwillingly in this change from their habitual biotope and try to lure it out in every possible way. When hungry the cuckoo flies to the forest edge and perches on a low branch or stump, where it receives food. When perching or flying the juvenile Indian Cuckoo utters in succession low and rather tuneful calls, a kind of *tu-fju, tu-fju*. At the moment of feeding it utters sounds resembling the hunger cry of the foster parents' chicks. Flying from place to place a frightened young cuckoo produced a loud ringing warble resembling that of the juvenile Common Cuckoo. Fledglings of the Indian Cuckoo at the age of one month weighed 119·5 and 127·0 gm., the same weight as adults. The weight of adult birds collected in

Neufeldt : Indian Cuckoo

Above : 13-day old Indian Cuckoo begs for food ; *Below :* 14-day old Indian Cuckoo in Amur Brown Shrike nest.

(*Photos : I. Neufeldt*)

Neufeldt : Indian Cuckoo



Young Indian Cuckoo newly out of nest being fed by foster-parent, an Amur Brown Shrike.

(*Photo : I. Neufeldt*)

Amurland was as follows: ♂♂ 112·0, 114·0, 115·0, 120·0, 124·0, 129·0 gm.; ♀ 119·0 gm.

The coloration of the Indian Cuckoo's juvenile plumage is so peculiar that young birds of this species cannot be confused with the chicks of any other cuckoo. The difference from the adult plumage is the absence of pure white colour and of various grey tints, and in the predominance of dirty cream, isabelline, dark-brown, and ferrugineous shades. The plumage of the upper part of the head (besides the crown), hindneck, and throat is basally black with broad isabelline apical bands. On the forehead, along the mouth, and around the eyes and ear-coverts the feathers are entirely black with a light base and black apex. The lower throat of the juvenile is also black with considerably longer covering feathers and has an additional black stripe against an isabelline background. By such coloration of some feathers in the lower part of the lower throat sparse transverse bars are outlined and the lower throat itself looks considerably darker. The plumage of the belly has a pure isabelline coloration and only the under tail-coverts sometimes have black markings. On the flanks and the breast grow feathers bearing two rather broad dark transverse bars on isabelline vanes. Those which are situated nearest to base are usually concealed by the apex of overlapping neighbouring feathers. Apical bars are distinctly seen; they impart typical cross-barred coloration to the underpart of young cuckoos (Plate IV). On the dorsal side isabelline or a paler colour stretches, except for the head and hindneck, to the apexes of some scapulars and to the ends of all the tail feathers. The crown and rump juvenile feathers grow later than the rest of the plumage and are dark-brown with ferrugineous apical bars and transverse stripes and speckles on the inner and outer webs, with a hardly noticeable purple shade. The primaries are of the same colour, their inner webs barred with ferrugineous. The ends of all the wing feathers are ochre-fulvous. The wing-coverts are dark brown with ochre apexes and spots or stripes of the same colour on the vanes. All the rectrices are greyish brown, and the preapical part black with transverse ferrugineous bars. The central part of each feather bears against each stripe hardly noticeable depigmented spots. The orbital ring is yellow, the legs flesh-pink, the iris dark-brown, the tongue and the inside of the mouth salmon-orange, the tip of the tongue black, the upper mandible, margins of the eyelids, and the nostrils black, the under mandible of horny colour darkening to the apex.

The food given to the young Indian Cuckoo is identical with that used by the foster parents themselves. Grasshoppers and locusts of various size, caterpillars and imagines of moths (Noctuidae, Geometridae) and sphinxes (Sphingidae) predominated in the diet (Plate IV). Gaily-coloured butterflies such as *Vanessa urticae* and *Papilio xutus* were recorded as food at that time. The shrikes pick up small beetles

(Carabidae and Cerambycidae) but rarely. Horseflies and cicadas (*Lyristes* sp.?) formed a large part of the diet of the Indian Cuckoo chicks. Sometimes the hosts brought small spiders (Plate II, *below*). The older juveniles were fed even with the meat of lizards (*Lacerta*) and shrews (*Sorex*). It is of interest that the cuckoo young digested large pieces of meat together with skin and bone and did not eject pellets. Adult Indian Cuckoos are typical insectivorous birds and, in this respect, do not differ from the Common and Himalayan Cuckoos living in the neighbourhood. The stomachs of all specimens collected in Amurland contained large caterpillars, mainly hairy ones which are serious forest pests. They feed very willingly on caterpillars of the Siberian Moth (*Dendrolimus sibiricus*), the pest of larches—we found up to 9 specimens in one stomach. Sometimes they pick up caterpillars of the Tussock Moth (*Dasychira albodentata*), click beetles (Elateridae), and black carpenter ants (*Campanotus*).

The Non-breeding Life, Moult

After the breeding period Indian Cuckoos become silent and very shy and are very difficult to observe. In Amurland in the second half of July and the beginning of August I saw only juvenile individuals. But this did not mean that the adults had left their breeding area ; they had merely become less noticeable. The majority of these birds leave the territory of the Soviet Far East apparently in the second half of August. In August-September they start to move to their winter quarters in most parts of China and India, though some individuals, generally immature ones, sometimes stay up to October (Whistler 1926 ; Caldwell & Caldwell 1931 ; O'Donel 1936 ; Shaw 1936 ; Hewetson 1956 ; etc.).

It is possible that before the autumn migration young Indian Cuckoos start a partial post-juvenile moult which lasts during their migration and in winter quarters. This process involves nearly all the contour feathers but does not include the remiges and their coverts, rectrices, and upper tail-coverts. Yearlings are easily distinguished among wintering or newly-arrived birds by the remains of this nest-plumage. By mid-summer the light bands on wings and tail feathers of the juvenile cuckoos become so shabby and faded that by this feature they can be easily distinguished from adult birds. During the summer the young birds change the most exposed and consequently the shabbiest and loosest feathers. Thus on 7 June 1961 in Amurland in a yearling-male among very shabby and faded wing feathers were seen fresh last secondaries and greater wing-coverts ; the upper tail-coverts, some wing-coverts, and other small feathers were moulting as well. The year-old Indian Cuckoo from 9 June 1959 changed many lesser wing-coverts, the

10th primaries and the 2nd, 3rd, 4th rectrices of the left side of the tail, which reached $\frac{2}{3}$ of the normal length. A male yearling shot on 27 June 1959 had lost its last secondary on the right wing whereas on the left wing the same feather and its coverts reached the normal length.

In the Zoological Institute of the Academy of Sciences of the U.S.S.R we have not got a collection of moulting adult Indian Cuckoos made during the breeding season. In one male collected by me on June 21 both the central rectrices are half grown. In a male dated 5 June 1934 obtained in China (Institute of Zoology, Academia Sinica) the tail feathers were moulting. Apparently adults (with a small exception) have a complete moult in their winter quarters, in late autumn and winter.

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More new races of birds from the Andaman and Nicobar Islands

BY

HUMAYUN ABDULALI

After the publication of my report on my collection of birds mainly from the Andamans (1964, 1965), I have visited the area again spending more time in the Nicobars and obtaining 280 specimens from Car Nicobar, Central Nicobars, and Great Nicobar.

I have also had the opportunity of examining at the British Museum (Natural History) the specimens collected by Hume, Davison, and others about a hundred years ago, enabling me to take some decisions which were not possible with the material available earlier. An account of the trip together with a general report on the birds of the Nicobars is ready but, as I understand that there is not much chance of its early publication, I am publishing the descriptions of new races earlier. The description of a new race of *Aplonis panayensis* from the Central and Great Nicobars is being published in the *Bulletin of the British Ornithologists' Club.*

1. **Rallus striatus** : Bluebreasted Banded Rail.

The race *obscurior* described by Hume from the Andamans has been accepted as the form found in the Nicobars.

A single male, obtained at Nancowri, Central Nicobars, has a 128 mm. wing and is much darker (almost black) on the upper parts and much deeper grey below than any of the specimens from India (9) and the Andamans (1) available in Bombay. At the British Museum there were no specimens from the Nicobars, but specimens from the Andamans were all smaller and much paler than the others of this species available for examination. Javan birds are also very similar to those from India, and it would therefore appear that the birds from Central Nicobars are different and I name them :

Rallus striatus nicobarensis subsp. nov.

Holotype : ♂ collected by B. R. Grubh at Nancowri, Central Nicobars, on 23 March 1966, Collection No. 193 and Bombay Natural History Society Register No. 22562.

2. **Macropygia rufipennis :** Cuckoo Dove.

The two males I obtained in the Middle Andamans can be separated from the two males and one female from the Central Nicobars by the outer webs of the primaries having a fine fringe of rufous against the basal two-thirds being entirely rufous in the Nicobar birds. This rufous shows as a strikingly different patch of colour in the folded wing which in Andaman birds is more or less concolorous with the other feathers of the back. This character is consistent in the large series (32 Andamans, 10 Nicobars) at the British Museum and Mr. Derek Goodwin who had a look at the specimens agreed that the Andaman birds were different, and I name them :

Macropygia rufipennis andamanica subsp. nov.

Holotype : ♂ collected by me at Betapur, Middle Andamans, on 24 February 1964, and bearing Bombay Natural History Society Register No. 22135

Paratype : ♂ collected by me at Bakultala, Middle Andamans, on 21 February 1964, and bearing Bombay Natural History Society Register No. 22134.

None of my specimens show the ' lilac-purple gloss on the crown of the male ' mentioned in most earlier descriptions. Though unfortunately not specially looked for, this was not noticed in the specimens handled at the British Museum.

Curiously, though the original type locality is Southern 'Nicobars' this species has always been called the Andaman Cuckoo Dove. These names will now have to be reversed.

3. **Oriolus xanthornus :** Blackheaded Oriole

This oriole has been accepted as a migrant to the Andamans, and I have already drawn attention (1965 : 549) to the single specimen I obtained being too small for the nominate race *xanthornus* (Type locality Chandernagor, Bengal) and its similarity to Ceylon birds, *ceylonensis* Bonaparte.

I have now had the opportunity of examining the material at the British Museum and there appears to be no difference in size.

Andamans		*Ceylon*	
	Wings		
6 ♂♂	122-134 av. 128·6	4 ♂♂	125-134 av. 128·75
5 ♀♀	125-130 av. 127·4	3 ♀♀	122-130 av. 125·3
	Tails		
6 ♂♂	72-84 av. 78·8	4 ♂♂	79-82 av. 80·2
5 ♀♀	76-82 av. 79·2	3 ♀♀	72-78 av. 76·3

The Andaman birds are however a deeper mango yellow, and have the edges to the outer webs of the inner secondaries yellow against pale yellow, almost whitish, in the Ceylon birds. On these differences I separate the Andaman birds as

Oriolus xanthornus andamanensis subsp. nov.

Holotype : a ♂ collected by me at Wrightmyo, South Andamans, on 16 February 1964 and bearing Bombay Natural History Society Register No. 22021.

From the material examined it also appeared that the females and immature males (with streaked throats) of Indian birds have pale underparts, while Andaman birds appear to be as dark as the adults, a fact to which Blyth (1846) had drawn attention many years ago.

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Reviews

1. THE BEHAVIOUR OF ARTHROPODS. By J. D. Carthy. pp. 148 ($5\frac{1}{2} \times 8\frac{1}{2}$ inches). 41 black-and-white figures (drawings and graphs). Edinburgh/London, 1965. Oliver & Boyd. University Reviews in Biology 1. Price 12*s*. 6*d*. net.

The arthropod nervous system comprises a few cells, with small cell bodies and a smaller receptive area than corresponding mammalian cells. Such a nervous organization produces rigid behaviour patterns under set circumstances, resulting in adaptive behaviour in changed circumstances which appears to be purposeful, though in fact it is not. An excellent account of the nervous system and its working was given by Roeder in 1963, in a book entitled NERVE CELLS AND INSECT BEHAVIOUR which was reviewed in this journal a few years ago. Dr. Carthy's book is concerned with the behaviour patterns produced by simple nervous systems of this type among the arthropods.

Hairs are the commonest sense organs on the surface of the arthropod body. They serve as chemoreceptors, or hygroreceptors, or are sensitive to bending or to touching. Many insects have hair plates on the articulation between the head and the thorax. An example of how these function is in the dance of the honey bees. When the insect is horizontal the head presses equally on the two neck plates, but when it is dancing vertically with its head directed upwards, the lower or heavier part of the head sinks and the pressure on the lower part of the head is greater. If a piece of lead is attached to the top of the bee's head, so that the top of the head presses down on the hair plate, the bee will confuse 'up' and 'down'. There are other hair plates at the articulation of the thorax and the abdomen, and at the leg joints, which are also involved in gravity perception.

Central summation takes place in the nervous system of arthropods. The stimulation of chemosensitive hairs on the tarsi of a fly by contact with sugar causes it to extend its proboscis. If a tarsus on one side is touched with a sub-threshold concentration at the same time as tarsus on the other side, the proboscis will be extended if the sum of the concentrations is greater than threshold. Heterogeneous summation can also take place when a group of stimuli act together to release an instinctive act. Mosquitoes are more attracted to dark than to fair skins, and to warm rather than to cool skins. A fair warm skin can be as attractive as a cooler dark one. Similarly, the spider *Salticus scenicus* can be induced to attack models, and shows a distinct preference for

three-dimensional models and for models moving fast. A flat fast-moving model can be as effective as a rounded one moving slowly.

One of the most interesting chapters deals with learning in arthropods. Many arthropods are capable of learning simple T-mazes to get at a food source, and wood-lice can in addition learn to take the upper or the lower of two alternative pathways. Ants can learn much more complicated mazes. These are examples of ' positive conditioning '. The spider *Salticus scenicus* can be trained to associate attacking a particular shape with an electric shock, and learn not to jump at it. This is ' negative conditioning '.

Arthropods also show ' latent learning ', where the experience is not of immediate importance but memory influences behaviour after an interval of time. Such learning of landmarks by social insects does not bring any immediate reward. A particularly interesting example is the ichneumon fly, which lays eggs on the flour moth *Ephestia kuhniella* caterpillars and will choose these by smell if offered a choice between them and other lepidopteran larvae. But, if the parasites after emergence are exposed to an air-stream bearing the scent of the moth *Meliphora grisella*, they choose this scent as often as that of *Ephestia* in the olfactometer.

Most work on arthropod behaviour has been concerned with insects. The author has integrated this with information about other groups wherever possible.

R. R.

2. THE COMPANY OF ANIMALS. By Ronald McKie. pp. 225 (22·5×14·5 cm.). With 31 photographs on 16 plates. Sydney, 1965. Angus & Robertson Ltd. Price $3·75, 37*s.* 6*d.*

Since the War there has been a spate of books on animals, particularly on those that are usually termed as large game. The bombs effectively prevent universal participation in the so-called peoples wars which occur like brush fires in odd spots of the world and the searcher for vicarious thrills has to rely on the exploits, often questionable, of the hunter. The trend now shows a welcome inclination towards conservation of Wild Life rather than its decimation. This book is, however, slightly different being the biography of James Hislop, the last ' white ' Game Warden of the King George V National Park in Malaya.

Many of the incidents are related at considerable length and being told by a person who was not present, leave an air of scepticism about the whole story. There are also unfortunate repetitions of some of the old saws like the King Cobra's speed equalling that of a galloping horse,

and other stories which one is inclined to view with surprise e.g. a small bird crossing the river seated on the tail of a Great Hornbill (p. 20) and lightning visible at several miles created by elephants shaking their bodies. It is added that the cows and the bulls make different kinds of lightning, while Seladang also produce a flickering lightning. A wild elephant cow was seen nursing six calves, and Mouse Deer are said to tap with their feet when courting. The baby Mouse Deer is 3 inches long and 2 inches high, a miniature of the adult.

On page 16, reference is made to the many volumes of the Bombay Natural History Society's *Journal* which formed an important part of Hislop's library. Some of the items mentioned in the book would certainly have made excellent subjects for Miscellaneous Notes and it is unfortunate that we do not get them directly from the observer, for there is little doubt that some of them have been misquoted.

In Malaya as in India, Wild Life is on the decline. The Javan Rhinoceros is extinct and the Sumatran Rhinoceros well on the way to extinction. The passage, from the book, quoted below precisely expresses what protection of Wild Life asks of the human population of a country.

'Preservation is a state of mind, a climate of opinion, a realizable aim. It doesn't emerge from apathy and indifference. It doesn't prosper on the assumption, rooted in ignorance, that animals, and the land that is their home, are limitless and will last for ever. It is a product of maturity. It rises out of intelligent concern not only for animals but for the nation's most precious asset, its land.'

J. C. D.

3. THE PHYSICAL GEOGRAPHY OF THE OCEANS. By Charles H. Cotter. pp. 317 (16×24 cm.). Numerous figures. London, 1965. Hollis & Carter. Price 35*s*. net.

This book is a welcome addition to the large number of books that are now being published on Oceanography. The study of the oceans has made rapid advance during the last score of years. With the dwindling of natural resources on land, man is now turning his attention to the vast unexplored and less exploited regions of the oceans and many nations of the world are planning large-scale studies of the oceans.

In this context, bringing together all the related knowledge of the oceans and presenting it in a concise form is very essential and Cotter's book is an admirable job in this respect. The author's long career as a navigation officer in the Merchant Navy from 1939 and later as lecturer in Navigation at the South Shields Marine and Technical College

since 1962, has helped him to present different aspects of Oceanography in simple and precise language. On account of this, the book is eminently suitable as a text book for colleges, and more particularly for marine science and marine engineering students, who require a basic knowledge of the science of Oceanography.

The book covers almost the entire gamut of Oceanography and includes chapters on origin and distribution of the Continents and Oceans, coastlines and shores, the ocean bed, properties of sea water, life in the sea, corals and coral reefs, sediments and deposits on the sea floor, weather and climate over the oceans, tides and related phenomenon, ocean currents, and instruments used in ocean research. The book ends appropriately with a chapter on the history and progress of the science of the sea.

T. S. S. R.

4. BUDONGO. By Vernon Reynolds. pp. 228 (14×24 cm.). 16 black-and-white plates. 5 figures. London, 1965. Methuen & Co. Ltd. Price 36*s*. net.

The exuberant Chimpanzee, man's nearest relative in the Animal Kingdom has been studied in captivity more than any other species of ape. Their life and social behaviour in the wild was little known. In this book Vernon Reynolds tells of his field observations on the Chimpanzee, during the eight months, he and Mrs. Reynolds spent in the Budongo forests of Uganda studying the daily life and social behaviour of the Chimpanzee. The results of their hours of patient observation make absorbing reading.

The Chimpanzee's social organisation is not family based like that of the Gorilla but is a loosely knit community of sixty to seventy animals using a home range of six to eight square miles where their life revolves round the different fruiting seasons of their main food plants. Its extreme noisiness and the habit of drumming on the buttress roots of forest trees, advertises the movement of Chimpanzee groups through the forest when food is abundant, and enables groups to concentrate at the source of food. The hooting and drumming by a group in movement is so fantastically loud that it is very intimidating to other species including Man.

The book is a fund of information on the Chimpanzees, other animals, the forest and the people that the Reynolds saw and lived with, during their eight months stay in Uganda.

J. C. D.

5. HANDBOOK OF WATERFOWL BEHAVIOUR. by Paul A. Johnsgard. pp. 378 (24 × 16 cm.). With 11 plates and 96 figures. London, 1965. Constable & Co. Ltd. Price 75*s*.

Based on earlier publications in scientific journals and extensive original research, mostly at the Wildfowl Trust in England, Dr. Johnsgard provides a detailed survey of the fixed action behaviour patterns of ducks and geese. The method is comparative and each species is described individually and then related to those it most resembles. The result is an important contribution to the taxonomy of the group. More than 100 pages of photographs and drawings make this work one of the most effective exercises in descriptive ethology yet completed and the waterfowl the best known group of birds in this respect.

This book is, however, by no means the last word on waterfowl behaviour. Most of the study is based on observation under captive conditions and much further information regarding species ecology, population dynamics and population dispersion in different seasons is needed before a comprehensive evolutionary analysis can be attempted. Johnsgard's book remains an important step forward and will be essential reading to those whose research interests include comparative avian ethology or any aspect of wildfowl life.

J. H. C.

Miscellaneous Notes

1. CALCIUM DEPRIVATION AND OSTEOMALACIA IN A SLENDER LORIS, *LORIS TARDIGRADUS* (LINNAEUS)

(*With a plate*)

In November 1964, a tame male loris, *Loris tardigradus* (Linnaeus), was purchased in Bangalore. This animal handled easily and climbed freely on anyone. He was taken to Vellore and permitted to live free in the bedroom of E.E.C. His diet consisted of half a banana and three ounces of whole unboiled milk daily. In February 1965, a wilder and larger female loris was obtained and she too was placed in the same room as the male. The food ration was doubled.

The two animals spent their days huddled together sleeping in a corner but became active at night, eating and exploring. A small residuum of milk and banana in the morning proved the adequacy of the diet offered. They appeared to get on well. Following the addition of the female, however, the male was less easily picked up.

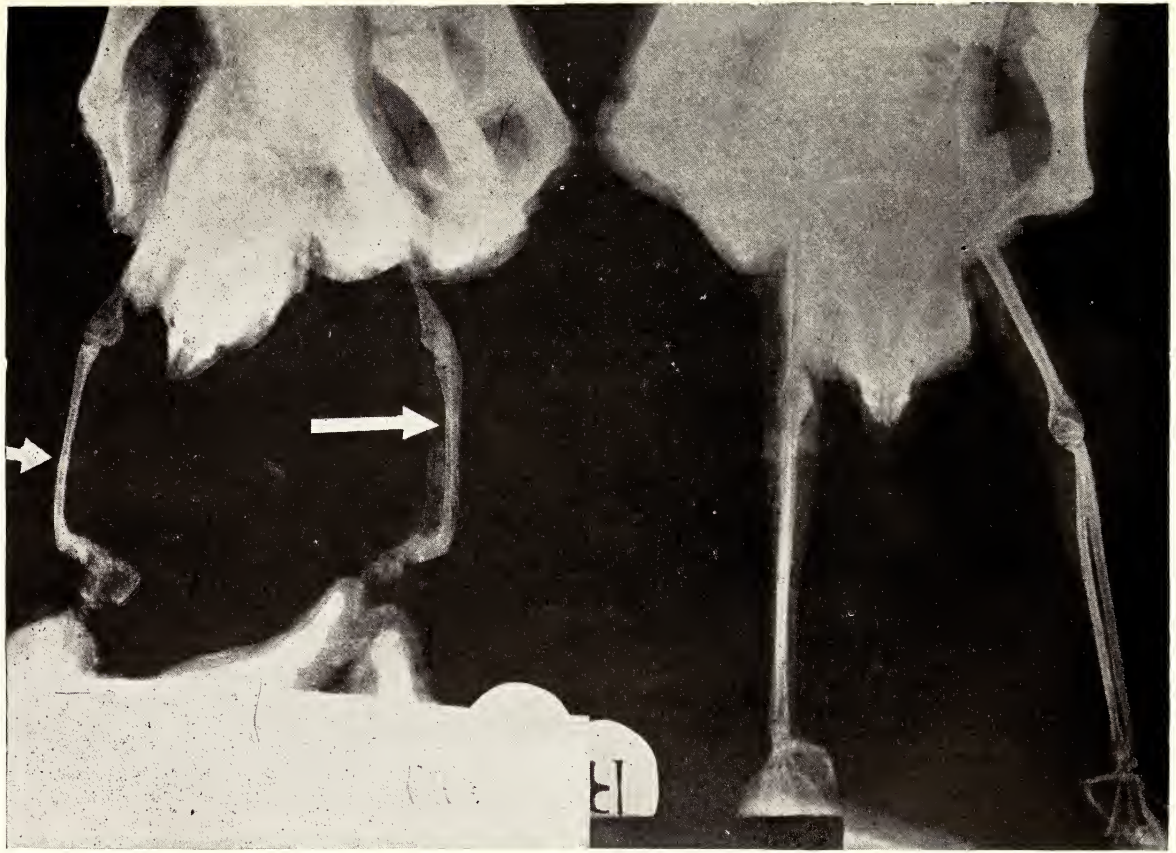
In mid-April 1965, we left Vellore for three months, leaving the lorises in the care of a couple who occupied our home. On our return in July 1965, the male was found huddled in a corner, scarcely walking and objecting noisily to any handling. He seemed in pain whenever he moved. He did not climb at all. His arms were noted to be markedly bowed. The female appeared normal.

X-rays (Plate) of the arms of both animals were read by Dr. A. S. Tucker, Department of Radiology, Christian Medical College Hospital, Vellore, as follows :

> " View shows under mineralization of the bones of the forearms, and several irregular bands of sclerosis across the bones which seem to represent healing fractures.
>
> " There is bowing of the forearms, most marked just above the wrists.
>
> " The cortex is rather thin in both upper and lower arms, which fact is rather readily apparent on comparison of the film with those of the control adult female."

Questioning then revealed that, instead of their regular two cups of milk daily, the lorises had in our absence been offered only one cup.

Apparently, the stronger, more aggressive female had consumed this leaving the male without milk and practically without calcium and vitamin D. As a result, he had, it seems, over the three-month period lost sufficient calcium from his bones to render them incapable of supporting his weight when he climbed, thus leading to the fractures.



X-ray of arms of calcium-deficient loris (*left*) and normal comparison (*right*)
Arrows mark areas of healing fractures.

According to Duncan (1953) an adult human requires 7-8·5 mgm. of calcium per kg. per day. The original diet offered supplied approximately 89 mgm. of calcium per day to each of the 200-300 gram lorises.

A full milk and banana diet was restored, and the loris was given in addition 400 units of vitamin D daily for a month. Within two weeks there was marked improvement in his activity but it was approximately six weeks before he was again climbing. The deformities, as would be expected, persisted. Although activity returned to normal, there was little change to be seen in a X-ray taken ten weeks following the first.

Shortly thereafter he was accidentally electrocuted while climbing on a lamp.

This report is offered simply as an interesting case and also as yet another example of the pervasiveness of what James Thurber has termed the 'War Between Men and Women'.

CHRISTIAN MEDICAL COLLEGE,
VELLORE,
May 5, 1966

DONALD E. CAREY
EDWARD E. CAREY

REFERENCE

DUNCAN, G. O. (1953): Diseases of Metabolism, 3rd ed. W.B. Saunders Co., Philadelphia.

2. AUTHORSHIP OF THE NAME *PRESBYTIS GEEI* [MAMMALIA: PRIMATES]

The existence of the Golden Langur in Assam was first brought to the notice of the writer of this note and his colleagues by Mr. E. P. Gee in the winter of 1954-55. On that information, the Zoological Survey of India sent a party headed by Mr. H. Khajuria in March-April 1955 to Jamduar, Goalpara district, Assam, to obtain some specimens of that langur for the department. Mr. Khajuria brought back six specimens which on careful study were found to represent a hitherto unknown species of langur of the genus *Presbytis*. Mr. Khajuria prepared the description and in appreciation of Mr. Gee's contribution to the discovery of the species, named it after him as *Presbytis geei*. While this paper was still under publication in the *Annals and Magazine of Natural History* (Sr. 12, Vol. **9**, pp. 86-88, published February 1956), an article on the habits and a brief description of the Golden Langur by Mr. Gee appeared in the *Journal of the Bombay Natural History Society* (Vol. **53**, pp. 252-254, published January 1956), in which he wisely and carefully refrained from

using a scientific name for this species. Unfortunately, the editors of the *Journal* added a note to Mr. Gee's paper (*op. cit.*, p. 254): 'We understand from Mr. Khajuria of the Zoological Survey of India that his description of this new species of langur, which he has named *Presbytis geei*, will shortly be published in *Annals and Magazine of Natural History*.' Mr. Khajuria's paper also bore an editorial note (*op. cit.*, p. 86): 'Following a strict interpretation of the International Rules of Zoological Nomenclature this species has already been named (although unintentionally) *Presbytis geei* by E. P. Gee (*J. Bombay Nat. Hist. Soc.* 1956, **53**: 252-254, 1 fig., published 20th January 1956). The present work is however the first scientific description of the new species.'

Since Mr. Gee was not responsible for the new name, the present writer has been ignoring his paper for the purpose of nomenclature. However, in the recently published revised edition of Prater's THE BOOK OF INDIAN ANIMALS (Bombay, 1965), there is a footnote on p. 42, which ays thats the author of the name *Presbytis geei* is Gee and not Khajuria, and this has prompted the writer to examine the question in detail.

All this confusion has arisen from the editors of the *Journal of the Bombay Natural History Society*, publishing the manuscript name *Presbytis geei* of Khajuria simultaneously with Mr. Gee's descriptive paper. Now, according to the Article 50 of the International Code of Zoological Nomenclature (1961) the author of a name is the person who 'is alone responsible both for the name and the conditions that make it available.' It is very obvious that Mr. Gee is not responsible for the name *Presbytis geei* even though the descriptive matter in the text are not only diagnostic but also made by him. The editorial note to the paper (Gee, *op. cit.*, p. 254), however, constitutes, for the purpose of nomenclature, a separate article by separate authors. In this separate article no description is given and the authorship of the new name is clearly credited to Mr. Khajuria. At this place and in this separate paper by the editors the name *Presbytis geei* is a *nomen nudum*. Furthermore, the authorship of this footnote article is anonymous and the name *Presbytis geei* would be unavailable according to Article 14 of the Code, even if it were otherwise considered available. In Mr. Gee's paper the name *Presbytis geei* does not occur anywhere except in the caption of the distribution map, but there is no indication anywhere if this name refers to the Golden Langur. As such, Mr. Gee cannot be held responsible for introducing the new name.

It follows, therefore, that the first publication of the name *Presbytis geei* in a manner to satisfy the provisions of the Code for availability is that in the *Annals and Magazine of Natural History*, Series 12, Volume 9, pages 86-88, and that the authorship of the name is to be credited to Mr. Khajuria as of February 1956.

The writer is greatly indebted to Professor Ernst Mayr and Dr. Krishna Kant Tiwari for their wise counsel in his attempt to solve this problem.

ZOOLOGICAL SURVEY OF INDIA, BISWAMOY BISWAS
INDIAN MUSEUM,
CALCUTTA 13,
August 1, 1966

3. SOME OBSERVATIONS ON THE HAIRYFOOTED GERBILLE, *GERBILLUS GLEADOWI* MURRAY, IN THE RAJASTHAN DESERT

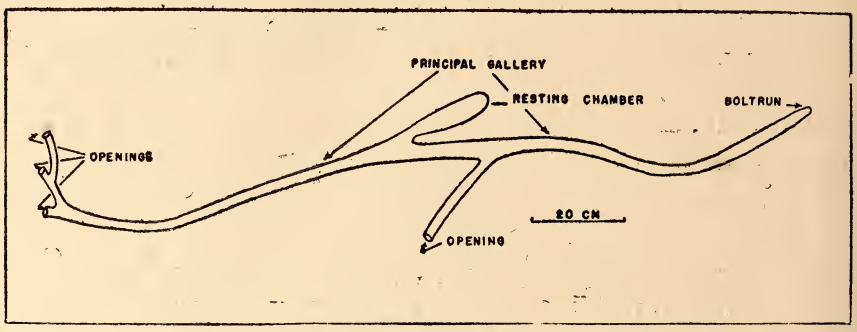
(*With a text-figure and a photograph*)

There is little information available on the ecology of the Hairy-footed Gerbille, *Gerbillus gleadowi* Murray (Blanford 1888-91). These observations were, therefore, recorded on the rodent in the westernmost part of the Rajasthan desert.

Habitat. *G. gleadowi* is distributed in the arid belt of Jaisalmer-Gadra Road-Jodhpur and is more common in the Gadra Road region where its burrows are found on sand dunes, usually in association with the bushes *Calotropis procera*, *Zizyphus nummularia*, *Capparis decidua*, and *Aerva tomentosa*—they seem to prefer the first plant to burrow under. Their burrows are not found on sandy plains in this area ; there they are replaced by the Desert Gerbille, *Meriones hurrianae.* In the Jaisalmer tract, the desert is predominantly characterized by gravelly sand formations and the *Gerbillus* inhabit mainly the sides of the roads, where their burrows are to be found under *Calotropis* and *Zizyphus* bushes. Their habitat is characterized by *Calotropis* bushes and long streaks of sand dunes in the sandy plains, away from the road where they are found in patches and their number is usually very low. In this region they prefer habitat having hummocks of sand. Discussing the habitat preference of the gerbilles of Israel, Zahavi & Wahrman (1957) grouped *G. gerbillus*, the Middle Eastern species nearest to *G. gleadowi*, as psammophile, i.e. ' confined to either shifting sand dunes or to more or less stable sand formation '. In the Rajasthan desert, *G. gleadowi* is also psammophile in its habitat preference.

Burrows. The burrows follow a simple pattern and have a principal gallery with two to three smaller tunnels leading to openings outside, a bolt run, and a resting chamber (see Figure). The burrow resembles that of *G. gerbillus*, which comprises of a main tunnel bifurcating at both extremities into four galleries (Petter 1961), a bolt run, and an ampulla

accommodating the nest and corresponding to the resting chamber of *G. gleadowi.*



Text-fig. View (from above) of the burrow of *Gerbillus gleadowi* Murray

Habits. The Hairyfooted Gerbilles (photograph) are nocturnal, venturing out soon after dusk and retiring after midnight. They are not crepuscular like the Desert Hare, *Lepus nigricollis dayanus.*

We did not find any gerbille in the Jaisalmer region during winter, which suggests that they either hibernate or are torpid during the cold spell.

Although their hind feet are quite long they do not move about only on them as the true jerboas do. When chased they leap to keep the collector at a distance. Collection of gerbilles was done with spot light and butterfly net. While collecting them we observed that they stand erect on their hindfeet and jerk their body forward and backward in quick succession. At times, while escaping, they entered the burrows of the merion gerbille but quickly came out to enter their own burrows, which they closed from the inside by shovelling sand on to the opening, an action done so quickly and neatly that it was very difficult to locate the burrow opening afterwards. This might be an effective adaptation to evade the snakes which feed on the rodents.

Stems of *Cenchrus biflorus*, the leaves and flowers of *Crotalaria burhia*, stems of *Eleusine compressa*, and seeds of *Lasiurus sindicus* were found in the burrows. In captivity, *Gerbillus* thrived on grains and preferred millet, *Pennisetum typhoideum*, and the pulse *Phaseolus acontifolius*, the total daily consumption being 16·20 and 15·07 gm. per 100 gm. body weight respectively. Their food requirement appears to be more than that of the Desert Gerbille, which consumes 8·08 gm. of millet and 5·29 gm. of the pulse per day per 100 gm. body weight. *G. gleadowi* being of a smaller size than *Meriones hurrianae*, a higher rate of food consumption per unit body weight is to be expected as the former will have a higher metabolic rate than the latter.

Sex Ratio. In collections from the Rajasthan desert females were slightly in excess, 29 against 25 males, but the difference was not statis-

tically significant. Contrariwise, a sample of this gerbille from Sind (Ellerman 1961) comprised 14 males and 10 females.

The Hairyfooted Gerbille, *Gerbillus gleadowi* Murray

Note white pelage around eyes and on bases of ears

Breeding. Out of the summer collection, two females were pregnant, carrying three and four young respectively. Two more females delivered litters of two young each. Out of 19 rodents collected in July 1964, 8 were sub-adults, indicating that littering had taken place in June. In the Gardens of the Zoological Society of London, *G. gerbillus* delivered from April to June and litters consisted of three to five young (Zuckerman 1953). Our observations also indicate that littering in *G. gleadowi* occurs during summer.

The New-born. Pink in colour; skin translucent and abdominal

contents almost visible; no hair coat; eyes closed; pinnae folded and enclosed in a membrane; very short vibrissae.

The young ones in the two litters were almost equal in size; head and body length 39·0-40·0 mm. (mean 39·5 mm.); tail 15·0 mm., hind-foot 8·0-9·0 mm. (mean 8·2 mm.); weight 1·8-2·0 gm. (mean 1·9 gm.).

Zoogeography. Most species of the genus *Gerbillus* are distributed in the Palaearctic deserts (Ellerman 1961), only three species having entered the Oriental Region : *G. nanus* distributed from Algeria and south Egypt to Baluchistan ; *G. dasyurus* from Algeria to Thar Desert ; and *G. gleadowi* found only in the Sind-Rajasthan desert and regarded as an endemic desert species (Prakash 1963). Presumably *G. gleadowi* evolved after xeric conditions started establishing in this subcontinent.

Acknowledgements. Thanks are due to Dr. Pulak K. Ghosh, Animal Physiologist, Shri L. R. Kametkar, Senior Scientific Assistant, and Shri H. P. Sharma, Junior Scientific Assistant, for assistance during the field work.

DIVISION OF SPECIAL ANIMAL STUDIES,
CENTRAL ARID ZONE RESEARCH INSTITUTE
JODHPUR,
February 2, 1966.

ISHWAR PRAKASH
K. G. PUROHIT

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4. AN OUT-SIZE ELEPHANT (WITH A NOTE ON MEASURING ELEPHANTS)

On 21 May 1965 at about 6 p.m. in Koilamari Tea Estate grant, bordering on Reserve Forest and North East Frontier Agency, I came upon the out-size tracks of this very large Bull Elephant, after a day of heavy rain. The tracks led out of the Reserve Forest and along a boundary path which separated the Koilamari T. E. grant from the

Reserve Forest. The spoor was very fresh and, as I hurried along the gloomy path following the spoor, my ears were attuned to hear the crash of breaking jungle which normally heralds the close proximity of elephant.

Tree trunks along the path I now followed showed rub marks which to me passing beneath and beside them indicated a gigantic animal. The tracks crossed a small water course and, as evening was now closing in fast, I knew that if I did not contact the animal within half an hour, I would have to look for him another day.

About sixty yards after crossing the stream, he had rubbed himself against a large dead tree stump, so recently that water and mud were still dripping off the trunk. I stopped and listened, and about forty yards to my right front I heard the cracking and breaking of branches. The tracks led off the boundary path towards the noise I heard. Quietly and quickly, as there was not much time, I hurried along the path he had made—fortunately the jungle was thin and the undergrowth sparse. He was very close now, and not being able to check wind direction, I paused a few seconds in order to calm down and make final checks on my rifle.

Fifteen yards ahead was a giant tree, and from just behind this had come the last sound of elephant noise. Creeping forward, I peered around the tree and saw the huge rear of the elephant, who was still unaware of my presence. So I stepped around the tree, raised my ·404 rifle, and prepared to shoot as soon as I could see a vital spot—the distance was twenty paces. He slowly swung three-quarters round and I saw the dull gleam of ivory. Using the ¾-angled brain shot for the head for the first time, I pressed the trigger as soon as line and angle were right.

With the roar of explosion, the huge beast slumped to his knees and I am quite sure he did not hear the shot which killed him. However, I ran up at once and administered my normal safety shots.

As my eyes ran over his magnificent proportions, I realized that here indeed was a very large elephant, possibly one of the largest I would ever shoot. His measurements, taken next day, more than proved this.

I note below the measurements which have been verified by the Forest Range Officer, North Lakhimpur:

Circumference Measurement:	Left Forefoot	65½ in.
do	Right Forefoot	65¼ in.
do	Left Rearfoot	56½ in.
do	Right Rearfoot	56½ in.

Height at shoulder taken down the length of the leg, right side (measured with steel tape): 10 ft. 11½ in.

Estimated height (2 × circumference of forefoot): left 10 ft. 11 in.
right 10 ft. 10½ in.

The right forefoot had one toe nail damaged which would account for the ¼ in. difference between the forefeet measurements.

KOILAMARI TEA ESTATE,
LAKHIMPUR NORTH P.O.,
NORTH LAKHIMPUR,
ASSAM,
August 6, 1965.

DUNCAN HAY

[Mr. E. P. Gee, whose comments were invited, writes:

'I have read with interest the account by Mr. Duncan Hay of the killing by him of a very large wild elephant, and find that his report appears to be authentic. I would point out, however, that it is extremely difficult to avoid errors in measuring elephants—whether dead or alive. I have myself done quite a lot of measuring of live tame ones, and I seldom find it easy to do—even with a very docile captive elephant, because of uneven ground, continual changes of posture of the animal, and the measuring tape (for the forefoot measurement) being either too stiff (of steel) or too soft (of cloth).

'I have found that the only accurate method of measuring the forefoot is to use a piece of thin, flat cane and to have another man lift up the other forefoot so that the one that I am measuring is pressed down. For measuring the shoulder height two stiff and straight bamboo sticks are required, with another man standing some distance away to see that I have got the upper piece of bamboo flat across the shoulder and absolutely level with the ground. Even with all these ideal conditions, I find a lot of differences and discrepancies in the measurements, and usually have to take the average of a number of times. And the shoulder height is seldom exactly, usually only approximately, double the circumference of the forefoot.

'Obviously measuring a dead elephant, especially one lying in an awkward position or on uneven ground, must be very much more difficult.

'The measurements of the largest dead wild elephants are nearly always greater than those of the largest live captive ones; and this fact has always led people to believe either one or both of the following: (1) that elephants grow to a bigger size in the wild state, and/or (2) that elephants measure more when lying down (whether dead or alive) than when standing up.

'The only case, I think, of anyone putting to the test whether live elephants measure more when lying down than when standing up is the late E. O. Shebbeare. He once measured the shoulder heights of 23 female elephants both standing up and lying down, and also the circumferences of their forefeet. The average of these measurements

shows an increase in height of no less than six inches when the elephants were lying down: 8 ft. 7½ in. compared with 8 ft 1½ in. Incidentally the twice-round-the-forefoot measurement came to 8 ft. 2 in., almost coinciding exactly with the standing height. Now a difference of six inches in 8 ft. 6 in. means a difference of 7¾ in. in 11 ft., so this amount of allowance would have to be made in all measurements of record dead elephants unless these were based on the forefeet circumference.

'Shebbeare's own conclusions after the above experiment were that "a live elephant measures approximately 6·3% more lying down than standing up and that the twice-round-a-forefoot measurement is a good approximation on the average though there may be glaring exceptions in individuals."

'So it follows that the large elephant shot by Mr. Duncan Hay, and also the record 11 ft. elephants recorded by Mr. P. D. Stracey in the *Journal*, Vol. **46** at pp. 717-718, must also have 6·3% deducted from their dead measurements to show what they must actually have measured when alive.

'The following two museum pieces are, I think, the record Indian elephants of all time (within the last hundred years or so): (1) the one which I think is in the Madras Museum measuring over 11 ft., and (2) the skeleton in the Indian Museum of Calcutta, which measures 11 ft. 3 in. at the anterior dorsal vertebra just above the scapula, and bears the laconic description: "Santal Parganas, W. M. Smith 1879." When alive this latter elephant must have stood about 12 ft. high—a truly formidable creature.']

5. THE SHORT-TAILED OR RED-BILLED TROPIC-BIRD (*PHAETHON AETHEREUS INDICUS* HUME) AT KIHIM ON THE MAHARASHTRA COAST

On the 8th of May 1966, a Short-tailed Tropic-bird was found dead in some bushes at around 11.00 a.m. on the coast of Kihim, about 12 miles south of Bombay, location *c.* 18° 45′N., 72° 53′E., by Idrees Ali and Nisar Sikander. It was skinned by me there, and sent to the Bombay Natural History Society through Mr. Humayun Abdulali.

33, Pali Hill, RAUF ALI
Bandra, Bombay-50,
May 24, 1966

[The author is a twelve year old boy. The skin, now in the Society's collection, is identified as that of *Phaethon aethereus indicus* Hume.

According to Hume (1876, *Stray Feathers* **4** : 481) the bird is found in a zone between 7 and 30 miles offshore. Sinclair (1886, *J. Bombay nat. Hist. Soc.* 1 : 168) included it among pre-monsoon strays and swept-ins but recorded no specimen actually taken on the coast. The first such record, from Marine Drive in Bombay, was reported by Novarro (1962, *J. Bombay nat. Hist. Soc.* **59** : 649). The present specimen, found in good condition in vegetation 8 to 10 yards above high-water mark, is probably a bird that was washed ashore in an exhausted state. A sight record in February (Novarro, ibid.) is interesting as it suggests the possibility that the bird is commoner ashore than is generally realised.

—EDS.]

6. NOTES ON INDIAN BIRDS 10—OCCURRENCE OF THE CHINESE GREY DUCK/SPOTBILL (*ANAS POECILORHYNCHA ZONORHYNCHA* SWINHOE) IN INDIA

In *Cheetal*, the journal of the Wild Life Preservation Society of India, for October 1964, Mr. M. J. S. Mackenzie of Balijan North Tea Estate, Chabua P.O., Assam, referred to Chinese Spotbill (*Anas poecilorhyncha zonorhyncha* Swinhoe) as regularly found in Assam during the cold weather. Since the earlier records of this form were discarded in the FAUNA and the SYNOPSIS and the only evidence of its occurrence in India was believed to be the bird obtained by Inglis in Bihar (*J. Bombay nat. Hist. Soc.* **34** : 810), I suggested a mistake in its identification.

Mr. Mackenzie promptly countered by shooting and sending to me two ducks which, from the specimens and literature available to me in Bombay, appeared to be *zonorhyncha* and this has been confirmed by Dr. Dillon Ripley. I also found these specimens to be identical with another shot by Parsons at Pasighat, Sadiya Frontier, Assam, and noted by Stuart Baker (*op. cit.*, **39** : 638) as intermediate between *zonorhyncha* and *haringtoni* [from Burma with a green speculum—H. A.]. His note however went on to say that the latter had a purple-blue, speculum[1]. This prompted me to make a more careful examination of the earlier records with the following results :

In 1904 (*J. Bombay nat. Hist. Soc.* **15** : 718) Stuart Baker said that he and, earlier, Moore and Mandy had shot several *zonorhyncha* out of a flock of about 40 birds on Sirsi Bheel in Dibrugarh in the extreme east of Assam, and repeated the statement in the first (1908) edition of INDIAN DUCKS AND THEIR ALLIES. In the latter, he discredited Oates's recently described *haringtoni* from Burma, holding that they were only

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[1] This statement appears to be due to some oversight. The error was corrected in the *errata* list at page xviii of Vol. **39**, Nos. 3-4 of the *Journal*.—EDS.

immature birds in which the red spots at the base of the bill had not yet developed.

In 1913 (*J. Bombay nat. Hist. Soc.* **22**: 806) he agreed that *haringtoni* was separable and classed the east Assam birds as of this race. This was repeated in the second (1921) edition of INDIAN DUCKS, and in the FAUNA, where Inglis's specimen from Bihar, referred to earlier, was said to be the only record of *zonorhyncha* from India.

In 1931 J. C. Higgins (*J. Bombay nat. Hist. Soc.* **35**: 460), seeing Inglis's note and having access only to the first edition of INDIAN DUCKS, drew attention to the earlier records of *zonorhyncha* and said he had seen and shot them himself in Assam. Inglis (*op. cit.* **35**: 687) replied that the earlier records were of *haringtoni* 'a quite different bird with a *blue* and not *green* speculum'. Higgins (*op. cit.* **36**: 266) drew attention to this error in colour, but Inglis neither offered an explanation nor admitted an error. Later Higgins repeated his earlier records (*op. cit.* **36**: 421) and referred (*op. cit.* **37**: 224) to two more *zonorhyncha* shot on the north bank of the Brahmaputra.

In all this confusion one can only guess that, when accepting *haringtoni* as a valid race from Burma, Stuart Baker made the mistake of assuming, without examination, that the earlier records of *zonorhyncha* from Assam were all in error for this form. That these Assam birds were not *haringtoni* is endorsed by the fact that Oates, when describing this race specifically referred to two specimens from Assam 'recently acquired for my collection and recorded in the Society's Journal as *zonorhyncha*'.

From the material and literature available in Bombay, *zonorhyncha* is distinguished from the typical race by:

(*a*) the absence of red spots at the base of the bill (a character shared with *haringtoni*, at least at certain seasons or stages),

(*b*) the lower portion of the underparts being more or less uniformly brown, and not spotted,

(*c*) the absence of the white bar on the secondaries above the speculum,

(*d*) the speculum being purple-blue and not green. Regarding the colour of the speculum it must be noted that, though the speculum of typical *poecilorhyncha* from peninsular and western India is green and at the same angle outstandingly different from the purple-blue in *zonorhyncha*, these colours change and replace each other at different angles and it is possible to get a purple-blue effect in the greenest speculum, and *vice versa*. From the limited number available for examination, it also appears that this tendency to turn from one to the other increases as one approaches an intermediate area and is most prominent in specimens of *poecilorhyncha* from Assam and in *haringtoni* from Burma, though both can be accepted as green.

(*e*) a dark line formed by speckles extending from the base of the bill towards the ear-coverts. This character is shared with at least three races of *Anas superciliosa* (vide Delacour's THE WATERFOWL OF THE WORLD 2 : 62) but does not occur in *poecilorhyncha*.

The westernmost record of *zonorhyncha* is still Inglis's from Bihar, which is now at the Yale University, and whose identity is confirmed by Dr. Ripley. But there is also no doubt that the earlier records from Assam were correct and there was no need to discard them.

The number of mistakes that have dogged the descriptions and accounts of this species is indeed remarkable—even the colleague whose birds Stuart Baker first identified as *zonorhyncha* has had his name written as Mandy, Mondy, and Mundy in the notes referred to above !

However there can now be no doubt that *A. p. zonorhyncha*, The Chinese Grey Duck, is a fairly regular winter visitor to eastern Assam, and once strayed as far west as Darbhanga in Bihar.

75, ABDUL REHMAN STREET, BOMBAY-3,
June 7, 1966

HUMAYUN ABDULALI

7. THE PINKHEADED DUCK [*RHODONESSA CARYOPHYLLACEA* (LATHAM)] AGAIN

(*With a plate*)

This is to inform the Bombay Natural History Society that, in the year 1947 on the 27th January in the afternoon, I shot a Pinkheaded Duck [*Rhodonessa caryophyllacea* (Latham)] at Manroopa Lake in Khagaria subdivision, Dist. Monghyr, in my Estate area known as Bahadurpur Estate. The said duck, six in number, took off from Manroopa jheel and came over me and I shot only one. Sir Hugh Dow, Governor of Bihar, and Mr. E. O. Lee, I.C.S., Member of the Board of Revenue, Bihar, were in the shoot. The latter gave me a letter of testimony which read that the Pinkheaded Duck is rarely found in India and he congratulated me, but this letter is misplaced at present.

Again in 1948-49 I saw some Pinkheaded Duck on the Lake Manroopa, about 5 to 8 of them, but they did not come over me so I could not shoot.

SHAKARPURA RAJ,
P.O. SHAKARPURA RAJ,
DISTRICT MONGHYR, BIHAR,
January 18, 1965.

LALITESHWAR PRASAD SINGH

Pinkheaded Duck *Rhodonessa caryophyllacea* (Latham) in the Patna Museum.

(*Photo : T. P. Singh*)

[The last authentic record of the Pinkheaded Duck dates back to 1935. It is feared that the species is extinct, and for some time now the Society has been making enquiries about it. A report of an unsuccessful investigation in north Bihar is published at pp. 415 ff. of Vol. **57** of the *Journal*. Immediately after the report follows a claim by Mr. K. L. Mehta, Deputy Game Warden, Himachal Pradesh, to have seen Pinkheaded Duck in February 1960 about 40 miles south of Simla. This, however, was in circumstances which made identification difficult, by torchlight between early dawn and sunrise (see H.A.'s review at page 626 of Vol. **59** of the *Journal*). The present claim comes from near Bakhtiarpur (generally known as Simri Bakhtiarpur to distinguish it from Bakhtiarpur in Patna District), formerly in Monghyr District and from 1965 in Bhagalpur District, where a pair of Pinkheaded Duck were shot in 1924 (see Plate opposite and our Editorial Note at the top of page 417 of Vol. **57** of the *Journal*).

The letter of testimony referred to by our correspondent has not been traced. Mr. E. O. Lee is dead. Sir Hugh Dow, now in London, remembers the shoot but not the shooting of a Pinkheaded Duck. He adds, however, that he sees no reason to doubt our correspondent's statement. It is not impossible that the species still survives in some remote corner of its former haunts. We are therefore placing the present claim on record, in the hope that those of our readers who live in or visit this area or any other area where the species is known or believed to have been seen will keep a look-out for it. We may add that since 1956 it is a punishable offence to kill or capture the bird. Sportsmen would therefore be wise to learn to recognise the bird. If the bird is found, intimation should be sent at once to the Society.

We are grateful to Mr. T. P. Singh, Chief Secretary, Government of Bihar, for sending us the photograph of the Pinkheaded Duck exhibit in the Patna Museum.—EDS.]

8. AGGRESSIVE BEHAVIOUR OF A SPOTTED OWLET [*ATHENE BRAHMA* (TEMMINCK)]

A pair of Spotted Owlets, *Athene brahma* (Temminck), have their roost under the roof of the Range Forest Office here. One of the pair has an annoying habit; when they come out of the roost in the evening, it attacks anybody walking or sitting outside in the Range Office compound.

On 20 March 1966, at about 17.15 hrs., while I was walking about the compound, it swooped down on my head from behind giving me a nasty shock! At that time, I thought it overshot one of the common yellow bats (*Scotophilus heathi*?), which were flying around, and landed on my head and I was thankful that I am not bald! On 27 March

evening, I was talking with a gentleman sitting outside in the Range Office compound ; I saw both the birds come out of the roost and perch on a branch of a *Zizyphus* tree. Suddenly without any reason or provocation, one of the owlets came sweeping down on my companion's head from behind. It made three more unsuccessful and determined attacks on us within the next fifteen minutes, and we beat a hasty retreat ! Only one of the pair made the attacks—the other just took a ringside seat.

The Depot Officer, who lives next to the Range office, reported that almost everybody in his family had been attacked by the owlet. The old forest guard sadly said that the *saitan* (devil) has a special liking for him, once or twice inflicting bleeding wounds. Only today the Depot chowkidar had the benefit of unwelcome attention from the owlet.

I do not know what makes it attack. It is not nesting and does not attack anybody in the Office—otherwise I would have run away by this time because they have their roost just six feet above my head, where I am sitting now.

RANGE FOREST OFFICE,
BASUGAON,
GOALPARA, ASSAM,
April 7, 1966

K. K. GUPTA

[The author informs us that the owls occupied the roost till the first week of July, when they were driven away by some children who had been attacked by the aggressive owl.—EDS.]

9. OCCURRENCE OF THE WIRE-TAILED SWALLOW (*HIRUNDO SMITHII* LEACH) IN NORTHERN CEYLON: A FIRST RECORD

While out looking at birds with Mrs. Nugawella, Miss A. Perera, and Dr. Somasunderam, on the afternoon of 26 February this year, we were motoring slowly along the coast road from Pooneryn to Mannar on the north-western coast of Ceylon ; near Illupaikkadavai, some 15 miles from Mannar, we noticed a party of about 10 swallows sitting on the telegraph wires that skirted the roadside.

As we approached we saw that all but one of the birds were the Swallow (*Hirundo rustica* Linnaeus), and our attention immediately focussed upon the single bird, sitting with the others, which was obviously of a different species. This bird, which was not more than10 ft. away, had two long wiry tail feathers and pure white underparts including throat, steely blue wings and back, and chestnut cap. We were all able to observe it closely and were unanimous in our identification of it as a Wire-tailed Swallow (*Hirundo smithii* Leach).

This swallow, although not recorded from Ceylon, is reported to

occur in Southern India in winter, so the bird we saw had probably overshot its usual winter habitat.

STORTH, MANOR WAY,
ALDWICK BAY, (MRS.) E. M. WYNELL-MAYOW
BOGNOR REGIS,
March 20, 1966.

[Mrs. Wynell-Mayow's father Major W.W.A. Phillips first recorded the occurrence of the Indian Cliff Swallow (*Hirundo fluvicola* Blyth) in Ceylon (1948, *J. Bombay nat. Hist. Soc.* **47**: 740). That stranger, like the stranger in the present case, was in a party of *H. rustica* and Major Phillips suggested that it might have straggled into Ceylon with them at the time of their annual migration. *H. smithii* is not common in S. India. Sálim Ali has seen it several times in Mysore, but there is no record from Travancore and Cochin. We know of no evidence to indicate that it is a winter migrant to S. India; this species is accepted as a resident form, except perhaps for small local migrations.—EDS.]

10. BEHAVIOUR MIMICRY BY THE LARGE RACKET-TAILED DRONGO [*DICRURUS PARADISEUS* (LINNAEUS)]

The tongue of land on which the Tourist Lodges are situated at the Periyar Lake Wild Life Sanctuary is an ideal place for birdwatching. Among the many species of birds that can be seen in this area, one of the most vocal is the Large Racket-tailed Drongo [*Dicrurus paradiseus* (Linnaeus)] whose exasperating habit of mimicking the calls of other birds limits one's bird list to sight records only.

While on a visit to the Sanctuary in May this year, I was intrigued by the large repertoire of calls of this drongo and, after being twice 'taken in' by its mimicry of the Giant Squirrel (*Ratufa indica*), made a habit of investigating each call from unseen sources. On one such occasion, while following a mixed hunting party of birds, I heard the agitated squeaking calls of a Jungle Babbler (*Turdoides striatus*) and was surprised to see that the calls were being made by a drongo perched on a low branch. While calling the drongo had the feathers of its body fluffed out, its wings drooping, and its tail depressed, and was pivoting from side to side on its perch—an exact mimicry of the behaviour of the Jungle Babbler while thus calling!

There were no babblers in the vicinity.

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE, J. C. DANIEL
BOMBAY 1-BR, *Curator*
August 17, 1966.

11. RECOVERY OF RINGED BIRDS

Ring No. and species	Date and place of ringing	Date and place of recovery	Remarks
A-10400 *Passer hispaniolensis* ♀	25.3.1962. Bharatpur (*c.* 27° 13′ N., 77° 32′ E.), India	+, 9.5.1965. Ernazar, near Djambul, Djambul Region, Kazakh SSR (42° 54′ N., 71° 24′ E.)	Reported by Bird-Ringing Bureau, USSR
A-10616 *Passer domesticus parkini* ♂	26.3.1962. do.	+, 15.5.1965. Dekhkan-Abad near Parkhar, Parkhar District, Tajik SSR (*c.* 37° 30′ N., 69° 20′ E.)	do.
AB-8264 *Philomachus pugnax* ♀	20.10.1965. do.	(V), 16.2.1966. Naral Subdiv. Jessore District (*c.* 23° 10′ N., 89° 30′ E.), E. Pakistan	Reported by Mr. S. M. Ilias
AB-10217 *Tringa glareola*	26.3.1965. Beliaghata, N. Salt Lake, Calcutta (*c* 22° 35′ N., 88° 21′ E.)	+, 25.5.1965. Srednyaya, Olekma, Tungiro-Olekminsk District, Chita Region, USSR (*c.* 55° 15′ N., 120° E.)	Reported by Bird-Ringing Bureau, USSR
B-1609 *Philomachus pugnax* ♂	3.10.1965. Bharatpur (*c.* 27° 13′ N., 77° 32′ E.), India	V. (13.2.1966), Ramkola, Uttar Pradesh (*c.* 26° 30′ N., 83° 30′ E.)	Reported by Mr. Sant Prasad of Ramkola
B-1657 *Tringa totanus* o?	6.10.1965. do.	+, Spring 1966, Altai Region, Near Blagoveshchenka, USSR (52° 50′ N., 79° 53′ E.)	Reported by Bird-Ringing Bureau, USSR
B-1721 *Philomachus pugnax* ♂	10.10.1965. do.	+, 28.2.1966. Uzbek SSR near Syrdariya (40° 50′ N., 68° 42′ E.)	do.
B-1931 *Philomachus pugnax* ♂	13.10.1965. do.	+, 23.3.1966. Sheikpura District (31° 30′ N., 74° 30′ E.) near Lahore, W. Pakistan	Reported by Pakistan Zoological Survey Department
B-1938 *Philomachus pugnax* ♂	13.10.1965. do.	+, 18.4.1966. Turkmenian SSR near Kunya-Urgen (42° 20′ N., 58° 55′ E.)	Reported by Bird-Ringing Bureau, USSR
B-3476 *Tringa glareola*	1.1.1965. Bakhri, Monghyr Dist., Bihar (*c.* 25° 23′ N., 86° 30′ E.), India	+, 8.5.1966. Irkutsk Region, near Cheremkhovo (53° 10′ N., 103° 05′ E.)	do.

RECOVERY OF RINGED BIRDS (*contd.*)

Ring No. and species	Date and place of ringing	Date and place of recovery	Remarks
C-147 *Anas crecca* ♂ ?	18.2.1964. Manjhaul (*c.* 25° 23′ N., 86° 30′ E.), Monghyr District, Bihar, India	+, 8.5.1966. Near Nizhnii Ingash (56° 10′ N., 96° 28′ E.), Krasnoyarsk Region	Reported by Bird-Ringing Bureau, USSR
C-1008 *Anas querquedula* ♂	27.9.1965. Bharatpur (*c.* 27° 13′N., 77° 32′ E.), India	+, 10.5.1966 Novosibirsk Region, Chylum District, near Uzhanikha (54° 40′ N., 81° 03′ E.)	do.
C-1193 *Anas crecca* ♂	7.10.1965. Bharatpur (*c.* 27° 13′ N., 77° 32′ E.), India	+, 2.1.1966, Kasimpur village, Agra (*c.* 27° 10′ N., 78° 03′ E.)	Reported by Mr. R. S. Sharma, Sr. Supdt. of Police, Agra
C-1230 *Anas crecca* ♂	8.10.1965. do.	+, 2.3.1966. Uzbeck SSR, Bukhara District near Karakul (39° 34′ N., 63° 50′ E.)	Reported by Bird-Ringing Bureau, USSR
C-1288 *Anas querquedula* ♂	17.10.1965. do.	+, 21.1.1966. Devakottai, near Madurai (*c.* 9° 57′ N., 78° 51′ E.)	Reported by Mr. Kailasam, Chairman of Devakottai Panchayat
C-1710 *Anas crecca* o ?	3.12.1964 Manjhaul (*c.* 25° 23′ N., 86° 30′ E.). Monghyr District, Bihar, India	+, 19.5.1966. Yakutian ASSR, near Churapcha (62° 02′ N., 132° 36′ E.)	Reported by Bird-Ringing Bureau, USSR
C-1711 *Anas crecca* ♂	3.12.1964. do.	+, 7.10.1965. Novosibirsk Region, near Kraznozerskoe (54° N., 79° 16′ E.)	do.
C-1715 *Anas crecca* ♂	3.12.1964. do.	+, 11.5.1966. Near Khorinsk (52° 10′ N., 109° 44′ E.), Buryatian ASSR	do.
C-1958 *Anas crecca* ♀	6.1.1965. Bakhri, Monghyr District., Bihar (*c.* 25° 23′ N., 86° 30′ E.), India	+, 12.5.1966. Krasnoyarsk Region, near Ilanskii (56° 14′ N., 96° 05′ E.)	do.
C-1968 *Anas crecca* ♀	8.1.1965. do.	+, ?.9.1965. Chita Region, Nerchinsk district, near Olinsk (52° 14′ N., 116° 12′ E.)	do.

RECOVERY OF RINGED BIRDS (*contd.*)

Ring No. and species	Date and place of ringing	Date and place of recovery	Remarks
C-2090 *Anas crecca* ♀	3.2.1964. Bakhri, Monghyr Dist., Bihar (*c.* 25° 23′ N., 86° 30′ E.), India	+, 3.5.1966. Irkutsk Region, near Zima (*c.* 53° 56′ N., 102° 02′ E.)	Reported by Bird-Ringing Bureau, USSR
F-1017 *Anas acuta* ♂	27.9.1965. Bharatpur (*c.* 27° 13′ N., 77° 32′ E.), India	+, 1.5.1966. Omsk Region, near Tara (56° 54′ N., 74° 20′ E.)	do.
F-1058 *Anas clypeata* ♂	15.10.1965. do.	+, 1.5.1966. Severo-Kazakhstan Region, near Bulaevo (54° 54′ N., 74° 30′ E.)	do.
F-1090 *Anas clypeata* ♂	17.10.1965. do.	+, 30.4.1966. Altai Region, near Blagoveschenka (52° 50′ N., 79° 53′ E.)	do.
F-1130 *Anas acuta* ♂	18.10.1965 do.	+, ?.12.1965. Karimnagar, Andhra Pradesh (*c.* 18° 26′ N., 79° 08′ E.)	Reported by Mr. Rahim Khan of Karimnagar Police Headquarters
F-3044 *Anas acuta* ♂	7.2.1966. Dibrugarh (*c.* 27° 41′ N., 94° 57′ E.), Assam	+, 6.5.1966. Buryatian ASSR, Selenga River (52° 20′ N., 106° 23′ E.)	Reported by Bird-Ringing Bureau, USSR

Note. + = shot or killed by man.
(V) = trapped and died in captivity.
V = caught alive and released with ring removed.

All these birds were ringed in the course of BNHS/WHO Bird Migration Field Study Project, except AB-10217 (B. Biswas, Calcutta), and F-3044 (M. J. S. Mackenzie, Assam).

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE,
BOMBAY 1-BR,
August 27, 1966.

EDITORS

12. OCCURRENCE OF THE TOAD *BUFO FERGUSONII* BOULENGER IN HYDERABAD, ANDHRA PRADESH, INDIA (ANURA : BUFONIDAE)

On 8 August 1961, JPD, accompanied by Schuyler Giles, collected several frogs and toads from grassy monsoon puddles in the Banjara Hills neighbourhood of Hyderabad, Andhra Pradesh. Among the specimens were two calling males of *Bufo fergusonii* Boulenger (JPD 136, 137), with snout-vent lengths of 30 mm. and 33 mm., respectively.

This species has apparently not been previously reported from Andhra Pradesh, although it has been recorded from the states of Mysore, Kerala, and Madras (J. C. Daniel, 1963 : Field guide to the amphibians of western India, part 1. *J. Bombay nat. Hist. Soc.* **60** : 415-438).

Other anurans collected the same night from similar puddles were *Rana cyanophlyctis* Schneider, and *R. limnocharis* Boie.

All specimens mentioned in this note are deposited in The Museum, Michigan State University.

DEPARTMENT OF ENTOMOLOGY,
MICHIGAN STATE UNIVERSITY, JULIAN P. DONAHUE
EAST LANSING, MICHIGAN, U.S.A.

BOMBAY NATURAL HISTORY SOCIETY,
HORNBILL HOUSE, J. C. DANIEL
BOMBAY 1-BR,
August 17, 1966.

13. AN INSECT'S PERSISTENT VITALITY

Entomologists, and even a few laymen like myself, are familiar with the ' decentralization ' of an insect's nervous system. Nevertheless, the following instance of persistent vitality may prove of some slight interest.

About 9 o'clock of an April morning, I discovered a large specimen of the Hooded Grasshopper known as *Teratodes monticollis* on a plant in my garden. I picked it up by the wing-cases and found it somewhat sluggish. To kill it, I forcibly pinched its head, and while doing so unintentionally pulled the head clean off; it came away with the front pair of legs and practically all the entrails attached to it. I dropped this on the ground, and close by I dropped the remaining portion consisting of the hind-legs, median legs, wing-cases and the now hollow thorax and abdomen (all attached together).

A few minutes later, I happened to observe that this ' rear end ' was standing normally erect, exactly as though it had not lost its head and

forelegs and 'innards'. When I picked it up, the powerful hind-legs attempted to push my fingers away in the usual manner. Being curious to see how long this half-insect's life would persist, I carried it indoors and placed it under an inverted glass in my room.

About noon, three hours after separation from the head, this rear portion was still standing normally, and showed the usual reaction when I picked it up. Six hours after decapitation, at 3 p.m., I lifted the glass and lightly touched the wing-cases, whereupon the creature executed a typical leap, which landed it some two feet away and reached a roughly estimated height of 15 inches. At 6 p.m. there was some sign of sagging from the upright stance; but it was only at 9 p.m., twelve hours after decapitation, that the body definitely collapsed and spontaneous movement ceased.

DEV KUNJ,
PRABHAT ROAD,
POONA-4,
April 26, 1966.

THOMAS GAY

[A. D. Imms (1957, A GENERAL TEXTBOOK OF ENTOMOLOGY) writes '. . . each segment of the (insect) body, with its ganglion, is capable of a considerable degree of autonomous reflex behaviour . . . Centralization of function is, therefore, less well developed than in the vertebrates. . . . Local reflexes are also involved in reproductive movements—the isolated abdomen of a female silkworm moth can be fertilized and lay eggs, while in mantids the copulatory movements of the male and movements of the ovipositor can be made after decapitation.'—EDS.]

14. RECORD OF *PARACLEPSIS PRAEDATRIX* HARDING, 1924 (ANNELIDA: HIRUDINEA), FROM A NEW HOST, *NATRIX PISCATOR* (SCHNEIDER), THE CHECKERED KEELBACK (REPTILIA: SERPENTES)

The leech *Paraclepsis praedatrix* Harding, 1924, is distributed throughout India, mostly in a free-living state in ponds, tanks, etc. (but not in running water). The only record of parasitization by the leech is on the freshwater tortoise, *Lissemys punctata granosa* (Schoepff) (Harding & Moore 1927). The present note deals with another record of parasitization on a reptile, the new host being the Checkered Keelback *Natrix piscator* (Schneider), a very common snake of India. The leech was seen coming out of the buccal cavity of the snake, collected alive by Dr. B. Biswas from Salt Lake, off Calcutta, when the snake was freshly killed by chloroform in the laboratory two days after collection.

The translucent leech (in live state) had a pinkish white ground colour, profusely ornamented with dull green pigment cells on the dorsal surface. It had three pairs of eyes disposed in two subparallel rows. The first and second pairs were situated on third and fourth rings respectively, while the third pair was on the seventh ring, separated from the others by two annuli.

We are thankful to Dr. B. Biswas of the Zoological Survey of India for letting us identify the specimen and make this interesting record.

ZOOLOGICAL SURVEY OF INDIA,
CALCUTTA, MAHESH CHANDRA
August 8, 1966. S. S. SAHA

[Two earlier instances of leeches feeding on snakes have been recorded in the *Journal*. Wall collected two unidentified freshwater leeches from the mouth of a Copperheaded Ratsnake (*Elaphe radiata*) which he caught in water (Vol. **23** : 208 ; 1914), and Kinloch records a land leech on a species of *Dryophis* which he caught on the ground in a coffee estate in the Nelliampathy Hills (Vol. **28** : 557 ; 1922).—EDS.]

REFERENCE

HARDING, W. A. & MOORE, J. P. (1927): Fauna of British India, Ceylon and Burma. Hirudinea : 88-90. London. Taylor and Francis.

15. INTERTIDAL ENTOPROCTA AND ECTOPROCTA (BRYOZOA) OF BOMBAY

(*With one plate*)

In this second paper in the series on the marine fauna of Bombay are listed the Entoprocta and Ectoprocta. These two phyla were earlier included as two groups under the phylum Bryozoa, also known as Polyzoa but were assigned phylum rank by Hatschek (1888) and are now accepted as such by most workers.

Most of the taxonomic work on these phyla done in India is on forms living in fresh water. Thus Annandale has published a series of papers between 1907 and 1916. Seshaiya (1946) described a new species of *Urnatella* from Annamalainagar (South India). Marine forms from India have been studied by Thornely (1907) and Hincks (1884). Thornely has also dealt with Polyzoa from Ceylon (1905) and from the Indian Ocean (1912—material from the Percy Sladen Trust Expedition).

Other papers on Indo-Pacific Polyzoa have been by O'Donoghue & de Watteville (1935-1944) from South Africa, Waters (1913) from British East Africa and Zanzibar, Kirkpatrick (1888) from Mauritius, Waters (1909-10) from the Red Sea, Hastings (1932) from Australia, Canu & Bassler (1929) from the Philippines, and Okada & Mawatari (1935-1956) from Japan.

In addition to the general works on Indian Polyzoa, those of Bengal have been dealt with by Robertson (1921). The polyzoan fauna of the west coast of India has, however, not received much attention in the past, except for the work by Thornely (1916) at Okha. The vast area south of this has remained unexplored, except for stray records by the same author from Mangalore, and by Patil (1953) from Karwar. It was, therefore, decided to make a representative collection from Bombay. Collections were confined to the inter-tidal zone.

A total of 11 species, belonging to seven different families, comprises the present collection. None of these has been previously recorded from Bombay.

Phylum ENTOPROCTA

Family PEDICELLINIDAE

Genus *PEDICELLINA* Sars

1. **Pedicellina cernua** (Pallas)

Genus *BARENTSIA* Hincks

2. **Barentsia gracilis** (Sars)

Phylum ECTOPROCTA
Class GYMNOLAEMATA
Order CTENOSTOMATA
Suborder STOLONIFERA
Family VESICULARIIDAE

Genus *AMATHIA* Lamouroux

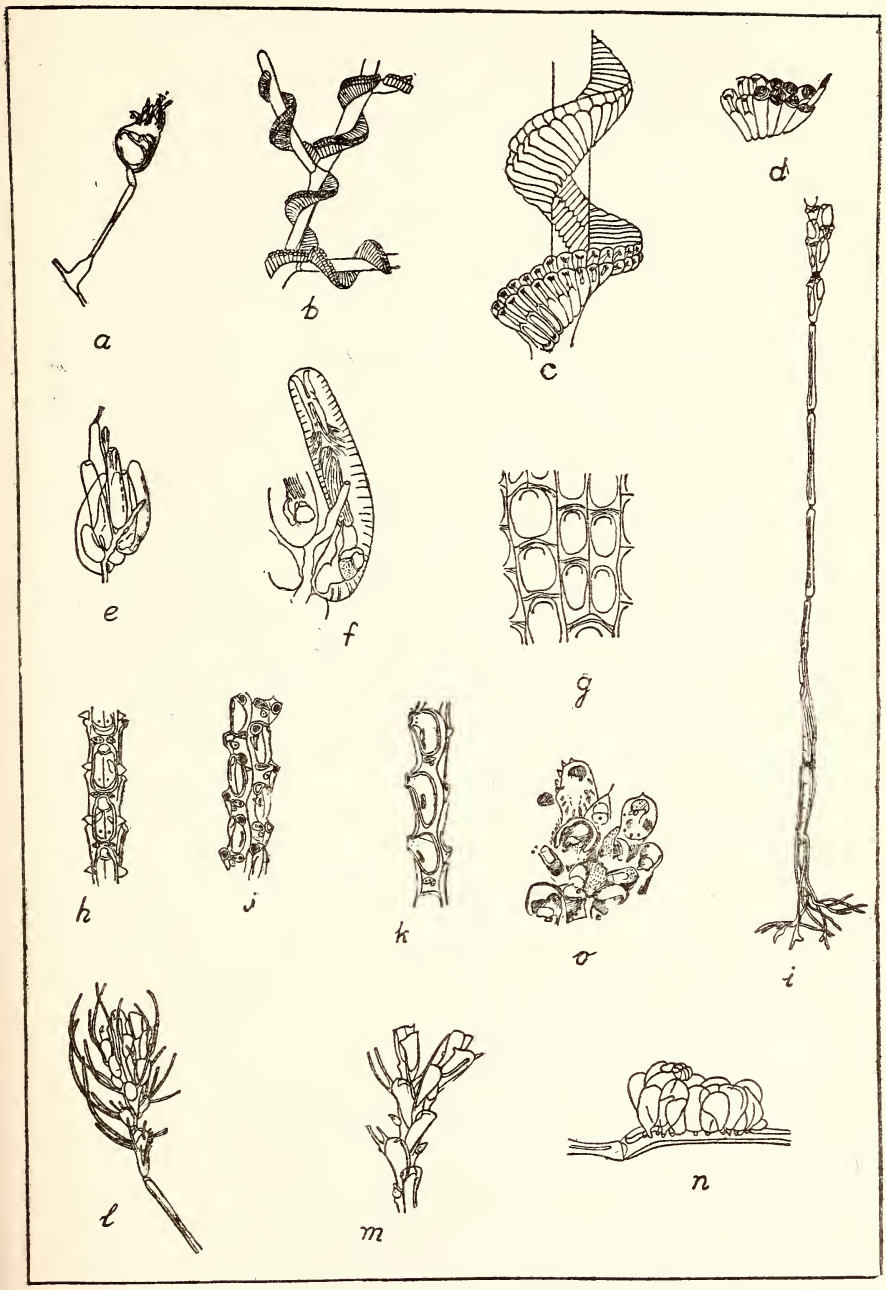
3. **Amathia convoluta** (Waters)

Genus *BOWERBANKIA* Farre

4. **Bowerbankia imbricata** Adams

Order CHEILOSTOMATA
Suborder ANASCA
Division MALACOSTEGA
Family MEMBRANIPORIDAE

Genus *ELECTRA* Lamouroux



Barentsia gracilis: a. side view of individual. *Amathia convoluta*: b. part of zoarium; c. group of zooecia; d. zooecia. *Bowerbankia imbricata*: e. group of zooecia; f. portion of stem with one complete zooecium and parts of several others. *Acanthodesia savartii*: g. zooecia. *Nellia oculata* var. *quadrilatera*: h. ovicells. *Poricellaria ratoniensis*: i. proximal part of young colony; j. front view; k. side view. *Caulibugula zanzibariensis*: l. zooecial fan, showing modified proximal zooecium, and end of last kenozooecium of stalk; m. part of branch, showing avicularia; n. parts of two kenozooecia, one with a group of stem-vesicles near distal end. *Celleporaria pilaefera*: o. zooecia, avicularia and ovicells. (*All illustrations after Harmer*).

5. **Electra pilosa** (Linnaeus)

Genus *ACANTHODESIA* Canu & Bassler

6. **Acanthodesia savartii** (Audouin)[1]

Genus *NELLIA* Busk

7. **Nellia oculata** var. **quadrilatera** D'Orbigny

Division COELOSTEGA

Family PORICELLARIDAE

Genus *PORICELLARIA* D'Orbigny

8. **Poricellaria ratoniensis** (Waters)

Division CELLULARINA

Family BICELLARIELLIDAE

Genus *CAULIBUGULA* Verrill

9. **Caulibugula zanzibariensis** (Waters)[2]

Suborder ASCOPHORA

Division ASCOPHORA IMPERFECTA

Family CELLEPORARIIDAE

Genus *CELLEPORARIA* Lamouroux

10. **Celleporaria** prox. **pilaefera** (Canu & Bassler)

Division ASCOPHORA VERA

Family VITTATICELLIDAE

Genus *VITTATICELLA* Maplestone

11. **Vittaticella** sp.

KEY TO THE IDENTIFICATION OF ENTOPROCTA AND ECTOPROCTA OF BOMBAY

1. Anus lying inside the circlet of tentacles (Entoprocta) 2
   Anus lying outside the circlet of tentacles (Ectoprocta) 3
2. Stalk approximately of the same diameter and muscularity throughout, lacking special muscular enlargements .. .. .. *Pedicellina cernua*
   Stalk has muscular thickenings along it, also a basal muscular socket .. .. *Barentsia gracilis*

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[1] The specimens in the present collection do not show the internal proximal cryptocystal denticle characteristic of this species.

[2] The stolons of the specimens in the present collection do not bear the large vesicles which are characteristic of this species.

3.	Zoecia not calcified, membranous; orifice terminal or subterminal, closed by a pleated collar, ovicells and avicularia absent (Ctenostomata)	4
	Zoecia box-like, with small subterminal orifice closed by a hinged operculum; brood chambers frequently in the form of ovicells; often with avicularia (Cheilostomata)	5
4.	Zooids in spirally curved double rows ..	*Amathia convoluta*
	Zooids in clusters	*Bowerbankia imbricata*
5.	Zooids without compensation sac (Anasca) ..	6
	Zooids with compensation sac (Ascophora) ..	9
6.	Zooids more or less contiguous, generally calcified except for the frontal membrane; with or without ovicells and avicularia (Malacostega)	7
	Cryptocyst extending to orifice, leaving opesiules; ovicells hyperstomial or endozoecial ..	*Poricellaria ratoniensis*
	Zoecia uncalcified or only moderately so, in branching colonies; with hyperstomial ovicells and typical avicularia	*Caulibugula zanzibariensis*
7.	Frontal membrane occupying entire ventral surface (Membraniporidae)	8
	Frontal membrane reduced to an oval area bordered with spines	*Electra pilosa*
8.	Gymnocyst and ovicells wanting ..	*Acanthodesia savartii*
	Short gymnocyst and small, entozoecial ovicells present	*Nellia oculata* var. *quadrilatera*
9.	Colony with irregularly piled up, erect zooids.	*Celleporaria* prox. *pilaefera*
	Colony with delicate, jointed branches with one to three successive zooids, all facing in one direction, making up each internode between joints	*Vittaticella* sp.

ACKNOWLEDGEMENTS

The authors are grateful to Miss Patricia Cook, of the British Museum (Natural History), London, for identification of some specimens and confirmation of the identification of others, and to Dr. C. V. Kulkarni, Director of Fisheries, Maharashtra State, and Dr. H. G. Kewalramani, Senior Scientific Officer, for facilities for work at the Taraporevala Marine Biological Station, Bombay.

TARAPOREVALA MARINE BIOLOGICAL STATION,
BOMBAY 2-BR, B. F. CHHAPGAR

c/o SACHETAN,
L/4-5 SITARAM BUILDING,
PALTON ROAD,
BOMBAY 1-BR, S. R. SANE

August 27, 1966.

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16. CORRECT NAME FOR *VENTILAGO CALYCULATA* TULASNE

The present note gives the correct name, *Ventilago denticulata* Willd., for *Ventilago calyculata* Tulasne. To explain the change, I have put the list of necessary synonyms after the correct name.

Ventilago denticulata Willd. in Ges. Naturf. Fr. Neue Schr. 3 : 417, 1801. *V. maderaspatana* Roxb. Pl. Corom. 1 : 55, t. 76, 1796-98 ; Wt. & Arn. Prodr. 164 (non Gaertn. 1788). *V. maderaspatana* var. *β* Roxb. loc. cit. *V. calyculata* Tulasne in Ann. Sc. Nat. (Ser. 4) 8 : 124, 1857. *V. macrantha* Tulasne in Ann. Sc. Nat. (Ser. 4) 8 : 123, 1857. *V. silhetiana*, *smithiana* et *sulphurea* Tulasne in Ann. Sc. Nat. (Ser. 4) 8 : 125, 1857. *V. maderaspatana* Gaertn. var. *calyculata* King in Journ. As. Soc. Bengal 65(2) : 378-79, 1896.

DEPARTMENT OF GENERAL EDUCATION, G. M. OZA, PH.D., F.L.S.
M. S. UNIVERSITY OF BARODA,
BARODA,
February 18, 1966.

17. A NEW SYNONYMY IN UMBELLIFERAE

Pternopetalum vulgare (Dunn) Hand.-Mazz. Symbol. Sinic. 7 : 719, 1933. *Cryptotaeniopsis vulgaris* Dunn in Hook. f. Ic. 8 : t. 2737. 1902 et in J. Linn. Soc. Bot. 35 : 494. 1903 ; Wolff in Engl. Pflanzenr. IV. 228 : 176. 1927. *Pternopetalum davidii* Boissieu in Bull. Herb. Boiss. II. 2 : 806. 1902, non Franch., 1885. *Deringa vulgaris* (Dunn) Koso-Poljansky in Monit. Jard. Bot. Tiflis 11 (3-4) : 6. 1915 et in Bull. Soc. Nat. Mosc. 29 : 136. 1915. *Pimpinella clarkeana* Watt ex Banerji in J. Bombay nat. Hist. Soc. 50 (1) : 88. 1953.

Pimpinella clarkeana Watt ex Banerji being based on *Watt* 6556, a syntype (here chosen as Lectotype) of *Cryptotaeniopsis vulgaris* Dunn in Hook. f. Ic. 8 : t. 2737. 1902, is a synonym of the latter.

CENTRAL NATIONAL HERBARIUM, D. B. DEB
INDIAN BOTANIC GARDEN,
HOWRAH,
May 26, 1966.

18. FLORAL VARIATIONS IN THREE SPECIES OF *CESTRUM* LINN., VIZ. *C. DIURNUM* LINN., *C. ELEGANS* SCHLECHT., AND *C. NOCTURNUM* LINN.

Introduction

Though a considerable literature is available on the teratology of vegetative organs, the data on floral variations are comparatively rare. It may be because such a study involves a critical examination of a number of flowers. Whenever a variation is observed, it is often by-passed as an abnormality. If floral variations have to play an important role in taxonomy, a detailed study of several flowers is necessary to find out the nature and frequency of such variations.

Cestrum diurnum L., *C. elegans* Schlecht., and *C. nocturnum* L. belong to the family Solanaceae. Reports on teratological variations in this family seem to be scanty. Singh (1935) reported the flattening of the vegetative and reproductive axes in *Lycopersicon esculentum* Mill. Floral variations occur in *Solanum melongena* L. (Sayeeduddin & Salam 1936) and *Capsicum annuum* (Sunderaj & Balasubramanyam 1956).

According to Linnaeus (1753), Dunal (1852), and Bentham & Hooker f. (1876), the genus *Cestrum* is characterized by 5 sepals, 5 petals, and 5 stamens. In fact Dunal (1852) and Bor & Raizada (1954) have described pentamerous flowers for *C. diurnum* L. and *C. nocturnum* L., though the last-named authors casually mention that the corolla is 5 or more lobed in the genus *Cestrum* and in *C. elegans* in particular. This seems to be the only report on floral variation in the genus. In a cursory study of these plants a few hexamerous and tetramerous flowers were observed. A critical study of as many fresh flowers and buds as possible was, therefore, undertaken to find out the range of variation. Since the variations were many even in the same plant and even in the same inflorescence, it was thought necessary to record them. They will be taxonomically useful while comparing the descriptions of these plants with those in published books.

The material of *C. diurnum* L. and *C. elegans* Schlecht. was collected from different plants growing at Vallabh Vidyanagar and Mahableshwar respectively, while that of *C. nocturnum* L. was obtained from both localities.

Observations

220 flowers of *C. diurnum* L., 300 flowers of *C. nocturnum* L., and 113 flowers of *C. elegans* Schlecht. were examined, of which 93 flowers (42·3%), 94 flowers (31·3%), and 40 flowers (35·4%) respectively showed variations. They were in the number of sepals, petals, and stamens,

but the gynoecium remained unaffected. About 14 types of variations were seen in *C. diurnum* L., 9 types in *C. nocturnum* L., and 12 types in *C. elegans* Schlecht. They can be grouped as follows : (*a*) Variations in three whorls, i.e. sepals, petals, and stamens of the same flower; (*b*) Variations in two whorls, i.e. (i) sepals and petals, (ii) sepals and stamens, and (iii) petals and stamens of the same flower; (*c*) Variations only in one whorl, i.e. sepals, petals, or stamens of a flower. Instead of describing them separately they are tabulated (Tables 1-3) so as to enable one to see the range of variations at a glance.

TABLE 1. *C. diurnum* L.

Serial number.	Number of flowers showing variations.	Number of sepals.	Number of petals.	Number of stamens.
1	10	4	4	4
2	36	6	6	6
3	1	6	6	6
4	2	6	5	6
5	1	6	5	4
6	2	5	7	7
7	20	5	6	6
8	1	5	4	4
9	1	6	6	5
10	2	4	4	5
11	1	4	5	5
12	5	6	5	5
13	3	5	5	4
14	8	5	5	6
Total ..	93			

Fasciation. In addition to the floral variations described above, fasciation was observed in three cases of *C. elegans* Schlecht. In two cases, the sepals of the two adjacent flowers were so fused that they had a common whorl of ten sepals. In a third case, a flower consisted of eight sepals, nine petals, eight stamens, and two fused gynoecia.

TABLE 2. *C. nocturnum* L.

Serial number.	Number of flowers showing variations.	Number of sepals.	Number of petals.	Number of stamens.
1	5	3	3	3
2	71	4	4	4
3	1	3	4	4
4	1	4	6	6
5	1	5	6	6
6	1	7	5	5
7	1	5	4	5
8	11	5	5	4
9	2	4	5	5
Total ..	94			

TABLE 3. *C. elegans* Schlecht.

Serial number.	Number of flowers showing variations.	Number of sepals.	Number of petals.	Number of stamens.
1	13	6	6	6
2	3	7	6	6
3	1	10	6	6
4	1	6	6	4
5	1	6	5	4
6	1	4	5	4
7	1	10	6	5
8	1	6	6	5
9	5	5	5	3
10	3	5	5	4
11	8	6	5	5
12	2	7	5	5
Total ..	40			

This was due to a complete fusion between different whorls of the two adjacent flowers.

Summary

Observations on floral variations in *C. diurnum* L., *C. elegans* Schlecht., and *C. nocturnum* L. are recorded. Among the flowers with variations, the hexamerous flowers are by far the largest in number in the first two plants and the tetramerous ones in the last one. There are fourteen types of variations in *C. diurnum* L., twelve types in C. *elegans* Schlecht., and nine types in *C. nocturnum* L. The variations are in the number of sepals, petals, and stamens, but the gynoecium remained unaffected.

Acknowledgement

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Department of Botany,
Sardar Patel University,
Vallabh Vidyanagar,
Gujarat State,
May, 17, 1965

G. L. SHAH
B. SURYANARAYANA

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19. *UTRICULARIA MINUTISSIMA* VAHL : A NEW RECORD FOR NORTH INDIA

A species of *Utricularia*, collected near Nuanai bridge in October 1965 during a botanical exploration in Balukhand Reserve Forest, Puri District, Orissa State, has been subsequently identified as *U. minutissima* Vahl, a new record for northern India. The plant grows in abundance in sandy marshes in association with *U. baouleënsis* A. Chev., *U. bifida* L., *U. caerulea* L., *U. hirta* Klein, and *U. stricticaulis* Stapf.

C. B. Clarke (1885) in Hooker's FLORA OF BRITISH INDIA includes *U. minutissima* in the group of imperfectly known species. Subramanyam & Balakrishnan (1960) reported the occurrence of *U. lilliput* Pell. in India, based on a collection from Courtallam, Madras State; this name has been subsequently proved to be synonymous with *U. minutissima* Vahl. Recently Vasudevan Nair (1965) has reported this species from Palghat, Kerala State. So far there is no other report of this plant from anywhere else in India and its presence in Orissa State adds information about its distribution in India. The specimens are deposited in Blatter Herbarium (BLAT), Bombay.

In essential characters, the present collection of *U. minutissima* matches with the details of its earlier reports; certain variations noticed are pointed out below: (i) Leaves bear 8-14 minute bladders arranged alternatively; (ii) flowers bluish white, unlike the previous reports, where they are described as pinkish or pinkish red. The bladder has a lateral mouth. As in other semi-marshy species, this also has bladders but lacks the sensitive hairs on the door. The mouth is guarded by the door, velum, and threshold and bears the usual type of sessile glands as in other semi-marshy species. Within the bladder, there are a few digestive glands, usually quadripartite, sometimes bipartite. Exomorphic characters of the seeds of *Utricularia* are highly variable from species to species and they could be used for their identification. In this species the shape and structure of the seed are unique; they are globose and reticulate and look almost similar to seeds of *U. squamosa* Wt.

Specimens examined:

Abraham 264, 354 (BLAT), Balukhand Reserve Forest, Orissa, October 1965.

My thanks are due to Dr. K. Subramanyam, Joint Director, Botanical Survey of India, Calcutta, for encouragement and for the facilities provided for this study.

BOTANICAL SURVEY OF INDIA,
76, LOWER CIRCULAR ROAD,
CALCUTTA 14,
April 6, 1966.

V. ABRAHAM[1]

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VASUDEVAN NAIR, R. (1965): New record of *Utricularia minutissima* Vahl in South India. *J. Bombay nat. Hist. Soc.* **62**: 180-182.

[1] Present Address: Biology Division, Atomic Energy Establishment, Trombay, Bombay 8.

20. TWO INTERESTING ORCHIDS FROM N. W. HIMALAYAS

The author who was a botanist member of the mountaineering expedition to the Tirsuli Peaks, Pithoragarh District, Kumaon, undertaken by the Himalayan Association, Calcutta, during April-May 1965, collected two plants of the genus *Pleione* D. Don, viz. *P. grandiflora* Rolf. and *P. humilis* D. Don var. *albata* Reichb. f., from Kalamuni Pass at an altitude of 2600-2700 m. The former is a central Asiatic (Yunan, Mengtze) species and has not been previously reported from India. The other taxon is known only from temperate Nepal and the Sikkim Himalayas. Both the species have been collected from mossy rocks in *Quercus-Rhododendron* forest. The specimens are deposited in the Central National Herbarium, Sibpur, Calcutta (CAL) and Herbarium of the Botanical Survey of India, Northern Circle, Dehra Dun (BSD).

P. grandiflora Rolfe in Orch. Rev. 11 : 291, 1903 ; Pfitz. et Kraenzin Pflanzenr. 32 : 124, 1907. *Coelogyne grandiflora* Rolfe in J. Linn. Soc. 36 : 22, 1903.

Rhizome repent ; root fibrous. Pseudobulb ovate to flask-like, surrounded by leaf fibres, 3 to 4 cm. long, about 1·5 cm. in diameter ; apical annulus, cylindrical, dentate, 1-leaved. Leaf lanceolate, acute, projecting much above the annulus, 4 to 5 cm. long when the flower opens. Scape appearing with the leaves, erect, 4 to 5 cm. long, single-flowered ; basal sheath tubular, obliquely truncate, thin and membraneous, almost transparent, shining, equalling the pseudobulb in length. Bracts narrowly elliptic, tip rounded. Flowers white. Sepals and petals similar, lanceolate-oblong, obtuse, 4 to 5 cm. long, 0·75 cm. broad, 5- to 7-nerved. Labellum white, streaked and spotted brown inside, trilobed with rounded lateral lobes and trapeziform median lobe, emarginate, margin fimbriate ; carina with 5 longitudinal fringed lamellae. Gynostegium slender with triangular wing which towards the apex become two-lobed.

N. C. Nair 35536.

Pfitzer & Kraenzlin (loc. cit.) report that the size of the scape is 10 to 12 cm. long and sheath 12 cm. long. In the present material the scape and sheath were short.

P. humilis D. Don var. **albata** Reichb. in Gard. Chron. 1 : 392, 1888 ; Pfitz.et Kraenz. 32 : 122, 1907. *Coelogyne humilis* (D. Don) Lindl. var. *albata* (Reichb.) Hook. f. in Fl. Brit. Ind. 5 : 841, 1890.

Pseudobulb flask-shaped, 3 to 3·5 cm. long, 1 to 1·5 cm. diameter, single-leaved ; annulus membraneous. Leaves oblong-obovate, acuminate, 5-nerved, 20 cm. long appearing later than the single-flowered scape. Bracts longer than the ovary. Flowers white. Sepals lanceolate, sub-acute. Petals similar, obovate from a cuneate base. Labellum

streaked and spotted purple inside ; margin lacerate towards the tip ; lamellae 5, fimbriate.

N. C. Nair 35519.

I am thankful to Dr. M. A. Rau for encouragement.

Botanical Survey of India, N. C. NAIR
63, Rajpur Road,
Dehra Dun,
April 27, 1966

21. *ELEOCHARIS FISTULOSA* SCHULT. : A NEW RECORD FOR THE UPPER GANGETIC PLAIN

Duthie (1929) recorded three species of *Eleocharis* (Cyperaceae), namely, *E. atropurpurea* Kunth, *E. palustris* R. Br. and *E. plantaginea* R. Br. from the Upper Gangetic Plain. Recently one more species of *Eleocharis* was collected by the authors from Meerut, which was later identified as *E. fistulosa* Schult. Since this species has not been reported from the Upper Gangetic Plain, the publication of this record may be of some interest.

Eleocharis fistulosa Schult. : Hook. f. Fl. Brit. Ind. **6** : 626, 1893 ; Cooke, Fl. Bomb. Pres. **2** : 863, 1908 ; Haines, Bot. Bih. & Or. 912, 1924 ; Fischer, Fl. Pres. Mad. 1948, 1931.

A rush-like caespitose herb, 30-90 cm. high ; rhizome stoloniferous. Stems tough, terete, glabrous, triquetrous at the top, basally embraced by loose, membranous, obliquely truncate, sheaths. Spikelets terminating the stems, embraced at the base by a short rounded bract, cylindric, acute, dusky, green, 2-4 cm. high, as broad as stem. Glumes laxly imbricate, much striated, suberect, obovate, subacute. Bristles 6, slightly longer than the nut, brown. Nuts obovoid, faintly striate, pale or dark brown, tipped with persistent style bases.

Flowers and Fruits : October-December.

Amhera, Meerut, November 5, 1965, *Murty & Singh* 2495.

This species was growing gregariously in marshy places near village Amhera, associated with *Eleocharis plantaginea* R. Br. and *Isoëtes coromandelina* Linn. It can be readily distinguished in the field from other species of the genus occurring in the Upper Gangetic Plain by its sharply triquetrous stem at the top.

Hooker (1893) gives the distribution of this species from Nepal and Assam to Burma and Ceylon. Probability of its being overlooked by earlier collectors is strong.

The authors record their thanks to Professor V. Puri for his interest

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SCHOOL OF PLANT MORPHOLOGY,
MEERUT COLLEGE,
MEERUT,
June 10, 1966

V. SINGH
Y. S. MURTY

22. DISTRIBUTION OF *SPINIFEX LITTOREUS* (BURM. F.) MERR. ALONG INDIAN COASTS

Although most plants in Indian coasts are more or less well known, information on their habitats and distribution is meagre. Recently a population of *Spinifex littoreus*, a suffructicose dioecious perennial grass, near Digha of Midnapur coast in West Bengal was observed. This is the first report for West Bengal State, thus indicating an extension of the known range of distribution from the shores of Puri, Cuttack and Balasore.

This hardy grass is found along the western and eastern coasts of India. It is ecologically restricted to the maritime strand ecosystem and is prominent there. It occurs along the tropical coasts of China, Formosa, Siam, the Malay archipelago, Burma, the Laccadive and Maldive islands, and Ceylon where it forms a major component of the strand vegetation. Along Indian coastal areas it occurs along the west coast; Domas near Surat in Gujarat State is the north-western limit of its extension; along the east coast its occurrence has been reported from the sandy shores of Puri by Prain (1903) and Cuttack and Balasore by Haines (1924). Recently, male clumps were found near Digha in Midnapur District. These observations thus indicate that *Spinifex* perhaps has invaded this area only recently.

The plant is sometimes associated with the sand-binding *Ipomoea pes-caprae* (L.) Sweet. However, it does not have any consistent association with any plant species, but exhibits special adaptations for competing successfully with other species of the strand ecosystem.

BOTANICAL SURVEY OF INDIA,
76 ACHARYA JAGADISH BOSE ROAD,
CALCUTTA 14,
May 3, 1966

T. ANANDA RAO
P. G. SHANWARE

REFERENCES

HAINES, H. H. (1921-5): The Botany of Bihar and Orissa. London.

PRAIN, D. (1903): Bengal Plants. Calcutta.

23. A NEW SPECIES OF *HYDROGONIUM* FROM THE WESTERN HIMALAYAS

(*With a plate*)

Hydrogonium mussoorianum Vohra, sp. nov.

Affine *H. amplexifolio* (Mitt.) Chen, ab eo tamen differt foliis minoribus, fortiter carinatis, obtusis, nervo lato et complanato desinente ad apicem vel in dentem brevem; cellulis basalibus versus marginem subquadratis.

Typus, *Vohra 453A*, et isotypus, *Vohra 453B*, lecti ad Mussoorie in Himalaya Septentrionali occidentali, ad altit. 2000 m. die 22.3.1963. Holotypus positus in CAL, isotypus in BM.

Hydrogonium mussoorianum Vohra, sp. nov.

Allied to *Hydrogonium amplexifolium* (Mitt.) Chen, but differs in leaves being smaller, strongly carinate, obtuse, nerve wide and flattened, ceasing with the apex or projecting in a short tooth; and basal cells towards margin somewhat quadrate.

Plants laxly tufted, brownish green or dark green. Stems slender, weak, 2-3 cm. tall, simple or branched with 2-4 subapical innovations. Leaves when dry coiled round the stem with apices incurved or circinate, when moist spreading from an erect sheathing base, amplexicaul, strongly carinate, apices more or less curved upwards, 0·75-1 mm. × 0·5-0·6 mm., ovate lanceolate, obtuse; margin erect, entire, somewhat crenulate due to papillae; nerve yellowish brown, wide, 70-90 μ at base, flattened, uniform or slightly narrow at apex, ceasing with the apex or projecting into a short tooth, papillose at back; cells rounded-quadrate, 5-7 μ, densely papillose with 4-5 minute semilunar papillae in each cell, obscure, at base pellucid, oblong, thick-walled, 8-11 × 14-34 μ, 5-10 rows toward margin short and quadrate.

The holotype of this species (*Vohra 453A*) and isotype (*Vohra 453B*) were collected from Mussoorie, NW. Himalayas at an altitude of 2000 m., on 22-3-1963. The holotype has been deposited in the Central National Herbarium, Howrah, CAL, and isotype in the British Museum (Nat. Hist.), London, BM.

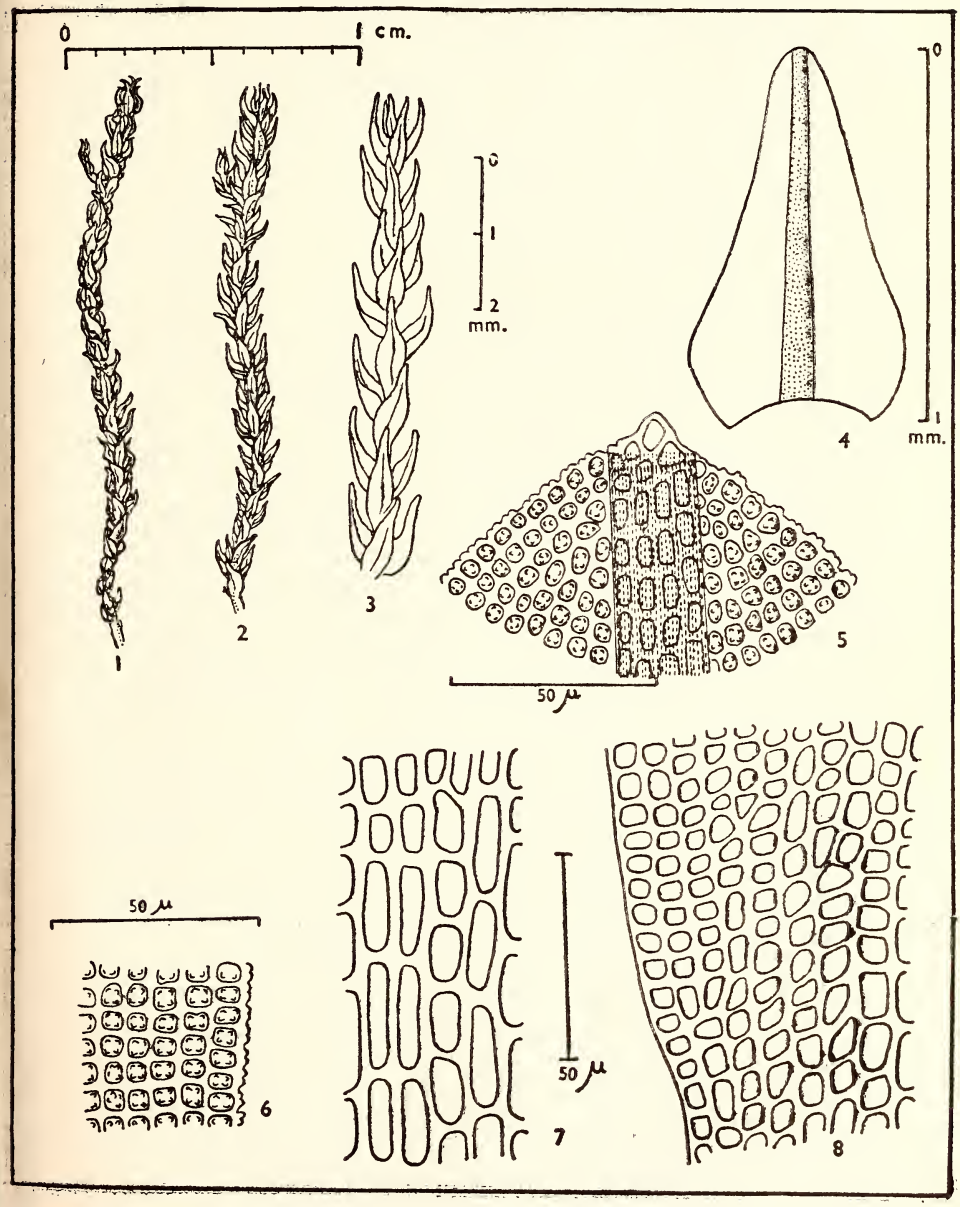
ACKNOWLEDGEMENTS

I wish to thank Dr. Santapau, S.J., F.N.I., Director, Botanical Survey of India, for going through the manuscript and for the Latin diagnosis, and Mr. A. H. Norkett of the British Museum (Nat. Hist.) for his valuable opinion on this species.

BOTANICAL SURVEY OF INDIA,
76 ACHARYA JAGADISH BOSE ROAD,
CALCUTTA 14,
May 18, 1966.

J. N. VOHRA

Vohra : *Hydrogonium mussoorianum*



Hydrogonium mussoorianum Sp. nov.

1. Dry Plant 2. Moist Plant 3. Shoot Apex 4. Leaf 5. Leaf Apex 6. Laminar cells 7. Basal cells towards nerve 8. Basal cells towards margin

24. OCCURRENCE OF *STREPTONEMA TRILOBATUM* WALL. AT RAIPUR, MADHYA PRADESH

Wallich in 1855 reported *Trigonema trilobatum* from lower Bengal and later in 1860 synonymised it with *Streptonema* and described it. Subsequently it was reported and described by Turner (1892) from East India and since then there are no reports of this alga from any other parts of the country. During the author's collection of algae from here in October 1964 it was found submerged in Mahant Tal near Science College. When the water is disturbed the filaments come very near to the surface but do not float. There are no reports about the habit of the alga by previous authors. The filaments do not form clusters and were found only at the margin of the pond. It was observed for nearly two months in 1964 ; in 1965, perhaps due to lack of rains, the alga was not seen.

The author could not get any reproductive stages. The alga shows a little difference in size from the previously reported forms. The filaments are 2 to 3 cm. long or even longer. Semi-cells 20 to 24 μ long, 40-45 μ broad and processes 4 to 7 μ long.

I am thankful to Dr. R. Ross, Keeper, British Museum (Natural History), London, for identification, and to Dr. G. S. Venkataraman for giving me the literature.

DEPARTMENT OF BOTANY,
GOVERNMENT COLLEGE OF SCIENCE,
RAIPUR, M. P.
December 30, 1965.

K. SANKARAN UNNI

REFERENCES

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WALLICH, G. C. (1860) : Descriptions of Desmidiaceae from Lower Bengal. *Ann. Mag. Nat. Hist.* 5 : 196-197.

WALLICH, G. C. (1855) : ibid. 39-46.

ANNUAL REPORT OF THE BOMBAY NATURAL HISTORY SOCIETY FOR THE YEAR 1965-66

Executive Committee

President

Dr. P. V. Cherian, *Governor of Maharashtra*

Vice-Presidents

Major-General Sir Sahib Singh Sokhey, I.M.S. (Retd.)
Dr. Sálim Ali, D.Sc., F.N.I.
Rev. Fr. H. Santapau, S.J.

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Mr. Zafar Futehally

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HONORARY SECRETARY'S REPORT FOR THE YEAR 1965

At the last Annual General Meeting of the Society held on 30th July 1965, we presented a report on the activities of the Society up to April 1965. The present report covers the 8 months thereafter up to 31st December 1965.

MEMBERSHIP

The total number of members on our register on 31st December 1965 was 1415. Out of this 71 were nominees of the Forest Department (who received the *Journal* at the concessional rate of Rs. 20), 249 were life members, and 2 honorary members. The position of the six previous years is tabulated below :—

Year	Life	Honorary	Ordinary		Total
			Paid	*Pending*	
1960	235	3	680	180	1098
1961	237	2	749	174	1162
1962	240	2	763	208	1213
1963	242	2	741	297	1282
1964	241	2	764	306	1313
1965	249	2	836	328	1415

During the year under report 100 ordinary and 6 life members were enrolled as against 23 ordinary and 7 life members who resigned or died. Even after allowing for the fact that Natural History is not a very popular subject in this country there is still scope for enlarging our membership very considerably. It may be pointed out that corporate members pay

the same fees as individuals and business firms, many of which are getting increasingly public spirited, could be induced to become members and support the Society in its various schemes.

The Society's Journal

Three numbers of the *Journal*, Vol. 61, No. 3, and Vol. 62, Nos. 1 and 2, were published during the period under report. The 620 pages include 9 papers on Botany, 7 on insects, 3 on birds, and 2 each on mammals, fishes, crustacea, and molluscs. The 64 Miscellaneous Notes covered many subjects and, together with the papers, included descriptions of several new species and races of plants and animals.

With financial assistance received from authors of two articles we were able to include colour plates in two of the issues published during the year. The Society records its appreciation for this assistance.

It is unfortunate that we have not been able to publish the Journal on its scheduled date. This delay is, among other things, due to the fact that the Society is very understaffed for its editorial and clerical work.

General

BNHS/WHO Bird Migration Study Project. During the period under report one bird banding camp was held at Bharatpur, Rajasthan, between 22nd September and 25th October 1965. This year the main effort was on ringing ducks and waders. 2085 ducks and waders were ringed ; the trapping was done with the help of professionals recruited from Bihar. Blood samples collected from the birds were sent to the Kievskae Shosse Institute of Poliomyelitis and Virus Encephalitis, Moscow, U.S.S.R., for virological investigation. We have had several recovery reports of these ringed birds, five of which are from Russia and one from East Pakistan. These recoveries are very important from the point of view of studying the migratory routes of birds.

A pilot survey party was also sent to the Chilka Lake area in Orissa and information collected by them will be useful for future camps.

This work, as you know, is carried out with the financial assistance of WHO with Dr. Sálim Ali as the Chief Investigator. During the year a sum of $ 1000 has been received for continuing with this project.

Additions to the Collections. During the year 639 additions were made to our collections as under :

Mammals	..	9
Birds	..	136 (20 specimens were received in exchange from Berlin and Denmark Museums)
Reptiles and Amphibians	..	406
Insects and other invertebrates	..	88

Interesting additions among these are :

Birds

Astur gentilis
Anser fabalis
Anser fabalis brachyrhynchus
Catharacta maccormicki

Reptiles

Cabrita leschenaulti
Oligodon travancoricus

Amphibians

Rana brevipalmata
Rana dobsonii
Microhyla zeylanica

Wild Life Preservation. We mentioned in our last report that a seminar was held in Delhi in April 1965 between representatives of the Planning Commission, the Ministry of Food & Agriculture, and the Indian Board for Wild Life. At this meeting a memorandum was submitted on behalf of the Society dealing with the administrative set-up necessary for wild life preservation in this country. This was followed up by a seminar in New Delhi on 24th of November 1965 in which several distinguished members of the International Union for Conservation of Nature and Natural Resources participated. The report of the seminar has not yet been published in our *Journal* because the minutes of the meeting have not yet come in from the Ministry of Food & Agriculture. The seminar, however, proved a useful forum for drawing attention to matters of importance in connection with nature conservation in this country.

The Society had been concerned about the proposal to establish an air rifle factory in the Punjab, and representations had been made to the Home Ministry advising that it was necessary to have suitable legislation enacted to prevent damage to our bird life by youngsters handling these air rifles. We have now been advised that this project has been dropped.

The Society has been exerting itself to preserve the small area of forest around Karnala Fort in Kolaba District, and to have it designated as a bird sanctuary. Members will recall that in this area a new bird record for the Indian limits, namely *Pericrocotus divaricatus*, the Ashy Minivet, has been found. This was reported in Vol. 62, No. 2, of the *Journal*, at page 303. The Maharashtra State Wild Life Board on which the Society is represented is recommending to the Government that this

area be designated as a bird sanctuary, and it is hoped that this representation will be successful.

At our instance Mr. M. Krishnan of Madras, a member of our Advisory Committee, wrote to the Secretary, Forest Department, Government of Kerala, about the destruction of the forest in the Periyar Wild Life Sanctuary, and stressing the importance of preserving this area in its natural condition. We hope that the Government of Kerala will consider this representation carefully.

Publications

A SYNOPSIS OF THE BIRDS OF INDIA AND PAKISTAN. Our stock of this book was exhausted during the year and Dr. Ripley was kind enough to donate 100 copies from the lot of 750 sent to the U.S.A.

The sale of our popular publications THE BOOK OF INDIAN BIRDS and THE BOOK OF INDIAN ANIMALS is satisfactory. The stock of SOME BEAUTIFUL INDIAN CLIMBERS AND SHRUBS and SOME BEAUTIFUL INDIAN TREES is now nearly exhausted and the Committee is considering the possibility of reprinting these publications as well as the book CIRCUMVENTING THE MAHSEER AND OTHER SPORTING FISH IN INDIA AND BURMA by Macdonald. The main difficulty is the lack of funds, though the profits from the sale of our publications are the mainstay of the Society's finances.

HANDBOOK OF INDIAN BIRDS, by Sálim Ali and S. Dillon Ripley. Work on the Handbook is continuing and the first volume is now in the press and is expected to be published in 1967. The paintings for the Handbook have been received and blocks will be prepared before the end of 1966.

FAUNA OF MAHARASHTRA. The Society has undertaken to prepare a volume on the Fauna of Maharashtra in the Maharashtra Gazetteer series. The work is now in progress and is expected to be completed before the end of the year 1966.

Donations

Members are aware of the generous manner in which the late Dato Loke Wan Tho assisted the Society. The executors of Loke Wan Tho's will have donated to the Society a bird-call tape recording set and accessories, a photo enlarger, and all the negatives of photographs taken by Dato Loke Wan Tho, and Col. R. S. P. Bates. Col. Bates's negatives were earlier purchased by Loke Wan Tho. The Society is deeply indebted to the executors for this most valuable and useful gift.

Sálim Ali/Loke Ornithological Research Fund. We are glad to report that Dr. Sálim Ali has donated a sum of Rs. 10,000 for starting a research fund for the study of field ornithology and generally to promote the cause of bird preservation in this country. The interest from the fund will be available to both amateur and professional biologists and we appeal to our members for further contributions so that a substantial fund can be built up for use in future years.

A donation of Rs. 100 has already come in from Dr. (Miss) R. Reuben.

Dr. Sálim Ali has also donated his entire library of about 500 volumes and 1000 separates of scientific papers to the Society. We are deeply grateful for this very generous gift.

Col. R. W. Burton Fund. The late Col. R. W. Burton who was one of the most active members of our Society during the 70 years of his stay in this country left the Society a sum of Rs. 3000. The Society proposes to invest this fund and use its proceeds for furthering the cause of Nature Conservation.

Furniture. The National Institute of Oceanography who have been given temporary accommodation in our building and who have been using our library and auditorium for their training programme in Oceanography have thoughtfully donated to the Society furniture and fittings for the auditorium.

Research Studies

The Sir Dorabji Tata Trust Fund. One of the research fellows of the Society was given financial assistance for investigating the status of the Largebilled Reed Warbler, *Acrocephalus orinus*. The study was carried out in Rampur in Uttar Pradesh. Another member was given monetary assistance for doing a survey of the Hazaribagh National Park. The report of the survey will be published in a future issue of the *Journal*.

Field Ornithology. A student from Cambridge University under the guidance of Dr. Sálim Ali is at the moment working on the social behaviour and breeding biology of the Indian Hill Myna (*Gracula religiosa*).

Herpetology. With the financial assistance from the California Academy of Sciences herpetological collections were made in two selected areas in Madras and Mysore States and some very interesting material has been obtained. Further work under the same programme will be continued during 1966.

Sea Anemone Fauna. Facilities were offered to a CSIR Research Fellow for the study of Sea Anemones of Maharashtra.

Nature education scheme

The Nature Education Scheme financed by the Government of Maharashtra is now in its 18th year. Tours of the Natural History Section of the Prince of Wales Museum and special talks on natural history subjects with the aid of exhibits and specimens, films, and living animals were continued. The activities under the scheme have now been extended to Poona and Bassein and Virar in the Bombay environs. Efforts are being made to reprint booklets in the " Glimpses of Nature " series which are out of print and also to publish new booklets in the series.

Library

During the year 125 books and bound journals were added to the library, of which 7 books were purchased, 9 received for review, and 11 presented. Our thanks are due to the donors.

Exhibition

An exhibition of wild life paintings by Shri Basu Roy Choudhury was held at the Society's auditorium from 30-7-1965 to 7-8-1965.

Revenue Account

The audited accounts for the year are attached. It will be seen that the revenue account is somewhat better than in previous years mainly because of the sale of our two popular books THE BOOK OF INDIAN ANIMALS by S. H. Prater, and THE BOOK OF INDIAN BIRDS by Sálim Ali.

Staff

The Committee wishes to record its appreciation of willing co-operation of the entire staff in the activities of the Society.

Acknowledgements

The Committee's thanks are due to Mr. J. L. Bernard who continues to look after the Society's interests in the United Kingdom.

Registered No. F. 244 (BOM.)

BOMBAY NATURAL HISTORY SOCIETY

THE BOMBAY PUBLIC TRUST ACT 1950

SCHEDULE VIII [VIDE RULE 17 (1)]

BALANCE SHEET AS AT 31 DECEMBER 1965

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Trust Fund or Corpus :			*Immovable Properties* :		nil.
Life Membership Fund :			*Motor Car* :		
Balance as per last Balance Sheet ..	77,535.28		Balance as per last Balance Sheet ..	9,913.60	
Add : Amount received during the year	2,300.00		*Less* : Depreciation during the year..	1,982.72	7,930.88
		79,835.28			
Fixed Assets Fund :			*Furniture, Fixtures & Equipment* :		
Balance as per last Balance Sheet ..	45,959.62		Balance as per last Balance Sheet ..	38,251.44	
Less : Depreciation adjusted ..	6,834.40		Addition during the year ..	562.00	
		39,125.22		38,813.44	
Other Earmarked Funds :			*Less* : Depreciation during the year..	4,851.68	
Field Work Fund :			*Investments* : (At cost)		33,961.76
Balance as per last Balance Sheet 3,399.14			Rs. 14.000 4% Bombay Port Trust Bonds .. 10,780.00		
Less : Spent during the year 634.50			Rs. 5,000 4% Bombay Improvement Trust Bonds 3,800.00		
	2,764.64		Rs. 36,000 3% Funding Loan 1966-68 .. 35,812.62		
Wild Life Fund :			Rs. 25,000 3% Conversion loan 1946-86 .. 25,000.00		
Balance as per last Balance Sheet 1.43			Rs. 2,000 3% 1st Development Loan 1970-75 .. 1,948.75		
Less : Spent during the year 1.43					
	..		Rs. 82,000 (Market value Rs. 68,692.00) .. 77,341.37		
Expedition Fund :			Rs. 3,000 12 years National Defence Certificates. 3,000.00		
Balance as per last Balance Sheet ..	386.00				
Mammal Survey Fund :			Rs. 85,000 80,341.37		
Balance as per last Balance Sheet 158.54					
Less : Spent during the year .. . 133.30					
	25.24				
Carried forward ..	3,175.88	1,18,960.50	Carried forward ..		41,892.64

BALANCE SHEET AS AT 31 DECEMBER 1965—(*continued*)

FUNDS AND LIABILITIES		Rs. P.	Rs. P.
Brought forward ..		3,175.88	1,18,960.50
Other Earmarked Funds (Contd.)			
Building Fund:			
Balance as per last Balance Sheet ..		30,000.00	
Publication Fund:			
Balance as per last Balance Sheet..		30,725.00	
Staff Welfare Fund:			
Balance as per last Balance Sheet ..		500.00	
Sálim Ali/Loke Wan Tho Ornithological Research Fund:			
Amount received during the year ..	10,000.00		
Add: Interest earned during the year ..	80.55		
		10,080.55	
Col. Burton's Nature Conservation Fund:			
Amount received during the year ..	3,000.00		
Add: Interest earned during the year ..	24.16		
		3,024.16	
Carried forward ..		77,505.59	1,18,960.50

ASSETS			Rs. P.	Rs. P.
Brought forward ..				41,892.64
Investments: (*At cost*) (Contd.)				
Rs. 85,000		80,341.37		
£470 4½% Defence Bonds (2nd issue) at cost		6,266.67		
		86,608.04		
Less: Provision for Depreciation		6,750.00		79,858.04
Loans: (Unsecured)	*Good*	*Doubtful*		
Loan Scholarship	nil	nil		
Other Loans (to staff)	345.00	nil		345.00
Advances:	*Good*	*Doubtful*		
To Trustees	nil	nil		
,, Employees (WHO Orissa Trip)	1,000.00	nil		
,, Lawyers	nil	nil		
,, Nature Education scheme	1,907.25	nil		
,, C.S.I.R. for the Scheme on the role of Birds in our National economy ..	500.00	nil		
,, Others ..	53.12	nil		3,460.37
Stocks: (At cost or under)				
Books and Publications ..			40,736.35	
Ammunition (Cartridges) ..			755.59	41,491.94
Income Outstanding:				
Rent			..	
Interest (Accrued)			1,340.79	
Other Income:				
Supplies and Services			45,521.15	
Carried forward ..			46,861.94	1,67,047.99

FUNDS AND LIABILITIES		Rs. P.	Rs. P.
Brought forward ..		77,505.59	1,18,960.50
Other Earmarked Funds—(Contd.)			
Grant from California Academy of Sciences for Herpetological Survey:			
Amount received during the year ..	1,423.00		
Less: Utilised during the year ..	525.00	898.00	
Grant from Govt. of Madhya Pradesh for the Survey of Wild Buffaloes in Bastar:			
Amount received during the year ..	2,000.00		
Less: Utilised during the year ..	2,000.00	..	
Grant from Govt. of Bhutan to Dr. Sâlim Ali for the Survey of Birds:			
Amount received during the year ..	10,000.00		
Less: Utilised during the year ..	37.80	9,962.20	
Carried forward ..		88,365.79	1,18,960.50

ASSETS	Rs. P.	Rs. P.
Brought forward ..	46,861.94	1,67,047.99
Other Income: (Contd.)		
Government of Maharashtra		
Educational Activity Grant 1965-66.	4,000.00	
Government of Maharashtra Maintenance Grant 1965-66 ..	23,356.00	
Government of India		
Grant for Journal Expenses 1965-66	10,000.00	
Grant for the Secretarial Assistance for the publication of Hand Book of Indian Birds in five volumes 1965-66	2,250.00	
Grant for Nicobar Survey of Birds Expenses 1965-66	9,000.00	
Grant for the purchase of steel cabinets 1965-66	31,500.00	
Government of Madhya Pradesh:		
Grant for the Survey of Wild Buffaloes in Bastar 1965-66	2,000.00	1,28,967.94
Cash and Bank Balances:		
(*a*) In Current Account with:		
National & Grindlays Bank Ltd., Bombay. ..	12,088.79	
National & Grindlays Bank Ltd., London (£258-3-2) ..	3,442.11	
Chartered Bank, Bombay ..	316.47	
In fixed Deposit with:		
National & Grindlays Bank Ltd., Bombay	25,000.00	
Bank of India Ltd., Bombay ..	13,000.00	
(The above Accounts are in the name of the Bombay Natural History Society)		
(*b*) With the Trustees	..	
(*c*) With the Cashier	397.77	54,245.14
Carried forward ..		3,50,261.07

BALANCE SHEET AS AT 31 DECEMBER 1965—(*continued*)

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Brought forward ..	88,365.79	1,18,960.50	Brought forward ..		3,50,261.07
Other Earmarked Funds—(Contd.)					
Unspent Grant-Government of Maharashtra					
1964-65 Unspent Balance Brought forward .. 14,859.94					
Less : Spent during the year (as per Income & Expenditure Account) .. 10,584.27					
	4,275.67				
Grant from Government of Maharashtra					
1965-66 Grant for the year 23,356.00					
Less : Spent during the year (as per Income & Expenditure Account) .. 15,569.64					
	7,786.36				
Unspent Grant World Health Organization					
Balance as per last Balance Sheet 16,914.77					
Add : Amount received during the year .. 4,762.00					
21,676.77					
Less : Utilized during the year .. 13,390.89	8,285.88				
Carried forward ..	1,08,713.70	1,18,960.50	Carried forward ..		3,50,261.07

BALANCE SHEET AS AT 31 DECEMBER 1965—(*continued*)

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Brought forward ..	1,08,713.70	1,18,960.50	Brought forward ..		3,50,261.07
Other Earmarked Funds—(Contd.)			*Income and Expenditure Account*		
Grant Government of India (Unspent) (for the publication of Handbook of Indian Birds in five volumes)			Balance as per last Balance Sheet ..	22,684.44	
Balance as per last Balance Sheet 25,750.00			*Add :* Deficit as per Income and Expenditure Account	2,872.96	
Add ; Amount received during the year 2,250.00					25,557.40
28,000.00					
Less : Spent during the year 3,000.00	25,000.00				
Grant Government of India					
For the purchase of steel cabinets 1965-66	31,500.00				
For the survey of birds at Nicobar Islands 1965-66	9,000.00				
		1,74,213.70			
Carried forward ..		2,93,174.20	Carried forward ..		3,75,818.47

BALANCE SHEET AS AT 31 *DECEMBER* 1965—(*continued*)

FUNDS AND LIABILITIES	Rs. P.	Rs. P.	ASSETS	Rs. P.	Rs. P.
Brought forward ..		2,93,174.20	Brought forward ..		3,75,818.47
Liabilities					
For Expenses	71,947.60				
,, Advance Subscriptions ..	662.84				
,, Sundry Credit Balances ..	10,033.83				
		82,644.27			
Total ..		3,75,818.47	Total ..		3,75,818.47

The above Balance Sheet to the best of my belief contains a true account of the Funds and Liabilities and of the Property and/Assets of the Trust.

As per our report of even date

(Sd.) A. F. FERGUSON & Co.,
Chartered Accountants

(Sd.) J. D. KAPADIA,
Trustee

BOMBAY, 26*th May*, 1966

Registered No. F. 244 (BOM.)

BOMBAY NATURAL HISTORY SOCIETY

THE BOMBAY PUBLIC TRUST ACT 1950

SCHEDULE IX [VIDE RULE 17(1)]

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1965

EXPENDITURE	Rs. P.	Rs. P.	INCOME	Rs. P.	Rs. P.
To Expenses in respect of properties :			*By Rent :*		
			Accrued	nil	
Rates, Taxes, & Cesses			Realized	nil	
Repairs, and Maintenance ..		nil			nil
Salaries		nil	,, *Interest* (Accrued and Realized)		
Insurance		nil	On Securities	2,844.75	
			,, Bank Account	1,361.50	
Depreciation (by way of provision or adjustments)		nil			4,206.25
			,, *Dividends :*		nil
,, *Expenditure from Grants from Government of Maharashtra :*			,, *Donations :*		
			In cash	10.00	
			In kind	—	
					10.00
For 1964-65 : Salaries	5,237.67		,, *Grants :*		
Rent	5,346.60		,, *Government of Maharashtra :*		
		10,584.27	For 1964-65 (Expended as per contra)	10,584.27	
For 1965-66 : Salaries		15,569.64	For 1965-66 (Expended as per contra)	15,569.64	
			For Educational Activity Grant 1965-66	4,000.00	
			Government of India :		
			For Journal Expenses for 1965-66	10,000.00	40,153.91
Carried forward ..		26,153.91	Carried forward		44,370.16

16A

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1965—(*continued*)

EXPENDITURE	Rs. P.	Rs. P.	INCOME	Rs. P.	Rs. P.
Brought forward ..		26,153.91	Brought forward ..		44,370.16
To Establishment Expenses : ..					
Salaries including Dearness Allowance	38,907.25		,, *Income from Other Sources :*		
Society's contribution to Staff Provident Fund	2,177.97		Membership Subscriptions ..	22,167.77	
Postages	1,503.46		Entrance Fees	500.00	
Printing and Stationery	1,704.42				22,667.77
Advertisement	85.50		,, *Publications :*		
Telephone charges	609.91		Journal Sales	5,114.72	
Electricity charges	722.44				
Bank charges	250.05		,, *Profit on Sale of Books :*		
Meeting expenses	780.80		Book of Indian Birds ..	15,006.66	
Motor Car Charges	788.48		Some Beautiful Indian Climbers and Shrubs	526.30	
Conveyance and Travelling ..	184.55		Some Beautiful Indian Trees ..	745.72	
		47,714.83	Butterflies of the Indian Region ..	1,302.82	
To Building Maintenance Account :			Synopsis of Birds of India and Pakistan	106.48	
Salaries	1,981.16		Book of Indian Animals ..	10,590.36	
Miscellaneous Expenses	515.00		Indian Molluscs	179.32	
		2,496.16	Identification of Indian Butterflies, by Evans	11.00	
,, Remuneration to Trustees ..	nil		Other Publications	231.70	
Remuneration (In the case of Math)	nil		Nature Calendars	4,437.50	
Legal Expenses	203.00				
Audit Fees	750.00				
Contribution and Fees	nil				
		953.00			
,, *Amounts Written off :*					
(*a*) Bad Debts	nil				
(*b*) Loan Scholarships	nil				
(*c*) Irrecoverable Rent	nil				
(*d*) Other Items	nil	nil			
Carried forward ..		77,317.90	Carried forward ..	38,252.58	67,037.93

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1965—(*continued*)

EXPENDITURE	Rs. P.	Rs. P.	INCOME	Rs. P.	Rs. P.
Brought forward ..		77,317.90	Brought forward ..	38,252.58	67,037.93
To Miscellaneous Expenses :			*Less : Books Written-off :*		..
General Charges	741.84		Identification of Poisonous Snakes Charts .. 2,503.10		
Opening ceremony of New Building..	1,504.70		Game Birds of India Vol. III .. 22.44	2,525.54	
Office Shifting Expenses ..	1,385.98			35,727.04	
Fire and Accidental Insurance ..	229.30		*Less :* Packing and forwarding charges	881.37	
Donation to Zoological Society of London	66.67				34,845.67
Repairs to Furniture	200.00		,, *Miscellaneous receipts*		5,610.73
		4,128.49	,, Deficit carried over to Balance Sheet.		2,872.96
,, *Depreciation :*					
On Investment	3,000.00				
On Furniture	..				
		3,000.00			
,, *Expenditure on Objects of the Trust :*					
(*a*) Religious	..				
(*b*) Educational—Journal Expenses	22,423.71				
,, *Library Account :*					
Subscription to other Societies .. 997.05					
Purchase of Books .. 638.37					
Periodical and Binding charges 724.50					
	2,359.92				
, *Maintenance of Reference Collections*..	1,137.27	25,920.90			
Total ..	..	1,10,367.29	Total ..		1,10,367.29

As per our report of even date

(Sd.) A. F. FERGUSON & Co.,
Chartered Accountants

BOMBAY, 26*th May*, 1966

(Sd.) J. D. KAPADIA,
Trustee

BOMBAY NATURAL HISTORY SOCIETY

NATURE EDUCATION SCHEME

Receipts and Payments Account for the year ended 31 *December* 1965

RECEIPTS	Rs. P.	Rs. P.	PAYMENTS		Rs. P.
To Balance as at 1st January 1965 Brought forward :			By Balance brought forward being advance from Bombay Natural History Society		1,915.71
Cash with Cashier	46.80		,, Salary of Nature Education Organiser ..		5,640.00
Balance with National & Grindlays Bank Ltd., Bombay on Current Account	130.53		,, Postages		179.02
		177.33	,, Printing and Stationery		291.95
,, Grant—Government of Maharashtra 1964-65		7,640.00	,, General Charges		1,649.95
,, Sales of Booklet No. I	93.19		,, Balance as at 31st December 1965 :		
,, Sales of Booklet No. II	31.18		Cash with the Cashier	50.00	
,, Sales of Booklet No. III ..	92.20		On current Account with National & Grindlays Bank Ltd., Bombay ..	509.63	
,, Sales of Booklet No. IV ..	144.30				559.63
,, Sales of Booklet No. V ..	150.44				
		511.31			
,, Sales of Nature Study Pamphlets ..		0.37			
,, Balance carried forward being advance from Bombay Natural History Society		1,907.25			
Total ..		10,236.26	Total ..		10,236.26

BOMBAY, 26*th May*, 1966

(Sd.) A. F. FERGUSON & Co.,
Chartered Accountants

(Sd.) J. D. KAPADIA,
Trustee

BOMBAY NATURAL HISTORY SOCIETY

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH GRANT-IN-AID

Receipts and Payments Account for the year ended 31 *December* 1965

RECEIPTS	Rs. P.	PAYMENTS	Rs. P.	Rs. P.
Balance as at 1st January 1965		*Grant No. I* :		
Brought forward :		Salaries	6,673.41	
With National and Grindlays Bank Ltd., Bombay on Savings Account	2,306.62	Miscellaneous	744.36	7,417.77
Grant No. I for the year 1965-66	3,847.65	*Grant No. II* :		
Grant No. II for the year 1965-66	1,860.00	Salaries	600.00	
Interest on Bank Account	37.00	Miscellaneous	..	
Refund of Travelling Expenses for the previous year	1.00			600.00
Balance carried forward being advance from Bombay Natural History Society	500.00	*Balance as at* 31*st December*, 1965 :		
		On Savings Bank Account with National and Grindlays Bank Ltd., Bombay		534.50
Total ..	8,552.27	Total ..		8,552.27

BOMBAY, 26*th May*, 1966

(Sd.) A. F. FERGUSON & Co.,
Chartered Accountants

(Sd.) J. D. KAPADIA,
Trustee

MINUTES OF THE ANNUAL GENERAL MEETING OF THE BOMBAY NATURAL HISTORY SOCIETY HELD AT HORNBILL HOUSE, APOLLO STREET, BOMBAY 1, ON FRIDAY, 26TH AUGUST 1966, AT 6.30 P.M., WITH DR. SÁLIM ALI, D.SC., F.N.I., IN THE CHAIR

(1) The Honorary Secretary's report for the year ending 31st December 1965 having been previously circulated to members was taken as read and was adopted.

(2) The Balance Sheet and Statement of Accounts presented by the Honorary Treasurer were approved.

(3) The following were elected as members of the Executive and Advisory Committees for the year 1966-67.

EXECUTIVE COMMITTEE

President

Dr. P. V. Cherian, *Governor of Maharashtra*

Vice-Presidents

Major-General Sir Sahib Singh Sokhey, I.M.S. (Retd.)
Dr. Sálim Ali, D.SC., F.N.I.
Rev. Fr. H. Santapau, S.J.

Hon. Secretary — *ex officio*

Mr. Zafar Futehally

Hon. Treasurer

Mr. J. D. Kapadia, I.C.S. (Retd.)

Member

Secretary, Ministry of Education, Govt. of India

Elected Members

Mr. Humayun Abdulali
Mr. G. V. Bedekar, I.C.S. (Retd.)
Prof. P. V. Bole
Mr. R. E. Hawkins
Dr. C. V. Kulkarni, M.Sc., Ph.D.
Mr. S. Majeedullah, I.P.S.
Dr. A. N. D. Nanavati, M.D.
Mr. D. J. Panday
Dr. T. Ramachandra Rao, D.Sc., F.N.I.
Mr. D. E. Reuben, I.C.S. (Retd.)

ADVISORY COMMITTEE

Mr. H. G. Acharya	*Ahmedabad*
Mrs. Jamal Ara	*Ranchi*
Mr. F. C. Badhwar, O.B.E.	*New Delhi*
Sir Chintaman Deshmukh, Kt., C.I.E., I.C.S. (Retd.) ..	*New Delhi*
Mr. E. P. Gee, M.A., C.M.Z.S.	*Shillong*
Mr. M. Krishnan	*Madras*
Dr. N. K. Panikkar, M.A., D.Sc., F.N.I.	*New Delhi*
Dr. Baini Prashad, D.Sc. F.N.I.	*Dehra Dun*
Mr. P. D. Stracey, I.F.S.	*New Delhi*
Lt-Gen. Sir H. Williams, C.B., C.B.E., M.I.C.E., M.I.E. ..	*New Delhi*

(4) A Talk was delivered by Mr. Zafar Futehally on the International Union for Conservation of Nature and Natural Resources. The Talk was followed by a film show.

(5) The meeting terminated with a vote of thanks to the British Information Service for the films, and to the Chairman of the meeting.

Gleanings

Sound production by an Indian catfish

A common Indian catfish, *Heteropneustes fossilis*, has been found to possess three types of sound-producing organs. A high-pitched sound, particularly audible during the breeding period especially at the time of spawning, is produced by the movements of the pectoral spine. It is caused by the rubbing of striations on the pectoral spine against striations on the groove of the cleithrum of the pectoral girdle into which the pectoral spine fits. A sound of lower pitch is produced by the rubbing together of numerous small fine teeth situated in four tooth-patches, two in the roof and a corresponding pair on the floor of the buccal cavity. The third sound, of infrequent occurrence, is caused by the expulsion of gas from the suprabranchial diverticulae. The authors do not suggest any useful purpose served by these several sounds.

1965, V. P. Agarwal & R. S. Sharma, *The Annals & Magazine of Natural History*, ser. 13, Vol. **viii** : pp. 339-344.

The ethology of the Marabou Stork

The African Marabou Stork (*Leptoptilos crumeniferus*) is well known as a carrion eater, but it also consumes numerous small living vertebrates e.g. frogs, mice, and fish, especially when rearing young. It eats great quantities of termites at the time when they are swarming. In turbid water it is capable of finding food by tactolocation. One means of heat dissipation employed in hot weather is the excretion of dilute urine on the legs, which by evaporation cools the blood supply to the legs ; this causes the white deposits so commonly seen on the legs. In a group of Marabou Storks dominant individuals can be easily picked out by the inflated throat sac ; apparently, in adults the throat sac functions as a warning signal. Contrary to some published statements, the Marabou is not voiceless. It is very vocal, particularly near the nest, and some of its noises can be heard several hundred metres away. The young in the nest are fed by regurgitation by both the parents, the regurgitated food being dropped for the purpose on the floor of the nest—a procedure which gives the advantage to the older, stronger chicks. These and many other observations are recorded at length by M. P. Kahl in a paper, the first of a series planned for the study of the storks (Ciconiidae) from the point of view of comparative behaviour.

1966, M. P. Kahl, Comparative Ethology of the Ciconiidae.

Part 1. The Marabou Stork, *Leptoptilos crumeniferus* (Lesson) *Behaviour*, Vol. **27**, Parts 1-2, pp. 76-106.

A selective control for the Red Cotton Bug

An interesting possibility of the discovery of a selective control for the pest, the Red Cotton Bug (*Dysdercus koenegii* F.) is opened up by observations reported by K. N. Saxena and C. M. Williams in a recent issue of *Nature*. Previous observations by K. Sláma and C. M. Williams have shown that certain species of American wood used for paper pulp contain a powerful analogue of the juvenile hormone of the European bug, *Pyrrhocoris apterus* L., and that the metamorphosis of the 5th instar larva of this bug is inhibited by rearing the larva in contact with ' active paper ' or by a topical application of an extract of the ' paper factor '. Contact with ' active paper ' has been found to inhibit the hatching of newly laid eggs and, when an extract of the ' paper factor ' was topically applied to freshly moulted adult females, the eggs subsequently laid by them were similarly affected. The present observations show that the 5th instar larvae of *D. koenegii* are sensitive to the ' paper factor ', though not as sensitive as those of *P. apterus*. It is noted that the experiments in the present instance were performed with a crude extract prepared from 250 paper napkins, containing at most only trace amounts of the ' paper factor '.

1966, K. N. Saxena & C. M. Williams : ' Paper Factor ' as an Inhibitor of the Metamorphosis of the Red Cotton Bug, *Dysdercus koenegii* F., *Nature*, Vol. **210**, pp. 441.

Thermoregulation in Brooding Python

It is generally believed that there is no internal regulation of body temperature in reptiles. As long ago as 1832 Lamarre-Piquot read a communication to the French Academy in which he claimed that the python, after laying eggs, coils itself about them and produces heat to help in incubation. His statements were not accepted. Recent observations on Indian Pythons (*Python molurus bivittatus*) at the New York Zoological Park have indicated that brooding pythons are able to maintain their body temperature up to 7·3° C. above the ambient air and substrate temperatures for long periods. They do this by a process analogous to shivering in birds and mammals. One of the brooding pythons was kept in a respiration chamber in a temperature-controlled room. At temperatures below 33° C. there were spasmodic contractions of its muscles, which resulted in an increase in metabolism and in body temperature. Between 33° and 25·5°C. the metabolic rate and the number of contractions per minute increased as the air temperature was lowered, but below 25·5°C. the snake could not maintain its metabolism

and the metabolism fell. The same snake was tested when it had finished brooding ; this time there was no thermoregulation and the metabolic rate fell as the temperature was lowered below 33°C.

1966, Victor H. Hutchinson, Herndon G. Dowling, & Allen Vinegar, *Science* **151,** pp. 694-696.

On ecotypes in the Indian Shad

On a study of the literature S. Dutt, Department of Zoology, Andhra University, suggests the possible existence of three ecotypes of the Indian Shad, *Hilsa ilisha* (Hamilton) : (1) Anadromous stock, feeding and growing in coastal water and spawning in middle or lower reaches of rivers ; (2) Potamodromous stock inhabiting the middle reaches of river, and ; (3) Stock that lives and spawns in the sea.

1966, S. Dutt, *Current Science*, Vol. **35,** No. 13, pp. 329.

A war-use of biological luminiscence

' *Cypridina* is a small crustacean with two hinged valves covering its body. It is found in both fresh and salt water, but only the marine forms are luminous. During World War II, Japanese soldiers used dried *Cypridina* as a source of low-intensity light when they did not want to run the risk of using a flashlight. A small quantity of *Cypridina* powder placed in the palm of the hand and moistened provided enough light for reading a map or a message.'

1962, William D. McElroy & Howard H. Seliger, *Scientific American*, December 1962, pp. 79.

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EDITORS: H. SANTAPAU, ZAFAR FUTEHALLY & J. C. DANIEL

THE SOCIETY'S PUBLICATIONS

Mammals

The Book of Indian Animals, by S. H. Prater. 2nd (revised) edition. 28 plates in colour by Paul Barruel and many other illustrations. **Rs. 30**
(*Price to members Rs.* 25)

Birds

The Book of Indian Birds, by Sálim Ali. 7th (revised) edition. 64 coloured and many monochrome plates. **Rs. 25**
(*Price to members Rs.* 20)

A Synopsis of the Birds of India and Pakistan, by S. Dillon Ripley II. An up-to-date checklist of all the birds resident and migrant, including those of Nepal, Sikkim, Bhutan, and Ceylon. **Rs. 25**
(*Price to members Rs.* 20)

Snakes

Identification of Poisonous Snakes. Wall chart in English, Gujarati, and Marathi. **Rs. 10**
(*Price to members Rs.* 8)

Miscellaneous

Butterflies of the Indian Region, by M. A. Wynter-Blyth. With 27 coloured and 45 monochrome plates. **Rs. 28**
(*Price to members Rs.* 22.50)

Indian Molluscs, by James Hornell. With a coloured and many monochrome plates, and text-figures. **Rs. 6**
(*Price to members Rs.* 4.50)

Picture Postcards of 12 representative Indian Birds (In colour) per set **Rs. 2·50**

Glimpses of Nature Series Booklets :

1. Our Birds I (with 8 coloured plates) in Hindi, and Marathi. **Rs. 0·80**
   Kannada **Rs. 0.62**
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Back numbers of the Society's Journal. Rates on application.

Correspond with :
The Honorary Secretary,
Bombay Natural History Society,
Hornbill House, opp. Lion Gate, Apollo Street, Fort, Bombay 1-BR.

Agents in England :
Messrs. Wheldon & Wesley Ltd.,
Lytton Lodge, Codicote, Near Hitchin,
Herts., England.

The Society will gratefully accept back numbers of the *Journal*, particularly numbers prior to Vol. 45, from members who may not wish to preserve them.

TERMS OF MEMBERSHIP

Life Members pay an entrance fee of Rs. 5 (5sh.) and a life membership fee of Rs. 600. (Inland), £ 45-10-0 (Foreign).

Ordinary Members pay an entrance fee of Rs. 5 (5sh.) and an annual subscription of Rs. 36. (Inland), £3 (Foreign).

Members residing outside India should pay their subscription by means of orders on their Bankers to pay the amount of the subscription to the Society in Bombay on the 1st January in each year. If this cannot be done, then the sum of £3-0-0 should be paid annually to the Society's London Bankers—The National & Grindlays Bank Ltd., 26 Bishopsgate Street, London E.C. 2.

The subscription of members elected in October, November, and December covers the period from the date of their election to the end of the following year.

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Journal of the Bombay Natural History Society

Vol. 63, No. 3

Editors
H. SANTAPAU, S.J.,
ZAFAR FUTEHALLY, & J. C. DANIEL

DECEMBER 1966

Rs. 15

WILD LIFE ISSUE

NOTICE TO CONTRIBUTORS

Contributors of scientific articles are requested to assist the editors by observing the following instructions:

1. Papers which have at the same time been offered for publication to other journals or periodicals, or have already been published elsewhere, should not be submitted.

2. The MS. should be typed (double spacing) on one side of a sheet only, and the sheets properly numbered.

3. All scientific names to be printed in italics should be underlined. Both in zoological and in botanical references only the initial letter of the genus is capitalized. The specific and subspecific names always begin with a small letter even if they refer to a person or a place, e.g. *Anthus hodgsoni hodgsoni* or *Streptopelia chinensis suratensis* or *Dimeria blatteri*.

4. Trinomials referring to subspecies should only be used where identification has been authentically established by comparison of specimens actually collected. In all other cases, or where identification is based merely on sight, binomials should be used.

5. Photographs for reproduction must be clear and show good contrast. Prints must be of a size not smaller than 8·20×5·60 cm. (No. 2 Brownie) and on glossy glazed paper.

6. Text-figures, line drawings, and maps should be in Indian ink, preferably on Bristol board.

7. References to literature should be placed at the end of the paper, alphabetically arranged under author's name, with the abridged titles of journals or periodicals underlined (italics) and titles of books *not* underlined (roman type), thus:

Banerji, M. L. (1958): Botanical Exploration in East Nepal. *J. Bombay nat. Hist. Soc.* 55 (2): 243-268.

Prater, S. H. (1948): The Book of Indian Animals. Bombay. Titles of papers should not be underlined.

8. Reference to literature in the text should be made by quoting the author's name and year of publication, thus: (Banerji 1958).

9. *Synopsis:* Each scientific paper should be accompanied by a concise, clearly written synopsis, normally not exceeding 200 words.

10. *Reprints:* Authors are supplied 25 reprints of their articles free of charge. In the case of joint authorship, 50 copies will be given gratis to be distributed among the two or more authors. Orders for additional reprints should be in multiples of 25 and should be received within two weeks after the author is informed of the acceptance of the manuscript. They will be charged for at cost plus postage and packing.

EDITORS,
Journal of the Bombay Natural History Society.

Hornbill House,
Opp. Lion Gate,
Apollo Street, Fort,
Bombay 1-BR.

VOLUME 63, NO. 3—DECEMBER 1966

Date of publication : 20-7-1967

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A herd of Wild Buffalo at Kaziranga Sanctuary.

(*Photo : E. P. Gee*)

JOURNAL
OF THE
BOMBAY NATURAL
HISTORY SOCIETY

1966 DECEMBER Vol. 63 No. 3

Editorial

One of the problems of the Conservationist in India, is the lack of authentic knowledge of the status of species and habitats in our country. This fact, well known to everyone, was brought home rather forcefully during the preparation of the fauna section of the Maharashtra Gazetteer by the Society. Everything that is now being written in the Gazetteer volumes about Birds and Animals is based mainly on past records and not on recent information procured from field observations. The intelligent, well informed, amateur naturalist, with a certain flair for writing and with leisure enough to worry about our wild life seems to be rare today. The Society has been making attempts to activate the Forest Department Personnel to take more interest in their surroundings and to carry with them at least the BOOK OF INDIAN BIRDS by Sálim Ali and the BOOK OF INDIAN ANIMALS by Prater, and to make an attempt to identify and keep records of the various forms of life in different areas. A letter was addressed to practically all the Divisional Forest Officers in India, stressing that the future of wild life was now mainly in their hands and requesting that they communicate with the Society about the position of wild life in their Districts.

The replies received (in those cases where a reply has come) have been pathetic.

Reproduced below is a part of a letter received from a Divisional Forest Officer, with the original spellings : ' Referring to your letter, sighted I am furnishing below the list of the animals and birds that are commonly seen in the Forest Division . . . . . Spoted deer, Royal tiger, Peageons, Jungle fouls . . . . . since there is no close watch of these animals and birds, it is difficult to give a discriptive picture of their status and habitats . . . . . '

What is the remedy for this situation ? Some insist that the Forest Department is mainly concerned with the economics of timber exploitation and will not be in a position to look after our wild life. They

stress the importance of having a separate Wild Life Service for the whole country.

The Executive and Advisory Committees of our Society have been greatly concerned about the situation and have recently evolved a policy statement on Wild Life, which is reproduced below.

1 'The Bombay Natural History Society has repeatedly stressed the importance of instituting a competent Wild Life Service to preserve the species and habitats of our country. This has been done in memoranda presented by the Society to the Planning Commission, to the Ministry of Agriculture, and in meetings of the Indian Board for Wild Life. It holds that legislation on the lines of the Bombay Wild Animals and Wild Bird Protection Act 1951, as originally enacted, is essential in all states, particularly the provision of having a separate Wild Life Preservation Officer on whom complete responsibility for protection of wild life throughout the State should devolve and who should be a full-time officer.

Recognising the immediate difficulties of instituting a comprehensive Wild Life Service, the Society feels that in the present circumstances the Forest Service can be made responsible for the preservation of wild life in the areas in-charge of forest department. Outside the areas in-charge of forest department the civil authorities would be responsible as under the Bombay Act. There should be a suitable cadre of Wild Life or Game Wardens both stipendiary and honorary for forest as well as non-forest areas working in association with the forest and the civil authorities, under the control of the Wild Life Preservation Officer.

2. In order to enable the Wild Life Circle or Division both at Central and at State level to discharge their responsibilities effectively, the following steps need to be taken :—

(*a*) *Centre :* A separate Wild Life Wing should be constituted in the Ministry of Food & Agriculture with a whole-time Secretary of adequate status, assisted by the necessary technical and administrative staff.

(*b*) *States :* In each State there should be a separate Wild Life Department, Circle or Division with the necessary administrative and field staff for the preservation of wild life. The Centre should provide the necessary assistance to the States for the purpose.

3. In order to provide suitable trained men for the purpose, advanced courses in wild life management should be instituted at the Forest Colleges and in other institutions.

4. In order to determine correctly the status of the various species of wild life and their natural habitats, advantage should be taken of technical aid programmes for bringing expert ecologists of international repute to India.'

The Society will continue to press for the implementation of this policy both with the Central government and with the State governments, but with the pressing problems of economic development which India faces today and with the general uncertainty created by the approach of the Election in February 1967, nothing very effective can be expected right away. All of us, nevertheless, who have the interest of our magnificent fauna and flora at heart, must continue to struggle for its survival and for a rational approach by government for its welfare and preservation.

We are, indeed, fortunate in being able to include in this volume a report on the status of wild life in the Sanctuaries of Northern India by J. Juan Spillett, who has been conducting ecological research in India for his Doctorate in Animal Ecology from The Johns Hopkins University, U.S.A. This work was made possible by a grant from the Foundation Volkart Brothers, Switzerland through the World Wild Life Fund. That this project came into existence was mainly due to the untiring work of Mr. E. P. Gee, one of the most dedicated advocates in the cause of conservation in this country. From January to June 1966, Spillett travelled a distance of over 13,500 miles by every conceivable form of transport from the aeroplane to the bicycle and the boat and covered 300 miles on foot and spent over 21 days on elephant back. Being accompanied by his wife, who is an expert typist, he was able to complete the report in record time. It is a matter of gratification that Spillett hopes to survey other areas of India, and when this has been done, a full ecological report of the more important species of wild life, will be available to this country.

In the context of the agitation for cow protection that is now in progress, it is not irrelevant to refer to Spillett's conclusion, that it is not only poaching that is the great threat to the continuance of India's wild life and wild places, but the disastrous effect of over-grazing by domestic livestock all over the country. Understanding a problem clearly, is the first requirement towards its solution, and we are grateful to the author of this report for the facts which he has uncovered.

We are also publishing in this issue a report on the Chital Deer (*Axis axis* Erxleben), by Dr. William Graf, Professor of Wild Life Management, San Jose State College, California, U.S.A., and Lyman Nicols Jr., Hawaii. This report is based on a study of the animal extending over a period of six years. The observations were made in Hawaii where the animal was introduced in 1868. However, as Prof. Graf says, the climatic conditions under which these animals live resemble closely that of many parts of India, where the Chital occurs. Our main object in publishing this very comprehensive report is to draw attention to the type of work that has to be done in this country if we are to be in a position to assess our wild life resources properly.

A Report on Wild Life Surveys in North India and Southern Nepal

January-June 1966

BY

J. JUAN SPILLETT

(*With two coloured and ten monochrome plates and eight maps*)

INTRODUCTION

At the request of the Chief Conservator of Forests, Assam, Mr. E. P. Gee, member of the Indian Board for Wild Life, informally applied at the First World Conference on National Parks (held in Seattle, Washington, U.S.A., in 1962) that an ecological survey of the Great Indian One-horned Rhinoceros be undertaken in northern India. This became the World Wildlife Fund Project No. 47 of 1962 and received the official welcome of the Indian Board for Wild Life. Although this

project was given high priority by the World Wildlife Fund Board of Trustees, lack of funds prevented any further action being taken until in 1965. The Foundation Volkart Brothers of Winterthur, Switzerland, then sponsored the study, which became World Wildlife Fund Project No. 173 : The Wild Life of India.

I was invited to undertake this survey of the Indian rhino, as well as several other short studies contained in this report. These were officially sponsored by the World Wildlife Fund, Morges, Switzerland. However, the project was assisted by The Johns Hopkins University Center for Medical Research and Training, Calcutta, India, and Baltimore, Maryland (U.S.A.), supported by U. S Public Health Service Grant ROTTWOOYL. Mr. E. P. Gee made the necessary arrangements with the Government of India and the State Forest Departments of Assam, West Bengal, and Uttar Pradesh. The sanction of the Rajasthan Forest Department was also obtained. In order to obtain an overall status of the Indian rhino, it was necessary to include Nepal, which extended the fullest co-operation. In addition, Mr. Gee supervised and assisted me in every way possible, and I particularly want to thank him for his counsel and advice.

Messrs. Joel E. Cohen and Rames C. De assisted me in a large mammal census of the Keoladeo Ghana Sanctuary, Rajasthan, the latter part of January 1966. Mr. Cohen was a Frederick Sheldon Travelling Fellow, 1965-1966, of Harvard University, Cambridge, Massachusetts (U.S.A.). Mr. De then conducted a study of the spotted deer in Corbett National Park, Uttar Pradesh, from February 1 through 29 May 1966, with my assistance. He was a research assistant, supported by The Johns Hopkins Center for Medical Research and Training, and his study is included in this report.

Mr. E. P. Gee and I had also proposed a census of the Kashmir Stag on its wintering grounds. The Forest Department of Kashmir had extended an invitation to us and had promised to assist in every way possible with this undertaking. We attempted to travel to Srinagar for five successive days but, although we travelled as far as Jammu twice, we were unable to reach our destination because of inclement weather. Therefore, this study was regretfully abandoned.

The author received an M.S. in Wildlife Resource Management from Utah State University, Logan, Utah (U.S.A.). Since October 1964 he has been conducting ecological research in India for his doctorate in animal ecology from The Johns Hopkins University, Baltimore, Maryland (U.S.A.).

J. JUAN SPILLETT

The Kaziranga Wild Life Sanctuary, Assam

BY

J. JUAN SPILLETT

(With two plates and two maps)

TABLES AND MAPS

I. INTRODUCTION

Kaziranga is renowned as one of the finest wild life sanctuaries in southern Asia. Although it is particularly noted for harbouring large numbers of Great Indian One-horned Rhinoceros (*Rhinoceros unicornis*), the other large mammals found here also deserve attention. In addition to rhino, wild buffalo, hog deer, swamp deer, and wild pig are almost invariably seen by visitors. It is practically guaranteed that visitors will see both rhino and hog deer, as well as swamp deer during certain seasons of the year. Indian elephant, gaur or Indian ' bison ', sambar, barking deer, tiger, leopard, two or possibly three species of bear, and numerous smaller mammals are also represented. A list of some of the animals found in the sanctuary and their local and scientific names is presented in Table 1. Numerous birds, including red junglefowl, partridge, various doves and many species of water birds, are also common to the sanctuary. A nesting colony of spottedbilled pelicans (*Pelecanus phillippensis*) was first discovered inside the sanctuary in 1958. This is one of India's few pelicanries and the only one known in the northern part of the country.

The Kaziranga Sanctuary officially includes 165·84 sq. miles. However, due to erosion by the Brahmaputra River, the curve of which forms the northern boundary, the present size is probably less than 150 sq. miles. Most of the southern boundary is formed by the Mora (dead) Diphlu River, which roughly parallels National Highway No. 37, better known as the Grand Trunk Road of Assam. The eastern boundary is formed by both stream beds and surveyed lines. The shape of the

TABLE 1

NAMES OF SOME ANIMALS INHABITING THE KAZIRANGA WILD LIFE SANCTUARY, ASSAM, AND POSSIBILITIES OF VISITORS SEEING THEM

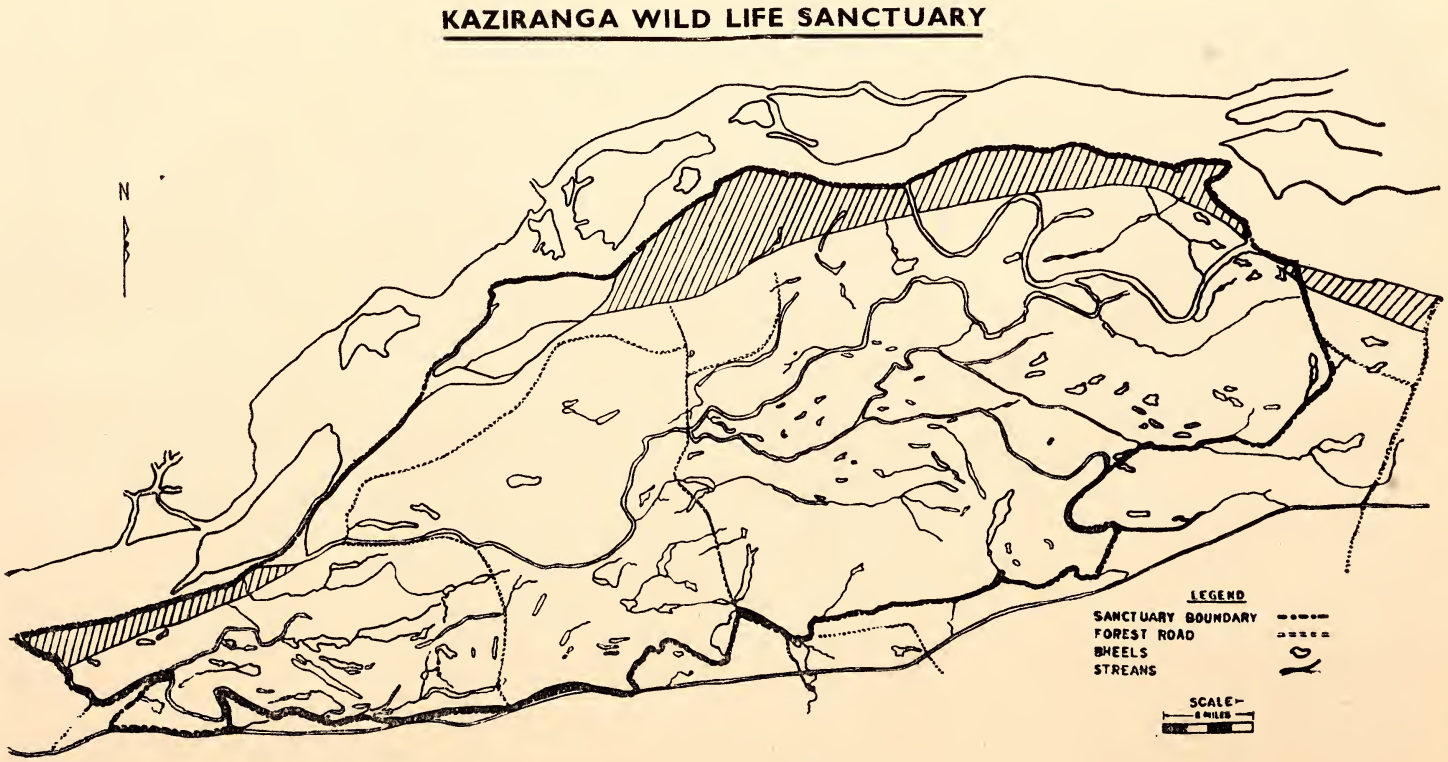
English	Local	Scientific	Remarks
Great Indian One-horned Rhinoceros	Gorh *or* Garh	*Rhinoceros unicornis*	Common
Indian Elephant	Hati	*Elephas maximus*	Frequent
Wild Buffalo	Bonoria Mah	*Bubalus bubalis*	Common
Gaur *or* Indian ' Bison '	Methun *or* Mathoon	*Bos gaurus*	Rare
Swamp Deer	Dol Horina : *Male* Batina-Sakal Jati ; *Female* Belingi	*Cervus duvauceli*	Common
Sambar	Sar *or* Katkhowa Pahu	*Cervus unicolor*	Frequent
Hog Deer	Khatia *or* Chagli Pahu	*Axis porcinus*	Common
Barking Deer *or* Indian Muntjac	Hugari *or* Sugari Pahu	*Muntiacus muntjak*	Infrequent
Indian Wild Boar	Borah *or* Bonaria Gahori	*Sus scrofa*	Frequent
Pangolin	Bon Rou	*Manis* sp.	Rare
Porcupine	Ketala Pahu *or* Palm	*Hystrix* sp.	Rare
Squirrel	Kerketua		Infrequent
Gangetic Dolphin	Seho, Hiho, Huh	*Platanista gangetica*	Rare
Tiger	Dhakiapatia Bagh *or* Bagh	*Panthera tigris*	Infrequent
Leopard *or* Panther	Naharphutuki Bagh	*Panthera pardus*	Rare
Jungle Cat	Bonoria Mekuri	*Felis chaus*	Rare
Large Indian Civet	Hepa	*Viverra zibetha*	Rare
Indian Wild Dog *or* Dhole	Rang kukur	*Cuon alpinus*	Very rare
Jackal	Sial	*Canis aureus*	Infrequent
Common Mongoose	Neul	*Herpestes edwardsi*	Infrequent
Common Otter	Ood	*Lutra lutra*	Common
Hog-Badger	Joiga Borah	*Arctonyx collaris*	Rare
Himalayan Black Bear	Rola Bhaluk, Satum, Sitam, Mapol, Mansu, Bhurma	*Selenarctos thibetanus*	Infrequent
Sloth Bear	Mati Bhaluk	*Melursus ursinus*	Infrequent
Rhesus Macaque	Nilaji Bandar	*Macaca mulatta*	Frequent (Baguri Block)
Common Langur *or* Hanuman Monkey	Hanuman Bandar	*Presbytis entellus*	Frequent (near Bara-Porhar)
Hoolock *or* Whitebrowed Gibbon	Holou Bandar	*Hylobates hoolock*	Infrequent (near Bara-porhar)
Water Monitor	Pani Guin	*Varanus salvator*	Infrequent
Indian Python	Ajagar	*Python molurus*	Infrequent
Common Cobra	Feti Sap	*Naja naja*	Rare
King Cobra	Chakori Feti Sap	*Naja hannah*	Rare

KEY.—Common=almost invariably seen ; Frequent=generally seen ; Infrequent=only occasionally seen ; Rare=rarely seen.
This is only a relative index as to the possibilities of a visitor observing animals and does not always infer the relative abundance of the species in the sanctuary.

sanctuary is more or less an oval, which is approximately 25 miles long and 8 miles wide at the widest point (Map 1). The nearest airport is Jorhat, 60 miles to the east. Gauhati is 135 miles to the west. There is a well-constructed tourist lodge and a tourist bungalow at Kohora, which is about mid-way along the southern boundary of the sanctuary. Both are administered by the Tourist Department, which also provides catering service for visitors. The Forest Department has two forest rest houses—Baguri, located along the Grand Trunk Road near the western end of the sanctuary, and Arimora, which is in the heart of the sanctuary about 10 miles north of Kohora. Catering is not provided at these two places. Riding elephants are also provided for visitors by the Forest Department. The ease with which visitors may view rhino and other animals at close range from elephant back during a very short visit makes Kaziranga a unique experience. A Forest Range Officer stationed at Kohora is in charge of the sanctuary and supervises a staff of over 100 men. These patrol and protect the sanctuary and its wild life, maintain the sanctuary's roads, buildings and equipment, and care for the domestic riding elephants.

There were a number of reports during 1964 and 1965 concerning the slaughter of rhino by poachers inside the sanctuary. Although some of these reports were clearly exaggerated and others appeared to be unfounded, the Forest Department decided to conduct a full scale census to determine the exact status of the wild life and particularly of the rhino. Upon the suggestion of Mr. Gee, member of the Indian Board for Wild Life and a noted authority on the Great Indian One-horned Rhinoceros, Mr. P. Barua, Chief Conservator of Forests for Assam, solicited my assistance. I am grateful to both of these men for the opportunity to have participated in this census. I spent most of the time between March 2 and 17 on elephant-back inside the sanctuary, attempting to become acquainted with as much of the area as possible. The actual census was conducted on March 17 and 18 and the collected data was tabulated on the 19 and 20. I revisited the sanctuary between June 9 and 14. Observations were then made both from boat and elephant back as to the effects of the monsoon and flooding inside the sanctuary.

The nature of the vegetation and the terrain in Kaziranga thwart the use of most methods commonly used to determine wild life populations. Counting animals from an airplane was tried on 24 March 1949, but the grass cover was so dense that only a few animals could be counted. A six-seater airplane was used during this attempt and was not flown below a height of about 400 feet. Perhaps the use of a lighter airplane, which could be flown at lower altitudes, would provide a relatively accurate and inexpensive means of counting most of the rhino in the sanctuary. This was further confirmed by a discussion



Map 1. General map of the Kaziranga Wild Life Sanctuary, Assam, depicting the areas along the Brahmaputra River which have been lost to erosion

with a Capt. Tamang when I was visiting Nepal in April. Capt. Tamang is a pilot for the Royal Nepalese Airlines, but regularly flew over Kaziranga while he was in the Air Force. He stated that the wild animals were readily observed from the air and that he often sought out particular individuals.

A wild life survey of Kaziranga was conducted with 11 elephants on 19 April 1963. The sanctuary was divided into seven blocks and from one to four elephants were used to count the wild animals in each block. However, it was found that the areas were much too large to be effectively covered in a single day by the number of elephants employed. Only a sample count was obtained. Therefore, this report covers the first extensive wild life census of the Kaziranga Wild Life Sanctuary.

II. Habitat

The Kaziranga Wild Life Sanctuary lies in the Brahmaputra River flood plain. This riverain habitat consists primarily of tall, dense grasses interspersed with open forests, interconnecting streams, and numerous small lakes called '*bils*' or '*bheels*'. Much of the sanctuary is submerged by the annual flood waters of the Brahmaputra. However, the well-forested Mikir Hills, which rise to a maximum height of 4000 feet are located across the Grand Trunk Road to the south. These offer a ready retreat for many animals from the sanctuary during the flood season. The climate is monsoonal with rains usually from May to October. The average rainfall is approximately 80 inches per annum. The ground and grass become fairly dry by late November or early December and during February and March much of the grassland area is burned by the sanctuary staff.

Grassland

A transect taken from the Brahmaputra River inland indicates the vegetational succession of the area. *Kash* (*Saccharum spontaneum*), a thin wiry grass with a maximum height of about six feet, first invades the dry sandy-silt soils recently deposited by the river. *Jhau* (*Tamarix* sp.), an evergreen shrub resembling some ornamentals used in gardening, is often interspersed with *kash*. Depending upon the nature of the habitat, these are generally followed by other species of grass. The bamboo-like *nal* (*Arundo donax*) predominates in marshy areas near permanent water, while in somewhat drier, but still moist, areas it is *khagra* (*Phragmites karka*). Areas flooded during the rains, but later dry, are mostly covered by *ekra* (*Erianthus* spp.), which is the most common grass in the sanctuary. The slightly higher or drier areas are dominated by *kher* or thatch (*Imperata cylindrica*). Most of these grasses, often collectively called 'elephant grass', attain a height of 15 feet or more by late summer.

Animals literally tunnel through them and even a herd of elephant may pass near by in this grass jungle without being observed. Each year between one-third to one-half of the sanctuary's grasslands are burned. Many animals were observed to re-enter the burned areas almost immediately and appeared to relish the remaining mineral-rich ash. The new growth, which shoots up within a few weeks after burning, also attracts the wild animals and probably provides the most palatable forage. The lowlands surrounding the *bils* favour the andropogonous grasses. These are relatively short (less than three feet high) and provide the only open areas in the sanctuary during much of the year. These areas appear to be favoured by most of the ungulates and probably provide the best year-round grazing for much of the wild life.

Forests

Without annual burning the aforementioned grasses are eventually replaced by flood-resisting species of trees. The dominants are silk cotton or *simul* (*Bombax ceiba*, formerly known as *Bombax malabaricum*) and the leguminous *koroi* (*Albizzia procera*). *Ajar* (*Lagerstroemia flos-reginae*) and *outenga* (*Dillenia indica*), as well as other species, are also present. There are scattered groups of trees on both ends of the sanctuary and denser stands along the banks of the major streams, such as the Diphlu River. The ridge-like banks of the larger streams are generally higher than the surrounding terrain. Some of the forests are relatively open, but others are a tangled mass of almost impenetrable undergrowth, much of which consists of thorny species such as cane or *tita bet* and *jati bet* (*Calamus* spp.). The dense undergrowth provides excellent cover for wild life, particularly for elephant and rhino. Dense stands of the broad-leafed *tara* (*Hedychium* sp.), which is greatly relished by elephant, are also frequently associated with the forested areas.

Fire and Flood

Annual burning of the grasslands along the Brahmaputra River valley has been practised for so many hundreds of years that it can probably be considered as an integral part of the ecology of this region. In fact, the grasslands are maintained by fire and without it many would eventually become forests. There are invariably a sufficient number of unburned areas to provide cover for the animals until re-growth takes place. In fact, it is practically impossible to burn an entire area clean. Without burning there might actually prove to be a lack of suitable forage during the late summer season. The only animals which were observed not to benefit from the burning were some of the early nesting birds and some of the slower-moving reptiles, such as the python, which are occasionally consumed by the roaring flames.

Annual flooding of the sanctuary by the Brahmaputra River is probably essential for the maintenance of optimum habitat for some

species, such as rhino and wild buffalo. However, it is also probably a limiting factor in so far as populations of other species, such as sambar and barking deer, are concerned. Almost all of the sanctuary's streams and *bils* have been invaded during recent years by water hyacinth (*Eichhornia crassipes*). Floods are presently the only means by which these water areas are temporarily cleared and without floods they would shortly become solid green masses of vegetation. Although the dry water hyacinth plants are burned in the ephemeral *bils*, it is not yet known if this is of any benefit in checking re-infestation by this undesirable weed. Overall flooding is probably beneficial, if not essential, for most species of mammals in the sanctuary. Besides temporarily clearing the water areas of water hyacinth, they replenish the water supply in the numerous *bils*, and essentially irrigate the savannah-like grasslands. The numerous fish of several species in the sanctuary's *bils* are also dispersed by the annual floods. This serves the useful purpose of re-stocking areas adjoining the sanctuary with valuable fish. Because of this and the fact that the sanctuary serves as a spawning ground the Forest Department has resisted attempts by local interests to exploit the sanctuary's fishery resources.

Between June 9 and 14, during the monsoon season, I visited the Baguri Block twice by boat. During the first visit we travelled about six miles up the Mora Diphlu from the western end of the sanctuary. Three rhinos were observed to be contentedly grazing along the bank in water approximately three feet deep. Other rhino were heard moving in the flooded grasslands, but we were unable to see them. A large herd of wild buffalo was also seen, but it was impossible to get a count as they sloshed through the flooded grass. During the second visit we crossed the block from south to north in the area behind the Baguri Forest Rest House. The water in most of the *bils* was over 12 feet deep and much of the grassland was under more than six feet of water. We briefly visited the high-forested area near the Diphlu River. Although we saw a female rhino with a calf here, relatively few tracks of other animals were seen. I estimated that almost 80% of the Baguri Block was under water. Forest Department personnel observed large numbers of wild elephant crossing the Grand Trunk Road into the Mikir Hills to the south on the first of June. Some animals, such as hog deer, were also known to have crossed the road. Rhino and wild buffalo appear to be little affected by flood waters under four feet deep, but it is not known where the vast majority of the wild animals in the sanctuary take refuge during the flood season.

Mihi Mukh was visited on elephant back on June 11. Swamp and hog deer appeared to be concentrated on the relatively dry grasslands near the edge of the sanctuary. However, nine of the sixteen rhino which we saw were in water about four feet deep. Several were feeding

on vegetation under the water and two were observed to swim distances of over 50 yards. A group of sixteen buffalo were also seen in an area flooded by about two feet of water.

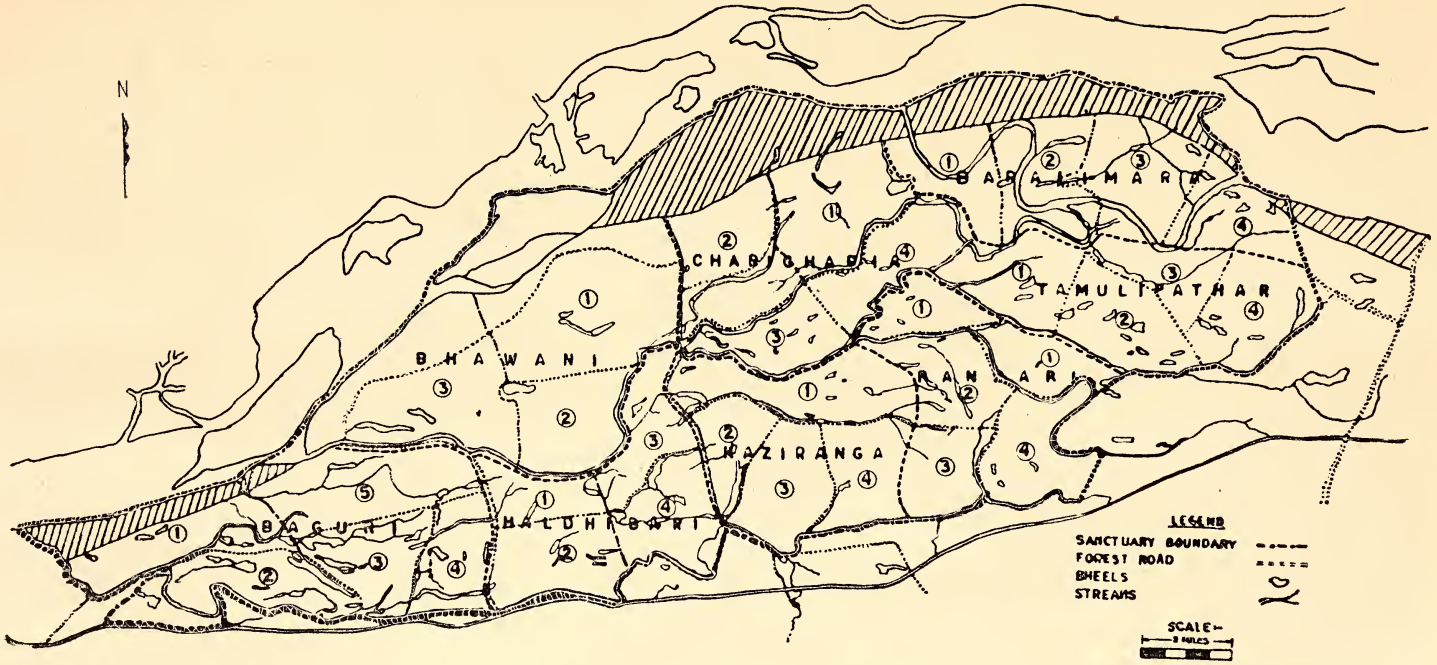
III. Census Methods

Prominent features, such as rivers or roads, were used to divide the sanctuary into eight blocks : Baguri, Haldhibari, Kaziranga, Panbari, Tamulipathar, Bhawani, Charigharia, and Baralimora. Each block was subdivided into three to five compartments including approximately five square miles each. There were a total of 33 compartments (Map. 2). Where it was not possible to use natural features, such as *bils* or streams, 10-foot wide compartment boundaries were cut through the vegetation by the sanctuary staff.

A total of 18 census parties consisting of an enumerator, helper, guide, mahout, and elephant were used to carry out the census. Both the enumerators and helpers were experienced Foresters, Deputy Rangers, or men acquainted with wild life. Guides were members of the sanctuary staff that had worked in and were acquainted with the particular area to which they were assigned. Ten mahouts and their elephants from the sanctuary were used during the two-day census operation. However, it was necessary to hire eight mahouts and elephants from outside.

Enumerators were in charge of their respective parties and recorded all the wild animals observed as to species and sex or age class (i.e. adult male, adult female, or young). Special forms were provided for recording this data. If there was any doubt as to the sex of an adult animal it was recorded as ' non-sexed '. Only the eight most common large mammals in the sanctuary were listed on the form. Other miscellaneous observations (animals fighting, mating, etc.) were recorded either in the miscellaneous or remarks columns. The helper was provided with a map of the block and compartment to which he was assigned. He plotted the approximate line of travel for the census party, the location of the animals observed by the use of abbreviated symbols (i.e. eight buffalo= 8 B), and the location and approximate area which had been burned within the compartment. The guide assisted the helper and ensured that the party remained inside its assigned compartment and did not trespass into others. The mahout directed the elephant and assisted the enumerator in identifying and determining the sex or age of the animals observed.

The enumerators and helpers were instructed and tested for two days prior to the census. During this time the guides inspected and became well acquainted with the assigned compartments. Each party camped the previous night at an assigned starting point prior to censusing the compartment the following day. Census operations were conducted



Map 2. Map of the Kaziranga Sanctuary, Assam, depicting the blocks and compartments used during the 1966 Wild Life Census

from 05·00 to 09·30 hours in the morning and from 14·00 to 17·00 hours in the afternoon. Sunrise was at approximately 05.30 and sunset at 17·00 hours.

A few compartments, which were relatively small or open areas, were covered in less than the assigned time. However, other compartments took longer than the assigned time. A total of 158 census hours were spent during the morning by the census parties and only 96 hours in the afternoon during the two-day census. The average census time per compartment was 7·7 hours. The four blocks south of the Diphlu River, namely Baguri, Haldhibari, Kaziranga, and Panbari, consisted of 18 compartments. These were censused the first day, March 17. The census parties then moved that evening to pre-arranged starting points in the four blocks north of the Diphlu River, namely Tamulipathar, Bhawani, Charigharia, and Baralimora, which consisted of 15 compartments. These were censused the following day, March 18.

After completion of the two-day census, all forms and maps were collected and the data individually reviewed with the enumerator or helper concerned to ensure that it was complete and free from errors. The overall census operation was well-planned and efficiently run. I feel that the data collected was reliable and subject to very little error. The methods used, however, give only a minimum count of the principal species of large mammals. A great deal of care and judgment, based upon experience and an intimate knowledge of the entire sanctuary, must be used to estimate the numbers of the different species that were overlooked or missed.

IV. Results

A riding elephant in open country can cover between 3·5 and 4·0 miles per hour (mph). However, when forcing its way through dense grass or undergrowth it does well to cover 2.0 mph. Using a figure of 2·5 mph. for the average of 7·7 census hours per compartment, it can be assumed that approximately a 20-mile transect was covered in each compartment. The compartments averaged just under 5 sq. miles each and were probably slightly less than 2·5 miles per side. Each census party should have made about eight transects per compartment. Therefore, to cover completely the average compartment, each transect would have to cover a strip slightly less than one-fourth mile wide. The majority of the larger mammals could probably be observed in an even wider strip in open or burned areas, but in tall dense grass or undergrowth, visibility was limited to a few yards or even feet on either side of the elephant. Transects, however, were not run in regular lines. By use of the map provided, an attempt was made to cover those sites where animals were most likely to be seen, such as burned areas and the short grasslands

TABLE 2

TOTAL COUNTS FOR LARGE MAMMAL SPECIES PER BLOCK DURING THE 1966 WILD LIFE CENSUS OF THE KAZIRANGA WILD LIFE SANCTUARY, ASSAM

Kind of Animal	Block						Sanctuary			
	Baguri	Haldhi-bari	Kazi-ranga	Panbari	Chari-gharia	Bhawani	Barali-mora	Tamuli-pathar	Total Counted	Estimated Total
Rhino ..	157	49	32	30	22	59	8	9	366	400
Elephant ..	45	—	29	7	—	257	5	6	349	375
Wild Buffalo ..	337	41	23	17	17	6	—	30	471	550
Gaur ..	—	—	—	—	1	—	—	—	1	20
Swamp Deer ..	72	25	16	69	19	1	11	—	213	250
Sambar ..	43	8	1	1	2	61	1	3	120	300
Hog Deer ..	485	77	95	122	223	282	5	22	1,311	4,000-5,000
Barking Deer ..	12	10	—	7	—	—	—	—	29	100
Wild Pig ..	45	29	33	18	10	—	10	10	155	500-600
Bear ..	1	—	1	—	—	—	—	—	2	30
Tiger ..	—	1	—	—	—	1	—	—	2	20
Leopard ..	—	—	1	—	—	—	—	—	1	12
Otter ..	7	9	—	1	8	1	—	—	26	200-300

surrounding the *bils.* In short, each census party attempted to observe as many animals as possible during the allotted time, without duplication. When disturbed most of the animals moved into dense cover. This generally required a movement of less than 100 yards. Many animals, if not closely approached, did not even seek cover. Therefore, there was probably little, if any, duplication in the counts. After examining the maps and the approximate line of travel taken by each census party, I roughly estimated that less than 70% of the sanctuary was covered. However, it appeared that most of the preferred habitats were covered. Therefore, it can be assumed that much less than 30% of most of the larger mammals were missed. The numbers of animals tallied per compartment and the completed compartment maps, which indicated the burned areas, were compared with my previous observations for that area. I then made a conservative estimate of how many animals I felt may have been overlooked during the census. The actual census count as per block and my total estimates for the sanctuary are given in Table 2.

Age Composition and Sex Ratios

Age composition, although often difficult to determine accurately in the field, is generally a reflection of the status of a species in terms of its reproductive potential. A high percentage of young as compared to adults generally indicates a growing or thriving population. In contrast, a relatively small percentage of young usually indicates a low reproducing or senile group. Sex ratios likewise are an indication of reproductive potential. Most large mammals, particularly the ungulates or cud-chewers, are promiscuous about mating and can increase rapidly with five or even more females per adult male. Therefore, within limits of course, a population with more females than males generally has a higher reproductive potential than does one that is predominantly male. However, adult males are more spectacular and visitors to a sanctuary generally prefer to see them rather than females or immature animals. With reliable age composition and sex ratio data a biologist can often compute the average annual rate of net increase or loss, as well as determine the present status of a population.

Field glasses were not available for the census workers. Age composition data was, therefore, restricted to two categories (adult and young), which in most cases could be readily distinguished without the aid of binoculars. However, rather than bias the sex ratio data which was collected, whenever there was any doubt as to the sex of the adult animals observed, they were tallied in the ' non-sexed ' column. No attempt was made to sex young animals or hog deer. The age composition and sex ratio data collected during the census are presented in Table 3. These, along with data which I collected, will be discussed later.

Wild life populations do *not* remain static. Increases or decreases often occur rapidly and a single census rarely provides answers to questions about several aspects of the population. An accurate census of the total wild life population is essential for the proper management of a sanctuary, but data should be collected and analyzed continuously in order that current conservation measures may meet the demands of changing situations. Therefore, it should be realized that the results of the 1966 wild life census of Kaziranga provides only a basis for future management. And an annual census of the wild life should be considered as a part of the sanctuary's management plans. An effort should also be made to determine the most economical means of conducting wild life surveys in Kaziranga, while still providing reliable results. For example, if the guides were thoroughly acquainted with their assigned compartments, there would be no need of going to the expense of cutting compartment lines. There is no reason why a census could not be conducted over a one or even two-week period. This would permit the use of only sanctuary elephants and experienced personnel and would result in less expense to the Forest Department, while providing more accurate data (i.e. information concerning sex ratios and age composition). As previously discussed, there is also the possibility that the use of airplanes would provide an economical, but satisfactory, means of conducting wild life censuses in Kaziranga.

Perhaps of interest, two carcasses of rhino, which had apparently died of natural causes, were found during the course of the census. The sale of the collected horns at public auction by the Forest Department should more than meet the total expenses incurred by the census operation.

Rhino

Rhino are relatively difficult to sex in the field, except in the case of females with young. Similar to many wild animals, when disturbed rhino frequently urinate. This enables a keen observer to sex individuals accurately. But, other than observing their private parts, there appears to be no fool-proof criterion for sexing solitary rhino. However, some claim to be able to differentiate the sexes by the size or shape of the horn and others maintain that the males have a thicker neck than the females. These criteria were not substantiated by my observations.

TABLE 3

SEX AND AGE CLASSIFICATION DATA FOR THE COMMON LARGE MAMMALS OBSERVED DURING THE 1966 WILD LIFE CENSUS OF THE KAZIRANGA WILD LIFE SANCTUARY, ASSAM

Species	Non-sexed	Number of Animals		Young	Total
		Adult Male	Adult Female		
Rhino ..	172	67	83	44	366
Wild Elephant	214	62	44	29	349
Wild Buffalo	115	54	217	85	471
Swamp Deer	141	17	49	6	213
Sambar ..	6	33	61	20	120
Hog Deer ..	1,033	105	119	54	1,311
Wild Pig ..	72	36	27	20	155

A total of 366 rhino were tallied during the two-day census. Three hundred and twenty-two or 88% were adults, of which 172 or 53% were 'non-sexed'. Eighty-three or 55% of the 150 sexed adults were females and 44 or 29% of these were accompanied by young. Admittedly, with such a high proportion of 'non-sexed' animals, the true sex ratio of the population cannot be ascertained. However, assuming a 50-50 sex ratio for the 322 adults observed, there was only one young for every 3·7 of the assumed adult females or only 27% were accompanied by young.

Dr. George Schaller observed a total of 48 adult rhino and five young in May 1965. Once more assuming a 50-50 sex ratio for the adults, he observed only one calf for every 4·8 of the assumed adult females or 21% were accompanied by young.

I personally observed 162 rhino between March 3 and 18 : 62 'non-sexed' adults, 21 adult males, 45 adult females, and 34 young. Sixty-eight% of the sexed adults were females and 34 or 76% were accompanied by young. Again assuming a 50-50 sex ratio for the 128 adults observed, there was one young for every 1·9 of the assumed adult females or 53% were accompanied by young.

Most of the rhino which I observed were in the Baguri Block, which has the highest rhino density and is the most productive block in the sanctuary. Almost 43% (157 of 366) of the adult rhino and over half (23 of 44) of the young tallied during the census were observed in this block. No rhino were reported in eight of the sanctuary's 33 compartments. Therefore, my sample may indicate a much higher young-female ratio than is true for most of the sanctuary. However, this is perhaps an indication of what the young-female ratio should be in a thriving or growing population. Perhaps this is an indication that the rhino population

Spillett : Kaziranga Sanctuary

Above : A herd of Wild Buffalo in Kaziranga. The master bull is in the rear. *Below :* Mother and young rhino in Kaziranga. The baby is leading the way as usual.

(*Photos : E. P. Gee*)

Spillett : Kaziranga Sanctuary

Above : A census party in Kaziranga crosses a *bil* covered with water hyacinth. *Below :* One of the cold weather jeepable roads inside Kaziranga

(*Photos : J. Juan Spillett*)

in many parts of Kaziranga has reached its peak. Nevertheless, the animals appear to be in good condition and with the high number present there is no reason why the Forest Department cannot begin to realize a financial return from the sale of some of its rhino resources. A few rhino could probably be sold to reputable zoos each year without any appreciable effect upon the sanctuary's rhino population.

I noted during my observations that almost invariably when a female rhino was accompanied by a calf, other females with calves could be located near by. For example, while visiting the Kaziranga Block on March 14, we observed five females within a radius of 200 yards, all of which were accompanied by young. In fact, even though these were in an open forest area intermingled with tall, dense grass, we were able to observe eight of the rhino (4 females and 4 young) at one time. There were also no *bils* or other features near by which could be considered as an attraction to these rhino. No young were reported from the Kaziranga Block during the census. Therefore, it appears that this entire group was probably missed by the census party in this compartment. On other occasions, up to 20 adult rhino would be tallied at a stretch, then within a relatively short time several females with calves would be observed, one pair right after another. This same phenomenon was later noted during studies in April in the Jaldapara Wild Life Sanctuary of West Bengal. Whether or not there is a definite social relationship among females with young deserves further investigation. There is, however, the possibility that ' pockets ' of females with young were missed during the Kaziranga census and that the young-female ratio for the sanctuary was not as disproportionate as was recorded.

Rhino calves apparently remain with their mothers for almost four years, after which the female again breeds. The young attain puberty at about four-and-a-half years of age and the females have heat periods at intervals of 40 to 50 days. The gestation period, as observed with captive animals in the Whipsnade Zoo, is 488 days or approximately 16·3 months (Asdell 1964). Therefore, it appears that the maximum rate of increase in the wild state would probably be little more than one calf per female every five to six years. With such a slow rate of increase it would generally be assumed that the young-female ratio should perhaps approximate my figures.

The reason or reasons for the apparently low reproductive rate of much of Kaziranga's rhino population is not readily apparent. However, 366 rhino were counted during the two-day census, which was conducted when only about one-third of the sanctuary's grasslands had been burned. I am certain there are at least 400 rhino in the sanctuary. This means that over one-half of the Great Indian One-horned Rhinoceros in existence are located in the Kaziranga Wild Life Sanctuary !

Wild Elephant

Elephant are readily sexed in the field when they are clearly observed. However, the forests or dense habitat in which they are usually encountered in Kaziranga, their generally shy or retiring nature, and the fact that they are usually met in fairly large groups, make it difficult even for an experienced observer to record accurately sex and age composition data for groups encountered. The gradual increase in size from a new born calf to a mature elephant also makes it difficult to determine which animals should be classified as adults and which as young. This is particularly true when only two categories (adult and young) are used. Therefore, the sex and age ratio data collected for wild elephant during the census has little significance, but the total number counted does.

The tribal Mikirs were burning extensive areas for their *jhum* cultivations in the Mikir Hills south of the sanctuary prior to and at the time of the census. There were perhaps more elephant in the sanctuary due to this disturbance than would normally be expected. This was further indicated by numerous trails and recent elephant tracks entering the sanctuary through the south-west corner where the forest provides a natural passageway into the nearby hills. Elephant are migratory or nomadic and, except for some solitary males, rarely remain in the same vicinity for long periods of time. Also, they tend to move as a group or herd, which can generally be identified by its composition or by the presence of easily identified or ' marker ' individuals.

A total of 349 elephant were tallied during the two-day census. Three herds totalling 241 or 69% of all the elephant censused were observed in compartment 1 of the Bhawani Block. Twenty of the sanctuary's 33 compartments reported no elephant and five reported only solitary males. Prior to the census I observed many fresh signs and frequently heard elephant nearby, but I saw only four solitary males. However, I tallied two elephants during the census and observed movements in the forest undergrowth where others remained hidden. It is certain that some elephant were missed. Therefore, there were probably at least 375 elephant in the sanctuary during the census, although many of these are probably not permanent residents. This is relatively high number for an area the size of Kaziranga and exceeds all previous estimates. Elephant may become too numerous in the sanctuary and eventually become a major problem. *Kheddas* and *mela shikar* conducted in the Mikir Hills south of the sanctuary would help to hold the number of wild elephant in check. This would result in no disturbance to the sanctuary and could also provide a source of revenue to the Forest Department.

Wild Buffalo

Buffalo are not difficult to sex in the field, although immature males may be quite easily mistaken for females. There may also be some

ambiguity as to whether a yearling or even a two-year-old should be classified as adult or young. With the exception of solitary males, buffalo are usually encountered in groups or herds. However, in contrast to herds of elephant which may contain a number of adult males, a herd of buffalo usually contains only one adult male and perhaps a number of immature males. Buffalo herds in Kaziranga are generally observed in or around the *bils*, particularly during the warmer part of the day when they come to lie or wallow in the water and mud. Buffalo in some areas regularly visited by tourists have become accustomed to the presence of man. But in most parts of the sanctuary they are wary and generally seek cover and remain hidden whenever man appears on the scene.

A total of 471 buffalo were tallied during the two-day census. Three hundred and eighty-six or almost 82% were adults, of which 115 or almost 30% were 'non-sexed'. Two hundred and seventeen or 80% of the 271 sexed adults were females and 85 or 39% of these were reported to be accompanied by young. This is one young for every 2·6 sexed females. Thirteen of the sanctuary's 33 compartments reported no wild buffalo and five reported only solitary males. Three hundred and thirty-seven or almost 71% of the 471 total were observed in the Baguri Block. Others were undoubtedly missed during the census and there are probably at least 550 wild buffalo in Kaziranga.

Considering the predominance of females in the sexed adult population observed during the census (four adult females per adult male) and the relatively high reproductive potential of this species (one young per adult female per year or at most every two years), it appears that the sanctuary's buffalo population could easily become too numerous. Both wild buffalo and elephant are little endangered by the annual floods covering the sanctuary and, except for small young, are relatively immune to the effects of natural predation. Another factor to be considered is the relatively large number of semi-wild buffalo in the sanctuary. Over 2000 head of domestic buffalo are presently grazed in Kaziranga. Graziers are unable to keep domestic males with their herds, because they are usually killed by wild males. Therefore, domestic females are practically always served by wild males and the resulting cross-breed young males are sometimes permitted to become feral. This problem could be eliminated with the elimination of domestic livestock grazing inside the sanctuary. However, when discussing the possibilities of the wild buffalo becoming too numerous, Mr. Gee informed me that the sanctuary's population has not increased during recent years, but has actually appeared to decrease. Whether or not this can be attributed to diseases contacted from domestic animals or other factors should be thoroughly investigated.

Swamp Deer

The slender and graceful swamp deer of Kaziranga are usually seen in groups or herds on the short andropogonous grasslands surrounding the *bils*. Predominantly female with young or male groups were generally encountered during the census. According to the Forest Department staff, the breeding season of the sanctuary's swamp deer is between November and December. Groups or harems of females are then observed with adult males. Brander (1923) stated that the rut is ill-defined, but that mating in central India is mostly from mid-December to mid-January. The gestation period was observed in the London Zoo to be 240 to 250 days or approximately 8·2 months (Zuckerman 1952-53). The fawning period in Kaziranga is reported to start in the latter part of May or first of June. Prior to and during the census, very few small young were observed and most young were approaching yearling size. The antlers of all males that I observed were in velvet and most were in the early stages of development. This coincides with the reported November-December rut, as well as the hardening of the antlers by late October, and the shedding of the antlers in late December or early January.

A total of 213 swamp deer were tallied during the two-day census. Two-hundred and seven or 97% were adults, of which 141 or 68% were ' non-sexed '. Forty-nine or 74% of the 66 sexed adults were females and only six or 10% were reported to be accompanied by small young. Eighteen of the sanctuary's 33 compartments reported no swamp deer and two reported only a single female each. None were reported in the entire Tamulipathar Block and only a single female in the Bhawani Block. Because of the large proportion of ' non-sexed ' adults and the fact that all except small young were classified as adults, it is difficult to derive any conclusions from the census data as to the reproductive status of the sanctuary's swamp deer population.

I observed 152 swamp deer between March 3 and 18 : 21 ' non-sexed ' adults, 45 adult males, 57 adult females, and 29 young (including those approaching yearling size). Fifty-six% of the sexed adults were females and almost 51% were accompanied by young. Dr. George Schaller classified a total of 108 swamp deer in May 1965. Fifty-three% of his sexed adults were females and approximately 33% were accompanied by young. Both of our observations were apparently prior to the fawning season. Considering these factors, Kaziranga's swamp deer population appears to be thriving. Because of the open areas which they generally frequent, swamp deer are readily observed in Kaziranga. However, some were undoubtedly missed during the census and there are probably at least 250 head in the sanctuary.

Sambar

Sambar are usually shy and somewhat solitary in nature and the forested areas in which they are generally encountered makes it difficult to census their numbers accurately. This deer has a wide distribution in southern Asia and its reproductive behaviour apparently varies with the region. Blanford (1888-91) reported that in peninsular India the rut period is from October to November, but Phillips (1927-28) stated that in the lowlands of Ceylon there is no definite season. Cahalane (1939) claims that in its 'native habitat' the fawning season for the sambar is usually May or early June and Lydekker (1924) stated that the gestation period is about eight months. Information concerning antler development or size of the young was not recorded during the census. However, the sanctuary staff claimed that adult males in the sanctuary have hard antlers in October, the rut period occurs in November and December, and the antlers are shed in late December. It was also claimed that the main fawning period takes place between May and June, which is too early to coincide with a November-December rut period coupled with an eight month gestation period. I saw only two sambar during my observations in Kaziranga, a female and an adult male with hard antlers.

A total of 120 sambar were tallied during the two-day census. One-hundred or 83% were adults, of which only 6 were 'non-sexed'. Sixty-one or almost 65% of the 94 sexed adults were females and 20 or almost 33% were accompanied by young. It was surprising to see such a relatively high count during the census, but 19 of the sanctuary's 33 compartments reported no sambar, 6 reported only one each, and 5 reported two animals each. Three compartments (compartment 5 of the Baguri Block with 38, compartment 2 of the Bhawani Block with 60, and compartment 4 of the Haldhibari Block with 5) reported 103 or 72% of the total count of 120 sambar. Only one sambar each was reported for the Kaziranga, Baralimora, and Panbari Blocks, two from the Charigharia Block, and three from the Tamulipathar Block. Checking with the Forest Department staff, it was found that the three principal compartments were noted for their high densities of sambar. Also, other reliable sources have claimed that they have observed exceptionally high numbers of sambar in these areas and that, although this species is usually relatively solitary, they were often seen in groups of over fifteen. Therefore, the census reports are apparently reliable. Many sambar were also undoubtedly missed during the census and there are probably at least 300 in the sanctuary.

Hog Deer

The relatively small and gregarious hog deer is by far the most common ungulate in Kaziranga. Groups of these deer running through the

dense grasslands are very difficult to count, and accurate age composition and sex ratio data are even more difficult to collect. Therefore, no attempt was made during the census to record more than a total count.

A total of 1311 hog deer were tallied during the two-day census. This is probably only a small proportion of the sanctuary's population, which probably numbers between four and five thousand. Dr. George Schaller classified 290 hog deer in May 1965. Approximately 240 or 83% were adults, of which 118 or 49% were females. Forty-eight or 17% of the females were accompanied by young. He also observed that approximately 15% of the total population consisted of yearlings (between one and two years old). Although I observed over 500 hog deer prior to the census, I only classified groups totalling 128 : 53 adult males, 59 adult females, and 16 young. Fifty-three% of the adults were females and 27% of these were accompanied by young.

The sanctuary staff appeared to be indefinite as to when the majority of hog deer males have hard antlers, when the main rut occurs, and when the males shed their antlers. However, the majority of the males had antlers in velvet (later stages of development) at the time of the census. A relatively large number also had hard antlers and a few had recently shed their antlers. It was claimed that the main fawning season begins between May and June, but it appears that fawning is over an extended period of time or that there are more than one peak period. Hog deer are well distributed throughout Kaziranga and only two of the sanctuary's 33 compartments (1 and 4 in the Baralimora Block) failed to report them.

Barking Deer

Barking deer are solitary forest dwellers. They never form large groups or herds, although they are occasionally encountered in family groups of two or three. The dense forest undergrowth which they normally inhabit and their solitary and shy disposition make it extremely difficult to determine their numbers accurately. Little appears to be known about their reproductive physiology in Kaziranga, other than it is claimed that all of the males have hard antlers in July. Although they were reported to be relatively abundant in some of the sanctuary's forests, I observed only two and am, therefore, unable to add any additional information concerning this species.

A total of 29 barking deer were tallied during the two-day census. Sex and age ratio data was not recorded. However, all were observed in the forested areas of three of the sanctuary's eight blocks, Baguri, Haldhibari, and Panbari. This is probably only a small proportion of the total population and there are undoubtedly 100 or more in the sanctuary.

Wild Pig

Wild pig are relatively common in many parts of Kaziranga, particularly in the marshy grasslands. Except for solitary males, they are usually encountered in family groups or sounders. The dense grass which they generally frequent and their practice of breaking for cover when closely approached make it difficult to count their numbers accurately or to determine the sex and age composition for groups observed. Although they are reported not to have any definite breeding season, I did not see any small young among the 118 pigs which I observed prior to the census. Half-grown young were, however, frequently seen.

A total of 155 wild pigs were tallied during the two-day census. One-hundred and thirty-seven or 88% were recorded as adults, of which 72 or almost 52% were 'non-sexed'. Twenty-seven or 43% of the sexed adults were females and they were accompanied by 20 young. Eleven of the sanctuary's 33 compartments, including the entire Bhawani Block, reported no pig. Only a small proportion of the wild pig population was observed during the census and an estimate of five to six hundred for the sanctuary would not be unreasonable.

Other Animals

Other animals recorded during the census included : gaur or Indian 'bison', tiger, leopard, bear, otter, water monitor, and python.

Gaur—are not uncommon in the Mikir Hills to the south, but they have rarely been seen in Kaziranga. There is one unofficial report of a herd of nine of these impressive bovines and several skulls of adult males have been recovered from the sanctuary. These are presently on display at the Range Officer's office in Kohora. However, many men on the staff have never observed gaur in this area. A single solitary male was observed in the Charigharia Block during the census and probably fewer than 20 inhabit the sanctuary.

Tiger—have been infrequently observed in Kaziranga. However, based upon the relatively few tiger signs observed, they appear to be quite rare in the sanctuary. This is rather surprising considering the abundance of prey species, particularly hog deer and wild pig. Two were observed during the census, one each in the Haldhibari and Bhawani Blocks. A courting pair was also observed during my June visit at Mihi Mukh. Probably fewer than 20 exist in the sanctuary.

Leopard—have been seen in Kaziranga on only a few occasions. Some members of the Forest Department who are intimately acquainted with the sanctuary have never observed leopard nor their sign in the sanctuary. Except for a leopard skull, I likewise observed no sign of leopard. However, several visitors reported seeing a leopard climb a tree along the road leading to Arimora just a few days prior to the census.

A leopard was also reported in the Kaziranga Block during the census. Although their presence has been definitely established, they are still apparently rare and it is doubtful that more than a dozen reside in the sanctuary.

Bear—appear to be relatively common in Kaziranga. Although they are generally noted for being nocturnal in habits, they are quite frequently observed in many parts of the sanctuary. I saw what appeared to be an adult sloth bear in the Baguri Block on March 6. Many bear signs (i.e. scratches on trees and destroyed termite hills) were particularly evident in the forested areas of this block. Besides official sightings of sloth and Himalayan black bear, visitors have also reported seeing bear with a yellow ' U ' on their chest, which may well be the Malayan sun bear. Two bears were observed during the census, one each in the Baguri and Kaziranga Blocks. Although difficult to estimate, there are probably at least 30 in the sanctuary.

Otter—are frequently seen along the sanctuary's numerous streams and in many of its *bils*. Fishing is prohibited inside Kaziranga and as a result many of the streams and *bils* are literally teeming with fish. The abundance of food and suitable habitat probably account for the relatively large numbers of this interesting mammal, which has become all too rare in many parts of India. Prior to the census I observed more than 50 otter, including numerous family groups. A total of 29 were reported during the census from five of the sanctuary's eight blocks. There are probably several hundred otter in the sanctuary.

Water Monitor—Water monitor (*Varanus* sp.) are fairly common in some of the marshy areas or along some of the sanctuary's waterways. These reptiles often attain a total length of over six feet. Their large size and striking colouration, consisting of a dark background splotched with bright yellow, make an impressive sight. I observed two prior to the census and two were also reported during the census. A relatively accurate estimate of their total numbers in the sanctuary would be very difficult to ascertain.

Indian Python—are one of the various species of snakes which are not too uncommon in many parts of Kaziranga. However, due to the annual burning of much of the grassland, their numbers are probably held somewhat in check. I observed a python in the Baguri Block prior to the census. It was approximately 10 feet long and had recently swallowed a meal. Another python was also observed during the census in the Kaziranga Block. A cobra was seen near Baguri during my June visit. No attempt will even be made to estimate the numbers of python or other snakes in the sanctuary.

Time of Observation

It is generally assumed by many people that most wild animals are

more readily observed during the morning rather than in the afternoon or evening. However, my observations prior to the Kaziranga census indicated that this was not true for many mammals in the sanctuary during this time of the year. For example, on March 5, I spent three and three-fourths hours (06·15 to 10·00) in the morning and about three and three-fourths hours (14·15 to 18·10) in the afternoon on elephant back making a somewhat circular transect in the Baguri Block, visiting as many *bils* as possible. Besides other mammals, I observed 14 rhino and 34 buffalo during the morning and 17 rhino and 73 buffalo during the afternoon. The following day I followed the same route, but in reverse order. This time I spent four and one-half hours (06·45 to 11·15) in the morning and about four hours (14·00 to 18·10) in the afternoon on elephant back. Again fewer animals were observed during the morning than during the afternoon : 11 rhino and 55 buffalo as compared to 23 rhino and 88 buffalo. During an additional eight days spent on elephant back in other parts of the sanctuary, the same trend generally held true and I usually observed more animals in the afternoon than in the morning. Therefore, during the two-day census the counts were tabulated on a morning versus afternoon basis. Due to a number of factors, the census parties worked a total of 158 hours during the morning and only 96 hours during the afternoon. However, comparing the numbers of the common mammal species observed per hour for each period, the data again indicates that the afternoon was best to observe most animals in the sanctuary during this season (see Table 4).

TABLE 4

COMMON LARGE MAMMALS OBSERVED DURING THE MORNING AS COMPARED TO THE AFTERNOON DURING THE 1966 WILD LIFE CENSUS OF THE KAZIRANGA WILD LIFE SANCTUARY, ASSAM

Kind of Animal	Average Number Per Census Hour		Total Number Observed	
	Morning	Afternoon	Morning (158 hrs.)	Afternoon (96 hrs.)
Rhino ..	1·3	1·6	207	159
Elephant ..	0·4	2·9	69	280
Buffalo ..	1·2	2·9	194	277
Swamp Deer ..	0·9	0·8	139	74
Sambar ..	0·1	1·1	14	106
Hog Deer ..	5·1	6·1	724	587
Wild Pig ..	0·7	0·4	112	43

Other Factors

It will be noted that those blocks in which livestock grazing is permitted or that are most distant from the cultivated areas along the Grand Trunk Road had lower densities of wild animals, particularly rhino,

than did the other blocks. In the case of areas grazed by livestock, this can probably be attributed to a lack of suitable forage and perhaps to disturbances and other factors associated with domestic livestock grazing. However, in the case of the more distant areas that are not grazed by domestic livestock to any appreciable extent, it is difficult to pinpoint the exact reasons. The habitat may be less desirable or, perhaps, particularly in the case of rhino, poaching may be an important factor. Also, it may be that the cultivated areas along the southern boundary serve as an attraction to wild animals, such as the rhino, and that they tend to congregate in the adjoining parts of the sanctuary so as to have ready access to the cultivation during the crop seasons. Crop depredation, particularly by rhino, is a serious problem in this area and one man was recently killed by a rhino while trying to protect his crops. Wild buffalo, particularly solitary bulls joining herds of domestic cows, are also a problem and a number of people in the vicinity of Kaziranga have been injured by them.

V. Conservation Problems

Livestock

It was realized when Kaziranga was first recognized as a sanctuary that domestic livestock grazing is not desirable in an area dedicated to the preservation of wild life. However, grazing had previously been permitted when Kaziranga was recognized as a Reserved Forest. Therefore, graziers had established prior rights. Also, due to the prevalence of rhino poaching and a lack of sufficient number of Forest Department personnel to patrol the sanctuary and to protect the wild life effectively, the then Chief Conservator of Forests (Mr. A. J. W. Milroy) felt that the establishment of *khutis* along the bank of the Brahmaputra would help to deter poachers from the sanctuary. Poachers were generally known to enter this area from the Brahmaputra River. Therefore, an agreement was made between the Forest Department and the professional graziers whereby the graziers would immediately report to the Forest Department anyone whom they observed entering the sanctuary through their *khutis* or buffalo camps along the banks of the river. Although such information has oftentimes been of value, it is not known whether or not this service is presently of sufficient value to offset the deleterious effects of livestock grazing. Grazing fees are presently paid to the Forest Department by 39 professional graziers for rights to graze over 1500 head of adult buffalo in the sanctuary areas bordering the Brahmaputra River. Fees are not charged for animals under two years old and they are not included in the official total. Eight of these professional graziers also pay fees to graze almost 300 head of adult cattle in this area. Therefore, the actual number of domestic animals, including animals under

two years of age, presently grazing in the part of the sanctuary adjoining the Brahmaputra probably exceeds 3000 head.

Prior to 1950 domestic livestock grazing in Kaziranga was confined to the *khuti* areas along the Brahmaputra. However, due to political expediency, livestock grazing was then initiated in the Kaziranga Block. The Government then gave grazing rights inside the sanctuary to villagers living along the boundaries of Kaziranga. This initially involved the encroachment of domestic livestock upon a one-square-mile area, but has since been extended to a two-square-mile area. This grazing area is not demarcated and the cancerous disease of overgrazing by domestic livestock is slowly eating its way deeper and deeper into the sanctuary. Presently 10 professional graziers and 56 villagers have permits to graze over 450 head of adult buffalo in this area. Although cattle are supposedly excluded, I counted over 100 head of cattle during my brief visit to the Kaziranga Block on March 14. I also observed over 30 head of domestic buffalo near Charigharia on March 8, which is in the heart of the sanctuary. In addition, livestock belonging to villagers living along the sanctuary's boundaries almost invariably graze along the edges of the sanctuary. Therefore, in addition to illegal grazing, approximately four to five thousand head of livestock are presently grazed inside Kaziranga.

When domestic livestock and wild life are present in the same area there is direct competition for forage, and wild life is usually the first to suffer and become eliminated. This was dramatically demonstrated by the results of the Kaziranga wild life census. Areas inhabited by domestic livestock contained relatively few, if any, wild ungulates. This was particularly true in the case of rhino. For example, prior to the advent of grazing in 1950, compartment 4 in the Kaziranga Block was noted as one of the sanctuary's outstanding rhino areas. However, only eight rhino were reported during the census for the entire compartment. Further, none were observed in the two-square-mile area grazed by domestic livestock.

The presence of domestic livestock also presents the possibility of introducing diseases and parasites which may prove fatal to wild life populations. There is the possibility that the sanctuary's wild buffalo population is presently being controlled by parasites or diseases. An example which may be attributed to the drastic effects of disease upon wild animal populations is the case of the near extermination of the swamp deer in Kanha National Park, Madhya Pradesh.

The grazing of domestic livestock requires the presence of herders and other people. In addition to the domestic animals, these also create disturbances which many wild animals cannot tolerate. As a result, their numbers will decrease or the species may eventually disappear altogether from an area. The high incidence of mortality due

to injuries sustained in fighting among rhino in the Laokhowa Reserve may be the result of too many disturbances. Females with recently born young will often abandon them if they are frequently disturbed or if their young are touched by humans.

Erosion

Annual flooding of Kaziranga is undoubtedly essential for the maintenance of optimum habitat for wild animals such as rhino, wild buffalo, and so forth. However, the loss by erosion of relatively large portions of the sanctuary bordering the Brahmaputra is a major problem. Although some areas on the western end of the sanctuary are being built up by deposition, erosion from the eastern end is taking place at a more accelerated rate. It is presently estimated that about 15-square-miles of Kaziranga have been lost to erosion since 1950.

The Embankment and Drainage Department (E. & D. Dept.) has proposed that a *bund* for flood control be constructed along the Brahmaputra in the north-eastern part of Kaziranga. Preliminary surveys were initiated in 1965, but were discontinued upon the insistence of the Forest Department. The E. & D. Dept. maintains that the construction of a *bund* is essential for flood control. On the other hand, the Forest Department claims that annual flooding of the sanctuary is essential for the welfare of the wild life and that the consequences of flood control would be worse than the losses to erosion. Presently this issue is a controversy between the two departments.

Some experimental plantings of different grasses and shrubs for the control of erosion have been made in one area inside the sanctuary. Although the value of such plantings has not yet been thoroughly demonstrated, it appears that such methods of erosion control should be investigated. It also appears that overgrazing by domestic livestock along the banks of the river may be a contributing factor in the acceleration of erosion. As previously mentioned, without the annual floods temporarily clearing the water areas inside the sanctuary, they would shortly become a solid mass of water hyacinth. In addition, the elimination of annual flooding would change the ecology of the entire sanctuary. There is also the danger that if a *bund* was constructed it may be breached by the high flood waters of the Brahmaputra, which would then result in the devastation of the sanctuary and its wild life.

It is my opinion that the Forest Department is right in not permitting the construction of a *bund* in this area. However, measures should be taken to check the sanctuary's losses to erosion. These would probably include the removal of domestic livestock grazing along the banks of the Brahmaputra and extensive plantings in the affected areas. *Chapories* formed along the southern bank of the river at the western end of Kaziranga should also be considered as a part of the sanctuary.

Exploitation

Exploitation of Kaziranga's natural resources, with the exception of domestic livestock grazing, was prohibited until this year. However, in February 1966 the Government of Assam passed an order allowing the local people to collect thatch from the sanctuary for domestic use. It is argued by some that such natural resources should be exploited, rather than ' wasted ' or annually burned. However, if such exploitations are permitted inside the sanctuary, where is the line to be drawn ? Numerous examples could be given of how the wild life in many of India's other sanctuaries has been completely devastated by the ever-increasing demands of the local people for the exploitation of their natural resources. The results in many cases has been the conversion of once beautiful and choice areas, with great economic potential, into little more than deserts which are of little value to anyone.

Education

Without the co-operation of the inhabitants living and working in the vicinity of Kaziranga, it is difficult, if not almost impossible, to administer efficiently or to protect fully the sanctuary and its wild life. The importance of publicity and education cannot be over-estimated. The local villagers and particularly the local members of the legislature must be convinced of the long-term economic advantages of wild life resources. It is essential that the right kind of publicity and education be done so that these people will be emissaries of nature conservation, rather than advocates for immediate short-term exploitation of the sanctuary's natural resources. Perhaps the local people could most easily be convinced of the value of Kaziranga by some concrete and useful project, such as the construction of a school with funds proclaimed as having come from a part of the revenue earned by the sanctuary's wild life.

Kaziranga, in addition to already being the most outstanding wild life sanctuary in southern Asia, has the potential of becoming one of India's greatest sources of much needed foreign exchange. This potential will probably never be realized if political expediency is permitted to dominate the sanctuary's practices and policies. The question should be settled once and for all. Is Kaziranga going to be permitted to realize its potential long-term economic advantages based upon the conservation of its wild life resources ? Or are ever increasing demands for immediate short-term exploitation of its natural resources going to be met ? Both cannot be realized simultaneously ! Visitors to Kaziranga are not willing to pay travel and accommodation expenses for the opportunity of seeing domestic livestock or grass cutters inside the sanctuary. Now is the time to make the decision. If those in responsible positions are wise enough to choose the better course of action, they will probably initiate the necessary legislation to constitute Kaziranga legally as an inviolate

national park—dedicated to the preservation of a part of India's great wild life heritage and above the demands of exploitation by the local people and politicians. The status of a national park would also give added prestige and publicity to this outstanding wild life area.

Poaching and Illegal Fishing

Although poaching, particularly of rhino, is one of the problems confronting Kaziranga, it does not appear to have attained the proportions that some recent newspaper articles have indicated. Poaching also appears to be restricted primarily to the north-eastern part of the sanctuary, particularly in the areas most distant from the office at Kohora and specifically in the vicinity of Dhansiri Mukh. Poaching appears almost non-existent in the areas frequented by visitors, such as near Mihi Mukh and the Baguri Block.

The common method for poaching rhino in this area is the digging of pits along their trails. In this manner a small band of poachers has a very good chance of obtaining a number of rhino with relatively little danger of being apprehended. Rhino horn, most of which eventually reaches China where it is thought to have potent aphrodisiac qualities, is said to sell for as much as Rs. 6000 per kg. on the black market.

Professional fishermen also enter Kaziranga with their boats and nets during the flood season or by means of its many streams. They often hide their equipment in or near the numerous *bils* and return at irregular intervals to exploit the sanctuary's fishery resources illegally. It is claimed that a single party can remove as much as Rs. 2000 of fish from the sanctuary per day. We found and destroyed eight dug-outs, most of which had been hidden by sinking them along the edges of *bils*. However, due primarily to the dense cover, it is extremely difficult to apprehend the culprits and even more difficult to take them into custody.

It is not economically feasible to employ sufficient personnel to maintain a continual vigilance over the entire sanctuary. Neither should the sanctuary be ' honey-combed ' with numerous roads for patrolling purposes. However, there are a number of preventive measures which could be employed.

Both poachers and fishermen generally operate inside Kaziranga in armed bands. Therefore, a single or even several Wild Life Guards are practically helpless or take a great risk in attempting to take them into custody. In order to operate efficiently against such groups, patrol units of at least six armed men are needed. Also, the most efficient or practically the only means of travel in much of the sanctuary is by elephant back. Anti-Poaching Squads or Patrol Units consisting of at least two elephants, their mahouts and grass cutters, and armed guards supervised by a Deputy Ranger would probably be the best and most economical means of combating such illegal activities. Such units should be supplied with

tents and other equipment so that they could remain in the field indefinitely. Portable walkie-talkie sets would also be valuable in co-ordinating the activities of such groups and providing a means of communication with the rest of the sanctuary. These units would be completely mobile and their mere presence should act as a deterrent to poachers or other law-breakers. These units could also be shifted to patrol boats during the monsoon or flood seasons.

There is a dire need for a means of communication inside the sanctuary. Travel at best is slow and difficult. Presently it often takes the better part of a day for men stationed at the various guard posts in the sanctuary to send a report to the office at Kohora or vice versa. Under such conditions little can be done to co-ordinate activities in situations such as the apprehension of law-breakers. Either a telephone or radio communications system should be installed at least between all beats and the office at Kohora. Telephone communication between Kohora and Jorhat, Gauhati and Shillong should also be improved, both for official use and for use by visitors to Kaziranga.

Fair-weather roads presently connect Kohora and Baguri with the Forest Rest House at Arimora. However, travel on them is slow and rough and they are jeepable only during a part of the year. Although it is probably advisable to keep road construction inside the sanctuary to a minimum, it is suggested that the present roads be improved and maintained in good condition and that an east-west road be constructed along the south bank of the Diphlu River connecting the Kohora and Baguri roads. Vehicular traffic would thus be improved and the movement of men and supplies inside the sanctuary would be greatly facilitated.

Besides a lack of equipment such as arms and ammunition, there is presently little incentive for Wild Life Guards to apprehend those whom they encounter violating the law. They are subject to great personal risks when attempting to apprehend violators, but gain little, if anything, by taking them into custody. They receive the same pay, which in most cases appears to be inadequate, whether they fully meet their obligations as guardians of the public domain or whether they do very little in this regard. Men are rarely rewarded for work well done, while, on the other hand, they are rarely dismissed for not fulfilling their obligations. A system of rewards for acts of bravery and devotion to duty would serve as an added incentive to apprehend poachers. And, a more effective system of punishment should be established so that men who do not meet their obligations can be dealt with effectively.

The presence of visitors in an area acts as a deterrent to poachers and other law-breakers. Therefore, visitors to Kaziranga should be encouraged to visit as much of the sanctuary as possible. This can be done by the provision of accommodations and other facilities in as many parts of the sanctuary as possible. For example, if in addition to

Kohora, accommodations and elephants were furnished for visitors at Arimora, Baguri, and near Kaziranga, the greater part of the sanctuary would probably be immune to illegal activities such as poaching.

Administration

The Forest Department officers in charge of the Kaziranga Wild Life Sanctuary have been trained in forestry. Very few have received training in wild life management. Considering this, the supervision and administration of Kaziranga has been especially commendable. This may in part be attributed to the fact that many members of the staff have a personal interest in wild life and have taken it upon themselves to learn some of the basic concepts of wild life management. However, like forestry, wild life management is a technical profession and a fulltime job.

It has been wisely proposed in the Forest Department's present five-year working plan that the cadre for the protection and preservation of the State's wild life should be separated. A Wild Life Division within the Forest Department has worked well in other states such as Uttar Pradesh. Such a division would help to attract qualified men and would provide a means whereby personnel interested in this specialized type of work could be better trained. It would also make for better administration of the State's various wild life areas and provide opportunities for promotion in this field. Presently when a man is promoted for outstanding work in a sanctuary, such as Kaziranga, it almost invariably means that he must be transferred back to a regular Forest Department position.

VI. Recommendations

The following recommendations are made :

1. That Kaziranga be legally constituted and officially recognized as a National Park.

2. That the exploitation of Kaziranga's natural resources, including the cutting of reeds and thatch, felling of trees, fishing, and shooting, be perpetually prohibited and the rules and regulations prohibiting their exploitation be strictly enforced.

3. That all domestic livestock grazing be prohibited inside the sanctuary. If this is not presently possible, only established *khutis* along the bank of the Brahmaputra River in the northern part of the sanctuary should be allowed to remain and then the numbers of domestic grazing animals should be progressively reduced and strictly controlled. Livestock grazing in the Kaziranga Block should be stopped immediately.

4. That all areas south of the Grand Trunk Road into which rhino and other animals move during the flood season be declared as a Buffer Zone and be demarcated as such.

5. That the portions of the Mikir Hills south of Kaziranga into which elephant and other animals migrate be constituted as a Reserved Forest.

6. That, because of administrative and political difficulties involved, the actual area of Kaziranga not be added to, but that all *chapories* formed along the south bank of the Brahmaputra River, either by erosion or by deposition, be considered as a part of Kaziranga.

7. That the construction of roads and facilities within the sanctuary proper be maintained at a minimum. However, that the present roads be improved and that an east-west road connecting the present Baguri and Arimora roads be constructed along the south bank of the Diphlu River.

8. That a telephone or radio communication system be installed between each of the beats in the sanctuary and the office in Kohora. Telephone connections between Kohora and Jorhat, Gauhati and Shillong should also be improved.

9. That mobile patrol units (consisting of mahouts, elephants, and armed guards with portable walkie-talkie sets) be detailed to patrol regularly the entire sanctuary to minimise illegal activities, particularly the poaching of rhino.

10. That a separate Wild Life Staff or Division be established within the Forest Department on a State-wide basis. This would permit the selection of men interested in and qualified for positions in the State's wild life areas and would also provide opportunities for promotion for outstanding work in this field.

11. That a system of rewards and punishments be established to encourage Forest Department personnel to better meet their obligations concerning the preservation and protection of wild life. Rewards for acts of bravery and devotion to duty, as well as a portion of all fines collected, should be given to the Forest Department personnel concerned. Likewise, greater emphasis should be placed on meting out suitable punishment to those that neglect or violate their obligations as guardians of their nation's wild life.

12. That an *esprit de corps* be fostered in the Wild Life Staff by such means as : the provision of uniforms and appropriate badges for all personnel, the payment of salaries appropriate to the obligations and duties entailed, the provision of opportunities for advancement in all positions, the provision of adequate living accommodations, and a system of rewards and punishments as recommended in No. 11.

13. That additional facilities for visitors be provided. First class accommodations at Kohora need to be improved, and additional facilities are also needed during the December-April visitor season and for groups on scheduled tours. These could most economically be provided by the construction of dormitory facilities. Tourist Lodges with modern

conveniences, adequate staff, elephants, etc., are also needed at Baguri and at the eastern end of the sanctuary.

14. That transportation be provided for visitors from Jorhat to Kohora and within the sanctuary. The possibilities of constructing an airfield in the vicinity of Kaziranga should also be thoroughly investigated.

15. That private enterprise, under the direct supervision of the Forest Department, be encouraged in the construction, maintenance, and operation of the sanctuary's visitor facilities, such as Tourist Lodges, catering, transportation, boat excursions, souvenir shops, and so forth.

16. That a programme of education and publicity be undertaken both to help people in the vicinity of Kaziranga become aware of the importance and value of this area and to attract visitors.

17. That information concerning the sanctuary (i.e. pamphlets, folders, postcards, etc.) should be made available through the Department of Tourism and recognized tourist agencies.

18. That wild life enumerations, similar to this year's, be conducted on an annual basis. However, that the most efficient and economical means of conducting such surveys also be thoroughly investigated.

19. That scientific studies of the sanctuary's wild life, particularly of the rhino, be encouraged by qualified personnel and that facilities (i.e. accommodation, elephants, etc.) be provided whenever possible.

20. That wild life observations both by visitors and by the sanctuary staff be kept in a permanent record in the sanctuary. Also, that checklists of the sanctuary's birds, mammals, and reptiles be compiled and provided for visitors.

21. That aerial photographs be obtained of the sanctuary and that accurate maps depicting the vegetation types, *bils*, etc., of Kaziranga be made from them.

VII. Acknowledgements

I wish to thank the Forest Department of Assam and members of its staff, particularly Messrs. P. Barua (Chief Conservator of Forests), M. A. Islam (Upper Assam Circle Conservator of Forests), H. K. Nath (Sibsagar Divisional Forest Officer), and C. L. Chakravarty (Kaziranga Range Officer) for their hospitality and assistance. Also, the accommodations furnished both for me and my family during our two enjoyable visits to Kaziranga are greatly appreciated. Mr. A. C. Gohain (Wild Life Officer for Assam), who accompanied me in the field most of the time, deserves special thanks for his assistance and patience. The assistance and services of other Forest Department personnel, too numerous to list individually, were also most welcome.

The Forest Department of Assam and its staff are to be commended for the fine work they have done and are doing to help preserve wild

life and its habitat in Kaziranga as a part of India's wild life heritage. I am anxiously looking forward to Kaziranga being legally constituted as a national park in the near future and also recognized as Asia's outstanding wild life attraction.

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IX. Glossary of Local Terms

bil or bheel	..	A small lake or pond (same as *jheel*).
bund	..	A dike or embankment ; sometimes denotes the road running along the top of an embankment.
chapori	..	a riverain island formed either by erosion or deposition.
guddi	..	the pad used on a riding elephant ; Nichol's guddi is used on the elephants in Kaziranga.
jhum	..	a wasteful method of shifting cultivation as practised chiefly by hill tribes in north-eastern India.
khuti	..	a camp established for the grazing of domestic buffalo, such as along the bank of the Brahmaputra River in Kaziranga.
khedda	..	elephant catching, especially in a corral or stockade.
mela shikar	..	the noosing of wild elephants by men riding on trained domestic elephants.
mora	..	literally means dead, but also used to denote a former channel or a stream, i.e. Mora Diphlu,

mukh .. the confluence of two streams.

nala or *nulla* .. a small ravine or stream.

reserve .. (See Reserved Forest).

Reserved Forest .. an area of waste or forest land so constituted under the Indian Forest Act or other forest law, in which the Government has full proprietary rights over the forest produce and in which all acts are illegal unless specifically permitted.

Laokhowa and other Rhino Areas in Assam

BY

J. JUAN SPILLETT

I. LAOKHOWA

The 26-square-mile Laokhowa Reserved Forest was constituted as such about 1929, but has been recognized as a 'multiple-use' area since 1958 and was proposed as a Wild Life Reserve in 1965. The reserve includes one forest village of 51 households or approximately 535 people, seven *taungya*[1] villages with a total of 166 households or between 800 and 900 people and 140 acres of plantation forests. Each forest village household is allowed to cultivate two and one-third acres inside the reserve and each *taungya* household is allowed two acres. They are also permitted free and unrestricted grazing inside the sanctuary and it is estimated that each household has at least three head of livestock. In addition, the Ruphiahi Co-operative (a fishery and farming co-op.) has leased 400 acres for agricultural cultivation since 1958 for Rs. 1·75 per acre per year, and the reserve's *bils* are exploited for their fishery resources on a lease system. Permits are also given to villagers living in the vicinity of the reserve for the grazing of domestic livestock. In short, the Laokhowa Reserve has a human population of approximately 1400, contains at least 1000 acres of cultivation, and provides grazing for approximately 5000 head of livestock. This is apart from the fact that its forest and fishery resources are also exploited to the fullest extent.

[1] *Taungya* is a forest village in which the villagers cultivate plantation forests in return for rights of cultivation etc. in the forest area.

Approximately 70% of the reserve consists of open areas, including grasslands, cultivation, *bils*, etc., and the remaining 30% consists of forests, primarily of plantation or pure natural stands of *simul* (*Bombax ceiba*) or mixed open forests of *simul* and *koroi* (*Albizzia procera*). The relatively soft and light wood from these two species is used primarily for matches and match boxes.

We travelled from Kaziranga to Nowgong on March 12. I met Mr. P. C. Gogoi (Nowgong Divisional Forest Officer) that evening and discussed the status of the rhino in the Nowgong Forest Division. The following day we visited Laokhowa, which is 13 miles from the town of Nowgong. Elephants were provided by the Forest Department and we spent the morning inside the reserve searching for rhino. Members of the staff estimated that there were between 30 and 40 rhino in the reserve and it was claimed that 37 were counted in 1965. They further stated that rhino were restricted primarily to the eastern and central parts of the reserve. However, the largest *bil* (Khalihamari) which has the most suitable habitat (cover) is located in the north-western corner. The two rhino which we observed during our visit were located here. Other wild animals inside the reserve include : wild buffalo (we saw six), a few wild pig, hog deer, and swamp deer. A wild life enumeration, utilizing methods comparable to those used in Kaziranga, was conducted by the Forest Department on March 28. The reserve was divided into six compartments. Census parties consisting of an enumerator, guide, mahout, and elephant tallied the animals observed in each compartment. Most of the rhino were seen in the north-western part of the reserve or along the Mora Suti, a tributary of the Brahmaputra River. The results of the Forest Department's enumeration are presented in the Table.

TABLE

RESULTS OF THE LAOKHOWA RESERVE WILD LIFE ENUMERATION CONDUCTED BY THE FOREST DEPARTMENT ON 28 MARCH 1966

Kind of Animal	'Non-sexed'	Number of Animals		Young	Total
		Adult Male	Adult Female		
Rhino ..	1	25	12	3	41
Wild Buffalo ..	—	10	29	11	50
Swamp Deer ..	—	4	—	—	4
Hog Deer ..	—	6	—	—	6
Wild Pig ..	—	5	—	—	5

Numerous people were observed to be moving freely about the reserve during our visit. Overgrazing by domestic livestock was also evident in all parts visited. Besides the apparent lack of sufficient forage to main-

tain animals the size of rhino, cover also appeared to be almost non-existent. During the afternoon we jeeped to the north-eastern part of the reserve and questioned a number of villagers there as to the presence of rhino. They claimed that there were four, including a large calf, in that area. Based upon my limited observations and the degree of habitat abuse presently being practised in the Laokhowa Reserve, I doubt that its rhino population will be able to increase or even maintain its present status.

Three cases of rhino dying as a result of injuries sustained in fighting have been reported from Laokhowa since 1964. An adult female died in July 1964, a male in February 1965, and another male in November 1965. The weights of the recovered horns were 0·57, 0·14, and 2·20 kg. respectively. Whether or not this high incidence of mortality due to fighting can be attributed to a lack of forage and/or the presence of so many disturbing elements is not known.

II. Kukurata

En route to Nowgong, Mr. Gohain and I also visited the Kukurata Reserved Forest, located along the Brahmaputra River west of Kaziranga. This small reserve contains about 8000 acres, most of which consists of plantation teak (*Tectona grandis*). We were met by Mr. R. N. Saikia (Jaklabhanda Beat Officer), who informed us that the rhino in this area inhabited an approximately one-square-mile grassland marsh called Mohkhuti Bil. This *bil* is located along the north-western boundary of the reserve 11 miles downstream from Kaziranga. Although this area is outside the reserve and we were informed that the rhino rarely enter the reserve proper, Mr. Saikia stated that the nearby villagers come to the Forest Department for help whenever the rhino raid their crops. Also he counted seven different rhino, including two calves, while attempting to frighten them away from the paddy fields in January. He accompanied us to Mohkhuti Bil, where we met several members of the Embankment and Drainage Department. This department has constructed a *bund* along the southern edge of the *bil* for flood control and a small staff remains in the area. One man informed us that he saw a female rhino with a small calf cross the *bund* the previous day (March 11) and the watchman claimed that he saw four rhino (apparently all adults) on March 10. Some of the nearby villagers claimed that there were more than seven rhino in the area, but they had no idea what the actual number might be. However, it appears almost certain that there are at least seven in this vicinity.

III. Raja Mayang

It was proposed by the Forest Department in 1965 that the 4464-acre Raja Mayang Forest area be constituted as the Pobitora Reserved Forest. This reserve is also located in the Nowgong Forest Division and the Forest Department claims that it contains 12 rhino. Perhaps to be on the conservative side, this number should be reduced by half.

A case of poaching was detected by the Forest Department in Raja Mayang in 1964. The case was investigated by the police and the 1·75 kg. horn of an adult female was recovered and turned over to the Forest Department. An adult male also died in February 1966 from injuries sustained in fighting. The horn from this rhino weighed 1·265 kilograms.

IV. Orang

I was informed by Mr. Gogoi that the 24-square-mile Orang Reserved Forest in the Darrang Forest Division has a rhino population of approximately 25. However, many of these rhino do not permanently reside there, but frequently enter or leave the reserve. It was further stated that this reserve and the surrounding areas are probably inhabited by a total of approximately 50 rhino, including the near-by *chapories* of the Brahmaputra River, and that they are increasing in numbers every year. Mr. Gee estimated in 1964 that there were only 12 rhino in Orang. Therefore, to be on the conservative side, I will accept his figure, but will add a few to his estimate of total rhino found outside of the sanctuaries or reserved forests in Assam.

V. Elsewhere

Besides the rhino reported in the areas surrounding the Orang Reserved Forest, the Doboka Reserved Forest also contains two adult rhino, supposedly an adult male and a female. This area, located 32 miles from the town of Nowgong, also reported the death of an adult male in April 1964 as a result of injuries sustained in fighting. The collected horn weighed 1·875 kilograms.

Returning to Kaziranga from Nowgong, we also visited Bihdubi Chapori, which is located three miles west of Silghat. Mr. Gohain had observed a female with a calf in the dense grasslands of this sandy flood plain in mid-December of 1965. When we inquired about rhino at Ferryghat, we were informed that a solitary rhino (apparently a male) frequented the area, but had not been seen since the first of March. Six rhino were also reported in 1959 to inhabit an island (Sal Chapori) in the Brahmaputra River near Kaziranga.

The authenticity or accuracy of scattered reports of rhino outside of established wild life sanctuaries or reserved forests is very difficult to determine. The chances of these animals successfully breeding or attaining any appreciable numbers in these areas also appear to be very slight. In my opinion, strictly protected sanctuaries or reserved forests offer the only means of preserving this species from annihilation. Although I feel that these scattered animals add little to the reproductive potential for the species, I estimate that there are probably at least 40 rhino outside of the major reserved forests and the Kaziranga and Manas wild life sanctuaries in Assam.

The Jaldapara Wild Life Sanctuary, West Bengal

BY

J. Juan Spillett

(*With two plates and two maps*)

Table and Maps

I. Introduction

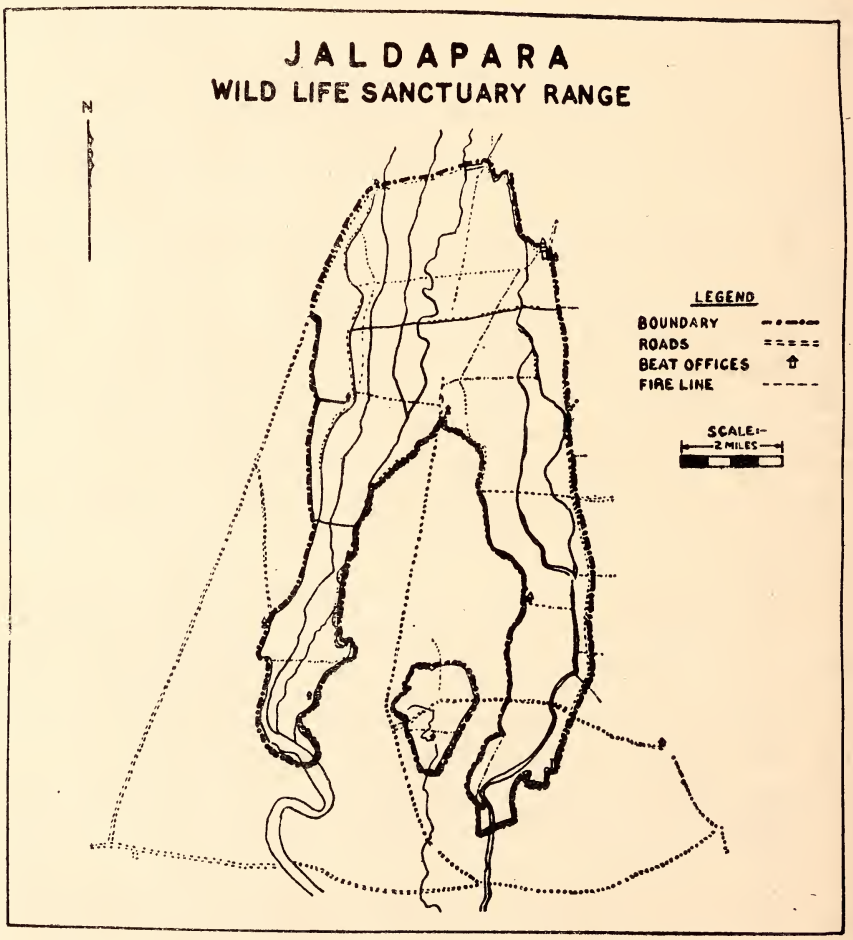
The Jaldapara Wild Life Sanctuary in northern West Bengal is an example of how conservation measures can preserve both a vanishing species and a worthy wild life area as a part of a nation's heritage. By the early 1930's the great Indian One-horned Rhinoceros was on the verge of extinction in what is now the state of West Bengal. The Bengal Rhinoceros Preservation Act of 1932 (Bengal Act VIII of 1932) condemned the indiscriminate destruction of this impressive animal and provided it with legal protection. However, illegal poaching and encroachment by cultivation and human habitation upon the few remaining haunts of this rare species continued. Although the area presently occupied by the sanctuary was unofficially recognized as such as early as 1936, it was not until 13 March 1941 that it was set apart as a sanctuary, primarily for the preservation of the rhino (Government Order No. 10549, which was later amended by Notification No. 5238 on 3 April 1943). Jaldapara was first known as a game sanctuary, but subsequently as a wild life sanctuary—dedicated to the preservation and conservation of all the wild life, both plants and animals, within its confines.

The Jaldapara Range covers a total of 25,833 acres (40·36 square miles). Besides the sanctuary, this includes the 1243 acre Salkumar Block, part of which is cultivated lands and the remaining forests are commercially exploited for forest produce. This block, however, forms an isolated island and, except for administrative purposes, has little relation to the sanctuary. The sanctuary proper includes 24,590 acres (38·42 square miles) and, with a little imagination, takes the form of a man's pair of trousers. The northern boundary or the 'waist' is approximately two and one-half miles across. The total length of the 'legs' is about 11 miles. And the length of the 'inseams' is almost eight miles.

Accommodation for visitors and catering facilities are provided by the Forest Department at the Baradabri Tourist Lodge on the east bank of the Malangi River, along the north-eastern boundary. The lodge contains three units, each of which accommodates two people. A youth hostel is also located near-by and provides accommodations for sixteen people. Although the hostel is under the direction of the Education Department and is primarily for the use of students, it is administered by the Forest Department and can be used by other visitors by special arrangement.

The nearest railroad station is Hasimara, less than four miles from the Baradabri Tourist Lodge. However, it should be noted by visitors arriving by train that the Assam Mail does not stop at Hasimara, but all trains stop at Madarihat, seven miles to the north-west. There is

also a Forest Rest House near the Madarihat station and from here an access road is presently being constructed by the Forest Department. This road runs along the western boundary of the sanctuary to the proposed site of a new tourist lodge to be built shortly by the Forest Department along the Holong River four miles south of Madarihat. Thrice weekly unscheduled air flights from Calcutta land at the Hasimara airfield, three miles distant from Baradabri. The office and quarters of the Jaldapara Range Officer in charge of the sanctuary are centrally located at the ' crotch '. Beat offices, each manned by a Forester and two Forest Guards, are strategically located along the sanctuary's boundaries (see Map 1).



Map. 1. General map of the Jaldapara Wild Life Sanctuary, West Bengal, depicting the beat offices, firelines, and principal streams

II. Habitat

Streams

Jaldapara is located in a level flood plain, 200 feet (61 metres) above sea-level. The sanctuary is intersected by numerous rivers and streams that flow basically from north to south. The west 'leg' is drained by the Torsa River, which is the largest river in the area. It rises in the Chumbi Valley of Tibet and then flows across Bhutan before entering India at Baladuar and finally emptying into the Brahmaputra near Cooch Behar. The east 'leg' is drained by the Malangi River, which becomes the Siltorsa in the southern part of the sanctuary. Both the Torsa and the Malangi have a rapid flow and are fed by numerous tributaries. Their clear waters, flowing over a rock shingle bed, are a welcome contrast to the muddy, silt-laden streams common in much of India. Some of the other principal streams of the area are the Holong, Chel, Basra, and Para rivers. Most of these are perennial, but some occasionally become almost completely dry between February and April.

Floods

Streams in this region have a tendency to cut new channels during the annual flood season, from May to September. They intercommunicate by a network of 'cross-country' watercourses. The frequent changes in stream beds result in numerous pools and marshes, favourite haunts of rhino.

The behaviour of these rivers is always unpredictable, but since 1950 there have been two devastating floods, one in 1952 and the other in 1954. The latter, which was caused primarily by the Torsa River, was of enormous magnitude. It flooded approximately 600-square miles in this area and did considerable damage to crops, bridges, roads, and human dwellings. Entire forests were washed downstream and many of those that remained standing were so laden with sand and silt that many of the trees subsequently died and their vegetational composition was radically changed.

Fire

The Forest Department maintains 20 miles of 50-feet wide firelines within the sanctuary. These are divided into 12 lines, most of which run east to west. The other sides of the blocks or compartments are formed by the north to south flowing streams. These lines are intended to protect the area against fire or to provide a means by which burning can be controlled and systematically utilized for management purposes. They also encourage the movement of animals and provide paths or landmarks both for visitors and workers within the sanctuary.

The sanctuary is annually burned by a controlled rotation method. Alternate blocks are first burned. The unburned blocks provide cover

and forage for the wild life until new growth in the burned areas is sufficient to provide these necessities. Then the remaining blocks are burned by the sanctuary staff. It is evident that what was once a predominantly forest area is gradually becoming a savannah or grassland due to annual burning. This is probably desirable for such species as rhino and hog deer, but may be detrimental for such species as sambar and barking deer.

Climate

Jaldapara is located in a moist tropical zone. Rainfall is monsoonal and the total annual precipitation is approximately 165 inches. The effect of the south-west monsoon is usually marked by a few heavy rains in May. Frequent heavy rains can then be expected throughout June, July, and August. The rains decrease by mid-September and usually cease before mid-October. However, the atmosphere is usually humid and there are heavy dews from November to January. Early rains can also be expected in April.

The mean daily temperature range from November to February, the winter season, is 60-70°F. (15·56-21·11°C). From May to September, the monsoon or rainy season, it is 80-90°F. (26·67-32·22°C.), and during the rest of the year it averages 75-80°F. (23·89-26·67°C.). Severe wind storms are common between April and May and sometimes occur in September and October.

Vegetation

The entire Sanctuary lies in a level flood plain. The soil consists mainly of a deep bed of sand, superimposed with a thin layer of light, friable loam. The whole formation is detritus, washed down from the neighbouring Himalayas. This riverain habitat consists primarily of forests interspersed with tall, dense grasses and interconnecting waterways. Much of the sanctuary is flooded each year by the rivers flowing through it. During these floods, most of the animals retreat to the slightly higher forest areas. The ground and much of the vegetation is fairly dry by late November or early December and between January and March most of the sanctuary, including both the forests and grasslands, is burned by the sanctuary staff. Although numerous vegetational types are found here, they can be roughly divided into two classes : riverain forests and grasslands or savannah.

Forests

Although complicated by numerous interconnecting streams, transects taken inland from the main rivers of the sanctuary indicate the forest succession for this area. A narrow fringe of deciduous forests, composed of more or less pure stands of *khair* (*Acacia catechu*) or *sissu* (*Dalbergia sissoo*), is generally encountered along streams, such as the

Torsa River. Both *khair* and *sissu* prefer porous alluvial soils, which may or may not be dry for a considerable portion of the year. *Sissu* is particularly evident in areas where the grass has been grazed heavily by livestock and is too short to be readily burned. In slightly more stable areas, *khair* and *sissu* yield to such species as silk cotton or *simul* (*Bombax ceiba*) and *siris* (*Albizzia* spp.). These may be either in pure or mixed stands, but are most often accompanied by numerous other species, such as *sidha* (*Lagerstroemia parviflora*), *tun* (*Cedrela toona*), *gamar* (*Gmelina arborea*), *pitali* (*Trewia nudiflora*), *kainjal* (*Bischofia javanica*), and *kadam* (*Anthocephalus cadamba*). Where the water level is not deep, almost pure stands of *pitali* and *kainjal* are evident, with perhaps a few *chalta* (*Dillenia indica*) and other species. Along the river beds, adjoining dry mixed forests or plateau-like areas where the permanent water level is fairly deep, *tanki* (*Bauhinia purpurea*) oftentimes predominates. Eventually on the more permanent sites or more stable areas are encountered mixed forests. Here the most predominate tree species are usually *harra* (*Grewia laevigata*) and *barkaule* (*Casearia graveolens*). *Sal* (*Shorea robusta*), a valuable hardwood species, is confined to the east bank of the Malangi in the northern and the extreme southern portions of the sanctuary.

A number of different species of weeds and climbers or vines are also associated with the forests of Jaldapara. *Assamlota* (*Eupatorium* spp.) is the most common weed and is associated both with trees and other vegetation. *Kowcha* (*Mucuna prurita*), a herbaceous climber which often kills the trees around which it entwines, is quite frequently seen. *Mikania* (*Mikania cordata*) is not yet widespread, but is already a problem in some areas and may eventually become a major problem in the sanctuary. It is reported to have been introduced from Malaysia and both trees and grass are killed by its strangling tentacles. Simple culling does little to deter its spread and burning does not kill its roots. There is apparently no inexpensive method to control this undesirable plant. *Charchare* (*Vitis* spp. or *Cissus adnata*) is also present.

The most common shrub in the sanctuary is *boroi* or *kool* (*Zizyphus mauritiana* var. *fruticosa*). With fire protection, *Macaranga denticulata*, *Alphia alughas*, *Trema orientalis*, and other species spread rapidly, particularly, in damp areas.

Grassslands

Transects from the main rivers inland also indicate the succession of the grasslands or savannahs. However, as has been previously mentioned, the sanctuary is predominantly forest and without annual burning almost all of the grasslands would eventually become forests. Besides burning, the successional stages are, of course, dependent upon the behaviour of the streams and the stability of the site. *Cassia* or

khasila (*Saccharum spontaneum*), a relatively short grass which is usually less than six feet high, has remarkable powers of colonization and is one of the primary invaders on new riverain accretions. This grass is commonly found on sandy soils, but may also be encountered in clay pockets, which are often silted-up old stream beds. *Dachla* or *khagri* (*Phragmites karka*) is also generally found in clay pockets, as is *Saccharum procerum*. Some of the other grasses present in the sanctuary are *Erianthus elephantinus*, *Anthistiria gigantea*, *Andropogon nardus*, *Arundinella brasiliensis*, *Arundo donax*, *Paspalidium punctatum*, *Sacciolepis myosuroides*, and so forth.

Improvements

In addition to controlled burning and the construction and maintenance of firelines, the Forest Department has attempted in various ways to improve the wild life habitat of the sanctuary and to improve the possibilities for visitors to view the wild animals. A total of 12 glades, eight in the east side and four in the west, are maintained by the sanctuary staff. Each glade consists of a circular clearing, about 150 feet in diameter, with a centrally located salt lick. The bushes have been removed from these areas and the grass is burned prior to December. Salt is regularly mixed with the soil in a bare spot in the center. Therefore, during the visitor season (January-April) both green forage and salt are present in these glades to entice animals into the open where they can be readily seen by visitors. A number of wallowing pools for rhino have also been constructed in different areas and natural wallows have been improved or enlarged.

Although the firelines within the sanctuary serve as paths or roads for workers and visitors on elephant back, the Forest Department has wisely refrained from constructing motorable roads. The sanctuary is not large and due to its unique shape almost any part of it can be quite easily reached from roads outside the boundaries. One exception to this rule is the present construction of a road entering the west side, which leads to the site of a new tourist lodge to be built along the Holong River. This will make some of the best wild life habitat in the sanctuary readily accessible to visitors. It will be interesting to note what effect this road has on the relatively dense animal populations now present in that area.

All forms of hunting, shooting, and fishing are prohibited in the sanctuary. However, Forest Officers of gazetted rank or designated members of the sanctuary staff are authorized to shoot dhole or Indian wild dog (*Cuon alpinus*) and otter (*Lutra lutra* or *L. perspicillata*). Throughout India wild dogs have the reputation of being merciless and ruthless killers. Nevertheless, there have been no reports of their presence in this vicinity during recent years and, even if they were present

they should probably be considered as an integral part of the faunal composition of the sanctuary. As such, they should be extended the protection of the sanctuary until such time as it is definitely established that their presence is a threat to the existence of other animal species. Because of its supposed depredations upon valuable fish resources, the otter is classed as vermin in West Bengal, as well as in a number of other Indian States. Whether or not there is a sound basis for this, there appears to be little basis upon which to persecute this animal in a sanctuary where all fishing is prohibited. It is, therefore, suggested that otter also be afforded the protection of the sanctuary.

III. Wild Life Enumerations

West Bengal was formerly very rich in wild life, but due primarily to the spread of cultivation, including tea plantations and human habitation, this valuable natural resource has been drastically reduced. It appears that only in sanctuaries, such as Jaldapara, can remnants be preserved of the vast numbers of wild animals once found here. Besides rhino, other mammals represented in the sanctuary include : wild elephant, gaur or Indian ' bison ', swamp deer, sambar, chital or spotted deer, hog deer, barking deer or Indian muntjac, wild pig, tiger, leopard, jungle cat, large and small Indian civets, mongoose, otter, jackal, sloth bear, common hare, northern palm squirrel, gayal, and so on. The Jaldapara range was never the natural habitat of the gayal, but six were introduced into the sanctuary from Manipur by the Forest Department in 1964. Larger mammals such as wild elephant, gaur, swamp deer, and chital are rare. Although wild buffalo (*Bubalus bubalis*) formerly inhabited northern Bengal they have been exterminated in this area and are presently restricted to a few locations in the neighbouring state of Assam. The Forest Department is considering their re-introduction into Jaldapara. Over 200 species of birds, including peafowl, red junglefowl, and several species of partridges and numerous species of fish and reptiles are also present in the sanctuary.

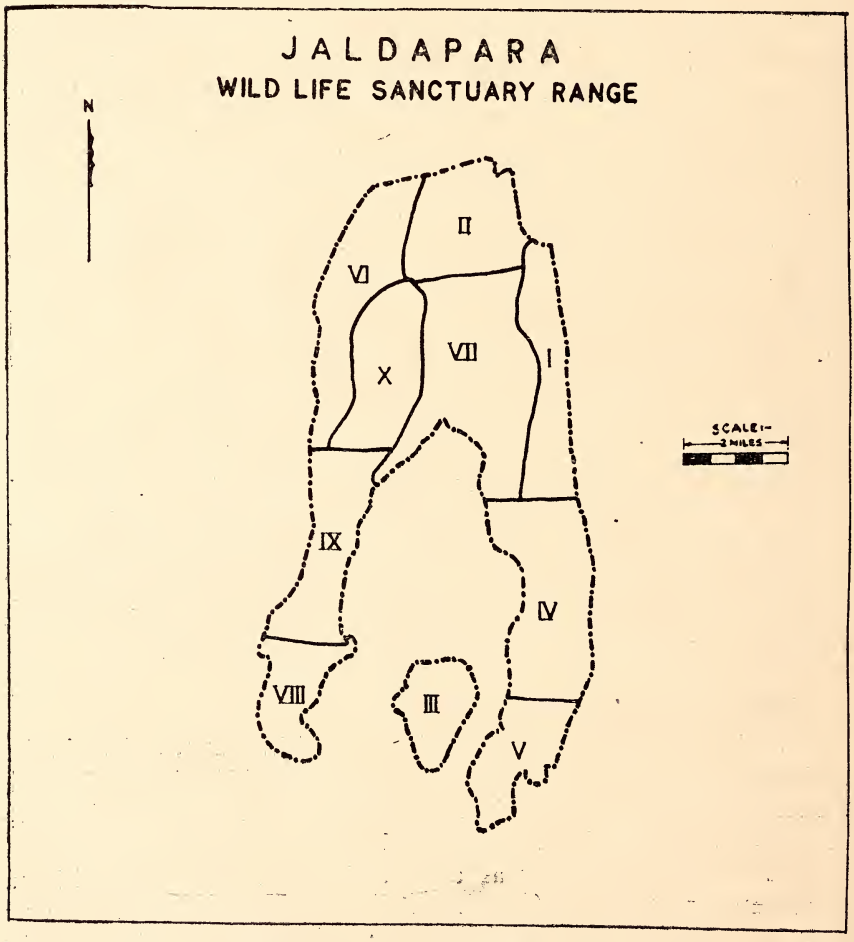
Previous Enumerations and Methods

The Forest Department has conducted wild life enumerations in the Jaldapara Sanctuary for three consecutive years (1964, 1965, and 1966). Therefore relatively accurate data is already available upon which future management plans and policies may be based.

The first enumeration was conducted on 21 May 1964. Eleven enumeration parties (each consisting of an elephant, mahout, enumerator, and Forest Guard) were employed in each compartment or block in the sanctuary between 04.00 and 12.30 hours. Firelines or features such as streams or boundary lines were used to divide the sanctuary into the

enumeration blocks, which averaged a little less than four square miles each. The parties systematically zigzagged across their assigned block, tallying all animals sighted. Although some animals are usually missed when this method is used, it gives a minimum count for the different species and provides a relatively reliable index of abundance. The same methods were again employed by ten enumeration parties on 25 April 1965.

These methods were slightly modified for the 1966 enumeration, which was conducted on April 26. As in 1965, ten parties were used, but each started counting at 04.00 on the southern boundary of their assigned blocks and terminated at 12.00 hours at the northern boundary (Map. 2). Therefore, the possibility of duplicate counts of the same



Map 2. Map of the Jaldapara Wild Life Sanctuary, West Bengal, depicting the census blocks utilized during the 1966 wild life enumeration

animals by enumerators in adjoining blocks was probably eliminated. As previously mentioned, the methods used give only a minimum count or index of relative abundance for the larger mammals in the sanctuary. A great deal of care and judgment, based upon experience and an intimate knowledge of the entire sanctuary, must be used to estimate how many animals of each species may have been missed or overlooked (Table).

Age Composition and Sex Ratios

Only the numbers for each species observed were recorded prior to the 1966 enumeration. This year an attempt was also made to classify the animals as to sex and age class (i.e. adult male, adult female, or young). If there was any doubt as to the sex of an adult animal, it was classified as ' non-sexed '.

Age composition generally reflects the status of a species in terms of its reproductive potential. A high percentage of young animals generally indicates that a population is growing or thriving, whereas a relatively small proportion a young indicates a low producing or senile population. Sex ratios likewise are an indication of reproductive potential. Most mammals, particularly ungulates, are promiscuous in their mating and a single adult male is generally sufficient to cover five or more females. Therefore, within reasonable limits, a predominantly female population has a higher reproductive potential than one with more males. With reliable age composition and sex ratio data a trained biologist can often compute the average annual rate of net increase or loss, as well as determine the present status of the population.

Age composition and sex ratio data collected during the 1966 enumeration, along with data previously collected, will be discussed under the various mammal species.

Rhino

No evidence of rhino poaching was observed during the eight days I spent on elephant back in the Jaldapara Sanctuary. Therefore, it may be reasonable to assume that practically none, if any, exists. Neither was any evidence of natural death among rhino encountered during the wild life enumeration. Therefore, I am unable to fully account for the discrepancy in the numbers of rhino counted this year as compared to the two previous years (32 versus 72 in 1964 and 75 in 1965). The day of the 1966 enumeration (April 26) was very warm and most of the rhino tallied were observed in or near wallows or streams. Perhaps, due to this factor, a relatively large number were overlooked. I observed as many as 20 different rhino in a single day (April 2) along the Torsa River in the western ' leg ' of the sanctuary. During seven days in the field prior to the enumerations I observed a total of 46 rhino, of which at

TABLE

TOTAL COUNTS FOR ANIMALS OBSERVED IN THE JALDAPARA WILD LIFE SANCTUARY, WEST BENGAL, DURING THE 1964, 1965, AND 1966 WILD LIFE ENUMERATIONS

Species		Year			Estimated Total
Common Name	Scientific Name	1964	1965	1966	(1966)
Great Indian One-horned Rhinoceros	*Rhinoceros unicornis*	72	75	32	50-60
Indian Elephant	*Elephas maximus*	2	2	0	1-2
Gaur or Indian ' Bison '	*Bos gaurus*	7	11	0	10
Swamp Deer	*Cervus duvauceli*	0	0	3	10
Sambar	*Cervus unicolor*	20	22	20	40-50
Chital or Spotted Deer	*Axis axis*	11	20	0	10
Hog Deer	*Axis porcinus*	141	101	132	400-500
Barking Deer	*Muntiacus muntjak*	188	171	68	125-140
Wild Pig	*Sus scrofa*	88	44	55	125-150
Sloth Bear	*Melursus ursinus*	0	3	2	10
Tiger	*Panthera tigris*	2	7	0	5
Leopard	*Panthera pardus*	0	0	0	1+
Jungle Cat	*Felis chaus*	0	0	3	—
Rhesus Macaque	*Macaca mulatta*	56	162	165	—
Common Hare	*Lepus nigricollis*	1	9	15	—
Northern Palm Squirrel	*Funambulus pennanti*	4	19	8	—
Indian Python	*Python molurus*	1	2	0	—
Common Cobra	*Naja naja*	1	0	2	—
Water Monitor	*Varanus* sp.	1	2	2	—

NOTE. Five rhino are also reported to inhabit Goru Mara, a small sanctuary west of Jaldapara in West Bengal. The gayal seen around the Baradabri Tourist Lodge being domesticated are omitted from the count.

least 40 were different animals. Included in my total count were two 'non-sexed' adults, 12 adult males, 21 adult females and 11 young. Thus, of the rhino which I observed, 36% of the sexed adults were males and 52% of the adult females were accompanied by young. In comparison, 54% of the adults observed during the enumeration were males and only 31% of the adult females were accompanied by young. In either case, the relatively high percentage of young would probably indicate that the population is thriving. I feel certain that there are at least 50 rhino in the sanctuary. A factor worthy of note is that wherever domestic livestock grazing is evident there are few, if any, rhino present. Examples are Blocks 3, 4, and 5 which reported a combined total of only two rhino.

Wild Elephant

No wild elephant were observed in the Jaldapara Sanctuary during the 1966 enumeration. However, a single male *makhna* was observed in the vicinity of the Jaldapara Forest Office on April 5 and 6. Two elephant were reported in both the 1964 and 1965 enumerations. A wild tusker also killed one of the Forest Department's domestic male tuskers near the Jaldapara Forest Officer's quarters in 1965.

Wild elephant are not permanent residents inside the sanctuary and are usually attracted into this area by crops, such as paddy. The enumeration was conducted in the dry season. Therefore, due to an absence of forage or crops only a few elephant at most would normally be expected in the sanctuary at this time of year. During their migrations or seasonal movements, elephant enter or leave the sanctuary by way of the Chilapata Range to the east, the Madarihat Range to the west, or the Nilpara Range and Bhutan to the north. The only side of the sanctuary not commonly traversed by elephant at one time or another during the year is the Patlakhawa Protected Forest area to the south.

Gaur or Indian 'Bison'

No gaur were reported during the 1966 enumeration. Several parties, however, reported fresh tracks. Mr. Sanyal, Assistant Divisional Forest Officer, Cooch Behar observed five head (3 males, a large female, and a calf) west of the Torsa River on April 2. We also observed two (a young adult male and an adult female) north of the Jaldapara Forest Rest House on April 5 and a solitary adult male in the same vicinity on April 6. These bovines are generally forest dwellers and are migratory in nature. Although some were obviously not counted during the 1966 enumeration, it is doubtful that as many as 20 are ever present in the sanctuary at one time.

Swamp Deer

Herds of swamp deer were once common in much of northern West Bengal. However, this animal is now very rare even in the Jaldapara

Sanctuary. None were reported in the 1964 and 1965 enumerations, but three adult females were observed in 1966. I also observed a single female on April 1. Here as in many parts of India, the outlook for this species is not promising and there are probably fewer than 10 in the sanctuary.

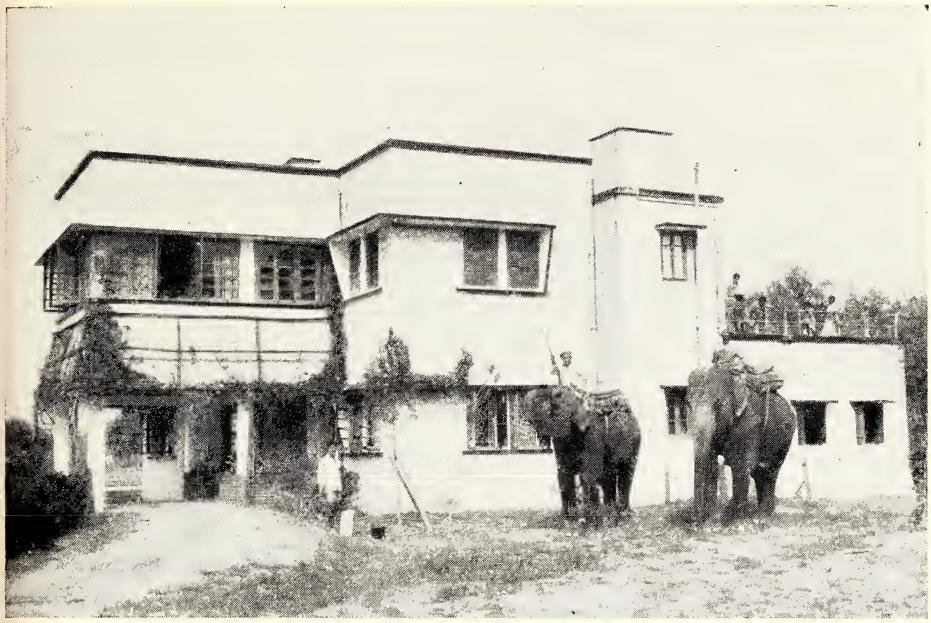
Sambar

Sambar are not encountered in herds and rarely in large numbers, but are still relatively common in many forest areas of India. However, due to their shy and somewhat solitary nature, it is very difficult to determine their numbers accurately. Twenty were observed in the 1964 enumeration, 22 in 1965, and 20 again in 1966. Undoubtedly less than half of the sambar in the sanctuary were observed during these enumerations, but the figures indicate that the population is probably stable. In the 1966 count, no young were observed and 60% of the adults reported were males. Prior to the enumeration I observed 12 sambar, including 7 adult males, 3 adult females, a yearling, and a small fawn. Therefore, 70% of the adults which I observed were males (all of which had hard antlers) and two of the three adult females were accompanied by young. This closely approximates the results of the enumeration. It is not known why almost twice as many adult males as adult females were observed. This indicates a very low reproductive potential for this population. There are probably between 40 to 50 sambar in the sanctuary and, although not overly abundant, they are not rare in the sanctuary as are chital and swamp deer.

Chital or Spotted Deer

Chital, although the most common deer in many parts of India, are extremely rare in the Jaldapara Sanctuary. Eleven were reported in the 1964 enumeration, 20 in 1965, but none were observed in 1966. I did not observe any chital inside the sanctuary. Further, the Jaldapara Range Officer stated that he has seen only one animal, which he could positively identify as a chital, during the almost two years he has been stationed here. The closely related hog deer often attain fairly large proportions before losing all of their spots. Therefore, I am inclined to believe that there have never been more than a few chital, at most, in the sanctuary during recent years, and perhaps some of those reported as such in 1964 and 1965 were actually young hog deer. It has also been observed that chital seem to prefer a deciduous forest habitat, which is not present in Jaldapara. Perhaps this is one of the reasons why they are apparently rare in this area ; and, if they are present, why their numbers have not increased.

Spillett : Jaldapara Sanctuary



Above : The Baradabri Tourist Lodge at the Jaldapara Wild Life Sanctuary. (*Photo: J. Juan Spillett*) *Below:* The author in the field in Jaldapara. (*Photo: E. P. Gee*)

Spillett : Jaldapara Sanctuary

Above : A rhino in typical riverain habitat in Jaldapara. (*Photo : J. Juan Spillett*)
Below : A young male hog deer. (*Photo : E. P. Gee*)

Hog Deer

Hog deer are by far the most common large mammal in the Jaldapara Sanctuary. This is to be expected in an area that is predominantly riverain habitat. These deer are most commonly encountered in small groups in savannah or grassland areas or along the forest edge, but rarely inside the forest where they are replaced by the solitary barking deer. Total counts for the 1964, 1965, and 1966 enumerations (141, 101, and 132 respectively) indicate that the sanctuary's hog deer population has been quite stable during the past three years. In the 1966 enumeration, 46% of the classified adults were males and only 4% of the adult females were accompanied by young. Prior to the enumeration I classified a total of 119 hog deer (34 adult males, 53 adult females, and 32 young). Therefore, only 39% of the adults I classified were males and 60% of the adult females were accompanied by young. Probable reasons for discrepancies in the enumerators' figures as compared to mine are: (1) most of the young were approaching yearling size and were often difficult to distinguish from adults, (2) the main rut season had passed and the males were shedding their antlers, making it difficult to distinguish antlerless males from females, and (3) without binoculars it is often difficult to distinguish hog deer from barking deer and the enumerators did not have binoculars to aid them as I did. Also, (4) I had been classifying animals as to age and sex almost daily for the past three months, while many of the enumerators were relatively inexperienced in such work. Based upon my data, the hog deer population appears to be doing well and I estimate there are probably 400-500 present in the sanctuary.

Barking Deer

Barking deer or Indian muntjac are solitary forest dwellers and are rarely encountered in groups of more than three. The dense forests which they inhabit and their solitary and shy nature make it difficult to census this species. Although totals of 188 and 171 were reported in the 1964 and 1965 enumerations, only 68 were reported in 1966. Barking deer and hog deer are generally encountered in different habitats. However, in much of Jaldapara where there is an intermingling of forests and grasslands, hog deer and barking deer are often in close association. Under such conditions it is often difficult to distinguish these two species without the aid of binoculars. I observed less than 20 barking deer during eight days inside the sanctuary and am inclined to believe that some of the animals reported as barking deer, particularly in the 1964 and 1965 enumerations, were probably hog deer. In the 1966 enumeration, 39% of the classified adults were males and 13% of the adult females were accompanied by young, whereas in my small sample the adult sex ratio was almost 50-50 and almost one-third of the adult females

were accompanied by young. In either case this species is probably doing fairly well and I estimate there are at least 125 barking deer in the sanctuary.

Wild Pig

Wild pig are relatively common in much of the Jaldapara Sanctuary. Except for solitary males, they are usually encountered in family groups or sounders. However, the dense cover which they generally inhabit and their practice of remaining hidden until closely approached and then suddenly breaking in all directions make it extremely difficult to count them accurately. Accurate sex and age ratio data is even more difficult to obtain. However, enumeration figures for the past three years indicate that the wild pig population in the sanctuary has been relatively stable. During the 1966 enumeration, eight adults were not sexed, but 57% of the adults classified were males and the 18 adult females tallied were accompanied by only five young. Prior to the enumeration I tallied 19 wild pigs : 11 unsexed adults, 2 adult males, 2 adult females, and 4 very small young. Totals in both cases indicate a very high adult/young ratio, particularly for a species with such a high reproductive potential. Many tribal people, who are experts with their primitive bows and arrows, are employed in the near-by tea estates. There is evidence that pig are perhaps the most commonly poached animal inside the sanctuary. However, hog deer also appear to be poached regularly. This may be one of the reasons for the small proportion of young pigs to adults. Wild pig are also common prey for many carnivores, such as tiger, and the young are more susceptible to predation than the adults. Nevertheless, the wild pig population appears to be in good condition and I estimate there are probably 125 to 150 in the sanctuary.

Other Mammals

Besides the mammals which have already been discussed, other mammal species observed during the enumerations also deserve attention. Bear were reported in both the 1965 and 1966 enumerations, three and two respectively. These were probably sloth bear, but there is the possibility that the Asiatic black bear (*Selenarctos thibetanus*) also inhabits this area. Tiger were reported in 1964 and 1965, but not in 1966. I saw evidence of at least three different tigers inhabiting the sanctuary. Although leopard is not common in this area and apparently had not previously been reported for the sanctuary, I observed the pug marks of a leopard north of the Jaldapara Forest Rest House prior to the 1966 enumeration. Wild cat, most probably the jungle cat (*Felis chaus*), were also reported during the 1966 enumeration. Asiatic jackal (*Canis aureus*) are present and most generally seen along the boundaries

of the sanctuary near villages. Mongoose (*Herpestes* spp.) are also frequently observed. Troops of rhesus monkey (*Macaca mulatta*) are commonly encountered inside the sanctuary. There is no evidence, however, of the presence of the common langur (*Presbytis entellus*). Northern palm squirrel (*Funambulus pennanti*) is common in the sanctuary's forests and the common hare (*Lepus nigricollis*) is frequently seen in the drier grassland areas. Although not reported, there was evidence that otter (*Lutra* spp.), large and small Indian civets (*Viverra zibetha* and *Viverricula indica*), porcupine (*Hystrix* sp.), and other small mammals are also present. The gayal, introduced into the sanctuary from Manipur by the Forest Department, are domestic and frequent the area around the Baradabri Tourist Lodge. One female had a calf in 1965.

Reptiles

Wild life enumerations such as have been conducted in the Jaldapara Sanctuary do not give an indication of the abundance of the reptilian species. However, Indian python (*Python molurus*) were reported both in 1964 and 1965, common cobra (*Naja naja*) were reported in 1964 and 1966, and water monitor (*Varanus* sp.) was reported in 1966. Other unidentified reptiles, particularly snakes, were also observed.

The great variety of faunal forms, including mammals, birds, reptiles, and fishes, as well as the abundance of floral species present in Jaldapara indicates a wise choice by the Forest Department in establishing a wild life sanctuary in this area and makes it even more imperative that the wild life of this outstanding area be protected and preserved.

Miscellaneous Observations

Mr. Sanyal and I spent seven days on elephant back between March 31 and April 7, becoming acquainted with as much of the Jaldapara Sanctuary as possible. Twice during this time the courtship behaviour of the Indian rhino was observed. Perhaps one observation, as recorded in my notes, would be of interest.

April 2 at 05.45 : Just after crossing the Torsa River north-west of the Jaldapara Forest Rest House, we heard the roar, followed by two honking snorts, of rhino somewhere along the river north of us. We started towards the noise, but within a short time encountered an adult rhino. We observed it until we were able to determine its sex and ensure that there were no other rhino present in the tall grass near by. After leaving the solitary male we sighted a large male at 06.00 coming directly towards us across an open island of sand in the river bed. On the distant bank were two more rhino. The male approaching us had a large bleeding gash, about 24 inches long, which extended across the top of his neck and down onto the left shoulder. Although the light was still poor, (sunrise was at 05.30 but there was a smoky haze in the sky) I attempted to take a few

photographs of the apparently ousted suitor. The male slowly moved into the dense grass on the river bank just north of us. We decided to try to get closer to the courting pair across the river. Although the river bed was open sand and gravel bars, we took our two elephants up to less than 200 feet from the two rhino without them apparently sensing our presence. The courting male was noticeably smaller than the ousted one and had a much shorter horn. I could see no evidence of aggression on either him or the female. We could only conjecture as to what had actually happened a few minutes earlier.

Whenever the female moved, the male followed closely at her side. When she stopped the male would move up near her head and rub his head along her neck and head and occasionally butt her lightly in the chest. She would occasionally open her mouth and several times appeared to be playfully nibbling at his head and ears. She would frequently begin her slow shuffle diagonally downriver towards us and the male would follow at her side until she stopped. The ' caressing ' would then be repeated. Approaching the main channel of the river, they swam across one of the few deep places in the river. They could have easily waded across only a few feet either up or downstream.

We remained motionless, but when they had moved directly downwind of us, they suddenly stiffened and became alert. Their heads went up, necks extended and ears cocked forward. They acted confused and would turn first one way and then the other. Although we were only about 75 feet upriver from them, they appeared not to be able to distinguish us and our elephant clearly. Suddenly they turned and dashed across a shallow stretch of water and disappeared into the tall grass on the river bank. After waiting a short while we attempted to follow, but their love-making had ceased and upon our approach all we saw were their wobbling rumps as they ran snorting through the dense grass.

Prior to coming to Jaldapara, I had observed during a three-week visit to the Kaziranga Wild Life Sanctuary in Assam that when a female rhino accompanied by a calf was observed there would almost invariably be other females with calves in the immediate vicinity. This also held true in my observations at Jaldapara. Discussing this point with Mr. E. P. Gee, during his visit to Jaldapara on April 3, he stated that he had noted the same in his observations.

The following day (April 4) Mr. Sanyal and I visited the western ' leg ' of the sanctuary along the west bank of the Torsa River. We encountered a female rhino with about a 3-year-old calf and shortly afterwards another female with about a 2-year-old calf. At the second location, a somewhat circular opening of relatively short grass, my mahout (Kancha Bhuzel) became excited and insisted that we stop while he told us what he had observed on this site the previous year.

Kancha claimed that he was passing through this area on his elephant

(Rukali Number 2, a large and fairly old female) when he came upon a female rhino giving birth to a calf on this site. The female was evidently in labour as she would lie down and then get up and move a short distance and lie down again. He stated that six adult females formed a sort of circle around the pregnant female and whenever he attempted to approach they would alternately charge him and his elephant. Therefore, he said he remained along the edge of the forest and watched the female have her calf. He also stated that at birth the calf was a pinkish colour and within a few minutes was upon its feet and the group slowly moved together into the near-by forest.

Whether or not there is a definite social tendency among female rhino or females with calves remains to be investigated.

IV. Conservation Problems

All exploitation of Jaldapara's natural resources, including grazing of domestic livestock, cutting of reeds and grass or thatch, gathering of fire-wood, felling of trees, shooting, fishing, etc. is prohibited. This is as it should be, but in actual practice is very difficult to enforce. The sanctuary's unusual shape, resulting in almost a 50-mile boundary, makes the problem of complete protection very difficult. In addition, much of the sanctuary adjoins cultivated lands inhabited by high densities of rural people, most of whom are illiterate and have little understanding of the need or value of areas such as wild life sanctuaries or reserved forests. Many feel little, if any, obligation (moral or otherwise) to comply with the laws which have been established for the protection of this area.

Livestock

The major problem confronting the Jaldapara Sanctuary is that of illegal grazing. Overgrazing by domestic livestock is evident in many parts of the sanctuary and particularly the eastern ' leg ' in the Chilapata Block. Several camps, each with well over 100 head of buffalo, have been established along the western boundary in this block. There are no grazing lands available for domestic animals in this area, except inside the sanctuary. Professional graziers are illegally maintaining their large herds upon the sanctuary's resources. From their camps, well-beaten paths lead deep inside the sanctuary. Little forage remains in many parts of the sanctuary and there are extensive areas that are severely trampled. There is not even sufficient grass left to burn in some parts and, as a result, *sissu* trees are invading what were formerly grasslands. Also, areas grazed by livestock are almost completely void of wild life. I saw only four hog deer and a solitary hare while visiting the 4556-acre Chilapata Block. Domestic grazing is also evident along both boundaries of the Torsa Block and the north-eastern corner of the Malangi

Block. I did not visit the exterior boundary of the Jaldapara Block. There is, however, little evidence of domestic grazing in the vicinity of the Jaldapara Range Office. The relatively high numbers of wild animals observed in this area is a marked contrast to what was observed where illegal grazing was evident.

On April 5, two professional graziers were apprehended by the Forest Department for illegal grazing of their buffalo inside the sanctuary in the Chilapata Block. Some of their buffalo were impounded and they paid a fine of Rs. 10 per adult head to the Forest Department, as well as an additional fine to the pound keeper. As a result, some of the remaining buffalo camps on the edge of the sanctuary were shortly moved to other areas by their owners.

Poaching

Rhino poaching does not appear to be excessive in the Jaldapara Wild Life Sanctuary. However, there is evidence that other animals, such as wild pig and hog deer, are regularly poached inside the sanctuary. This is further indicated by the fact that rhino can usually be closely approached on elephant back, whereas the other animals are shy and easily frightened. Shooting was heard inside the sanctuary on three occasions during my first visit (April 1-7). However, it appears that bows and arrows are most commonly used for poaching here. A party of poachers, labourers from a near-by tea estate, was also encountered.

The presence of large numbers of tea estate labourers, villagers, and military personnel along the boundaries of the sanctuary makes it imperative that the sanctuary staff be exceptionally vigilant to minimize illegal practices. However, the Forest Department presently does not have the legal authority that it should have to help the staff apprehend and prosecute those whom they encounter violating the law.

The size of the present sanctuary staff appears to be adequate. The nine beat offices, each of which is manned by a Forester and two Forest Guards, are also well situated along the boundaries. However, it is suggested that at least one patrol unit consisting of two armed guards, a mahout, and an elephant be detailed to patrol the sanctuary regularly. The objective of this unit would be to minimize poaching and other illegal activities throughout the sanctuary. Personnel from the present staff could be utilized to form such a unit. Beat Officers and Forest Guards should also be required to patrol their assigned blocks.

Poaching and other illegal activities inside the sanctuary are presently considered as problems of law enforcement. They should, however, be considered as a long-term problem of education. The public, particularly those living near sanctuaries or reserved forests, should not only be informed as to what the laws in these areas are, but should also be taught why these laws exist and their importance. This should be done

by every means possible—through the schools, through proper publicity, and through explanations by a well-informed staff. Concerning the latter, this can best be done by men that have been trained in the basic concepts of conservation. Basically, conservation is the wise use of natural resources so as to provide the greatest benefit for the greatest number of people.

Other Illegal Activities

Most of the natural resources of lands adjoining Jaldapara have been depleted. Therefore, in addition to illegal grazing or poaching, many of the near-by people also turn towards the sanctuary to supply their needs for firewood and construction materials, such as poles and thatch. Individually these violations may appear to be minor offences, but collectively they attain enormous proportions.

Practically all of the rural dwellings in the surrounding areas consist of thatch or *kutcha* huts constructed over pole and bamboo frames. Although some stands of bamboo are present on private lands, the only near-by source for thatch or wood is the sanctuary. In addition, reserve supplies of thatch, as well as stacks of firewood, are present in front of many dwellings. Families enter the sanctuary and clear cut relatively large areas of grassland for thatch. It is then tied into bundles and eventually carried out of the sanctuary.

Firewood is illegally collected from the sanctuary forests, primarily by women or young girls. If apprehended by members of the sanctuary staff, they often evade the offence by claiming that the staff members tried to molest them. In some areas, such as the Chilapata Block, the felling of large trees is evident. Some of the remaining stumps are over two feet in diameter. These illegally felled trees are sawed into suitable lengths so that they can be removed from the sanctuary by bullock carts. Therefore, some violations are not just a matter of supplying personal needs, but have attained the proportions of commercial exploitation.

Now is the time to halt violations of the sanctuary's laws and regulations. The longer these violations are permitted to continue the more difficult it will become to suppress them. In fact, through continually breaking the law, many people become convinced that it is not wrong, but their inherited right.

Military

The Bhutan border is less than 10 miles north of the Jaldapara Sanctuary. During the 1962 emergency, caused by the Chinese invasion into Indian territory, the military established an encampment at Baradabri along the north-eastern boundary. It is regretful that they chose this area when there are other near-by reserved forests that could have been equally well utilized.

Army personnel at Baradabri freely enter the sanctuary to bathe and to do their laundry in the rivers and streams. They also use the forests and grasslands as defecation sites. These activities are not restricted to any particular location, but depend upon the choice of the individuals. Military personnel may or may not participate in other illegal activities such as poaching, but their mere presence has resulted in the part of the sanctuary adjoining the tourist lodge being almost completely void of wild animals. Therefore, visitors staying at the lodge enter a considerable distance into the sanctuary by elephant before they can see wild animals.

The Commanding Officer of the military in this area should be contacted and should be requested that bathing and laundering by military personnel be restricted to specified areas. Toilet facilities should also be provided to eliminate the disturbing, as well as insanitary, practice of using the sanctuary as an outdoor latrine.

Because of the military situation, foreign visitors must first receive a permit from the Home and Political Department of West Bengal before they can visit northern West Bengal or the Jaldapara Wild Life Sanctuary. Due to the time and difficulties involved in obtaining such a permit, relatively very few foreigners presently visit Jaldapara. Every effort should be exerted to expedite the issuing of permits for Jaldapara with a minimum of delay and inconvenience to foreign visitors.

V. Recommendations

Most of my recommendations closely parallel those already presented by the Forest Department of West Bengal in its present working plan for the Jaldapara Wild Life Sanctuary. The following recommendations are made :

1. That the exploitation of the sanctuary's natural resources (including the grazing of domestic livestock, the cutting of trees and reeds or thatch, the killing or capturing of all animals, etc.) be perpetually prohibited and the rules and regulations prohibiting their exploitation be strictly enforced.

2. That mobile patrol units (consisting of armed guards, a mahout, and an elephant) be detailed to patrol the entire sanctuary regularly to minimize illegal activities.

3. That Beat Officers and Forest Guards be required to patrol their assigned beats regularly and to report violations or evidence of violations encountered.

4. That action be taken to obtain the necessary legal authority for Forest Department personnel to enforce the rules and regulations of the areas under their jurisdiction.

5. That a system of rewards and punishments be established to encourage Forest Department personnel better to meet their obligations. The establishment of a State Wild Life Division should also be considered to help train and attract the most suitable men for the special type of work required in wild life sanctuaries or national parks.

6. That no one but bonafide visitors and Forest Department staff or labourers be permitted inside the sanctuary. This would eliminate all excuses by others entering the sanctuary to violate its rules and regulations.

7. That a programme of education and publicity be undertaken to help people become aware of the importance and value of such areas as sanctuaries, as well as the necessity of preserving their flora and fauna and of obeying the rules and regulations established for their protection.

8. That a new tourist lodge be constructed on the western side of the sanctuary near the Holong River, as has been proposed by the Forest Department. However, private enterprise, supervised by the Forest Department, should be encouraged not only to construct and maintain these facilities but also to operate them for the convenience of visitors.

9. That information concerning the sanctuary (i.e. pamphlets, folders, post cards etc.) be compiled and made available to the Department of Tourism so that tourists will become aware of the Jaldapara Wild Life Sanctuary and the facilities which are available for their use.

10. That the Home and Political Department of the State be encouraged to expedite permits for foreign visitors wishing to visit Jaldapara.

11. That the Commanding Officer of the military units at Baradabri be requested to restrict the activities of military personnel (i.e. bathing and laundering) to specified areas along the boundary of the sanctuary.

12. That wild life enumerations in the sanctuary be conducted on a yearly basis as they have been during the past three years.

13. That scientific studies of the sanctuary's wild life species by qualified personnel be encouraged and that facilities (i.e. use of Forest Rest House, etc.) be provided for their use whenever possible.

14. That wild life observations by both visitors and Forest Department personnel be kept in a permanent record at the sanctuary.

VI. Acknowledgements

First I would like to commend the Forest Department of West Bengal and members of its staff for the fine work they are doing in wild life conservation in the Jaldapara Wild Life Sanctuary. I also wish to thank the Forest Department and particularly Messrs. K. L. Lahiri (Chief Conservator of Forests), J. N. Bhadury (Cooch Behar Divisional Forest Officer), H. P. Talukder (Jaldapara Range Officer), and S. K. Gupta

(Caretaker of the Tourist Lodge at Baradabri), for the invitation to assist in their 1966 wild life census, for the accommodations and facilities provided during my two visits to Jaldapara, and above all for their assistance and wonderful hospitality. Special thanks goes to Mr. S. S. Sanyal (Assistant Divisional Forest Officer, Cooch Behar) who accompanied me in the field and graciously answered my many questions. In this report I relied to a great extent upon the Forest Department's ' Jaldapara Working Plan ' which demonstrates much hard work and good judgment in the establishment of management plans for this outstanding wild life area.

VII. Glossary of Local Terms

basti	..	a settlement of cultivators.
chak	..	a village land surrounded by Reserved Forests.
jhora	..	a stream or water-course.
khola	..	a stream or water-course.
khasmahal	..	land owned by the Government.
kutcha	..	thatch hut, the wall of which may or may not be plastered with mud or a mixture of mud and cow dung.
kukat	..	any local tree species other than *sal* or teak.
makhna	..	a male elephant without tusks.
nadi	..	a river.
nala	..	a ravine.
paddy field	..	rice field (paddy is unhusked rice).
taungya	..	sowing and tending of forest tree species in conjunction with agricultural crops.

Wild Life Conservation in Nepal

BY

J. JUAN SPILLETT AND KIRTI MAN TAMANG[1]

(With two plates and one map)

I. INTRODUCTION

The two major industries in Nepal are the production of agricultural and forest products. Wild life is under the jurisdiction of the Forest Department and should probably be considered as an integral part of the forests. Most wild animals in Nepal are also forest or forest-edge dwellers and their basic requirements of food and shelter are usually provided on Forest Department lands. Therefore, generally speaking, the problems confronting the forests in this country are also the problems confronting the wild life.

[1] Forest Inventory Specialist for the Forest Department of Nepal, Kathmandu, Nepal.

Between 1846 and 1950 Nepal was under the rule of the Rana family. There were practically no wild life conservation laws during this time, but animals such as tiger and rhino were considered strictly as royal game and as a whole wild life in the country fared very well. This was changed, however, when the Rana regime came to an end in 1950 and democracy came into being. During the period of political instability which followed, lasting until the present Panchayat System of Government came into existence in 1961, wild life suffered greatly. Strong representations concerning the dire straits of both the forests and wild life were made by the Forest Department to the Government in 1962. Since then some notable gains in conservation have been achieved. Presently the outlook for wild life in this country is better than it has been at any time during the past fifteen years. However, there still remain some problems to be solved and much work to be done. Continued vigilance must also be exercised or the gains of the last few years may be lost almost literally overnight. It is to be hoped that Nepal can benefit from the mistakes of other countries and particularly that she will refrain from committing some of the errors that other Asian nations have committed in wild life conservation.

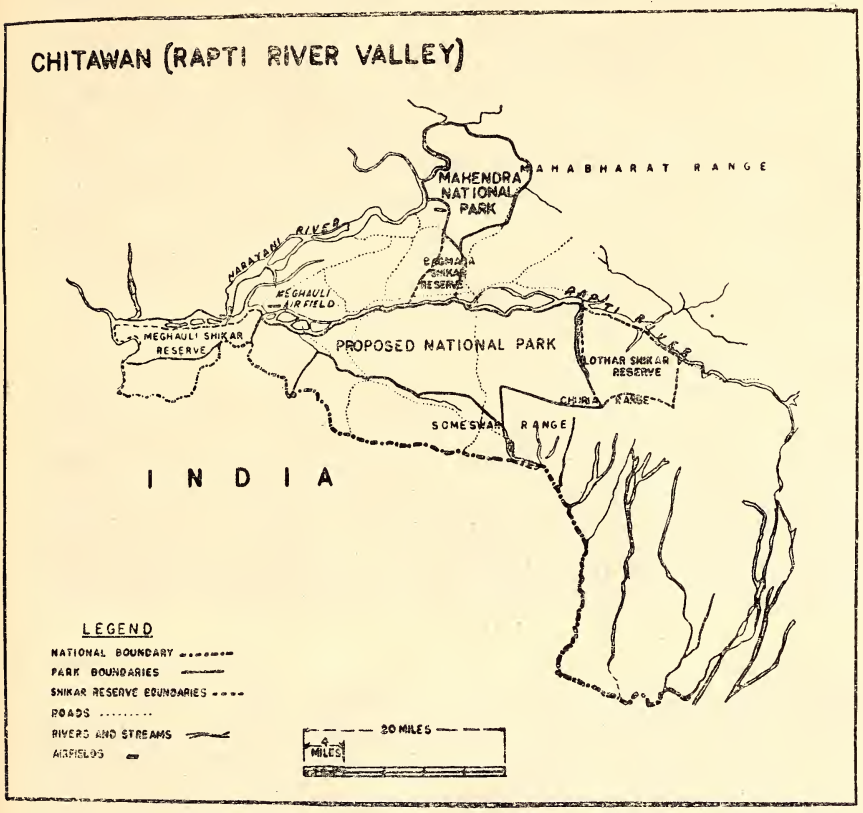
We spent 15 days (April 9-23) as guests of the Forest Department of Nepal, during which time information for this report was collected. Three days were spent meeting with Government officials in Kathmandu. Another three days were spent on elephant back in the rhino areas along the Rapti River and approximately 450 miles were travelled by jeep. Both of the proposed national parks were visited and two of the shikar reserves (Bagmara and Lothar). In addition we visited the Churia Hills and forests in the *bhabar* and *mahabharat* areas. We also spent two enjoyable days at 'Tiger Tops' as the guests of Mr. and Mrs. J. V. Coapman. Information concerning the Himalayan wild life areas is from Mr. Tamang's previous visits or from R. G. M. Willan (Chief Conservator of Forests) and other Forest Department personnel. Among the wild animals which we observed were : 11 rhino (including 5 adult males, 4 adult females, and 2 young), sambar, chital, hog deer, barking deer, four-horned antelope, wild pig, otter, tiger, and Gangetic dolphin.

II. General Review and the Present Situation

National Parks

The Mahendra Mrigan Kunja (Mahendra Deer Park), which was established in 1959, is presently being reconstituted as the Mahendra National Park. This was necessitated by the encroachment of settlers in some areas inside the former park, their subsequent resettlement also within the confines of the former park, and to include forest areas along

the Narayani River. Therefore, the boundaries of the proposed park do not exactly coincide with those that were formerly established. The total area of the present park is 60-square-miles (see Map).



Map of Chitawan (Rapti River Valley) in Southern Nepal, depicting the proposed national parks and shikar reserves

Another national park, yet to be named, is also proposed south of the Rapti River. This will include the riverain and low-lying forests in that area, as well as most of the present rhino habitat in Nepal. In addition, the adjoining extensive grasslands of Sukebhaar westwards up to Dhakray Khola, close to the confluence of the Rapti and Narayani rivers, will also be included. To the south the proposed park will extend to the Someswar Range (Indo-Nepal border), excluding the Madi areas of cultivation and the new resettlement areas south of the Reu River. It then extends eastwards to Amuwa and Hasta Khola back to the Rapti River. The total area to be included in this park, all of which is south of the Rapti River, is approximately 240-square-miles (Map). Concrete pillars have been placed to demarcate the boundaries. The wild life of this area is very rich, both in abundance and in the variety of species,

Large mammals found here include : rhino (*Rhinoceros unicornis*), wild elephant (*Elephas maximus*), gaur or Indian ' bison ' (*Bos gaurus*) sambar (*Cervus unicolor*), chital or spotted deer (*Axis axis*), hog deer (*Axis porcinus*), barking deer (*Muntiacus muntjak*), four-horned antelope (*Tetracerus quadricornis*), wild boar (*Sus scrofa*), tiger (*Panthera tigris*), leopard (*Panthera pardus*), Himalayan and sloth bear (*Selenarctos thibetanus* and *Melursus ursinus*). Over 100 species of birds also inhabit this area and the numerous species of fish found in the Rapti and Reu rivers offer excellent opportunities for sport fishing.

A draft act and rules for both national parks is presently under the consideration of the Government and it is hoped that these parks will be legally constituted in the near future. Both areas are already being rigidly protected and patrolled by armed rhino guards.

Visitor Facilities

(1) ' Tiger Tops ', a private hotel located inside the proposed national park south of the Rapti River, has been operating successfully since it was opened in November 1965. It has already gained considerable publicity and has made a commendable impression upon visitors by showing them the rich and varied wild life of this area. Situated near the confluence of the Rapti and Reu rivers, the location provides a magnificent view of the high Himalayas to the north, including such peaks as Annapurna (26,490 feet) and Machlapuchre (22,958 feet). It is located in the heart of the jungle and provides the luxuries and comforts of modern living, but in a primitive atmosphere. The Meghauli airstrip, built for use during the 1961 visit of Queen Elizabeth, is less than three miles from the hotel and is served by frequent flights. Royal Nepal Airlines flights take less than 30 minutes to cover the 35 airline miles from Kathmandu to Meghauli.

This hotel serves as an excellent example of how a national park can be developed for tourism by private enterprise and also earn revenue and foreign exchange with only a relatively very small investment by the Government or the department involved.

(2) Kasra Durbar was originally built as a shooting lodge during the 1930's for the Rana rulers. It is situated on the south bank of the Rapti River, approximately 10 miles east of ' Tiger Tops '. It is also located on the site of a former shooting lodge built for the 1911 visit of King George V, then the Prince of Wales. The Forest Department has proposed the renovation of this lodge for a tourist rest house. Approach roads from the east and west are presently being constructed. With accessibility by road and improved accommodations, this lodge should provide a much needed facility for the general public visiting the national park in which it is located. It should also help to generate public interest in wild life conservation in Nepal.

Spillett : Conservation in Nepal

Rhino in typical habitat in the Rapti River Valley, Nepal

(*Photos : J. Juan Spillett*)

Spillett : Conservation in Nepal

Above : Mother and large young rhino

These domestic buffaloes should be removed from the proposed national park where they are grazing.

Below : The ' Tiger Tops Hotel ' near the confluence of the Rapti and Narayani rivers, Nepal

(*Photos : J. Juan Spillett*)

Proposed Sanctuaries and Shikar Reserves

A 44-square-mile forest area near Sukla in the Kanchanpur District of western Nepal has been proposed as a wild life sanctuary by the Forest Department. A forest rest house and the demarcation of the boundaries for this sanctuary have already been completed. Besides wild elephant, sambar, chital, hog deer, barking deer, wild boar, tiger, leopard and bears, this area also has large numbers of swamp deer and a few blackbuck or Indian antelope. Nowhere else in Nepal are swamp deer found in such abundance. The open and extensive grassland vegetation in the Sukla Phanta area also provides visitors with excellent opportunities to view wild life. Although a few blackbuck are still to be found in the Mainapokhar area in the Bardia District and in the Bankey District in the terai of west Nepal, the future of this species in these areas is not promising. Both are near heavily populated villages and the short-grass areas, typical habitat for the blackbuck, are being abused through overgrazing by domestic livestock. Some of the short-grass areas in the Sukla Phanta area in Kanchanpur are ideal for the preservation of blackbuck in Nepal.

Presently, the area in which the proposed sanctuary is located is not readily accessible to visitors. The nearest airstrip is at Dhangarhi in the Kailali District, about 30 miles away. However, with proper development of roads and accommodations, the prospects of attracting visitors to this wild life area appear very promising.

Wild buffalo (*Bubalus bubalis*) have been practically exterminated throughout their former range in Nepal. However, 20 to 30 are reported still to inhabit the flood plain along the Kosi River in the eastern part of the country. The Forest Department is presently attempting to demarcate and establish a small sanctuary in this area, primarily for the protection of this species.

Throughout the history of Nepal royal shoots have been notable events. As has previously been mentioned, Chitawan or the entire Rapti River Valley was formerly a strictly protected shooting reserve for the Rana rulers. In keeping with this ancient tradition, three shikar reserves or royal hunting blocks have been established solely for the use of members of the royal family or their guests.

The Meghauli Reserve adjoins the proposed national park to the west and lies south of the confluence of the Rapti and Narayani rivers. It encloses approximately 75-square-miles of forest lands. The Bagmara Reserve consists of a narrow neck or forest belt connecting the two national parks. It is north of the Rapti River and is bordered on the east and west by cultivated lands. It also contains approximately 20-square-miles of forest. The Lothar Reserve adjoins the proposed national park to the east and lies south of the Rapti River. It consists of approximately a 60-square-mile area.

Rhino, once considered as royal game, is now strictly protected throughout its range in Nepal, including the shikar reserves. His Majesty King Mahendra is very conservation-minded. And, although the shikar reserves are officially recognized as shooting blocks for royalty, in reality little shooting will probably take place in these areas and they can probably be considered almost as extensions to the adjoining national parks.

Himalayan Wild Life Areas

The scenic grandeur of the high Himalayas of Nepal needs no emphasis. The flora and fauna of these mountain areas have been and will continue to be of exceptional scientific interest. Although there is practically no information, up-to-date or otherwise, concerning the large mammals of the high Himalayan regions of Nepal, there are a few unofficial reports that remnants of some species are still to be found in a few isolated places.

Concerning wild sheep : nayan or great Tibetan sheep (*Ovis ammon hodgsoni*), and bharal or blue sheep (*Pseudois nayaur*) are said to occur in a number of locations. Marco Polo's sheep (*Ovis ammon polii*) has never been recorded from Nepal and whether or not it exists inside the country is not known. Wild goats : fair numbers of Himalayan tahr (*Hemitragus jemlahicus*) are reported still to inhabit some parts of Nepal. The range of the ibex (*Capra ibex*) is given as Kashmir to Kumaon. However, a well-known *shikari* reported shooting a number of these rare animals in Nepal in the early 1960's. The markhor (*Capra falconeri*), said now to be on the verge of extinction, used to be found in Kashmir and westwards. It is not known whether or not it is or has ever been found in Nepal.

Goat-antelopes : the goral (*Nemorhaedus goral*) appear to be surviving in fair numbers in some parts of Nepal. On the other hand, the serow (*Capricornis sumatraensis*) is believed to be very rare throughout most of its range. The skins of ounce or snow leopard (*Panthera uncia*) and clouded leopard (*Neofelis nebulosa*) are still occasionally seen in the markets, although they are also becoming rare. The brown or red bear (*Ursus arctos*) is reported to be quite common in many of the mountainous regions.

The establishment of national parks or sanctuaries to protect the flora and fauna of the mountainous regions and to provide opportunities for people to see and study them is of paramount importance. The Khaptar forest area north of Doti, at an elevation of about 11,000 feet, and Rara Lake at 9805 feet, including the forests surrounding the lake, are two places in the western Himalayas of Nepal that deserve serious consideration.

Mr. Willan visited the forests around the Thyangboche Monastery

(13,500 feet) in Khumbu in May 1966. This is also the closest forest area to Mt. Everest. He reports that this is an incredibly beautiful and interesting place. The Head Lama, according to the Buddhist ideals, is very anxious to secure complete protection for the flora and fauna of the area. The Lama claimed that some years ago musk deer (*Moschus moschiferus*), Himalayan tahr, and bharal or blue sheep were commonly seen there. However, later on many were shot by Army Officers for their meat, which was taken down to Kathmandu and given to friends. As a result, now they are rarely seen. However, signs of musk deer were seen.

Mr. Willan has proposed that the Gosainkund area and the Langtang Valley be examined as possible Himalayan National Parks. The Langtang Valley, north of Kathmandu, is surrounded by peaks that exceed 23,000 feet.

Rhino

Mr. E. P. Gee, a noted authority on the Great Indian One-horned Rhinoceros, reviewed the history of the rhino in Nepal in his 1959 ' Report on a Survey of the Rhinoceros Area of Nepal '. He again visited Nepal in 1963 and reported further observations and recommendations in his ' Report on a Brief Survey of the Wild Life Resources of Nepal, including the Rhinoceros '. Mr. Willan has brought the record up-to-date with his reports in *Oryx* (1965) and the *IUCN Bulletin* (1965). Therefore, we will only briefly review the history and present status of the rhino in this country.

In ancient times rhino inhabited suitable areas, particularly in the *dun* country, throughout the entire length of Nepal. However, by modern times the range of this prehistoric-looking animal had decreased considerably. During the rule of the Rana family, which lasted over one hundred years, very few foreigners were even permitted to visit Nepal. Although there is little specific information concerning the status of the rhino during this time, there are numerous reports as to the abundance of big game, including rhino, particularly in Chitawan and neighbouring areas. The south central part of Nepal was strictly guarded as a shooting preserve for the Ranas. Royal hunts in these areas were renowned for their elaborate preparations and grandeur, as well as for the great numbers and variety of big game species shot. Hundreds of elephants were sometimes used in a single beat in honour of visiting royalty. Mr. E. A. Smythies, Forest Adviser to the Nepal Government during World War II, and his wife spoke of the abundance of wild life in the Narayani, Rapti, and Reu valleys between 1941-1945 in their books, BIG GAME SHOOTING IN NEPAL and TIGER LADY. This changed with the coming of democracy. Many rhino were poached and the horns sold to further the cause of the political upheaval which

ended the Rana rule. Poaching of rhino and other wild life continued in the following years. Of greater consequence was the influx of thousands of settlers into the areas once occupied only by rhino and other wild life species.

It is estimated that prior to democracy there were some 800 rhino in the open grasslands and swamps at the western end of the Rapti Valley. In 1957, Mr. P. D. Stracey, then Director of Forest Education in India, estimated about 400 rhino for the entire country. Their numbers were reduced to such an extent that in his 1959 visit Mr. Gee estimated only 300. Large scale poaching continued in 1959 and 1960, until it was estimated that only 165 rhino remained in the entire country in 1961. Strong action was taken in 1962 by the Forest Department and also by the present Government. Since then rhino poaching has been noticeably reduced. It is officially estimated by the Forest Department that there are now about 180 rhino in the country. However, based upon limited observations and discussions with people inhabiting the principal rhino areas, we believe there are probably fewer than 100 rhino in Nepal. The important factor, however, is not the exact number but the steps being taken by the Government and the Forest Department for the protection of those that are present. Under the present policies the country's rhino are relatively immune to further depredations and their numbers will undoubtedly increase.

Fish

The rich natural fishery resources of Nepal remain virtually unexploited and uncontrolled. The country has three major river systems, the Karnali in the west, the centrally located Narayani, and the Kosi in the east. Each has numerous tributaries that run mainly from north to south. Almost without exception, all are rich in fish and some are teeming with valuable fishery resources. *Mahseer* (*Barbus tor*), *catli* (*Barbus hexagonalepsis*), and a few other species offer excellent opportunities for sport fishing. In addition to these, there are numerous species which also offer excellent possibilities for commercial exploitation.

There is very little sport fishing presently done even in the first-class streams of the country. Further, there appears to be little realization that such fishing could easily become a major tourist attraction and could thereby become an important source of revenue and much-needed foreign exchange. In a few areas there is some fishing for local consumption, but there are no real commercial enterprises tapping this valuable food supply. Development plans for Nepal should include planned and managed exploitation of both types of fisheries.

Prior to extensive exploitation, a thorough survey of the country's fishery resources should first be undertaken. Scientific studies should

then be initiated to determine how these resources can best be utilized on a perpetual basis. For example, some areas should probably be restricted solely for sport fishing, while both sport and commercial fishing may be allowed in others. Spawning seasons and growth rates for the different fish species should be determined for the various rivers so that sound management principles can be practised. There is also the added possibility that certain rivers at higher elevations could be stocked with trout species, some of which have done exceptionally well in Kashmir and Bhutan. However, thorough studies should first be conducted to determine whether or not native species would be superior to introduced ones, as well as whether or not the introduced species would thrive in these areas.

Plans for hydro-electric and irrigation projects should also provide for the protection of fishery resources. Stream pollution is not yet apparently a problem. Nevertheless, steps should be taken now to ensure that streams are not polluted in the future. Conservation practices, particularly in the catchment areas, will also help to protect the fisheries and other resources, such as the land, forests, and agriculture. Planned management and control of the nation's fishery resources will result in untold benefits for the country, as well as the protection and perpetuation of these valuable assets.

III. Conservation Problems

Livestock

Overgrazing by domestic livestock is undoubtedly the major threat to wild life conservation in Nepal. Differing only in intensity, all forest areas are subject to livestock grazing. Forest lands near villages are the most drastically abused. Concentrated grazing throughout the year in these areas has resulted in extensive tracts of bare and badly trampled ground. Well-beaten trails continue to extend from the villages ever deeper into the near-by forests.

Although light to moderate grazing encourages the reproduction of some species of trees, overgrazing is detrimental both to the forests and to the wild life. The first result of this common practice is the replacement of desirable forage plants with undesirable ones, such as thorny shrubs and bushes. Continued abuse eventually converts entire forests into little more than deserts. Apart from direct competition for food and other disturbances resulting from the presence of livestock in areas inhabited by wild life, there is always the possibility of disease transmission.

It is probably impossible, as well as impractical, to stop livestock grazing completely in all but a few selected forest areas. However,

grazing must be controlled. Conservation practices and scientific management must replace the almost omnipresent practice of overgrazing. Otherwise, the entire nation will suffer. It is, therefore, suggested that in many areas the numbers of domestic animals be greatly reduced and that whenever possible rotational grazing or other scientific methods of range management be employed.

Encroachment

During the ten-year period of political instability which followed the advent of democracy in 1950, it became known that land for cultivation was available in the lowlands of Nepal. People from different parts of the mountains and hills, where agriculture at its best provides only a scant living, began to move into the richer valleys and forest areas. The effects of the devastating floods of 1954, the worst in the recent history of the country, gave impetus to this mass migration movement. Soil erosion, landslips, and other damages to farmlands in the high country caused thousands to leave their homes and migrate to the rich forest areas of the *dun* valleys and the *terai* plains. A malaria eradication programme initiated in the early 1950's also opened the way into areas which hitherto had been avoided primarily because of malaria.

The Rapti River Valley, known as Chitawan, once supported the best forests in Nepal. Its forests and grasslands, combined with an abundant supply of water, were inhabited by great numbers of wild animals, such as rhino, elephant, gaur, chital, sambar, swamp deer, hog deer, wild boar, tiger, and leopard. This area was also strictly protected until 1950 as the shooting preserve for the Ranas. In 1955 the Government of Nepal, in co-operation with the USAID Mission, launched the Rapti Valley Multi-purposes Project. This development programme envisaged, among other things, to develop and to settle the many grasslands (savannahs) of the valley as agricultural lands. Prior to this time, except for a few scattered villages of Tharus who were reputed to be immune to malaria, this large valley was uninhabited.

The construction of a road from Hetaura to Narayangarh, the eradication of malaria, and the distribution of land to the landless invited increasing numbers of people every year to come to the lowlands. Forest encroachment had reached such epidemic proportions by 1959 that it had spread all over the Rapti Valley, including Hetaura and the Churia Hills to the east. The illegal encroachment upon forest lands by these thousands of people resulted in the destruction of millions of valuable trees and untold numbers of wild animals.

The gravity of the situation was finally recognized by the Government. Starting in 1959, various bodies comprised of local administrative officers were formed. In 1963 a fact-finding commission headed by a senior government official investigated the situation. Upon the basis of the

report submitted, another government commission headed by a cabinet minister was formed in October 1963 to settle the problem on a permanent basis. This commission has functioned effectively ever since and its achievements thus far have been commendable.

Approximately 4400 families from different encroachment areas have been resettled along the Indo-Nepal border in the Reu Valley and near Thori. Six hundred families of ex-servicemen have also been settled in the forests north of Khaireni, south of the foothills and west of Lothar. Except for the oldest Tharu villages, all new cultivations and encroachments south of the Rapti River, north of the Churia Hills, and west of Lothar up to the Narayani River have been completely vacated. The encroached areas north and north-west of Tikoli, east of Khagari Khola, viz. Tilkaney, part of Jirauna, etc., have also been vacated. The total gain in terms of forest area from these evacuated areas comes to 10,200 acres and the forest area lost in resettlement of the ex-servicemen is 2500 acres. Concrete boundary pillars have been fixed by the commission along these settled areas, thus demarcating the forest areas that will be permanently retained as forests.

Except for a few cultivated patches in the remaining portion of the Rapti Valley, the overall situation in this area appears favourable. However, problems urgently remain to be permanently settled in the areas east of Lothar and Harda Khola up to Hetaura and the valley east of the Hetaura-Amlekhganj main road.

The present Government of Nepal is demarcating or has demarcated all forest lands in the *dun* and the *terai* areas. However, the problem still remains to maintain these boundaries against further encroachment. This is further complicated by increasing population pressures and demands for more and more agricultural land. Marginal lands or those best suited for forests should remain as such. Rather than continually seeking new crop lands, the emphasis should be placed upon intensive farming methods so that optimum production can be realized from those lands best suited to agricultural use.

Fire

Every year all forest areas in Nepal are subject to intensive burning between February and June, prior to the monsoon. The two main causes of fire are carelessness and the common belief by most rural people that burning improves grazing for their livestock. The movements of the local people are unrestricted in the forest areas where they graze their livestock, gather firewood and cut thatch for their huts. These factors must be considered in any future plans to control fires on forest lands.

Controlled burning in some areas, such as low-lying forests on relatively level terrain and with sufficient precipitation, is probably beneficial.

When properly managed, burning such lands helps to control undesirable plants, permits the regrowth of forage, and quickly returns the nutrients of old or undesirable plants to the soil. However, all burning should be controlled and not let to run rampant or left to haphazard methods. For example, early burning in the winter season, when plants still have a high moisture content and when humidity conditions are right, generally does not greatly hinder forest regeneration or destroy the humus on the forest floor. Burning later in the season under drier conditions often results in scorching fires that damage both the forests and the undergrowth.

It should also be recognized that burning at any time is probably detrimental on precipitous slopes or in forest areas with relatively scant rainfall, less than approximately 40 inches per annum. Fires eating their way up the steep forest slopes of Nepal are an all too common sight during the late winter months of April and May. Total damages as a result of these burnings are incalculable. The regeneration of entire forests is prolonged or completely destroyed. As a result of burning, large patches of low quality stunted trees can be observed in many areas. The net result of this practice is erosion and a loss of soil which results in devastating floods and silting in the agricultural lowlands and the ruin of the forest above. Although detrimental, early burning in many areas would be preferred to late burning and its more serious consequences.

The Forest Department is presently conducting scientific studies on the effects of burning under controlled conditions on 64 plots in the Ramoli-Pratappur forests west of Hetaura. Similar studies are also proposed in a low-lying forest area near Bharatpur. As soon as definite conclusions can be derived from these studies, the results should be utilized in determining fire control practices on an extensive scale.

Poaching

There was undoubtedly some poaching in Nepal during the Rana rule. However, due to the feudalistic powers of the rulers it was probably so restricted during this time that for all practical purposes it could be considered negligible. With the coming of democracy, however, poaching in many areas attained major proportions and continued unabated for a number of years. Under the present government the situation has improved, but poaching still remains a major problem in many parts of the country.

A Wild Life Management Division of the Forest Department, with headquarters at Tikoli, is responsible for the protection of wild life and its habitat in that area. This division is directly under the Kathmandu Circle Conservator of Forests, and is headed by a Wild Life Preservation Officer, Major Nara Raj Thapa. The division has a total of 185 employees, consisting of the Major, 1 lieutenant, 5 *subedars*, 23 *havildars*,

146 rhino guards, 4 clerks, and 5 peons. Major Thapa has instilled in his men an *esprit de corps* that is commendable. As a result of the fine work of this division, Major Thapa has been awarded the Gorkha Dakshin Bahu by His Majesty the King.

The rhino guards are stationed in different *chowkis* all over the Rapti and Reu valleys and in rhino areas in Nawalpur, west of the Narayani River. They are almost continually in the field and have done exceptionally well in the execution of their duties, including the protection of the forests and the evacuation of settlers from encroachment areas, as well as protecting the wild life. However, outside of the areas under the jurisdiction of the Wild Life Management Division, the regular Forest Department staff is charged with the protection of both the forests and the wild life.

Thousands of villagers in Nepal own muzzle loading firearms, most of which are locally made. The shooting of animals, such as wild pig and chital, by villagers for meat is the most common form of poaching. Perhaps it would help to minimize poaching if shooting regulations were made as simple as possible and if shooting licences and fees were well within the financial means of the common people. For example, if a nominal fee entitled a Nepali to a specified number of game animals, there would be little excuse for him to poach. In addition, licences should be readily obtainable from Forest Officers with a minimum of delay and forms or paperwork. Licences and fees for trophy species, such as tiger and leopard, should remain relatively high or perhaps even be increased. Fees for foreigners shooting in Nepal should also be high. It is further suggested that protective measures, similar to those used so effectively by the Wild Life Management Division in rhino areas, be used in all important wild life areas in the country.

IV. Recommendations

The following recommendations are made :

1. That the Government of Nepal recognize the importance of the country's wild life resources, both flora and fauna, and that necessary steps be taken to protect, utilize, and develop these resources on a perpetual basis for the benefit of the people.

2. That a programme of education and publicity be undertaken to develop an appreciation among the people of Nepal for the cultural and economic values of wild life preservation and conservation, and to develop tourism, based upon wild life conservation, as an important source of revenue.

3. That the Mahendra National Park, the proposed national park south of the Rapti River, and the proposed wild life sanctuaries in the Sukla area of Kanchanpur District in south-west Nepal and along the

Kosi River in the eastern part of the country all be legally constituted as such, as has been presented to the Government by the Forest Department.

4. That high altitude areas of special scenic and wild life attraction or significance be selected and legally constituted as national parks or wild life sanctuaries.

5. That measures, both protective and legislative, be taken to ensure the preservation of the flora and fauna in Nepal, and particularly in the parks and sanctuaries. This perhaps can best be done by a nation-wide Wild Life Branch of the Forest Department, which would have jurisdiction of all parks and sanctuaries, as well as the wild life on all Forest Department lands, and would be charged with the enforcement of all wild life legislation.

6. That facilities for visitors to the parks and sanctuaries (i.e. airfields, roads, accommodations, etc.) be developed and that private enterprise, supervised by the Forest Department, be encouraged in the development, maintenance, and use of these facilities.

7. That a systematic survey of the country's faunal resources, including fish, be undertaken by qualified personnel. This would form the foundation upon which long-range management plans could be based.

8. That shooting blocks be established in all suitable Forest Department lands not devoted to parks or sanctuaries and that, with proper control and management, the game species in these areas be systematically harvested. The shooting or harvesting of wild game is an integral part of wild life conservation. However, conservation practices, such as control and management, must be exercised to ensure that the wild life species involved are harvested on a sustained yield basis.

9. That the country's fishery resources be studied and then developed so as to ensure both a sustained yield of valuable protein food and an attraction for sport fishing.

10. That selected personnel from the Forest Department be sent abroad for conservation training in such fields as wild life and range management, recreation, and so forth, as well as deputed to visit and study management practices in parks and sanctuaries in other countries.

11. That the numbers of domestic livestock grazing on Forest Department lands be strictly controlled and that wherever possible scientific range management methods, such as rotational grazing, be employed. Also, that the grazing of domestic livestock in selected areas, particularly in national parks or sanctuaries, be completely prohibited.

12. That forest lands demarcated as such be retained inviolate to further encroachment by people seeking new agricultural lands.

13. That a programme of fire control or prevention, based upon the results of the studies presently being conducted by the Forest Department, be undertaken on all forest lands. This would entail both control and educational measures. People, particularly those living in or near

forest areas, should understand the serious consequences of uncontrolled or, in many cases, of any type of burning in forest areas.

14. That the protective measures that have so effectively reduced poaching in the rhino areas be extended to all important wild life areas.

V. Acknowledgements

This report was made possible by the courteous invitation of the Forest Department of Nepal. We wish to thank His Majesty's Government of Nepal, without the co-operation of which this undertaking could not even have been attempted.

We are also grateful to Mr. R. G. M. Willan, Chief Conservator of Forests, and to the Forest Department of Nepal for their hospitality and kind assistance, as well as for the facilities, including elephants, provided while we were in the field. All Forest Department personnel with whom we came in contact were most courteous and co-operative. Special thanks are also given to Mr. and Mrs. J. V. Coapman for their gracious hospitality and for the two enjoyable days spent with them at 'Tiger Tops'.

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VII. Glossary of Local Terms

Bhabar or *charkosya jhari*	..	an almost continuous dry belt 8-12 miles wide between the *terai* and the hills and at an elevation of 600-1000 feet. The soil is dry, porous, and infertile and consists mostly of sand, gravel and boulders washed down from the mountains.
chowki	..	a station or post, such as those used by rhino guards.
Churia Hills or *Siwalik Range*	..	2000-4000 foothills which rise sharply north of the *bhabar* and consist of sand, gravel, and boulders. They are irregular in size, comprise one or two chains and stop short east of the Kosi River.

dun .. a wide or flat valley between the *bhabar* and the *mahabharat* or Himalayan range. The best known *dun* in Nepal is the Chitawan or Rapti River Valley.

havildar .. a non-commissioned officer or head constable with the rank of ' Sergeant '.

khola .. a stream.

mahabharat .. the Himalayan range, which forms 80% of Nepal. It consists of sedimentary rock that has been disturbed by the uplifting of the crystalline Himalayas. The variety of soils and folds and the rocky alluvial deposits make for extreme complexity.

panchayat .. a committee or council, literally of five members, at any level of government.

shikar .. shooting or hunting

shikari .. a hunter or professional shooting guide.

subedar .. a junior commissioned officer.

tal .. a small lake.

tapoo .. an island in a river.

terai .. a fertile and moist alluvial plain, located south of the *bhabar*, a few miles from the foothills of the Himalayas and at an elevation of 250-600 feet. In Nepal the *terai* forms the northern end of the Gangetic plain and is 20 miles across at the widest point.

Brief Summary of the Status of the Great Indian One-Horned Rhinoceros

BY

J. Juan Spillett

The overall outlook for the Great Indian One-horned Rhinoceros presently appears to be better than at any time during recent years. Nevertheless the preservation of this species is fraught with numerous problems. Chief among these are overgrazing by domestic livestock, human encroachment or exploitation of its few remaining habitats, and poaching. Although there are frequent reports of rhino in areas outside established sanctuaries or reserved forests, particularly in Assam, it is my firm belief that these scattered animals contribute little to the preservation of this species. Only strictly protected and managed sanctuatries or reserves offer reasonable possibilities for preserving, maintaining, or increasing the numbers of Indian rhino presently in existence.

The 166-square-mile Kaziranga Wild Life Sanctuary in Assam was censused on 18 and 19 March 1966. Four hundred or well over half of the Great Indian One-horned Rhinoceros in existence are harboured in this outstanding sanctuary. It also offers better possibilities of maintaining relatively high numbers of rhino than any other area in its present range. However, problems confronting the rhino in Kaziranga include poaching, erosion by the annual flood waters of the Brahmaputra River, and to some extent grazing by domestic livestock.

The Forest Department reports that there are over 40 rhino in the 26-square-mile Laokhowa Reserve in Assam. However, it is doubtful that under present conditions this population will even be able to maintain itself, let alone increase in numbers. Poaching does not appear to be a major problem in Laokhowa. But, besides extensive crop cultivation and forest exploitation, the entire reserve is severely abused by overgrazing by domestic livestock and excessive disturbances caused by numerous people residing in the area. The seven rhino reported for Kukurata actually reside outside of the reserve in about a mile-square grassland area along the Brahmaputra River. In addition to being in an exceptionally vulnerable position in so far as poaching is concerned, these rhino must move elsewhere during the annual flood season when the area that they inhabit is completely inundated.

I did not visit the 7-square-mile Raja Mayang nor the 22-square-mile Orang reserved forests. The figures given in the Table below for these areas are based upon information received from Mr. P. C. Gogoi (Nowgong Divisional Forest Officer) and the Range Officer stationed at Orang. Mr. E. P. Gee's estimates for the 105-square-mile Manas or North Kamrup Wild Life Sanctuary and the 85-square-mile Sona Rupa Reserve are also given. These estimates, as well as those given for elsewhere in Assam, are based primarily upon information obtained from others. Therefore, I am not in a position to state the actual status of the rhino in these areas.

The 38-square-mile Jaldapara Wild Life Sanctuary in northern West Bengal was censused on 26 April 1966. Although only 32 rhino were tallied during the census, based upon my observations between March 31 and April 7, I am certain that the sanctuary contains at least 50 rhino. Poaching of rhino does not appear to be excessive in Jaldapara, but the illegal grazing of domestic livestock and forest exploitation by villagers living along the boundaries are major problems. In spite of these disturbances, I observed a relatively large proportion of young and the sanctuary's rhino population appears to be thriving. Five rhino are also reported to inhabit the near-by Goru Mara Sanctuary.

The outlook for the preservation of the Great Indian One-horned Rhinoceros in Nepal was very bleak until just recently when the Forest Department and the Government of Nepal took definitive measures to protect this threatened species. The distribution of the rhino in Nepal is restricted to Chitawan or the Rapti River Valley and a few of the near-by tributaries. Although considered until recently as royal game, King Mahendra has extended full protection to the rhino in his country, A Wild Life Management Division under the supervision of Major N. R. Thapa, consisting of over 100 'rhino guards', has also been established primarily for the protection of the rhino. The Forest Department's official total for rhino in Nepal is 185. However, based upon my limited observations between April 9 and 23, and discussions with people inhabiting the principal rhino areas, I believe there are probably fewer than 100 in the country. The most important factor, however, is not the exact number, but the steps being taken by the Government and the Forest Department for the protection of those that are present. The major problems presently confronting rhino in Nepal are overgrazing by domestic livestock and sporadic forays by poachers crossing the Indo-Nepal border.

Estimates for total populations of the Great Indian One-horned Rhinoceros throughout its present range are given below.

TABLE

ESTIMATES OF GREAT INDIAN ONE-HORNED RHINOCEROS, JUNE 1966

Assam	(1) Kaziranga ..	400
	(2) Laokhowa ..	40
	(3) Kukurata ..	7
	(4) Raja Mayang ..	6
	(5) Orang ..	12
	(6) Manas ..	15*
	(7) Sona Rupa ..	5*
	(8) Elsewhere ..	40
West Bengal	(1) Jaldapara ..	50
	(2) Goru Mara ..	5*
Nepal	..	100
	Total ..	680

* Mr. Gee's figures.

A Study of the Chital or Spotted Deer in Corbett National Park, Uttar Pradesh

BY

RAMES CHANDRA DE[1] AND J. JUAN SPILLETT

(*With three maps*)

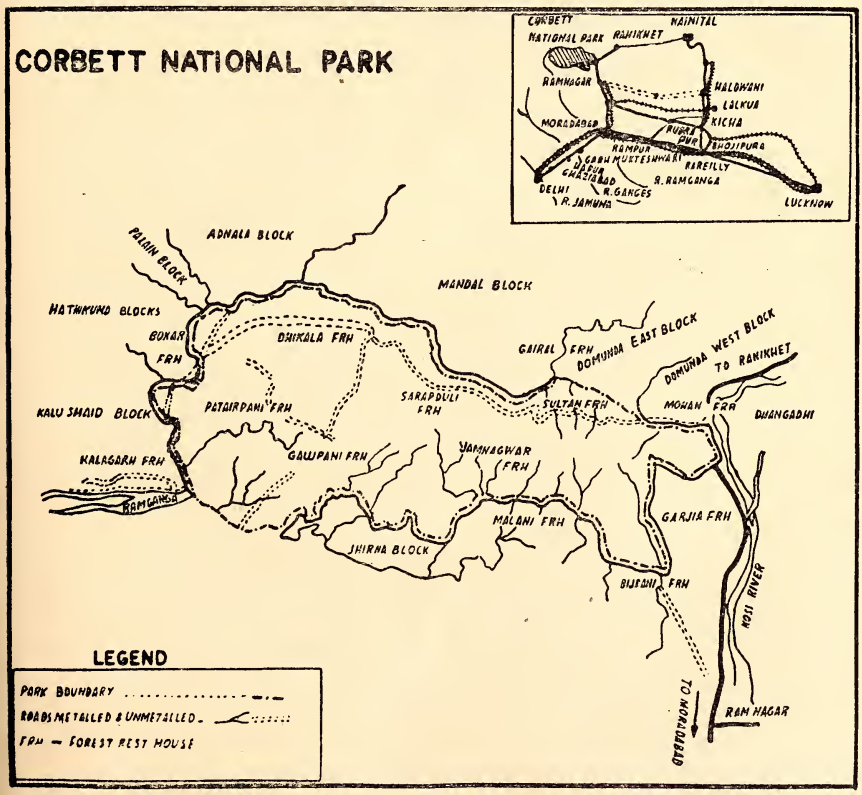
TABLES AND MAPS

[1] R. C. De's salary was paid by The Johns Hopkins University Center for Medical Research and Training, Calcutta, India, while the study was sponsored by the World Wildlife Fund, Morges, Switzerland, and supervised by J. J. Spillett.

I. Introduction

Corbett National Park, so named since 1957, has the distinction of being India's first national park. It was first constituted in 1935 as the Hailey National Park, later as the Ramganga National Park, and finally as Corbett.

This 125-square-mile park is located in the rugged Himalayan foothills in the districts of Nainital and Garhwal of Uttar Pradesh (U.P.). The Ramganga River forms the northern and western boundaries, the Ramnagar-Ranikhet road the eastern boundary and the Ramnagar-Kotdwara road the southern boundary (Map 1). Corbett Park is sur-



Map 1. Map of Corbett National Park, U.P.

rounded by shooting blocks. Shooting, however, has been fully prohibited in the Jhirna Block and partially in the Bijrani and Mandal Blocks, with the reported expectation that these areas totalling about 32-square-miles will soon be included in the park. Approximately 60 miles of fair weather roads inside Corbett Park are maintained by the Forest Department. The park is closed to the public during the monsoon season, mid-June to October.

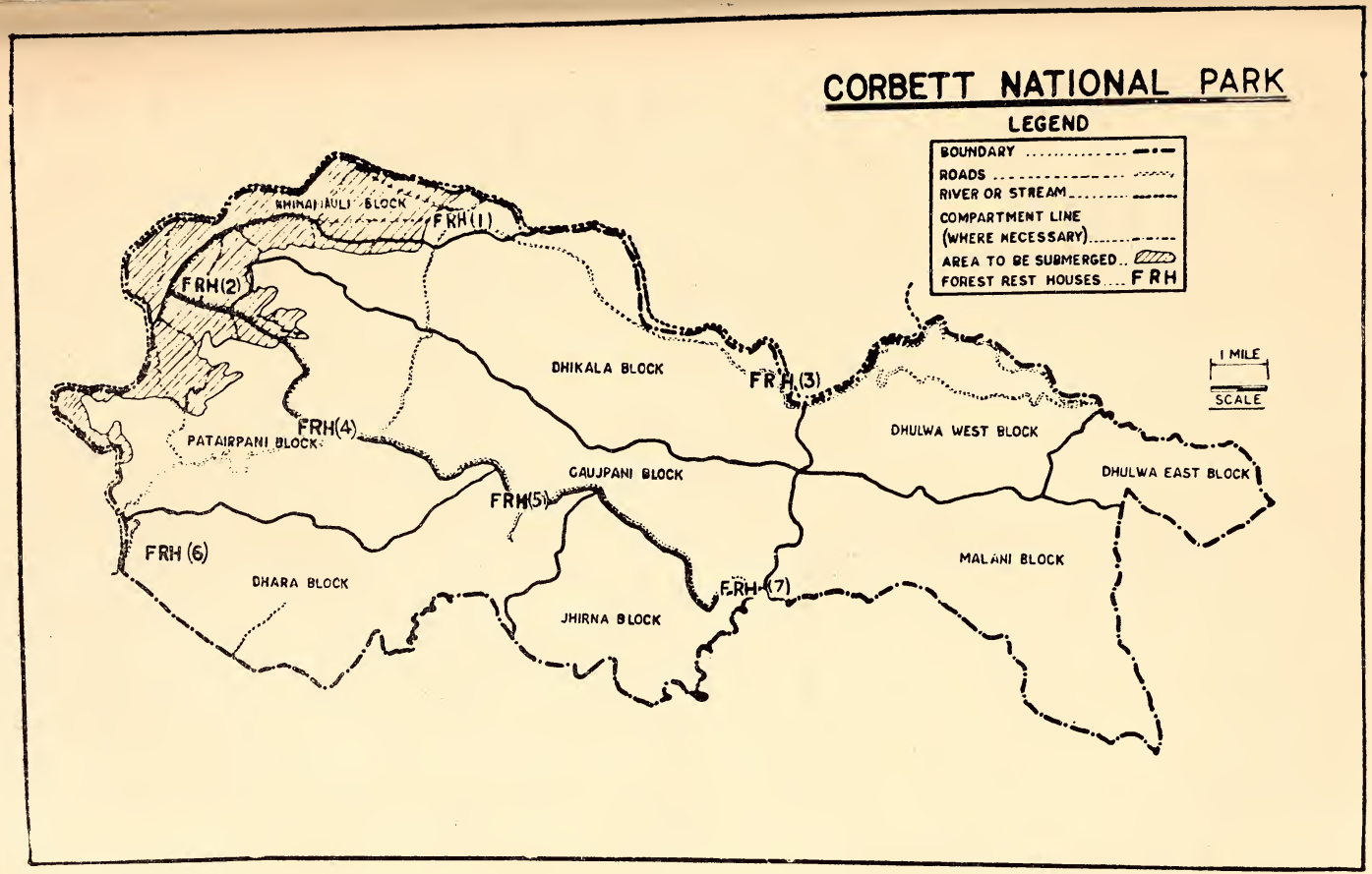
Dhikala is the main visitor center. Located here are two Forest Rest Houses, a hutment, a number of tents for visitors and houses for 14 members of the Forest Department staff. Forest Rest Houses are also located at Sultan, Sarapduli, Boxar, Patairpani, Gajpani, Jamnagwar and Malani. Corbett is under the jurisdiction of the State Forest Department and is supervised by a wild life warden, with a staff of several assistant wild life wardens and a number of wild life guards.

Numerous forms of mammals, some of which are listed in Table 1, are present in Corbett. In addition, several hundred species of birds have been reported, as well as several species of tortoises, snakes (both non-poisonous and venomous), and other reptiles. The 'Indian salmon' or *mahseer* (*Barbus tor*) is the most notable of the fish species found in the Ramganga River and the larger streams.

An irrigation and hydroelectric dam, to be completed in 1973, is presently under construction at Kalagarh. An area of approximately 18-square-miles of grasslands within the park, including parts of the Patairpani, Dhikala, and Gajpani forest blocks, will be inundated after the completion of the dam (Map. 2). The most common large mammal in the park is the chital, the vast majority of which inhabit these grassland areas which will be submerged. Therefore, the primary objectives of this study were to determine the present status of the chital in this area from the standpoint of their population density, movements, sex ratios, and age composition. Hopefully this report will provide information that will be useful in the preservation of wild life, particularly the chital, after the environment has been altered by the advent of the dam. Also that it will serve as a comparative basis for future studies, which may help to determine how wild life can best be considered in future projects of this nature.

The main area of study was in the vicinity of the tourist center at Dhikala, located at an elevation of 1265 feet. It consisted of about seven-square-miles of open grasslands, locally called *chaur*, and the adjoining forest areas. About four square miles were in the Khinanauli Block and about three in the forests of the Dhikala Block (Map. 3).

Daily observations were made from 04·30 to 11·30 hours and from 14·30 to 19·30 hours. Eight-power binoculars or a 20-60 x zoom spotting scope were used. Three watch towers or wooden machans in the *chaur* were also frequently used for observations.



Map 2. Map of Corbett National Park, U.P., depicting the area to be submerged by the Ramganga Dam Project and the forest blocks inside the park

TABLE 1

SOME OF THE LARGER ANIMALS REPRESENTED IN CORBETT NATIONAL PARK, U.P.

Common Name	Local Name	Scientific Name
Indian Elephant	Hathi	*Elephas maximus*
Sambar	Sambar	*Cervus unicolor*
Chital	Chital	*Axis axis*
Hog Deer	Para	*Axis porcinus*
Barking Deer	Kakar	*Muntiacus muntjak*
Tiger	Sher *or* Bagh	*Panthera tigris*
Leopard	Guldar	*Panthera pardus*
Hyaena	—	*Hyaena hyaena*
Sloth Bear	Bhalu	*Melursus ursinus*
Himalayan Black Bear	Bhalu	*Selenarctos thibetanus*
Wild Boar	Suar	*Sus scrofa*
Rhesus Monkey	Bandar	*Macaca mulatta*
Common Langur	Hanuman	*Presbytis entellus*
Porcupine	Soohi	*Hystrix indica*
Marten	Chitrole	*Martes flavigula*
Mugger	Magar	*Crocodilus palustris*
Gharial	Gharial	*Gavialis gangeticus*
Python	Ajgar	*Python molurus*

II. HABITAT

The study area can be roughly divided into three vegetational types : (1) *chaur* or savannah-like grasslands, (2) *sal* forest, and (3) river bed.

The Dhikala *chaur* was formed by past cultivation. The Ramganga River forms the northern and western boundaries and the Thandi-Sarak road runs along the edge of the forest on the south and east. The vegetation consists primarily of grasses such as *suthi* (*Aristida cyanantha*), *Cymbopogon confortiflorus*, *Arundinella nepalensis*, *bichroo* (*Neyraudia arundinacea*), *munja* (*Saccharum munja*), *S. arundinaceum*, *kans* (*S. spontaneum*), *Imperata cylindrica*, *ganeria* (*Narenga porphyrocoma*), *kus* (*Desmostachya bipinnata*), *khus* (*Vetiveria zizanioides*), *ulla* (*Themeda arundinacea*), *Chionachne koenigii*, *Alpuda varia*, etc.

There are a few patches of *sal* in the *chaur* and a few scattered trees such as *simul* (*Bombax ceiba*), *dhak* (*Butea monosperma*), *bauhinia* (*Bauhinia malabarica*), and *aonla* (*Emblica officinalis*). *Ber* bushes (*Zizyphus jujuba*) are also commonly intermingled with the grass.

The *sal* forest extends from the southern edge of the *chaur* towards the north. It may be divided into three levels or stories : (1) canopy, (2) middle level or storey, and (3) ground level.

The canopy consists mainly of *sal* trees (*Shorea robusta*). However, other species of trees, such as *sains* (*Terminalia tomentosa*), *haldu* (*Adina cordifolia*), *bahera* (*Terminalia belerica*), *jhingan* (*Lannea wodier*), *jamun* (*Eugenia jambolana*), *kharpat* (*Garuga pinnata*), and *tendu* (*Diospyros*

tomentosa), are also represented. In moist areas these trees replace *sal* as the dominant species.

The middle level or storey consists mainly of shorter trees, such as *rohinis* (*Mallotus philippinensis*), *chilla* (*Casearia tomentosa*), *amaltas* (*Cassia fistula*), *lisora* (*Cordia dichotoma*), *gaya* (*Bridelia retusa*), etc.

The ground level is characterized by small trees, such as *gandhela* (*Murraya koenigii*), shrubs such as *Glycosmis pentaphylla*, *Clerodendron infortunatum*, *dhaia* (*Callicarpa macrophylla*), other shrubs, herbs, and patches of grass, as well as tree seedlings. The dominant grass species are *Imperata* sp. and *Chloris incompleta*.

The river-beds are characterized by trees, such as *shisham* or *sissu* (*Dalbergia sissoo*) and a few *khair* (*Acacia catechu*), in the canopy. Shrubs or vines are represented by *bhang* (*Cannabis sativa*) and *lantana* (*Lantana camara*).

The vegetation near Boxar is typical river bottom. However, in one patch of forest, trees like *shisham*, *bel* (*Aegle marmelos*), *khair*, and *ber* predominate. The Patairpani area is open forest, consisting of about 50% *sal* and 50% grass. The dominant grass in the stream beds here is *pater* (*Typha elephantina*). Besides the Ramganga River, another source of water in the main study area was about a one and one-half mile long *nullah* or water course in the center of the Dhikala *chaur*. Other nullahs present in the study area remain dry, except during the monsoon. The annual rainfall for this region is reported to be about 100 inches. Mean monthly maximum and minimum temperatures during the study period are given in Table 2.

TABLE 2

THE MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURES RECORDED AT DHIKALA IN CORBETT NATIONAL PARK, U.P. (FEBRUARY 1-MAY 29, 1966)

Month	Means	
	Minimum	Maximum
February ..	41°F.	61°F.
March ..	56°F.	88°F.
April ..	64°F.	98°F.
May ..	75°F.	105°F.

Table 3

Forest Department estimates of reservoir water levels after the completion of the dam on the Ramganga River at Kalagarh

Date	Water storage in M. ac. ft.	Approximate reservoir level (feet elevation)
October 8 ..	1,504	1188
November 1 ..	1,559	1191
December 1 ..	1,386	1181
January 1 ..	1,126	1164
February 1 ..	875	1147
March 1 ..	708	1133
April 1 ..	539	1116
May 1 ..	416	1102
June 1 ..	273	1084
June 16 ..	203	1075

III. Results

Population Density

The highest total count of chital in the study area was 1584. Chital in the *chaur* were generally quite easily tallied with the aid of a spotting scope from the watch towers. Those in the forest, however, were censused by the strip method, i.e. we walked in parallel lines and maintained sufficient distance between the lines to avoid duplication in the counts.

In addition to the study area, the highest count for areas to be submerged inside the park (parts of three compartments in the Dhikala Block, three compartments of the Gajpani Block, seven compartments of the Patairpani Block, and adjoining grasslands) was 922. Compartments I, II, IIIA, IIIB and IV of the study area (Map 3) will not be submerged. Almost 600 chital were counted in these compartments. Therefore my totals for the chital population in the park areas to be submerged was about 1900 ($1584+922-600=1906$). Estimated water levels at different times of the year for this area are given in Table 3. It is almost certain that some animals were missed. Thus, it is estimated that as many as 2300 chital may have inhabited the area to be submerged during the course of the four-month study (February 1 through May 29). Total daily counts in the Dhikala *chaur* are given in Table 4.

TABLE 4

TOTAL DAILY COUNTS OF CHITAL ON THE DHIKALA *chaur*

Month	Date	Total chital
February 1966 ..	10	877
	11	920
	12	820
	14	898
	15	910
	16	940
	21	834
	24	924
	26	918
	27	975
	28	963
March 1966 ..	1	812
	3	954
	6	976
April 1966 ..	2	860
	5	703
	8	842
	12	694
	17	735
	21	922
	27	699
	29	641
	30	767
May 1966 ..	3	642
	5	631
	6	816
	7	669
	11	829
	12	685
	13	811
	14	892

About 1600 chital were primarily dependent upon the grass of the Dhikala *chaur* for forage. Although there was sufficient grass in the *chaur*, the areas along the forest edge were severely overgrazed. This overgrazing, coupled with the high frequency of dominance interactions and fighting, may indicate that the population density for the study area has passed the optimum level.

Movements

The movement of chital is affected by numerous factors, such as temperature, weather, food, water, and disturbances. The role of temperature on their movements is evident from Table 5. During the four-month study period, the chital observed demonstrated a general pattern of movement. During February, most of the chital remained on the *chaur* throughout most of the day and night, taking rest in the

forest only a few hours at midday. But during March, April, and May, when the temperatures went up, they left the *chaur* earlier and then

TABLE 5

RELATIONSHIP BETWEEN TEMPERATURE AND TIME OF ENTRANCE AND EXIT FROM THE FOREST BY CHITAL

Date (1966)		Temperature		Hours of			
		Min.	Max.	going in forest	coming out of forest	Sunrise	Sunset
March	2	55	89	11·30	14·30	06·30	18·12
	4	56	89	11·20	14·40	06·28	18·13
	6	50	78	10·50	14·30	06·26	18·14
	10	53	84	10.30	15.30	06.21	18·16
	31	57	91	10·00	15·40	06·03	18·23
April	2	61	96	09·40	16·10	06·01	18·24
	4	60	98	09·30	16·20	05·59	18·25
	8	59	92	09·00	16·00	05·55	18·26
	11	62	97	08·10	16·30	05·53	18·27
	14	63	98	08·00	16·40	05·50	18·28
	17	64	98	07·40	16·50	05·47	18·29
	21	63	100	07·20	17·10	05·44	18·31
	25	65	104	07·00	17·40	05·41	18·33
	28	71	103	07·00	17·40	05·39	18·34
	30	69	102	07·10	17·10	05·37	18·35
May	3	63	105	06·20	18·10	05·35	18·36
	4	69	108	06·10	18·25	05·35	18·36
	5	68	109	06·00	18·10	05·34	18·37
	6	71	108	06·10	18·10	05·33	18·37
	8	71	106	06·20	18·00	05·32	18·38
	10	68	97	07·30	16·30	05·31	18·39
	12	70	90	07·45	15·45	05·30	18·40

returned to graze between 14·30 to 18·25 hours until 06·10 or 11·30 hours the following morning. During periods of rainfall or during cloudy or foggy weather the chital remained on the *chaur* for longer periods of time. This can probably be correlated with lower temperatures on these days.

Chital are primarily grazers and prefer the shorter green grasses or the more palatable green shoots. Since there were very few patches of grass inside the forests, they regularly came out on to the grassy *chaur* to graze. It was reported by members of the Forest Department staff that during November and December chital were found in the river-beds. But, as the new grass shoots began to appear in January after the grasslands had been burned by the Forest Department, they began to congregate on the *chaur*. Besides grass, chital were observed to eat the leaves of trees, such as *maljhan* (*Bauhinia vahli*), *kachnar* (*B. mala-*

barica), *lisora*, *gandhela*, and *gaya* (*Bridelia retusa*); shrubs such as *Glycosmis pentaphylla* and the fruits of *bahera* (*Terminalia belerica*) and *aonla* were also eaten.

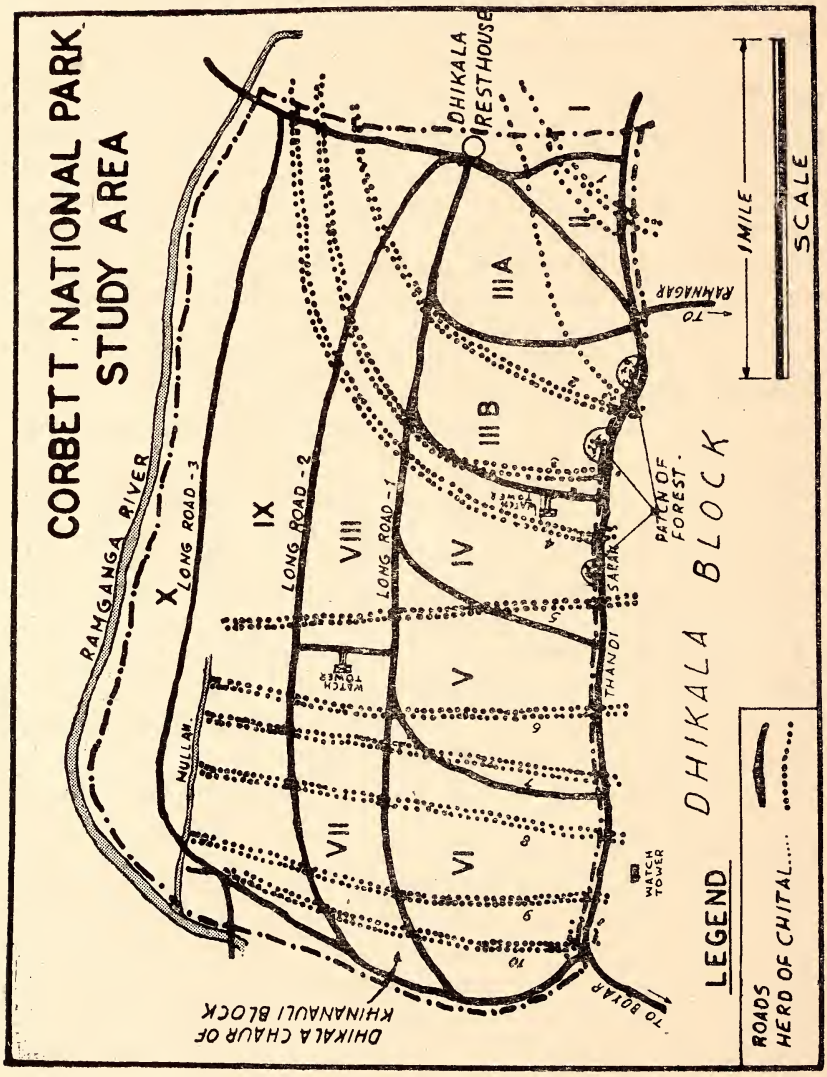
Water plays a major role in the movement of chital. Herds in different compartments of the study area moved across the *chaur* to reach either the nullah in compartment IX or the Ramganga River (Map 3). Most of the animals went to water in the late evening, but a few were also occasionally observed to drink in the early morning.

Due to the movements of visitors and crews working to clear-fell the areas to be submerged by the backwaters of the dam, disturbances in the Dhikala *chaur* were often excessive. However, moving vehicles or bicycles did not normally disturb the chital to any appreciable extent. Stopped vehicles, domestic elephants, and people on foot generally caused the chital to seek refuge in the near-by forests. The number of roads in this area are excessive and many disturbances could probably be minimized if only a few of the roads were maintained and the others were closed. Predators, such as tiger or leopard, also disturbed chital grazing on the *chaur*. The animals also appeared to be more easily frightened by our presence after having previously been frightened by a predator.

Daily observations enabled the senior author to distinguish the territories of ten more or less stable herds of chital (Map 3). Some of these were readily distinguished by ' marker ' individuals or those which had readily observed abnormalities, i.e. antler development. For example, herd 1 of compartment II occupied a territory covering compartments I and II. Herd 2 of compartment IIIB occupied a territory covering parts of compartments IIIB, IV, VIII, IX, X, IIIA, II, and I, and so forth. All ten herds also occupied areas from one-half to two miles inside the forests adjoining the *chaur*. Frequent mixing of herds was also observed, particularly when the chital were disturbed, i.e. by men or predators.

Sex Ratios and Age Composition

Age composition and sex ratio data were most commonly recorded when the chital made either their exit from or their entry into the forests. At this time they would normally move slowly in single file, enabling one to sex and age entire groups accurately. Watch towers were also used for this purpose. A more or less 1 : 1 sex ratio may usually be expected in an area which is free from selective shooting or predation. The percentages of adult females observed as compared to adult males for February, March, April, and May were 52, 58, 60 and 53% respectively. The variations are not significant and the observed sex ratio always approximated 1 : 1. The adult female-young ratios for February, March, April, and May were 33, 37, 37 and 31%. This indicates that the main fawning season was probably over by mid-March. Further



Map 3. Study area in the Dhikala *chaur* of Corbett National Park, U.P., with the daily movements of different herds of chital

information concerning sex ratios, age composition, and antler development on a monthly basis is given in Table 6.

Reproduction

Seasonal sexuality in chital males is manifested by the growth of antlers and mating behaviour. During February, March, April, and May the percentages of males observed with hard antlers were 2, 9, 12, and 51% respectively. The onset of the main rut in May was characterized by an increased frequency of fighting. Males appeared to eat less and frequently moved in search of females. The necks of some stags began to swell and their colouration became darker. The infra-orbital glands began to secrete a musky amber-coloured wax-like fluid, which trickled down the face.

The frequency of mating calls also notably increased from February through May. As presented in Table 7, the mean number of calls recorded per hour on a monthly basis increased from three during the later part of February to 11 during May. It appeared that the rutting season was just attaining its peak when the study was terminated the last of May. It is also evident that mating calls or bellows were more often given in the evening than in the morning. Mating calls also were frequently heard at night, although their frequency was not recorded. Calls were rarely heard between the late morning and late afternoon hours.

The frequency of mounting and copulation, as would be expected, also increased between February and the end of May. As recorded in ten observations, these typically involved the male chasing the female, frequent eversion of the penis, repeated licking of the muzzle, retraction of the lips from the upper gum while holding the muzzle up, sniffing of the vulva, mounting, insertion of the penis into the vagina, licking of the penis, and retraction of the penis into the sheath. Insertion of the penis into the vagina was sometimes accomplished only after numerous attempts. Mating males also occasionally had to challenge or threaten other approaching males and on a few occasions severe fighting was observed.

Generally speaking, chital are not aggressive animals. Sometimes, however, severe fights among them are witnessed. Observed fighting was either between males or between females, it was never between animals of opposite sexes. Fights among young males with spike antlers in velvet on three occasions involved dominance interaction, slapping at each other with the forefeet and pushing each other with the neck, while standing on their hind legs for as long as three or four minutes. Similar fighting between females was observed on four occasions near salt licks. Besides fighting, aggression was represented by chasing, butting, and the turning of the head or body towards another animal. Mild forms of

TABLE 6

CHITAL AGE COMPOSITION AND SEX RATIOS AS OBSERVED ON A MONTHLY BASIS

Month	Spike velvet	Spike hard recently lost antlers	Knob	4"-8" velvet	9"-15" velvet	9"-15" hard	16"-22" velvet	16"-22" hard	23"29" velvet	23"-29" hard	30"-36" velvet	30"-36" hard	37"-43" velvet	37"-43" hard	Total no. of ♂♂	Total no. of ♀♀	Total no. of young	Grand total	% of ♂♂	% of ♀♀	% of young	% of hard antlered ♂♂	% of velvet antlered ♂♂	Sex ratio ♂ : ♀
February 1966	40	35	120	0	87	39	0	27	7	32	0	11	0	0	0	398	434	215	1047	38	41	21	10	90	1 : 1
March 1966	6	3	45	0	22	16	2	16	1	13	1	15	8	0	0	148	200	116	464	31	43	26	10	90	3 : 4
April 1966	19	9	10	10	16	45	1	48	5	23	5	61	16	17	4	289	421	255	965	30	43	27	14	86	2 : 3
May 1966	26	6	0	13	0	10	0	25	23	14	12	21	27	7	20	204	229	103	535	38	42	20	43	57	1 : 1

fighting between males involved the simple interlocking of antlers and slight pushing. More severe fighting involved antler interlocking and severe 'jousting'. This form was most obvious among combating males during May.

The female gives birth after completing a gestation period of about seven and one-half months. Many newborn young were seen in February. Fawning also continued up until the first of May and then decreased considerably. Young from the previous year were also attaining adult size at this time.

Dominance interactions were particularly evident between males with hard antlers or antlers in the later stages of development. Such interactions generally involved two to seven animals walking in parallel lines or in circles with a stiff, slow gait—heads slightly bent to the side, ears laid back on the neck, and with the tail sometimes raised. Larger males usually dominated younger or smaller males, which moved away from them. Although numerous dominance interactions were observed in February, March, and April, these usually did not lead to fighting. When many males had hard antlers in May, however, dominance interactions often led to severe fighting.

Females were observed to hide their newborn young in the grass. On three occasions females were seen to leave a grazing herd to caress and suckle their young, which were lying elsewhere. Caress was represented by licking of the fawn's body, particularly the rump region. Suckling time varied from 45 seconds to five minutes. In 9 out of 13 suckling observations the mother again left the young.

Miscellaneous Observations

It was noted that when chital came out of or entered into the forest areas they almost invariably used narrow paths or game tracks. These were most numerous near salt licks and approaching the Thandi Sarak road, but diminished inside the forest or towards the center of the *chaur* where the chital were generally scattered. Chital appear to regularly use the artificial salt licks, which were provided by the Forest Department. The chital made shallow pits with the help of the forefeet and teeth and then ate the salty soil. The length of time that individuals licked salt varied from 2 to 37 minutes.

Chital are very social animals and are rarely encountered apart from a group or herd. The number of individuals counted in groups varied from 2 to 315. Herds generally consist of males, females, and young of all ages. Very few solitary males or females were seen. In a few cases all male groups were seen. However, most of the time males were seen with females, although during February and March they had a tendency to remain to one side of the herd when it was grazing more or less in a line on the *chaur*.

A matriarchal social system was indicated by the fact that females were generally more alert than males. Also, females led the way 110 times out of 136 occasions when chital were observed entering or coming out of the forest.

VI. Other Animals

Tiger and leopard probably play the major role in controlling the chital population in Corbett. The carcasses of four male chital, three adults and one yearling, killed by tiger or leopard were found in the forest areas adjoining the *chaur*. Three of these had large antlers in velvet. This may indicate that heavy or large antlers, as well as age, may be a factor in predation. A jackal on one occasion broke the lower jaw of a young chital, which was captured later by one of the forest guards. On four occasions chital were observed to run when approached by jackal. An eagle was observed to swoop down upon a very small chital and carry it away. Several adult female chital followed after the flying bird.

The actions of other animals also affect the behaviour of chital. For example, on two occasions chital were observed to follow mixed groups of common langurs and rhesus monkeys. They were feeding upon the leaves and fruits dropped from the tops of the trees. The alarm calls of both langur and rhesus also warn chital, particularly when in the forests, of the presence of predators such as leopard.

Although chital were observed to graze within a few hundred feet of wild elephants, they did not mix or intermingle with them. On nine occasions chital were observed to enter areas occupied by elephants much later than was their normal pattern. However, chital appeared to freely mingle with wild pig, hog deer, and sambar. No aggressive interactions were observed between these species. Birds, such as mynas and tree pies, would frequently light on the backs of chital and appeared to feed upon external parasites. This would probably be advantageous to the chital.

A recently born chital young examined on May 19 had an infection of maggots in the vicinity of the umbilical cord. Amphistome flukes (*Calicophon cauliorchis*), identified by the Zoological Survey of India, were collected from the rumens of two dead chital. This parasite may cause amphistomiasis.

Hog Deer

In addition to chital, hog deer will also suffer when grassland areas in Corbett are submerged by the backwaters of the Ramganga River dam. Greater concentration on chital observations, the relatively small size of hog deer, the dense grass which they generally inhabit, and their somewhat secretive habits prevented us from obtaining a total count of

the hog deer in the study area. However, we guess there were at least 100 hog deer present on the *chaur* of the study area.

Hog deer were observed to remain in the *chaur* throughout the day and night. In comparison to chital, they grazed in smaller or more restricted areas. It was difficult to note the time of grazing, but they generally grazed intermittently from late afternoon until late the following morning. In midday they would seek refuge in the tall grasses of the

TABLE 7

FREQUENCY OF MATING CALLS BY MALE CHITAL ON AN HOURLY BASIS

Month	Date	Hour when mating calls were counted	Number of mating calls per hour	Mean number of calls per hour	Maximum no. of bellowings in one call
February	14	07·00-08·00	3	3	8
	16	16·50-17·50	4		8
	18	06·50-07·50	3		7
	21	07·10-07·40	2		7
	22	06·30-07·00	3		8
	26	06·00-07·00	3		7
	27	06·20-07·20	2		5
March	3	06·15-07·15	3	3·5	
	28	05·45-06·45	4		7
April	5	05·45-06·45	5	6	7
	6	05·45-06·45	4		8
	8	05·45-06·45	5		6
	11	18·45-19·45	5		6
	12	05·45-06·45	6		6
	13	05·45-06·45	7		6
	13	17·40-18·40	4		6
	15	05·45-06·45	5		5
	17	05·45-06·30	5		6
	17	18·00-19·00	6		6
	21	05·45-06·20	5		7
	21	18·45-19·45	7		6
	23	17·45-18·45	8		6
	24	17·45-18·45	7		6
	25	04·50-05·50	6		7
	25	17·45-18·45	7		6
	27	04·45-05·45	5		7
	29	05·00-05·45	7		7
	29	18·10-19·00	8		7
May	4	04·45-05·45	8	11	7
	4	18·20-19·20	9		7
	5	04·95-05·45	8		7
	5	18·00-19·00	9		7
	8	04·45-05·45	9		7
	11	04·45-05·45	9		7
	13	04·45-05·45	10		7
	14	04·45-05·45	11		7
	14	18·20-19·20	13		7
	16	04·45-05·45	12		7
	19	04·45-05·45	11		6
	19	18·20-19·20	13		7
	20	04·45-05·45	13		6
	20	19·00-20·00	16		7

chaur. Four groups of hog deer were repeatedly seen lying in the open in compartments IIIB, IV, and VI. But, as the temperature went up in April and May and as the tall grasses were flattened, these groups then sought out tall grassy areas or the shade of scattered trees to take rest. Two groups of hog deer in compartment X were seen lying in the tall grass repeatedly, even in summer during the heat of midday.

Hog deer are social animals and in Corbett they usually remained in groups of from three to seven of both sexes and all ages. The males, however, had a tendency to graze somewhat apart from the groups of females and young. When disturbed they would usually take cover in the tall grass, rather than in the near-by forests as did the chital. No fighting, dominance interactions, or play among hog deer was observed.

Hog deer fawns were first observed during the last week of March. Recently born fawns then continued to be seen up until May. The reported gestation period is about eight months (Asdell 1964). The rut, therefore, was probably between August and October. Information concerning the sex ratio, age composition, and antler development for hog deer observed is given on a monthly basis in Table 8.

Sambar

Sambar are usually somewhat solitary forest dwellers and it was difficult to collect much information concerning them. However, seven sambar were repeatedly observed in the study area. It was noted that a group consisting of an adult male, three adult females, and two young usually occupied parts of compartments II, III, IV, VIII, IX, and X. A solitary adult male was seen frequently in compartments V, VI, and IX. This suggests that sambar may be territorial. Groups numbering up to six were seen and they generally contained one or two adult males.

Sambar were seen only occasionally in the *chaur* during February and March. Although they are considered to be primarily browsers, during April and May, they were observed quite regularly to enter the *chaur* in the evening and remain until 05·10 to 07·30 hours the following morning. They were also seen eating short grasses in the forest and hilly areas. The colour of their coat changed from dark grey in February and March to a whitish grey in April and May. During the first part of May, 33 out of 55 sambar seen had a whitish grey coat.

Small young sambar were rarely seen. A lactating female was killed by a tiger on February 23 and two young which were about three months old were seen in the second week of March. This suggests that the fawning period may be during December or January. Asdell (1964) reported that the gestation period for the sambar is eight months. Information on sex ratios, age composition, and antler development for sambar observed is given on a monthly basis in Table 9.

TABLE 8

HOG DEER AGE COMPOSITION, SEX RATIOS, AND ANTLER DEVELOPMENT AS OBSERVED ON A MONTHLY BASIS

Month	Males with recently shed antlers	Antlers from 4″-6″ velvet	Antlers from 7″-12″ velvet	Hard antlers	Total males	Total females	Total young	Total deer	Sex ratio male : female	% of males	% of females	% of young	% males with velvet antlers	% males with hard antlers
Feb. 1966	2	0	0	4	6	11	6	23	1 : 2	26	48	26	33	67
March 1966	5	0	2	4	11	15	7	33	4 : 5	34	45	21	63	37
April 1966	1	2	3	0	6	14	8	28	1 : 2	21	50	29	100	0
May 1966	1	0	3	0	4	5	3	12	1 : 1	33	25	33	100	0
Total	9	2	8	8	27	45	24	96	3 : 5	28	47	25		

TABLE 9

SAMBAR AGE COMPOSITION, SEX RATIOS, AND ANTLER DEVELOPMENT ON A MONTHLY BASIS

Month	Males with spike hard antler	Males with shed antlers	Antler over 4″ velvet	Hard antlers	Total males	Total females	Total young	Grand total	Sex ratio males females	% of males	% of females	% of young	% of males with velvet antler	% of males with hard antler
Feb. 1966	0	0	0	1	1	2	1	4	1 : 2	25	50	25	0	100
March 1966	0	0	0	3	3	11	8	22	1 : 3	14	50	36	0	100
April 1966	0	1	1	1	3	23	8	34	1 : 7	9	67	24	67	33
May 1966	1	2	4	2	9	36	10	55	1 : 4	16	66	18	67	33
Total	1	3	5	7	16	72	27	115	1 : 4	14	63	23		

TABLE 10

BARKING DEER SEX RATIOS AND ANTLER DEVELOPMENT ON A MONTHLY BASIS

Month	Males in velvet antler	Males in hard antler	Total males	Total females	Grand Total	Sex ratio	% of males in hard antler	% of males in velvet antler
March 1966		4	4	5	9	1 : 1	100	0
April 1966	2	5	7	5	12	1 : 1	71	29
May 1966	6		6	3	9	2 : 1	0	100
Total	8	9	17	13	30	4 : 3		

Barking Deer

Barking deer were never seen on the *chaur*, but were frequently observed along the roads and in the adjoining forests. Generally they were solitary, but were occasionally observed in pairs or groups of two. One pair near compartment IIIB and two males near compartment VI were repeatedly seen together. There was an indication that they may also be territorial. Asdell (1964) claims that the young are born in July and August. No small young were observed. Therefore no definite information can be given about the reproduction of this species in Corbett. Information concerning sex ratios and antler development is given in Table 10.

V. Recommendations

The following recommendations are made :

1. That forest areas adjoining the *chaur* areas to be submerged be clear-felled to create grasslands to compensate for the grazing habitat that will be lost. Artificial salt licks should also be provided in these areas to help attract animals, such as chital and hog deer, into them.

2. That controlled burning by the sanctuary staff be practised on the grassland areas of the park. Whenever possible burning should be done as early as possible in the season and at a time when it is not detrimental to ground-nesting birds or other animals.

3. That all domestic livestock grazing inside Corbett be prohibited. The Forest Department has already made very good progress towards this end.

4. That, in so far as is possible, the exploitation of forest produce inside Corbett be stopped. Exploitation should be completely prohibited in at least a few key wild life areas.

5. That the main roads inside the park be improved. If possible, they should be metalled. However, in some areas, particularly the Dhikala *chaur*, the number of roads should be greatly reduced.

6. That night driving inside the park be prohibited.

7. That transportation for visitors be provided at reasonable rates from Ramnagar to Dhikala.

8. That information concerning the park (i.e. pamphlets, folders, post cards, etc.) be made available through the Department of Tourism. Although a folder concerning the park is available at the office in Ramnagar and in Corbett, it should also be made available in the Tourist Bureaus.

9. That Forest Department personnel who show a genuine interest in wild life be employed in the park and that they be trained in the basic concepts of wild life management. Salaries in keeping with the specialized work of wild life management should also be provided.

10. That members of the Forest Department staff be enabled to visit other parks and sanctuaries in India to help them to better understand how they can improve and develop Corbett as a major tourist attraction.

11. That visitors visit the Dhikala *chaur* as a group to observe wild life and that they be accompanied and supervised by a member of the Forest Department staff.

12. That evening programmes (i.e. slide lectures) by the Forest Department staff concerning the park's wild life be scheduled regularly for visitors. Also that wild life films, specifically about Indian wild life, be solicited for use in the evening cinema being presented for visitors at Dhikala.

13. That attempts be made to show tiger regularly to visitors from well constructed machans. The provision of baits at regular intervals and the construction of artificial water-holes at these locations would probably help increase the possibilities of visitors regularly seeing tiger. There is also the possibility that the same could be done with leopard.

14. That reservations for visitors to Corbett be handled at Ramnagar, rather than in Lucknow.

15. That the possibility of regularly scheduled Department of Tourism bus tours from Delhi to Corbett be thoroughly investigated.

16. That a gift shop, operated by private enterprise but supervised by the Forest Department, be opened at Dhikala. Besides souvenirs, foodstuffs, drinks, postcards, etc., books (i.e. on the birds and mammals of India), should also be on sale.

17. That, although private enterprise should be encouraged, the Forest Department should strictly supervise the operation of tourist facilities within the park. Adequate staff (cooks, bearers, etc.) should also be provided at Forest Rest Houses other than at Dhikala.

18. That scientific studies of the park's wild life by qualified personnel be encouraged and that facilities, such as housing, be provided whenever possible, as was done during this study.

19. That wild life observations both by the staff and by visitors be kept in a permanent record at Dhikala.

VI. Acknowledgements

We wish to thank the Forest Department of Uttar Pradesh for the opportunity to conduct a study in Corbett National Park and for the accommodations and assistance which were given to us. Particularly we wish to thank Messrs. R. C. Soni (Chief Conservator of Forests), B. B. Singh (Chief Wild Life Warden), H. C. Joshi (Wild Life Warden for Corbett National Park), A. C. Agarwala and Mr. Roy (Kalagarh Subdivisional Forest Officers), D. S. Negi (Kalagarh Range Officer)

N. S. Negi (Assistant Wild Life Warden of Corbett), and Sohan Singh (Wild Life Guard).

The Forest Department is to be commended for their management of Corbett and it is our sincere desire that this study will be of value to them in the future management of this outstanding wild life area.

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A herd of Blackbuck.

(*Photo : E. P. Gee*)

The Blackbuck of Sikandra Uttar Pradesh

BY

J. JUAN SPILLETT

(*With two plates*)

Akbar's Tomb, one of India's outstanding archæological monuments, is located along the Delhi-Agra highway at Sikandra, six miles north of the city of the Taj. Thousands of tourists annually visit this impressive monument while travelling this route. Most visitors, however, are not aware that the enclosure behind these historical ruins contains a small herd of blackbuck—beautiful antelope which are unique to India. Historians have recorded that, during the reign of Akbar the Great in the latter part of the 16th century, over 1,000 Indian cheetahs were kept solely for hunting the fleet-footed blackbuck which then roamed the surrounding plains in herds of hundreds. The cheetah has since entirely disappeared from the Indian sub-continent and the blackbuck is presently becoming rare. It appears that blackbuck perpetually inhabiting the area dedicated to Akbar's memory would be a fitting tribute both to this man and the royal sport to which he was so dedicated. At the alarming rate at which these animals are presently disappearing, they might shortly become an even greater tourist attraction than the ruins which they inhabit.

Dr. George Schaller and I visited Sikandra the first part of February 1965. We counted a total of 128 blackbuck within the 50-acre enclosure and recorded sex and age ratio data. Only a few small young were present. Dr. Schaller returned to Sikandra the latter part of February and reported that five head had recently died, apparently from malnutrition or disease. The high walls surrounding the monument probably restrict the entry of dogs or other predators which might prey upon the captive herd. However, during the months between March and May most of the vegetation in the area becomes very dry and it was readily apparent that the carrying capacity of the forage within this enclosure was being exceeded, particularly during this time of year.

Messrs. Joel Cohen, Rames De, and I visited Sikandra in the latter part of January 1966. We counted a total of 104 blackbuck and again recorded sex and age ratio data. Therefore, during the intervening year the herd had diminished by almost 20%. While meeting with Forest Department officials in Delhi in the first part of February, Mr. E. P. Gee and I were informed that it had been proposed that the blackbuck be

removed from Akbar's Tomb and the area utilized in the present ' Grow More Food Campaign '. We therefore travelled to Agra and met with Mr. S. N. Singh, Superintendent of Archæological Gardens in India, on February 17. Happily we found that it had not been proposed that all of the blackbuck be removed, but only a part of the herd. We spent the better part of a day at Sikandra discussing the ' deer park ' and photographing the animals. Mr. Singh solicited our recommendations, which are as follows :

Recommendations

1. That the back (east) half of the 50-acre deer park be left untouched—a regular jungle of native plants, which will provide cover and a natural setting for the enclosed animals and also provide nesting cover for birds.

2. That if one-half of the 50-acre compound is watered the number of animals retained inside be not more than 100 (i.e. 75 blackbuck, 12 chital, and 12 chinkara).

3. That if one-fourth of the area is watered (as at present) the number be reduced to a maximum of 75 animals (i.e. 60 blackbuck, 7 chital, and 7 chinkara).

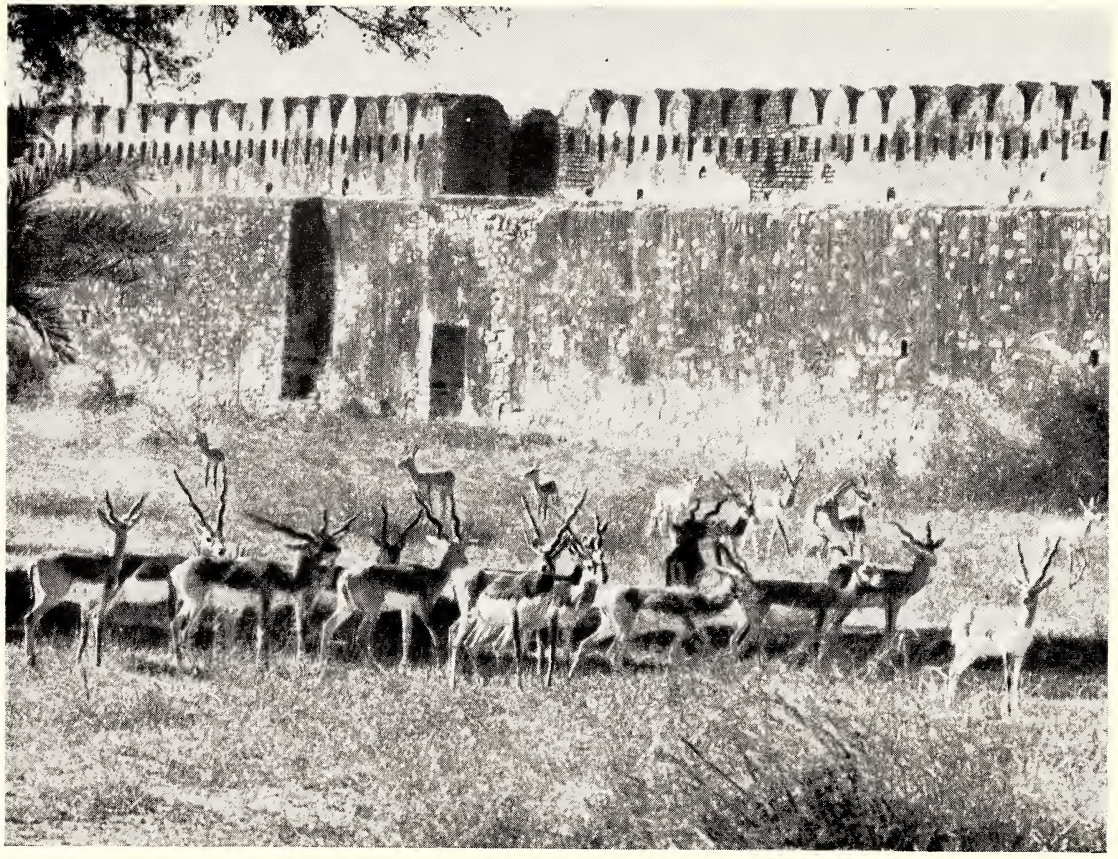
4. That, if possible, in either case approximately 60 % of the animals should be males (i.e. 45 male plus 30 female blackbuck and 7 male plus 5 female of both chital and chinkara). Males are more spectacular as a tourist attraction and a predominantly male sex ratio would reduce reproduction, and hence the efforts needed to maintain no more than the desired number of animals.

5. That if wild birds are introduced into the deer park, they be restricted to species presently or formerly inhabiting the area around Agra. For example, peafowl, red jungle fowl, and grey partridge.

6. That necessary precautions be taken to ensure that animals introduced into the park are healthy and free from diseases. Otherwise, their introduction could have disastrous results upon the fine herd already present.

7. That the deer park receive ample publicity along with the archæological attractions in the area. Blackbuck, chital, and chinkara are all species unique to India. In addition to being beautiful animals, blackbuck and chinkara are also becoming so rare that it is becoming increasingly difficult to see them in their natural setting. This park would readily provide people with this opportunity.

8. That a waterhole and salt-lick with suitable hides be provided so that those who so desire can closely observe and photograph these unique animals without disturbing them.



Blackbuck in the walled-in enclosure behind Akbar's tomb at Sikandra, U.P.

(*Photo : E. P. Gee*)

The 50-acre 'deer park' at Sikandra is divided into two 25-acre enclosures, which are connected by a narrow passageway. The blackbuck inside the enclosures can be observed readily from the elevated walk behind the tomb and along the west side. When disturbed the animals usually pass in single file from one enclosure into the other. Accurate counts, as well as sex and age ratio data, can easily be obtained during these movements. During our January visit we counted the entire herd three times with exactly the same results each time. However, during the February visit Mr. Gee and I were informed that the monument staff had recently counted the herd and claimed that it consisted of over 200 animals. A re-count gave our previous number. This is an example of how many people tend to over-estimate (count ?) groups of wild animals.

The large Mammals of the Keoladeo Ghana Sanctuary, Rajasthan

BY

J. Juan Spillett, Joel E. Cohen, and Rames C. De

I. Introduction

Keoladeo Ghana is known as one of the finest waterbird sanctuaries in India. However, it is not generally appreciated that this reserve also harbours such typically Indian 'big game' species as the blackbuck, nilgai, and chital, in addition to sambar, hog deer, leopard, and others. Schaller and Spillett conducted a census of the large mammals in the Keoladeo Ghana Sanctuary at Bharatpur in February 1965[1]. Spillett revisited the sanctuary for three days in November 1965. Although he did not attempt a census then, he spent over 20 hours walking throughout the sanctuary area and made several attempts to count all of the blackbuck. A deterioration in the abundance of the large mammals since the preceding February was apparent during this short visit and suggested the need for a thorough re-census of their populations. In order to determine exactly what changes had occurred, the authors spent six days, January 23 through 30, 1966, conducting a census of the sanctuary on foot. We repeated the census methods of Schaller and Spillett : in brief, walking three abreast and spaced so as to be able just to see each other,

[1] The Status of the Big Game Species in the Keoladeo Ghana Sanctuary, Rajasthan. *Cheetal*, Jour. Wild Life Preservation Soc. India, 8 (2): 12-16.

we covered the entire land area of the sanctuary. The sanctuary includes 7000 acres of which about half is marsh.

II. Results

Our estimates of the total population of each species, compared to the estimates of February 1965, are presented in Table. Chital, still the most abundant wild ungulate in the sanctuary, noticeably declined in numbers during the year. Though we counted only 200 individuals, we are willing to accept a generous estimate of the total population at 300 to 325 because of the extreme shyness of the animals encountered and the difficulty in observing them. Even with this allowance the population declined during the year by not less than 20%. The largest group encountered numbered 44, whereas groups of this size, or larger, were commonly observed the previous year. The animals' shyness made it impossible to collect data on sex ratios and age classes. All but a few males had antlers in velvet (later stages of development). Very few small fawns were observed.

The total number of nilgai increased markedly, by about 25%, to 152. This may be attributed to the fact that they commonly have twins. These animals were easily counted because they are large, are usually found in open areas, and were not much disturbed by our presence ; hence we believe our count to be quite accurate. We were also able to classify them according to sex and age. Of the classified adults, some 46% were males ; of these 57% were bluish and hence older, while the remainder were brownish and hence younger. Most of the males were encountered in bachelor groups of 3 to 11. The ratio of adult females to young was 1·6 to 1. The females were generally found in small groups of females and young, or in predominantly female groups which also contained one to three adult males.

Most of the blackbuck were congregated in one large herd at the time of the 1965 census and were therefore readily tallied. On the other hand, in 1966, the blackbuck were scattered in small groups in several parts of the sanctuary, which was probably due to greater disturbance. Though an accurate count was difficult, an overall decline in the population was obvious. We counted not more than 54 individuals and, though a few may have been overlooked, we believe there were less than 60 in the sanctuary. If the six or seven fawns one to three months old in the 1966 count are ignored, then approximately 30% of the population counted the previous year disappeared. About 40% of the classified adults were males ; of these 32% were black-backed and hence older and the remainder brown-backed and hence younger. The female-young ratio was greater than 3 to 1. However, some very young fawns may have been overlooked and the fawning season may not have been completed.

TABLE

THE NUMBER OF WILD UNGULATES IN THE KEOLADEO GHANA SANCTUARY, RAJASTHAN

Common Name	Scientific Name	Estimates of Numbers		Per cent. Difference (Approx.)
		February 1965	January 1966	
Chital or Spotted Deer	*Axis axis*	375-400	300-325	20–
Hog Deer	*Axis porcinus*	fewer than 20	fewer than 20	none
Sambar	*Cervus unicolor*	fewer than 20	fewer than 20	none
Blackbuck or Indian Antelope	*Antilope cervicapra*	70	fewer than 60	30–
Nilgai or Bluebull	*Boselaphus tragocamelus*	110-120	150-160	25+
Wild Pig	*Sus scrofa*	fewer than 40	fewer than 80	100+

We saw 13 different sambar : 2 males, 6 females, 4 young, and one adult not identified as to sex. We hazard no guess as to whether this species increased or decreased in abundance during the year. We still consider it unlikely that there are more than 20 in the sanctuary.

We saw only one male hog deer.

Of wild pigs, we counted 37 : a sounder of 18 (apparently two females with young), a female with 8 young, two groups of 3 adults and one of 3, and a solitary adult male. Thus the pig population increased. Because we undoubtedly missed others, we guess that the total population may number as high as 80.

We found no evidence of leopards in the sanctuary and doubt that more than one or two survive in the area. Jackal, fox, mongoose, jungle cat, hare, and other smaller mammals were seen. Indirect evidence suggested the presence of hyena, porcupine, and otter.

III. CONSERVATION PROBLEMS

Domestic Livestock

Overgrazing by domestic livestock continued unabated during the year. In addition, even the water plants from the marshy areas were being gathered as fodder, since there was obviously not enough grass. There are approximately 7000 head of cattle and buffalo descending on the sanctuary from the surrounding villages each morning and returning each afternoon. Much of the sanctuary has been trampled to bare ground or dust, thus aggravating the shortage of fodder. The most severely abused parts of the sanctuary, in the north and east, have been

reduced to near-desert. Besides cattle and buffalo, approximately 100 sheep and goats, officially prohibited from the sanctuary, were observed defoliating one area. If the present numbers of livestock are permitted to remain, much of the sanctuary will become desert within a very few years. And, very likely, the numbers of wild animals will not increase until the competition from livestock has been substantially reduced.

Since the 1965 census, the Rajasthan Forest Department has wisely fenced off a small area just north of the Rest House, and was fencing off another to the south at the time of the 1966 census. Some cattle still entered the fenced area and wild life tended to congregate there. However, even such partial protection for less than one year remarkably improved the condition and abundance of the forage within the fence.

Predation

Natural predation of the large mammals appears very slight. But the smaller carnivores, particularly mongooses, probably destroy many birds' eggs, nestlings, and smaller mammals.

Overall, the most effective predators in the area are men. In November Spillett found the head of a young chital stag and splotches of blood and hair in two areas. He also saw a female blackbuck with a broken hind leg. In January we saw a blackbuck male with a broken hind leg. Both injuries were probably caused by gun shots. In January we also found partial carcasses of five nilgai. One young animal was evidently poached, and four adults which may, or may not, have been shot.

Of the ungulates, chital are probably poached most frequently and blackbuck less. The young nilgai somewhat resemble deer and may be occasionally poached, but the adults, perhaps because of their resemblance to cattle which are protected for religious reasons, seem to be rarely shot.

The Maharaja of Bharatpur and his guests have shooting rights within the sanctuary. Although he was absent during the 1966 census, there was hardly an hour during the three-day visit in November 1965, from before daylight to well after dark, that shooting could not be heard somewhere in the sanctuary. Although the Maharaja's parties generally shot waterfowl, they took some big game as well.

Poachers took advantage of the disturbance caused by this legal hunting : shooting was also frequently heard in November from areas where the Maharaja or his guests were not hunting. During the 1966 census, we frequently heard shooting, and often saw men with guns openly travelling on bicycles along the main road through the sanctuary.

General human Disturbances

Human activity within the sanctuary was even more excessive than in the previous year. In addition to tending livestock and poaching,

villagers were gathering berries, cutting and removing grass, collecting and drying water plants for livestock feed, collecting firewood, making charcoal, and so forth. Whereas a year ago wood collectors were observed breaking limbs from growing trees, this year many of them had axes which they used to cut living branches and trees illegally to produce dead wood from live. We saw whole trees felled.

Almost invariably, when the people in the sanctuary saw wild animals, they attempted to frighten them by clapping their hands and shouting. As a result, the wild life was constantly disturbed.

IV. Recommendations

Our recommendations differ only slightly from those of Schaller and Spillett. They are :

1. That the number of cattle and buffalo be reduced immediately to a maximum of 1200 head. Each village should be given a definite grazing quota and assigned to specific grazing areas. Periodic checks should be made to ensure that these quotas are not exceeded and that animals are kept in the areas assigned. Because the villagers are charged almost three rupees per head of adult livestock per year for grazing rights in the sanctuary, this recommendation entails a substantial loss of income to the Forest Department. This loss could be converted to a large gain by enacting the following recommendation, No. 2.

2. That the Forest Department contact the central Tourist Department and arrange to include Bharatpur in the regular Delhi-Agra-Jaipur tours for visitors ; and that an entrance fee be charged all non-local visitors to the sanctuary. The increased abundance of wild life that would follow a reduction in overgrazing would attract and ensure a steady flow of tourists. The combination of these two recommendations would shift the Forest Department's source of income from the already-taxed villagers to more wealthy visitors.

3. That certain parts of the sanctuary be exclusively reserved for wild life and remain closed to all livestock. Perhaps this can best be done by fencing off certain areas, as the Forest Department has already begun to do.

4. That experimental preservation plots, including at least five acres each, be fenced off in various parts of the sanctuary. The fences should exclude both domestic livestock and wild ungulates. Such enclosures would demonstrate what the vegetation would be like if protected or properly managed.

5. That a good fence be completed and maintained around the entire perimeter of the 11-square-mile sanctuary ; and that the number of livestock entrances be reduced. At present, livestock pass through 14 legal gates and many more illegal ones, while many farmers in the surrounding

cultivated areas maintain fences or barriers to protect their crops from wandering wild animals. A secure and well-maintained fence would eliminate these problems for both the sanctuary and the farmers.

6. That Forest Department personnel patrol the sanctuary on foot at least once daily to eliminate poaching and other illegal activities.

7. That livestock in transit within the sanctuary be restricted to the main roads to reduce trampling.

8. That all so-called ' crop protection ' guns be withdrawn during non-crop seasons from the villages bordering the sanctuary ; and that no one (other than the Maharaja of Bharatpur and his guests) be permitted to carry a gun, along the main road or elsewhere, within the sanctuary.

9. That no villager be permitted to leave the main road in the sanctuary unless licensed for a particular task such as herding cattle or collecting firewood ; and that firewood collecting be strictly supervised to prevent damage to growing trees.

If strong action along the lines we have suggested is taken as soon as possible, Keoladeo Ghana Sanctuary could become a very valuable economic asset to India. It is close to other major tourist attractions ; it already offers good accommodations and could easily offer more without disturbing the wild life ; it already offers a great, but threatened, variety of wild animals and could easily offer these in fantastic numbers as well.

In addition, the Keoladeo Ghana Sanctuary could become a very valuable site for scientific studies. Besides its avifauna, which is enormous in size and complexity, the sanctuary offers three species of ungulates not found outside the Indian sub-continent and a fourth not found outside Asia. These species are living together under nearly ideal conditions for observation, in an easily accessible area of manageable size, with a potentially well-defined boundary. An ecologist could, for instance, investigate how species which differ in social systems relate to their different ecological niches, and how the social units of the different species interact. The possibilities are endless and, given the sanctuary's good living accommodations and weather, attractive.

Those who control the future of the Keoladeo Ghana Sanctuary must choose between a small income from the sanctuary, one which is sure now and equally sure to disappear soon, and a potentially much larger and assuredly long-term income from the sanctuary ; an income from those who want to enjoy it and from those who want to study it.

The choice will soon disappear if the sanctuary is left to continue as it is and the better alternative can be realized only if effective action is taken very soon.

Observations concerning the Sariska Wild Life Sanctuary, Rajasthan

BY

J. Juan Spillett

(*With one plate*)

I. Introduction

Sariska has the potential of becoming one of India's outstanding national parks. This 80-square-mile sanctuary is readily accessible to visitors throughout the year, contains areas of both natural and archaeological significance, and already has sizeable numbers of many species of wild life. Besides being one of the best areas in India for observing sambar, the sanctuary also harbours large mammals such as bluebull or nilgai, four-horned antelope or chousingha, spotted deer or chital, Indian gazelle, and wild boar. In addition, the sanctuary and its staff have already established a notable reputation for showing tiger regularly to visitors. Leopard are also occasionally seen. However, before Sariska can begin to realize its potential and even before its wild life can begin to attain the vast numbers which it could potentially support, a number of problems must be confronted and overcome.

II. Problems

Domestic Livestock

The major problem confronting Sariska, as well as most of the wild life sanctuaries in India, is the cancerous disease of overgrazing by domestic livestock. Approximately 10,000 head of livestock, including buffalo, cattle, goats, and camels, are presently grazed inside the sanctuary for a fee. However, based upon my limited observations, the actual

number probably far exceeds the reported 10,000 head. For example during a short walk east of the Tourist Rest House, I observed over 500 goats, almost 200 buffalo, over 100 cattle, and two camels. The number of sheep inside the sanctuary is reported as negligible, but I observed over 300 head. In contrast to fantastic numbers of domestic livestock, only nine nilgai were observed during this walk. It appears rather ironical to call many areas wild life sanctuaries when the numbers of domestic animals far exceed that of the wild animals !

Sariska was visited during the middle of May, which is near the end of the dry or summer season. Most of the domestic animals observed in the sanctuary were extremely thin and emaciated. Such animals are of little value to anyone. They cannot work, they produce no milk, and in such a condition they are often not even able to breed. Without exception, all the areas which I visited inside the sanctuary were severely overgrazed. All available forage had been utilized and many areas were badly trampled. Due to recent rain, evidence of erosion was also present.

Villages

The second major problem confronting Sariska is the presence of villages inside the sanctuary. Most of these villages are small and their total population is probably less than 2500 people. Although these villagers cultivate little land, most subsist primarily upon grazing animals. Domestic buffalo are their primary source of income and goats and cattle take secondary importance. Milk from these animals is used chiefly in the production of ghee (clarified butter), but some milk is also sold to the Central Training Institute of the National Fitness Corps located in the former shooting lodge of the Maharaja of Alwar across the highway west of the tourist rest houses. The presence of these villages creates a number of problems. First, as has already been discussed, overgrazing by their livestock is a major problem. Forest abuse and other practices, such as crop protection or poaching with muzzle-loading ' crop-protection ' guns, also present difficulties to the sanctuary. It would be desirable, if at all possible, to resettle these villagers and their livestock on other forest department lands outside of the sanctuary. Such action would eliminate most of the sanctuary's major problems.

It is realized that to advocate the maintenance of Sariska as an inviolate wild life sanctuary at the present is impractical. However, a few key wild life areas could be selected and maintained as inviolate to all commercial exploitation, including the grazing of domestic livestock and the extraction of forest produce. The ancient practice in India of establishing a ' sanctum sanctorum ' has worked very well in other areas, such as the Bandipur Wild Life Sanctuary in Mysore. Initially it may be necessary to fence off such an area, but this could quite easily be done with relatively few materials in one of Sariska's picturesque canyons.

Even without considering the sanctuary or its wild life, simple economics demand that all grazing and forest exploitation in the commercially exploited areas be strictly controlled and managed. In addition to collecting fees for all domestic livestock, methods must be devised so that animal numbers do not exceed the carrying capacity of the forage. Rotational grazing methods should be considered. These would at least ensure that all grazed areas would periodically be protected from all grazing for an entire year. This would permit forage plants to set seed and perhaps permit the re-vegetation of the most desirable plant species. All management should seek to provide the greatest returns for all concerned, while, in so far as is possible, leaving the sanctuary and its wild life unimpaired as a part of the nation's heritage. Only by so doing can the greatest benefits for all be realized.

Other Problems

Poaching, particularly from vehicles along the sanctuary's roads, does not appear to be a major problem in Sariska. This is further demonstrated by the fact that most wild animals in the sanctuary pay little heed to approaching vehicles. However, these same animals are often extremely wary of a man on foot. Most of the poaching that does occur in Sariska would probably be eliminated with the removal of villages from inside the sanctuary.

Visitor facilities presently consist of two tourist rest houses at Sariska. Each accommodates four people. The Forest Department is constructing another near-by rest house, which will accommodate an additional 14 persons. Therefore, the sanctuary will have accommodations for 22 visitors for the 1966-67 season. However, even this will not be sufficient during the peak visitor season between November and April or to accommodate entire groups arriving by Tourist Department tour buses. It is suggested that additional dormitory facilities be constructed or that as soon as the new tourist rest house is completed the other two be converted into dormitories. Not all facilities need to be first class, but accommodations for a minimum of 40 persons are essential so that visitors may be provided at least basic facilities or accommodations.

III. Advantages

Accessibility

Although problems confronting Sariska have been presented, the potential or advantages of this unique area by far outweigh the problems. The major advantage is that of accessibility. Many of India's sanctuaries or parks are virtually inaccessible to the average tourist or to a person without a vehicle. In contrast, regular daily bus services between Delhi and Jaipur will drop or pick-up the visitor to

Spillett : Rajasthan Sanctuaries.

Above : The Tourist Lodge and lake at Van Bihar. *Below :* A chital stag with antlers in velvet in Sariska.

(*Photos : J. Juan Spillett*)

Sariska at the gate of one of the tourist rest houses. The well-constructed and scenic National Highway No. 8 passes directly in front of the rest houses and passes through 13 miles of the sanctuary. Delhi is 124 miles to the north and Jaipur 67 miles to the south. Extending from the National Highway the metalled Pandupole-Thela Road forks six miles inside the sanctuary. One fork continues an additional seven miles to the Pandupole Temple and the other also seven miles to the village of Thela. Both pass through exceptionally scenic canyons inhabited by sambar and nilgai. In addition to metalled roads, forty miles of fair weather roads are maintained inside the sanctuary. A jeep is provided by the Forest Department for the use of visitors so that they may easily observe the wild animals.

Scenic and Other Attractions

Sariska consists primarily of a desert scrub forest intersected with steep rocky canyons. The sheer rock cliffs and the frequent oases of palms combined with the ease with which visitors can view wild life all make Sariska a unique experience. Excellent opportunities of seeing tiger at a kill from a comfortable and well-constructed tower, visiting the interesting Pandupole Temple (site of regular pilgrimages), viewing or climbing the stairway through a large natural arch or bridge, or visiting the partially excavated archaeological ruins dating back to the 9th century should make a visit to Sariska a memorable experience for anyone. These numerous attractions deserve national attention. It appears that not even a portion of the full potential of this fabulous area is realized. Sariska should not be considered as just another wild life sanctuary, but as a part of the nation's heritage and a valuable economic asset. A small but well-planned and managed capital investment in Sariska could easily result in a bounteous harvest.

Revenue

Although the potential of Sariska as a notable tourist attraction has not begun to be realized, the sanctuary is already a source of substantial amounts of revenue. An income of between Rs. 1·5 and 2·0 lakhs is annually realized from the sanctuary's forest produce. This is chiefly from the commercial exploitation of *dhok* (*Anogeissus pendula*) and other tree species (i.e. *Acacia* spp. and *Zizyphus* spp.) for firewood or the production of charcoal. The production of *katha* (a paste used on betel leaf) from the heartwood of *khair* (*Acacia catechu*) is also of importance.

Grazing fees for domestic livestock presently total between Rs. 50,000 to 60,000 per annum. Professional graziers are charged Rs. 10 per adult buffalo for camps inside Class I forest areas (the best grazing), while villagers are charged Rs. 8 per head in these same areas. A Rs. 6 fee is charged per adult buffalo in Class II areas and Rs. 4 in Class III or the most arid parts of the sanctury. Fees for adult cattle are Rs. 3

Rs. 2·50, Rs. 2, and Re. 1 respectively. A fee of Rs. 1·25 is charged per adult goat kept in the Class I areas, while Re. 1 is charged for those in the other areas. Fees are not charged for juveniles or young animals accompanying their mothers. A flat rate of Rs. 6 is charged for camels, which are restricted from the 'heart' of the sanctuary. There are no rules or regulations at present for the control of livestock numbers. Just as long as the fees are paid, villagers or professional graziers can graze as many head of livestock as they desire inside the sanctuary. A penalty is levied on those encountered with more animals than for which they have paid fees. Such animals are not removed but remain inside the sanctuary upon payment of the penalty by their owners. As a result, land abuse by overgrazing gradually increases and livestock numbers continue to spiral upwards. Unless drastic measures are soon taken to control livestock numbers, revenue from grazing fees will gradually disappear with the forage.

Revenue from visitors to Sariska presently constitutes only a very small proportion of the sanctuary's total income. However, indirect benefits to the State and the nation from the presence of Sariska are substantial, but difficult to determine precisely. For example, each visitor probably spends more travelling to and from Sariska than he does inside the sanctuary. These expenditures also contribute to the economy of the nation, particularly in the case of foreign tourists bringing foreign exchange into the country. These benefits are also apart from the aesthetic and recreational values of Sariska.

The emphasis in Sariska should be shifted from commercial grazing and forest exploitation to tourism based upon wild life conservation. This would eventually result in much greater returns to the sanctuary, the State, and the nation. However, under the present rate of abuse this potential source of revenue will soon vanish and even that realized from grazing and forest produce will continually decrease unless strict measures are soon undertaken to manage these priceless resources. On the other hand, sound conservation practices in only a few parts of the sanctuary left open to commercial exploitation would probably result in greater long term returns, both from grazing and from the forests, without greatly impairing the other values of the sanctuary.

IV. Recommendations

The following recommendations are made :

1. That the grazing of domestic livestock and the exploitation of forest produce inside the sanctuary be strictly controlled and managed.
2. That the numbers of domestic livestock be reduced to the carrying capacity of the forage and that rotational grazing or other scientific methods of range management be employed.

3. That key wild life areas be selected and maintained as a ' sanctum sanctorum ', which would be strictly protected for the exclusive use of wild life.

4. That villagers and their livestock living within the confines of the sanctuary be re-settled outside the sanctuary on other Forest Department lands.

5. That accommodations for a minimum of 40 visitors be provided within the sanctuary and that the present practices of providing transportation within the sanctuary and showing tiger to visitors be continued.

6. That a publicity programme extolling the numerous attractions of Sariska, such as its scenic and archaeological significance and its wild life, be initiated and that information concerning the sanctuary (i.e. pamphlets, folders, etc.) be compiled and made available to the Department of Tourism so that tourists will become aware of this unique sanctuary and the facilities which it provides for their use.

7. That the Department of Tourism be contacted and that Sariska be included in their scheduled Delhi-Agra-Jaipur-Delhi bus tours. The Keoladeo Ghana Sanctuary at Bharatpur should also be included in these tours. There is a possibility that regular tours exclusively for these sanctuaries would be profitable.

8. That scientific studies of the sanctuary's wild life by qualified personnel be encouraged and that facilities (i.e. accommodations, etc.) be provided for their use whenever possible.

9. That wild life observations by both visitors and Forest Department personnel be kept in a permanent record in the sanctuary.

10. That Forest Department personnel who demonstrate a genuine interest in conservation and wild life be employed in the sanctuary and that they be trained in the basic concepts of wild life management.

Notes on the Van Bihar and Ram Sagar Wild Life Sanctuaries, Rajasthan

BY

J. Juan Spillett

The 11-square-mile Van Bihar (often spelled Van Vihar) Wild Life Sanctuary is located 14 miles from the town of Dholpur in Rajasthan. Dholpur can be reached by regularly scheduled bus services from Agra, which is 36 miles to the north. A 12-mile link road leads to the sanctuary from the Delhi-Madras National Highway No. 3. A metalled road continues almost to the edge of the sanctuary, but bus services turn west at the crossroads four miles from the Tourist Lodge. Therefore, unless one wishes to walk the last four miles, a tonga or other means of transportation must be arranged in Dholpur. The smaller (approximately 8-square-mile) Ram Sagar Wild Life Sanctuary lies 12 miles west of the Van Bihar Tourist Lodge. Both are located in a plateau-like area, which overlooks the surrounding desert country. The vegetation consists of desert scrub—thick forests of short trees, such as *Khair* (*Acacia catechu*), *babul* (*Acacia arabica*), *dhok* (*Anogeissus pendula*), and thorny shrubs, which are typical for much of this region. Both sanctuaries are administered by the Forest Department and the same staff, which consists of a Game Warden and a number of Forest Guards.

The Van Bihar Tourist Lodge is an imposing castle-like structure with a walled-in courtyard. It has a beautiful setting on the edge of a small lake. Numerous peafowl inhabit the grounds ; and wild animals, such as chital and nilgai, can be observed from the lodge's balconies during their early morning or evening visits to the lake. The lodge formerly belonged to the Maharaja of Dholpur, who regularly visited this area and was famous for his kindness to wild animals. It is claimed that while driving through the sanctuary he would ring a bell and the wild animals would flock from the forests to greet him and to be fed from his hand. It is even claimed that such predators as tiger did not fear him and graciously received his affections.

My visit to Van Bihar was in mid-February, the start of the summer or dry season in this area. The trees were barren of leaves and all available forage had already been eaten by domestic livestock. Conditions were so bad that the livestock camps inhabiting the sanctuary (the entire area is utilized, or rather abused, by domestic animals) had previously left the area. The bare rocky soil and naked trees presented a bleak picture and it was difficult to imagine how the wild animals could survive until the rainy season in June. During two days of walking throughout the

sanctuary's forests, I observed fewer than 100 chital and most of these were in the vicinity of the small lake in front of the tourist lodge. I was able to classify 61 of these animals as to age and sex : 15 adult males (the antlers of 4 were in velvet and those of 11 were hard), 34 females, and 12 small young (1-2 months old). The adult sex ratio of over two females per male indicates a much higher mortality rate for males than for females, perhaps from shooting. Small groups of nilgai were encountered, which consisted primarily of female with small young less than two months old. All were exceptionally shy and the total number observed was less than 40. Approximately 27 chinkara or Indian gazelle were also seen inside the sanctuary. No sign of tiger was observed, although they were reported to inhabit the sanctuary. Surprisingly, however, I did observe the tracks of a leopard.

Greater numbers of wild animals can be observed from the tourist lodge at Van Bihar than by walking throughout the sanctuary. The Forest Department staff regularly provides paddy along the edge of the lake opposite the lodge for the wild animals such as chital, which congregate here in the early mornings and evenings. A casual visitor readily observing these animals would probably tend to assume that the sanctuary harbours much larger numbers of wild animals than it actually does.

Although I only briefly visited Ram Sagar by jeep, the status of the wild life in that sanctuary appeared even more bleak than in Van Bihar.

It appears that the Van Bihar and Ram Sagar Wild Life Sanctuaries are presently little more than glorified shooting camps. Evidence which I observed that further substantiates this claim has been given to the Forest Department. It is readily apparent that the situation is not what it should be for areas classified as wild life sanctuaries. There is also little reason to permit domestic livestock to devastate a wild life sanctuary, or any other area, to such an extent that even they must be removed to other areas to enable them to survive for a good part of the year.

General Wild Life Conservation Problems in India

BY

J. JUAN SPILLETT

(*With two plates*)

CONTENTS

I. INTRODUCTION

Many people have the mistaken idea that conservation means the 'locking up' of natural resources so that they cannot be utilized and hence are of no value to anyone. This is not true. In extreme cases conservation may be synonymous with preservation, such as when an attempt is made to save a threatened species from extinction. However, conservation basically means the wise *use* of natural resources so as to provide the greatest benefit to the greatest number of people in the long run. Therefore, true conservation involves both the use and the preservation of natural resources, which when destroyed oftentimes cannot be replaced.

Can you imagine a farmer not retaining a portion of his harvest or at least ensuring that he will have seed for the forthcoming year? However, the livestock grazier often permits his livestock to devour every available blade of grass or all of the vegetation without realizing that at least 25% of the forage plants should be left to provide seed, as well as protection for next year's forage crop.

Likewise, the poacher rarely thinks of leaving sufficient breeding stock for next year's game harvest.

India has been richly endowed with precious natural resources. Many of these, however, already have been destroyed or lost due to ignorance, tradition, apathy, or political expediency. On every side the remaining natural resources of this country are confronted with what often appear to be insurmountable barriers. Unless the leaders of India are soon able to implement definitive measures and initiate sound conservation practices, little more than want and poverty and the eventual weakening of this great nation can be expected.

II. Domestic Livestock

India is basically confronted with two major problems. I firmly believe that if these were brought under control, the numerous other problems which are presently receiving so much attention and publicity, such as the scarcity of food, lack of foreign exchange, poor living standards, and so forth, would eventually resolve themselves. Ironically neither of these problems is a lack of something. In fact, both are a matter of having too much of a resource. These two problems are: (1) too many people, and (2) too much domestic livestock. The former is recognized by the Government and is gradually becoming recognized by the general public as a major problem. Steps are being taken to bring India's population explosion under control. However, the latter problem, that of overgrazing by domestic livestock, is not even recognized as a problem by the vast majority of the people. And those that do recognize it as such are doing little, if anything, about it.

Overgrazing by domestic livestock is like cancer—it often overcomes its victims without them even becoming aware of its presence until it is too late. Unless an area is drastically abused, people not trained in conservation or range management may not be able readily to distinguish an overgrazed area from one that is in good condition. It must be realized that animals, both domestic and wild, cannot thrive on just any available greenery. They, like humans, must have a balanced diet of both palatable and nutritious forage to remain healthy and vigorous.

With the abuse of overgrazing, the most palatable or desirable plants are the first to disappear. They are followed in turn by the next most desirable plants and so on until eventually all that remain are plants which the animals would not normally eat, let alone depend

upon for a staple diet. All too often the whole ecology, hence both the floral and faunal composition, of entire regions have been changed by the unwise practice of overgrazing. Nature wisely placed checks or balances, such as predators, to control grazing by wild animals. However, with his domestic animals, man often fails to recognize the facts that nature has repeatedly demonstrated to him. As a result, forests are turned into deserts and choice grasslands are converted into barren wastes.

When discussing the all too common problem of overgrazing in India's forests and sanctuaries, I am almost invariably told by officials that the problem is realized, but that it is impossible to control grazing by domestic animals in a democracy such as India's. This is faulty reasoning. No government, particularly a democratic one, should permit its people to destroy the nation's most priceless possession—its land. Many feel that in a democracy public property belongs to everyone. But this does not mean that the people are free to destroy the public domain. For example, a public building belongs to everyone just as much as does a reserved forest or a wild life sanctuary. However, no one is allowed to destroy such buildings or to remove materials from them for private use.

The destruction of public forests and lands by men and their livestock is of greater consequence and the effects are much more drastic and longer lasting than the destruction of any public building. A building can be rebuilt in a relatively short time, but a forest converted into a desert or the loss of a single inch of precious top soil cannot be restored or may take centuries to replace. Must an entire nation suffer because of land abuse by a relatively few people and their livestock?

I have so far discussed the threat from overgrazing to India as a whole. Now what about one of her most valuable natural resources, her wild life? Domestic livestock grazing presents a triple threat to wild life: (1) direct competition, (2) diseases and parasites, and (3) disturbances.

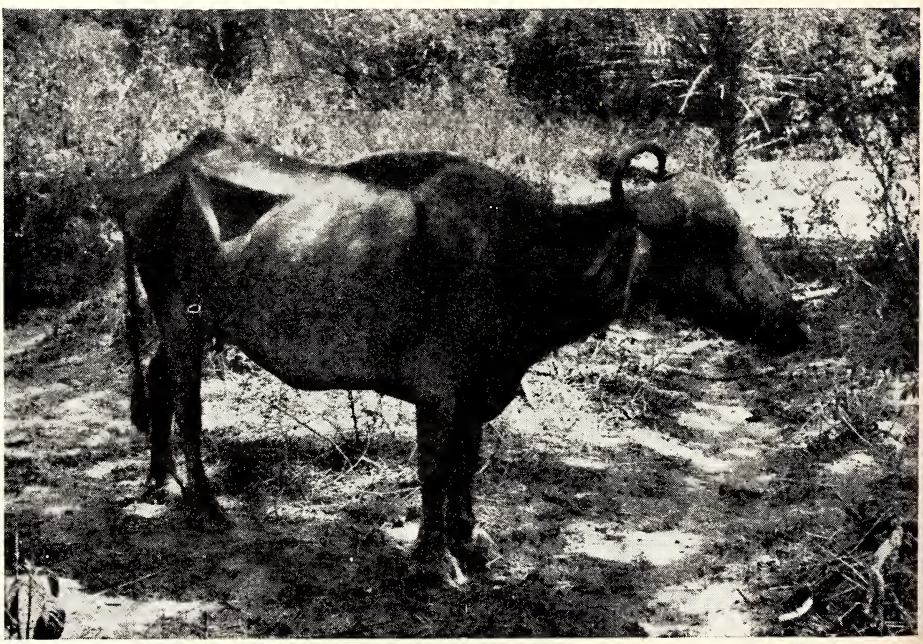
Many wild ungulates, like domestic livestock, are primarily grazers. Therefore, when the two inhabit the same area there is direct competition for forage. Domestic livestock may be provided with supplementary feeds, particularly during times of drought or hardship. The wild animals, on the other hand, must depend entirely upon the available forage. Therefore during 'bottle-neck' periods, such as drought and flood, they often have to struggle to survive. This is particularly true if they inhabit overgrazed areas.

Whenever animals are in close proximity to each other there is

Spillett : Conservation Problems in India

Above : Domestic livestock grazing inside a forest. *Below :* Part of a wild life sanctuary overgrazed by domestic livestock.

(*Photos : J. Juan Spillett*)



Above : Typical rural scene — too much livestock *(Photo : E. P. Gee)*. *Below :* Is an aged domestic animal like this of any value *(Photo : J. Juan Spillett)*

the possibility of disease or parasite transmission. Through centuries of adaptation, many domestic animals have become resistant or immune to diseases which often prove fatal to their wild relatives. Therefore the presence or introduction of domestic animals into areas inhabited by wild life presents the threat of introducing diseases or parasites, which may prove disastrous to wild populations.

Precautions should be taken to prevent the incidence of disease among domestic animals. These measures include: (1) the inoculation of livestock for the prevention of disease, (2) the immediate removal and disposal of unhealthy or sick animals, and (3) the maintenance of good forage conditions so that animals can maintain their health and vigour to resist disease. It should be noted that there are as yet no effective vaccines to combat diseases such as foot-and-mouth disease. The presence of diseases of this nature may take a heavy toll of both wild and domestic animals.

Mr. E. P. Gee (1955) reported:

> 'There are innumerable cases of valuable wild animals dying wholesale from epidemics spread by domestic cattle and buffaloes. In Kaziranga Sanctuary of Assam, for example, many rhino died in 1944 and in 1947, presumably from anthrax; and some wild buffalo died in 1952 from rinderpest, and in 1953 from haemorrhagic septicemia. As many as 150 wild elephants are believed to have died in the Reserved Forests of the North Cachar Hills in Assam in 1949 from anthrax. The "Indian bison" or gaur have become scarce in many places in north-east India and south India due to cattle-borne diseases.
>
> 'In the Hailey (Corbett) National Park, moreover, I was informed that there were severe outbreaks of rinderpest in 1942 and 1947, in which countless chital are reported to have perished, and probably hog deer, barking deer and sambar as well.'

The grazing of domestic livestock also invariably requires or results in the presence of herders and other people. These often create disturbances which some wild animals cannot tolerate. This is particularly true during certain seasons of the year, such as the mating or calving periods of particular species. Undue disturbances during these times may so alter the normal behaviour patterns of some wild animals that they will dwindle in numbers and eventually disappear from an area. For example, many animals prior to mating have extended periods of courtship or displays which ensure that their mating is successful. However, if courting animals are repeatedly disturbed, they may never mate successfully. As a result, there will be no offspring. Also females with recently born young often abandon them if they are frequently disturbed or if their young are touched by humans.

Admittedly domestic livestock forms an important and necessary part of a nation's economy. But it is generally recognized that in most parts of India where domestic animals are grazed, severe over-

grazing is the general practice. Primarily due to overgrazing by domestic livestock, India already has the notoriety of having created the largest man-made desert in the world. Also, due to continued land abuse, the Rajasthan Desert continues annually to enlarge its boundaries. Certain supposedly learned men still continue to advocate that India needs more livestock. Why?

It is a historical fact that more nations have fallen because of land abuse, such as overgrazing by domestic livestock, than by all other factors combined, political or otherwise. Tradition and false sentiment must be replaced by sound management, based upon facts, if a nation is to thrive and flourish. The misconception that numbers of animals determines wealth must be replaced by the fact that quality, not quantity, is the goal to be achieved.

The average milch cow in India produces less than one litre of milk per day. Whereas in many developed nations, such as the Netherlands, it has been found uneconomical to keep a cow that does not produce over 20 litres of milk per day. Most of India's valuable forage is being used just to maintain domestic animals, with little or no return to their owners for their financial investment. A single well-fed animal will often be of greater value and give a much greater return than ten or more poorly-fed animals. Also, present schemes to improve the breeds of domestic livestock in India will be of little value unless there is sufficient good quality forage to maintain such animals in a healthy and vigorous condition.

Draft animals or bullocks are also important in an agricultural economy such as India's. But all too often one sees large numbers of livestock, the majority of which are unfit for work, which do not produce any milk, and even are many times unable to breed. It is their lot to continue denuding, as best they can, an already almost sterile land, giving little or nothing in return until they eventually die from starvation or disease.

India's first Prime Minister, Mr. Jawaharlal Nehru, stated the following in the foreword to Mr. E. P. Gee's notable book (THE WILD LIFE OF INDIA):

> 'In India, perhaps even more than in other countries, there is this difference between precept and practice. In no country is life valued in theory so much as in India, and many people would even hesitate to destroy the meanest or the most harmful of animals. But in practice we ignore the animal world. We grow excited about the protection of the cow. The cow is one of the treasures of India and should be protected. But we imagine that we have done our duty by passing some legislation. This results not in the protection of the cow but in much harm to it as well as to human beings. Cattle are let loose and become wild and become a danger not only to crops but to human beings. They deteriorate and the very purpose for which we value the cow is defeated.'

Grazing by domestic livestock must be controlled. The time to act is now. Tomorrow may be too late. Tradition, false sentiment, apathy and political expediency must be replaced by sound conservation practices based upon facts if this nation is to thrive and flourish.

III. Encroachment and Exploitation in National Parks and Sanctuaries

Certain people in India today may be advocating the elimination of wild life sanctuaries and the cultivation of forest lands. They contend that a 'poor' nation such as India, particularly during the present food crisis, cannot afford 'luxuries' such as wild life sanctuaries or even forests. On the other hand, experts state that to maintain the basic economy of a nation a minimum of 1·0 acre of forests *per capita* must be perpetually maintained. India presently has only 0·54 acre *per capita* and many lands classified as forest lands are little more than barren wastes. 'Poor' nations, such as India, cannot afford *NOT* to have sanctuaries, parks, and forests!

Most of the best agricultural lands in India have been under cultivation for centuries. Attempts to cultivate the relatively few remaining forest areas, the vast majority of which are on marginal lands, will eventually result not in increased food yields, but in the destruction of other lands better suited to agricultural use. It is difficult for many to realize that the wanton destruction of forests and grasslands by such practices as overgrazing, or the cultivation of marginal agricultural lands, usually results in drought, such as India has just recently experienced, followed by devastating floods, which under the present practices of land abuse she may expect in the near future.

The presence of sufficient natural or well-managed forests modifies climatic extremes, builds or enriches the soil, and prevents water run-off, erosion, and floods. The existence of a forest may lower the temperature in that area as much as 30° F. during the summer months, while making it as much as 10°F. warmer during the cold winter months. Forest vegetation and humus gradually release their water, which is stored during the rainy season. Therefore, their presence helps to eliminate periods of devastating flood followed by periods of drought.

India has been endowed with some of the most extensive and richest agricultural lands in the world. However, in the use of these lands she has the notoriety of producing lower crop yields than any other country in the world. Nevertheless, she presently produces

enough food to feed her almost 500 million people. But due to primitive farming methods, waste in harvest and storage, and losses to birds, rodents, and insects, she must invariably seek aid from abroad.

Rodent studies, which I conducted in Calcutta between October 1964 and January 1966, demonstrated that in an average Calcutta grain storage godown rats were daily destroying the rations of over 10 human beings. International agencies, such as FAO (Food and Agricultural Organization of the United Nations), have estimated that the annual loss of food grains in India to rodents alone is probably about 30% of the total production. If food losses to rodents were controlled, even with her present food production India could be a food-exporting nation. Agricultural experts claim that many farm lands in India could easily quadruple their present yields. Even if yields were only doubled, India could become the greatest food-exporting nation in the world! There is little or no ecologically or economically sound basis upon which to advocate overgrazing or the agricultural use of wild life sanctuaries, parks, or reserved forests.

It may be argued by some that forest products inside sanctuaries or parks should be exploited. However, if such is permitted, where is the line to be drawn? If the cutting of thatch and reeds is allowed in one area, how can it be prohibited in others? Or, if such cutting is permitted, why not permit the cutting of trees? If people are allowed to collect dead wood for fuel, how can they be restrained from making dead wood out of live? If fishing is allowed, then why can't the other animals also be harvested? Each of these activities disturbs the wild life. If such activities are permitted, the area no longer remains as a sanctuary or park. Instead, it soon becomes only another depleted area—like too many thousands of others throughout India.

Numerous examples could be cited of how the flora and fauna in many of India's sanctuaries has been completely devastated by the ever-increasing demands of the local people for the exploitation of their natural resources. The results in many cases have been the conversion of once beautiful and choice areas, with great economic potential, into little more than deserts which are of little value to anyone. India is a huge country endowed with vast natural resources, many of which have already disappeared or have been lost due to political expediency or to a lack of understanding as to the true meaning of conservation. Isn't India large enough so that at least a remnant of its wild places, with both their native flora and fauna, can be maintained in their natural state as a part of the nation's heritage?

IV. Poaching

Poaching is in reality an uncontrolled and generally non-selective type of predation. When legalized and properly managed it becomes known as shooting or hunting. Selective harvesting of game animals in many areas is an important and even a necessary part of wild life conservation. Shooting, however, should always be controlled and based upon conservation principles, which ensure that the species involved will be maintained on a sustained yield basis. Poaching, combined with habitat abuse or destruction, has presently attained such proportions in much of India that with many species of Indian wild life it is now more a matter of preservation rather than sustained yield management. It is also imperative that at least a few select areas be maintained, in so far as is possible, in their natural state. These generally are recognized as national parks or wild life sanctuaries. Besides serving as tourist attractions and recreational areas, these also serve as outdoor laboratories and as a gauge with which to compare management practices in areas where shooting is permitted. I regret to report that at present many Indian sanctuaries dedicated to this end appear to be little more than glorified shooting camps. I have occasionally blundered into situations, while visiting India's wild life sanctuaries, which I am sure that officialdom and the general public do not realize exist.

Those participating in shooting, as it should be practised, often gain an insight as to the value and beauty of wild life. As a result, many of today's most avid conservationists are sportsmen who, through their outdoor experiences or shooting, have come to realize some of the problems faced by the country's dwindling wild life and hence are some of the most staunch advocates of wild life conservation. The poacher, on the other hand, usually fails to recognize that through his unethical practices he is eliminating one of his present sources of food or income. Also, with ever increasing pressures from human population, it is imperative in many cases that the rifle be replaced by the camera and the note-book if even remnants of the nation's wild life are to be preserved for the enjoyment of future generations.

The poacher in some cases is also reducing the grazing capacity of the land. This may at first sound ironical, particularly when you consider that he is subtracting rather than adding animals. However, through the aeons of time nature has evolved what is often termed 'the balance of nature'. Nevertheless, this is a dynamic 'balance', which is kept on an even keel by numerous natural checks. Generally

speaking, each plant and animal species in a natural environment plays a specific or special role in the overall scheme of nature. For example, some animals feed upon particular plants, while others prefer different ones. Then, of course, the predatory animals prey upon the herbivores so that they will not overly abuse the forage. Thereby, in a natural community the plants and animals are interrelated and the entire habitat is usually used to its full potential.

The African Black Rhinoceros (*Diceros bicornis*), in contrast to the Great Indian One-horned Rhinoceros, is primarily a browser. It feeds to a great extent upon thorny shrubs, which are unpalatable to most ungulates. By keeping such shrubs in check, it has been observed that the carrying capacity for grazing ungulates in a given area is often increased by the presence of the Black Rhinoceros. Livestock graziers in North America for many years advocated the removal of deer from their cattle grazing areas. They thought that their removal would result in more forage for their domestic livestock. However, just the opposite was found to be true. The deer species concerned were primarily browsers, while the cattle were grazers. The deer held the shrubs or woody plants in check and thereby favoured the growth of grass and increased the grazing capacity of the range for cattle. As a result, most cattle graziers in North America presently welcome deer on their grazing lands. In short, except in national parks and wild life sanctuaries, wild life conservationists do not advocate that livestock grazing be abolished. But that both the livestock and the wild life be properly managed so as to provide the greatest benefit for everyone.

Mr. E. P. Gee (1964) related how wild life conservation is somewhat of a tradition in the long history and culture of India. The treatise on Statecraft called the ARTHA SHASTRA, attributed to Kautilya about 300 B.C., provided for the protection of certain forests and their wild life. Also, in 242 B.C. the Emperor Asoka's fifth pillar edict gave protection to fish, animals, and forests. The rulers of many of the princely states also practised conservation in order to ensure the continuance of big and small game shooting. Since Independence in 1947, however, much of this good work has been undone by some people who, believing that the wild animals are rightfully theirs, sally into the forests to massacre whatever they can find. The most effective deterrent for poaching is conservation education. In its absence or until it can be universally achieved, the only remedy is strict law enforcement. These will be discussed in more detail in the following pages.

The poacher is actually a thief. He is stealing from his fellow

citizens of both today and tomorrow that which is rightfully theirs. Unless his depredations are soon brought under control, much of India's priceless and irreplaceable wild life will be lost forever. Man may again build a Taj Mahal, but once he exterminates a living species—that creature is lost forever.

V. Law Enforcement

Many people, particularly in some of the relatively new democratic nations, have the mistaken idea that democracy means that everyone is free to do as he pleases. Oftentimes they think that, because the public domain belongs to everyone, they have the right to take what they want from it. For example, many simple people feel that when they illicitly take natural resources from sanctuaries or reserve forests they are only taking that which rightfully belongs to them. This is not true. Democracy is dependent upon law and order and no one has the right to infringe upon the rights of others. Democratic laws are established not only for the maintenance of order, but also for the protection of the innocent and the punishment of the guilty. Although the public domain does belong to everyone, it is held in trust by the Government or appointed departments for the benefit of all—not just for the benefit of the few that take it upon themselves to take from it what they can.

Democratic laws are formulated by elected representatives of the people. Therefore, it behoves each and every citizen to strive to elect men that will formulate only good and just laws. If a law that is in force is not just, a loyal citizen will do all that is *legally* within his power to have it changed or repealed. But while so doing, he does not have the right to break that law.

The Forest Department is charged with the protection and management of all State forest lands, including parks and wild life sanctuaries, for the maximum benefit of the public. In order to meet these obligations, rules and regulations have been established both as guides to the public and for the Forest Department personnel. In turn, the Forest Department staff is charged with the responsibility of enforcing these rules and regulations. If a Forest Department officer knowingly permits their violation, he also becomes an offender and should be recognized as such. Negligence in protecting the public domain should not be tolerated.

Forest Department personnel, however, should be delegated sufficient legal authority to enforce the law in areas under their

jurisdiction. In many cases they do not have such authority. For example, many Forest Guards are armed, but they are not permitted to use these arms in enforcing the law, but only as a means of self-defence. At present even when a person is detected in the act of committing a violation they merely have to flee in order to avoid being taken into custody and to escape punishment. The most a Forest Officer can do is to attempt to apprehend the law-breaker by peaceful means. By so doing he runs the risk of bodily injury to himself and gains nothing in return for apprehending the culprit. As a result, relatively few people that violate the laws of the public domain are taken into custody and even fewer are tried by a court of law for their offences.

Violations, such as the cutting of thatch or reeds, gathering of firewood or even poaching in a wild life sanctuary, may be considered by many as only minor offences. However, it should be recognized by all that resisting or attempting to avoid arrest by an authorized representative of the law, such as a Forest Guard, is a major offence and should be dealt with severely. Although the taking of life should never be advocated, surely a public servant charged with the protection of the public domain should have the legal right to use force, if necessary, to carry out his duties. This might include, if need be, the shooting (only to injure) of violators attempting to avoid arrest. For example, if a Forest Guard encounters someone violating the laws of a sanctuary, he should inform them in a loud clear voice that they are under arrest. If the violator attempts to flee, a warning shot should perhaps first be fired and, if the person does not then halt, it is clearly evident that they are resisting arrest, which is a major offence. The Forest Guard should then have the legal right to do all in his power, including the use of force or firearms, to take the person into custody. Acting as a representative of the Government, he should also be absolved of any responsibility for injuries to others resulting from his action in attempting to enforce the law. However, those taken into custody should never be abused and as quickly as possible should be turned over to the civil authorities and brought before a court for trial.

A system of rewards and punishments should also be established, if not already in force. If Forest Department personnel take determined action and the risks involved in apprehending and taking into custody those violating the law, they should be rewarded for their efforts. This would also provide an added incentive to personnel better to meet their obligations as custodians of the public domain.

Determined action must be taken to ensure that Forest Department

personnel have the legal authority to fulfil their obligations properly to the public in maintaining the laws and protecting the public domain under their jurisdiction.

VI. Education

The importance of conservation education cannot be over-estimated. Without the co-operation of the general public, particularly those living or working in the vicinity of wild life areas, it is practically impossible to manage or to protect effectively the nation's wild life resources. It is also necessary that the proper type of education be undertaken. All possible means should be utilized to instil in the citizens of India the basic concepts and need for conservation practices. The members of the local legislatures must be convinced of the long-term economic advantages of wild life resources. Through proper education those who are presently advocating the immediate short-term exploitation of these resources will eventually become emissaries of nature conservation.

Mr. E. P. Gee most effectively stated the situation in his recent paper presented at the Conference on Conservation of Nature and Natural Resources in Tropical South East Asia at Bangkok, Thailand.

> 'Where poverty, hunger and often illiteracy are prevalent among the local people, it is mostly of no avail to stress the importance of wild life and wild places on aesthetic, cultural and scientific grounds. The main emphasis should always be on their economic value ; in other words it should be emphasised that rare wild animals are of infinitely greater value to the local villagers if kept alive in their natural habitat than if killed and eaten. Wild animals, especially rare ones, in their natural surroundings will attract visitors from near-by cities and tourists from abroad, and thus provide the necessary revenue and foreign exchange for the sorely needed development and elimination of the very poverty, hunger and illiteracy which everyone wants to remove.
>
> 'The problems of preserving rare species of wild life in existing or proposed sanctuaries in South and Southeast Asia are mainly political and administrative, and only in a lesser degree are they scientific or ecological. The staff or the department concerned with protecting a sanctuary, whether it be the Forest or some other department, and the local civil authorities including the police, will find it extremely difficult to enforce laws unless these laws are carefully drawn up and unless the full co-operation of the local villagers is first obtained.'

India's wild life sanctuaries and parks have great potential as international tourist attractions and as a source of much needed foreign exchange. Tourism, based upon wild life conservation, is presently the major source of income for many of the African nations. India has wild life areas, such as Kaziranga, Kanha, Periyar, and Bandipur, that with nominal investments in facilities (i.e. adequate

accommodations, transportation, etc.) could compete even now with what Africa has to offer. However, before the full economic potential of these areas can be realized, effective and well-planned programmes of education and publicity must be initiated.

Besides conservation education in the schools, publicity programmes extolling the sanctuaries—their numerous scenic and aesthetic values, as well as their wild life—should be initiated as soon as possible. Information concerning these sanctuaries (i.e. pamphlets, folders, posters, and post cards) should also be made available through the Departments of Tourism at the central and state levels and to approved Tourist Agencies. Almost invariably when I have enquired at both Government and State tourist offices, those in charge have not been able to give me complete information as to how these places may be reached and what facilities are available for visitors. Although some sanctuaries presently have pamphlets or folders, these are not usually available to the general public or distributed to visitors. For example, while visiting the Kaziranga Wild Life Sanctuary the Tourist Department Officer stationed at Kohora could supply me with no literature or information concerning this outstanding sanctuary. However, he had numerous pamphlets and folders concerning Agra, Delhi, and other tourist attractions in India. Thousands of tourists annually travel between Delhi, Jaipur, and Agra without even realizing that they have passed by the notable wild life sanctuaries of Keoladeo Ghana and Sariska. Peter Scott[1], the renowned naturalist, remarked upon visiting the Keoladeo Ghana Bird Sanctuary at Bharatpur: 'It is one of the most incredible places'. And, 'Enormous numbers of people would want to see such a spectacle'.

A nation which has preserved such renowned relics from the past as the Taj Mahal and the ruins of Khajuraho should also demonstrate to the world that it has the foresight to preserve and protect its invaluable wild life resources for the enjoyment of the people of both the present and the future.

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[1] For Peter Scott's account of his visit to Keoladeo Ghana, see *J. Bombay nat. Hist. Soc.* **63**: 206-209—EDS.

The Axis Deer in Hawaii

BY

WILLIAM GRAF, PH. D.

Professor of Wildlife Management, Department of Biology, San Jose State College, San Jose, California, U.S.A.

AND

LYMAN NICHOLS JR.[1]

Alaska Department of Fish and Game, Anchorage, Alaska, U.S.A.

(With two maps, fourteen plates, and seven figures)

CONTENTS

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[1] Formerly Wildlife Biologist, Division of Fish and Game, Hilo, Hawaii.

Abstract

A study of the physical characteristics of the axis deer [*Axis axis* (Erxleben), 1777], introduced into the Hawaiian Islands in 1868, shows no changes in weight and measurements from those of India and Ceylon although it has been isolated for almost 100 years. Tooth development and aging characteristics have been worked out. Upper canines are present at birth but are lost before the animal is a year old. Other physical characteristics are described and discussed in detail.

The reproductive cycle is found not to have changed from that of Indian axis deer. Peak fawning periods are November, December, January, and February. Fawns are produced during all months of the year. Males are sexually active during all months of the year and regardless of the stage of antler development. The majority of bucks are in full rut during June and July. Foetal development, weights, measurements, and methods for aging the foetus are presented in detail; also charts of the reproductive cycle and other aspects of reproduction.

A study of behaviour shows the beginning of a harem system similar to that in members of the genus *Cervus*. The rutting behaviour is typified by a highly ritualized behaviour pattern, both as individuals and towards other males. Posturing by dis-

playing facial expressions and body attitude seems to be related to territorial behaviour and territorial signpost behaviourisms.

The general behaviour as individuals and as a group in relation to types of cover and distances from cover is significant. The animals avoid extensive open areas as well as extensive closed forests. The behaviour of the animals by day and by night is discussed in relation to crop damage with possible significance and its meaning.

Introduction and Acknowledgement

The axis deer was, so far as can be determined from existing records, introduced into the Hawaiian Islands in 1868. These records, based entirely on several newspaper accounts, mention only eight animals, three bucks, four does, and one fawn. The various versions of the arrival of these deer and their subsequent release on Molokai Island are well documented by Cooke (1949). The entire stock of deer on both Molokai Island and Lanai Island dates back to this one introduction of eight deer. Lanai received a stock of 12 deer in 1920. There is some question about the total number of deer transplanted to Lanai but there is no question of the source of the deer, Molokai Island (Cooke 1949). From where or when the present remnant population of axis deer on Oahu Island was introduced is not known. It is possible that deer were brought from Molokai, possibly from other sources.

The most important point, however, is that on Molokai and Lanai the entire population of deer, estimated today at a total of 5000 to 6000 head, is the progeny of only eight animals. This should provide some interesting food for thought for those sportsmen who persistently contend that inbreeding degrades our game species—or rather that the deterioration of a stock of game is due to inbreeding.

As will be seen from our study, there has been no deterioration, physical or otherwise, in the Hawaiian deer herds. No one knows how many deer have been produced since 1868 on Molokai and Lanai. On several occasions, once on Lanai and once on Molokai, there was a determined effort to exterminate the entire deer population. Cooke (1949) quotes figures which give some idea of the tens of thousands that were slaughtered. It is a well-known fact that deer have been hunted continuously and hard during their entire existence on the Islands. All the evidence that we have been able to find, both from the past and during our present study, shows that the axis deer of Hawaii today is in every respect the equal of the Indian axis deer, both as compared with past measurements and present ones.

The habitat of the Hawaiian axis deer ranges from semi-desert types at altitudes generally below 1500 ft. to rain forest at the higher altitudes, reaching rainfalls of over 200 inches at 3000 to 4000 ft. The lower dry habitat is primarily an open savanna-type acacia forest, primarily kiawe or Algaroba (*Prosopis chilensis*) with an understorey of Lantana (*Lantana*

camara) and Ilima (*Sida fallax*) and a variety of grasses, primarily the native Pili grass (*Heteropogon contortus*). The rain forest habitat consists primarily of mixed fern and Ohia (*Metrosideros* sp.) forests and various native and introduced grasses. While many parts of this forest present dense growths of shrubs and ferns, other parts are open glades and open park-like forests of the giant tree fern (*Cibotium* sp.).

In all cases, both dry habitat and wet, the deer are found in semi-open habitats or where dense forests are liberally interspersed with glades and meadows. The affinity for such habitat will be discussed in greater detail under behaviour.

The study was financed in part by the State of Hawaii and the United States Government under the Federal Aid to Wildlife Management Programme (Project W-5-R) and in part through a sabbatical leave from San Jose State College. In addition the American Philosophical Society provided support for continued study during the summer of 1959 to complete some unfinished investigation on Molokai Island.

PHYSICAL CHARACTERISTICS

Axis axis (Erxleben) 1777

Type locality. Banks of the Ganges, India.

Flerov (1952) places this deer in the genus *Cervus* on the basis of morphological affinities and characteristics. In this respect our observations, on the basis of morphological characteristics, field characteristics, and habits, agree with his conclusions.

General Description and Measurements

In general appearance a small cervid, mature males standing about 36 in. at the shoulder, females about 30 in. ; males with antlers ; manes lacking ; colour fawn or tan with persistent white spots ; colour dimorphism weak and irregular. Antlers grow from high pedestals, rounded in cross section, and only lightly roughened near lower quarter ; beam simple, strongly concave in outline and sharply inclined backwards at a point just above the pedestal.

Measurements in millimetres of typical mature specimens are as follows :

Mature male collected 25 March 1958, Molokai Island, west end : Total length 1780 ; tail 280 ; hind foot 440 ; ear 135 ; height at shoulder 935 ; weight : live 156, dressed 116 lb.

Mature female, collected 9 Feb. 1958, Molokai Island, west end : Total length 1640 ; tail 265 ; hind foot 375 ; ear 125 ; height at shoulder 750 ; weight : live 105, dressed 70 lb.

Graf : Axis Deer

Family group. Doe with yearling daughter and current fawn
The terraine and vegetation is typical of the dry parts of Lanai and Molokai Islands.

(*Photo : Lyman Nichols*)

Graf : Axis Deer

Typical axis doe

Note comparatively thin neck and lack of dark colouring on neck and face. Terraine is typical of the steep gulches on Lanai and Molokai Islands.

(*Photo : Lyman Nichols*)

Largest male measured was from the west end of Molokai Island, taken 9 Jan. 1958 : Total length 2070 ; tail 300 ; hind foot 430 ; ear 144 ; height at shoulder 1000 ; weight : live 215, dressed 170 lb.

Largest female was taken on Lanai Island, 29 Oct. 1957 : Total length 1660 ; tail 274 ; hind foot 405 ; ear 129 ; weight : live 120·5, dressed 88·5 lb.

On the basis of condylobasal length, Pocock's (1943) specimens show a greater size in males. His male axis skulls all range from 260 mm. to 302 mm. with most of them in the upper limits. The largest buck collected in Hawaii, an old buck estimated at 8-9 years old, had a condylobasal length of 293 mm. Pocock's males may have been specimens collected by hunters, who tend to select older, trophy-sized animals. His female skulls show a range from 231 mm. to 260 mm. These compare favourably with Hawaiian skulls which ranged from 216 mm. to 265 mm. Eight fully matured does, i.e., two years or older, averaged 244 mm.

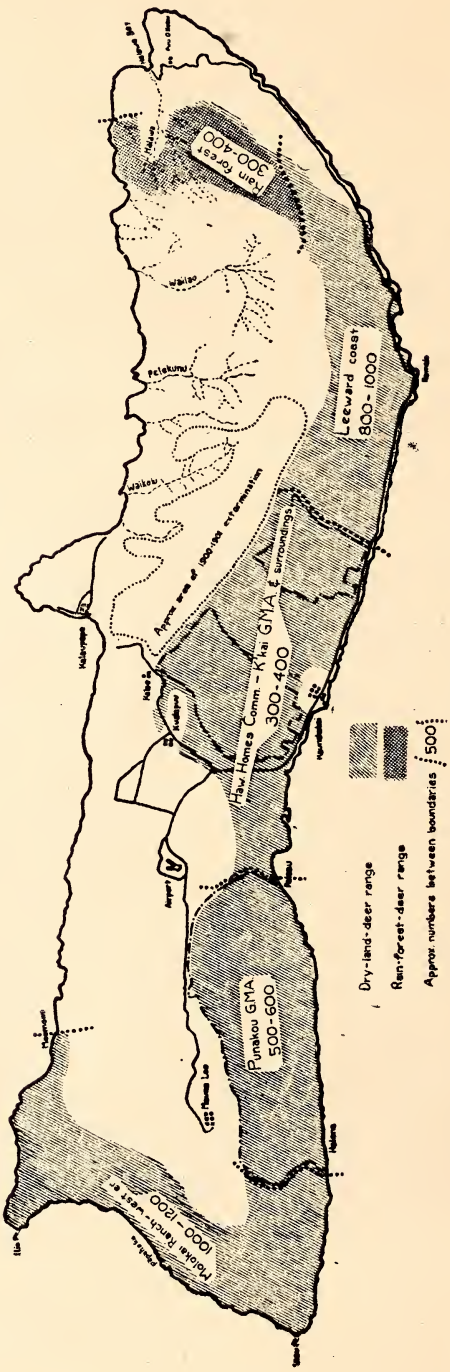
Phillips (1935) lists the average of 9 Ceylon males and 3 females.

Males : Total length 1420 ; tail 283 ; hind foot 392 ; ear 156 ; height at shoulder 831 ; weight (of 5 only) 162 lb.

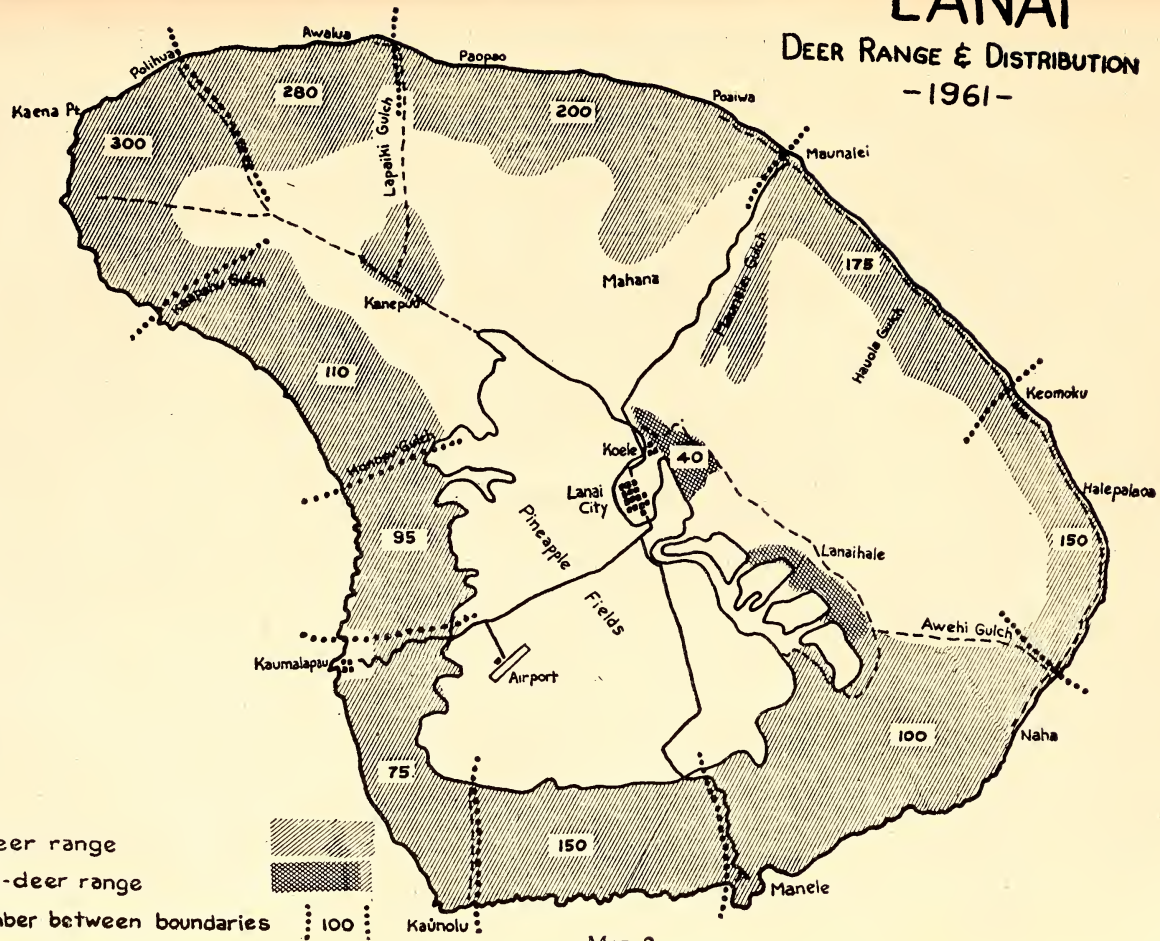
Females : Total length 1283 ; tail 177 ; hind foot 301 ; ear 115 ; height at shoulder 698 ; weight 109·3 lb.

If these measurements are representative, it would appear that Hawaiian deer do not differ greatly from the Indian. Pocock's female skulls bear this out and, although his male skulls are larger, the uniformity and measurements near the upper limits indicate selective collecting—as could be expected when skulls are obtained from sportsmen. Our Hawaiian skulls are, however, close enough to be comparable. The Ceylon measurements would indicate that the deer there are somewhat smaller if the averages given are from representative mature deer. The largest listed had a total length of only 1701·8 mm., a measurement more nearly that of our average (table 3) of 1781 mm. These discrepancies could very well be in the method of taking measurements. The axis deer has apparently lost none of its characteristics during more than 90 years of isolation and inbreeding from four original pairs.

These deer are considered the most primitive representatives of their group today, as shown by various morphological characteristics. These characteristics are particularly the high bony pedicles from which the antlers grow, the simple antler structure with only a basal brow tine and a simple upper tine always on the inside of the beam, the weak and inconsistent colour dimorphism, and the strongly spotted coat which is persistent throughout life. The weakly developed herding and harem characteristics for a member of this group probably also can be added to this category.


MOLOKAI
DEER RANGE & DISTRIBUTION
- 1961 -
Main forest 300-400
Leeward coast 800-1000
Area of 1908 reforestation
Hav. Homes Comm. - Kkai GMA & surroundings 300-400
Punakou GMA 500-600
Molokai Ranch - west of 1000 - 1200
Dry-land-deer range
Rain-forest-deer range
Approx. numbers between boundaries 500

MAP 1


LANAI
DEER RANGE & DISTRIBUTION
-1961-
Awalua
Paopao
Polihua
Kaena Pt.
280
200
300
Lapaiki Gulch
Poaiwa
Maunalei
Mahana
Kanepuu
Maunalei Gulch
175
Hauola Gulch
Keomoku
110
Koele
40
Lanai City
Halepalaoa
Pineapple Fields
95
150
Lanaihale
Awehi Gulch
Kaumalapau
Airport
100
Naha
75
150
Manele
Kaunolu
Dry-land-deer range
Wet-forest-deer range
Approx. number between boundaries
100

MAP 2

In outline the axis deer quite strikingly resembles a small elk or wapiti, with its high shoulders, thin neck, and rather long face which in shape and outline strongly resembles that of its large relative. In general the body is well-knit and graceful in appearance. Does with their thinner necks appear a bit ungainly about the head, somewhat after the manner of a cow elk, thus heightening the resemblance between these two groups even more. Bucks present a better balanced and more pleasing appearance to the eye, particularly during the rut when the necks are enlarged. Young bucks or even old ones, when the necks are still normal in size, show a tendency toward the same ungainliness observed in does, though not to the same extent.

Colour

All points considered, the axis deer probably rates as one of the most beautiful of all deer. The ground colour of the coat is generally a light reddish brown or yellowish brown. In the males the neck and foreshoulders may be darker, almost charcoal, and in one or two this part was observed to be a lighter yellowish or light fawn colour in contrast to the rest of the body. Females never show this darker colour. The entire dark part of the body is covered with snow-white spots about 20 to 25 mm. in diameter. These are arranged roughly in rows parallel to the mid-dorsal line and across the lower hips, flanks and shoulders ; on the neck up to the head and elsewhere, the spots are more or less arranged at random, but may at times take the form of broken rows.

The outer legs are without spots and the chest, belly, and inner legs, and at times the outer, lower legs, are pure white. A white throat patch extends from about half way up the throat and along the lower jaw to end just below the nostrils. The white of the belly and inner hind legs continues in a narrow band between the buttocks and along the under surface of the tail.

A dark chocolate-brown to blackish brown band extends along the mid-dorsal line from about midway of the neck to the rump ; within this band and on each side of its center line is a row of white spots. The upper side of the tail is light brown bordered with darker brown hairs where it joins the white under surface. A thin line of dark brown hairs splits the white of the chest from the lower throat down the brisket. The white spots on the neck give way to a solid light brown on the head, face, and back of the ears. The edges of the ears are rimmed with dark hairs, while the inner surface of the ears is white near the base.

Does are generally slightly lighter in colour than bucks, especially over the face and neck. Bucks have a black or dark brown diamond-shaped spot in the middle of their forehead and a black line that extends from the antler base to the eyebrow on each side of the head, and con-

Graf : Axis Deer

Three large axis deer bucks, Lanai Island, Hawaii

(*Photo : Lyman Nichols*)

tinues from the eyebrow to the bridge of the nose, thus forming a black inverted chevron on the face. The black may or may not continue down the nose to the muzzle, but there is always a black band that runs from the rear of the mouth forward and over the muzzle just behind the nostrils. The ground colour of the head and face is lighter brown than the body, while the naked portion of the muzzle is grey in colour. Does occasionally have dark faces, but the black chevron and nose band are not present.

Bucks often have darker necks than does. This darkening of the ground colour extends from the front of the shoulders to the head and is highly variable, from just a very slightly darker brown to almost charcoal black. On Molokai it was most pronounced during late summer and fall in bucks with fully hardened antlers. Bucks in shed or velvet condition appeared more uniform in colour. The dark necks were also more pronounced on the leeward side below Mauna Loa, some here having the almost charcoal black necks. This was also the area where one melanistic buck was seen.

No colour difference was observed between the deer of the high wet forest and the dry lowland areas although hunters claimed that deer were darker from the swamps of the high cloud forest.

Antlers take on the characteristic colour of the substances with which they come in contact when rubbed, and antler colour may vary greatly from range to range.

Melanism and Albinism

Melanism, i.e., an all black colour, is rare in deer. It was observed in one buck on the leeward side in the Punakau Game Area in 1958. This was a mature buck of better than average size with fully developed, hard antlers. The colour appeared as an overall charcoal black, rather than a glossy black. The white spotting appeared in normal pattern from a distance, but due to cover it was not possible to determine the colour of the underparts. This particular area also has shown the darkest neck colours of any area observed on Molokai. This 'black' colour appeared similar to the black observed in the melanistic mule deer specimens of northern California and Nevada. It was not possible to determine whether any brown hairs were mixed in with the black because of the distance. Lydekker (1893) mentions a black variety. He says: 'there is a rare black variety of the spotted deer, in which the spots are scarcely perceptible.'

Albinism apparently occurs, but is rare. One albino buck was reported seen in the mountainous country east of Kaunakakai, Molokai. Bahadur (1942), reporting on a captive albino, states:

'The original sire has horns about 2 ft. in length with no tines; they are always

in velvet, of a pink flesh colour, and the ends appear slightly raw. He drops his horns annually but the new ones grow in the same way.'

He described the albino as having pink eyes, nose, ears, and light coloured hoofs.

Mrs. Marie Palit, of Ranchi, India, in personal correspondence states that she has seen 3 albino fawns in the past 12 years near her home. Two were picked up and died, and the third, three-fourths grown, was seen with a normal coloured doe.

The Coat

The coat is composed of soft, fairly short hair which normally lies flat and gives these deer a very sleek appearance. The hairs are not brittle like those of North American deer and antelope, but are soft and flexible, and the coat is silky to the touch. There is a sparse undercoat of very fine hair beneath the outer coat of guard hair. Sebaceous and apocrine glands are found at the base of each hair shaft, and these exude an oily liquid which makes the coat shine and helps repel water. However, the amount of oil normally exuded is slight, and the coat feels dry and fluffy. On very hot days, though, the secretion is increased and tiny droplets may be seen on each hair, giving the appearance of sweat.

The coat of young fawns is somewhat heavier than that of the adults, but the hairs are finer and fluffier, giving the fawns a fuzzy appearance. The fine silky undercoat is also heavier.

Bucks, at least, have the ability to erect most of the hair on the neck and torso, as well as hair on the tail and of the rump patch. When a buck is threatening another, he will erect the hair over most of the body, particularly that of the white rump patch and the under-tail so that he resembles an angry, fluffed-up tomcat. Does have not been observed to fluff out their whole coat, but they erect the hairs of the rump patch and the under-tail when excited.

The coat is kept clean by frequent licking; in fact, these deer are one of the cleanest of all wild animals that we have observed, and none has ever been observed with a dirty coat unless it had very recently gotten up from a muddy bed.

The seasonal change in the coat is very gradual and, rather than the usual fall and spring moult observed in North American deer, there is a gradual thinning so that in the winter the coat becomes somewhat heavier and again in the summer somewhat lighter. A moult such as can be observed in North American deer could not be detected, and the process of moulting itself was hard to detect at a given time. The one difference that could be noticed, though it was slight, was that during the period when the antlers were shed or in the velvet some of

the bucks did not show the darker neck colour, appearing lighter on those parts.

Antlers

The antlers develop from bony pedicles which rise about one to one-and-a-half inches above the surface of the frontal bone, the antler forming a distinct burr at its base and growing in a line with the axis of the pedicle to a point where the brow tines branch from the beam. At this point the beam bends sharply backward, almost 45° from the original axis for roughly half its length and then bends upward again at nearly a right angle ; this presents a distinctly backswept and concave or dished outline from the plane of the face. The brow tines arise at right angles from the beam and grow forward and outward. The main beams turn slightly outward and continue to spread until about the main bend in the beam, then continue more or less parallel during the upward sweep. A single tine branches from the inner side of each main beam near the upper one-fourth of the otherwise unbranched beam. In well-formed antlers the view from the front is an almost perfect lyre shape. Some have very narrow, almost parallel, beams and others very widespread ones, though the latter appears to be less common. The most symmetrical antlers will have a spread of about $\frac{1}{3}$ to $\frac{1}{2}$ their length at the bend of the beam with the tips somewhat closer together. A good set of mature antlers in the 30-inch class makes an interesting and fine trophy, though somewhat plain in its simplicity.

The surface of the antlers is slightly to moderately roughened or veined, with the lower or basal part showing the greatest degree of roughening, and even beading at times. This varies from animal to animal, some antlers being almost smooth, others very rough on the lower $\frac{1}{3}$. A pair of large antlers in the office of the Molokai Ranch is covered over the entire surface of the beams with fine to very coarse beading. These antlers were said to have come from a castrated buck. Although roughened over the lower surface, the antler tips are nearly always smooth, polished, and sharp.

Beneath the drying velvet covering, the newly-matured antler is bone white, but as soon as the velvet begins peeling, blood begins to stain the antler brown. Rubbing against trees, shrubs, and sometimes the ground, continues to darken the stain while the roughened portions of the antler soon become filled with embedded bark fragments and dirt, leaving the antler surface relatively smooth and dark except for the ivory-coloured tips. The objects against which the antlers are rubbed will largely determine their final colour. In the kiawe (*Prosopis chilensis*) forest zone, they are frequently a light to a medium brown, and not uncommonly, a greenish brown colour from the embedded bark and stain. Some may

have a yellowish or reddish cast from the colour of the soil in the area—a soil which readily stains objects.

In the wet cloud forest of Molokai, antlers are so frequently washed by rain and by contact with wet shrubbery that the bark fragments do not have a chance to set into a hard paste, and are usually washed off, leaving the antlers more or less free of debris. They are, however, commonly coloured a dark chocolate-brown from the staining effects of plant juices and blood, and are usually darker than those from the lowlands.

The clean, ivory-white of the tips may result from gouging the antlers into the ground—a habit of some bucks, but may be partly due to the natural smoothness of the bone surface here, which does not take a stain readily nor hold a coating of bark or dirt.

Yearling bucks develop spike antlers that point to the rear like short, sharp daggers. Such spikes may at times be adorned with several short snags at their bases. Second-year bucks may develop a simple beam with brow tines or may develop light-beamed three-point antlers. In these the main-beam tine may be a mere stub or it may exceed the main beam above it. Such antlers usually lack the curving sweep of older bucks.

Antler variations and malformations are common. Bucks are commonly seen with one normal, fully developed antler, and one that is shorter and lacking the upper point, or is twisted and deformed. Some of the defects may be of a hereditary nature, but others are undoubtedly due to injuries sustained while the antler is still young and soft.

Old bucks are occasionally seen with antlers lacking the intermediate or main-beam tine, the main beams forming long curved spears. Such bucks have passed their prime sexually, and, as is common in most deer, antler points decline in number and size after this, the main beam being the last to be affected. Just what this age is is difficult to say. Rudolph, the captive buck on Molokai, grew antlers as large as any previously grown in his 9th year, indicating that he had not yet passed his sexual prime.

Antler Measurements

The largest antlers measured during the study were 37 in. in length along the curve of the beams. These were brought in too late to be included in our tables. There are without doubt larger bucks with better antlers on both Molokai and Lanai.

Table 1 lists the average measurements in cm. and inches of all the antlers measured during this study with the exception of spike bucks which are obviously not full grown. The upper and lower ranges of the measurements encountered in the study are also included. The various measurements were analyzed statistically to see if there was any significant

Graf : Axis Deer

Skull of typical, mature axis buck from Hawaii

(*Photo : Lyman Nichols*)

Graf : Axis Deer

Willie, the hand-raised Fawn

Left : At 9 weeks old. Was eating lawn grass in quantity. No sign of antler growth, only dark whorls of hair where antlers would appear. *Right :* At 30 weeks old. Antler growth just beginning.

(*Photos : Lyman Nichols*)

difference between antlers of Molokai and Lanai bucks, but in all cases it was found that there was less than one chance in 100 that there was a real difference noted in the sample of antlers measured between Molokai bucks and Lanai bucks—analysis showed that this was due to sampling error rather than to a real difference in size between the two populations. Consequently, all measurements of antlers of Molokai and Lanai bucks were lumped together and again statistically analyzed to give the data presented in Table 1.

TABLE 1

ANTLER MEASUREMENTS (IN CENTIMETRES) OF ADULT BUCKS
(The numbers in parentheses show the equivalents in inches)

Average Beam Length	
(Length of left and right beams averaged)	
Sample Mean (Average Beam Length)	55·89 (22·00)
Standard Deviation of the Mean	1·46
CI_{99} of the True Mean	52·11-59·66
Sample Range (Shortest and Longest Measurements)	24·2-80·4 (9·52-31·65)
Standard Deviation	12·93
CI of 99·7% of the True Range	17·10-94·68 (6·74-37·25)
Number of Measurements in Sample	79
Average Circumference above the Burr	
(Circumference of left and right beams averaged)	
Sample Mean (Average Circumference)	11·37 (4·48)
Standard Deviation of the Mean	0·03
CI_{99} of the True Mean	11·29-11·45
Sample Range (Smallest and Largest Circumferences)	9·0-15·6 (3·54-6·15)
Standard Deviation	1·55
CI of 99·7% of the True Range	6·71-16·03 (2·64-6·32)
Number of Measurements in Sample	79
Average Circumference above First Fork	
(Circumference of left and right beams averaged)	
Sample Mean (Average Circumference)	8·55 (3·36)
Standard Deviation of the Mean	0·17
CI_{99} of the True Mean	8·11-8·99

Sample Range (Smallest and Largest Circumferences) ..	6·0-12·4 (2·36-4·88)
Standard Deviation	1·46
CI of 99·7% of the True Range	4·16-12·93 (1·64-5·17)
Number of Measurements in Sample	76

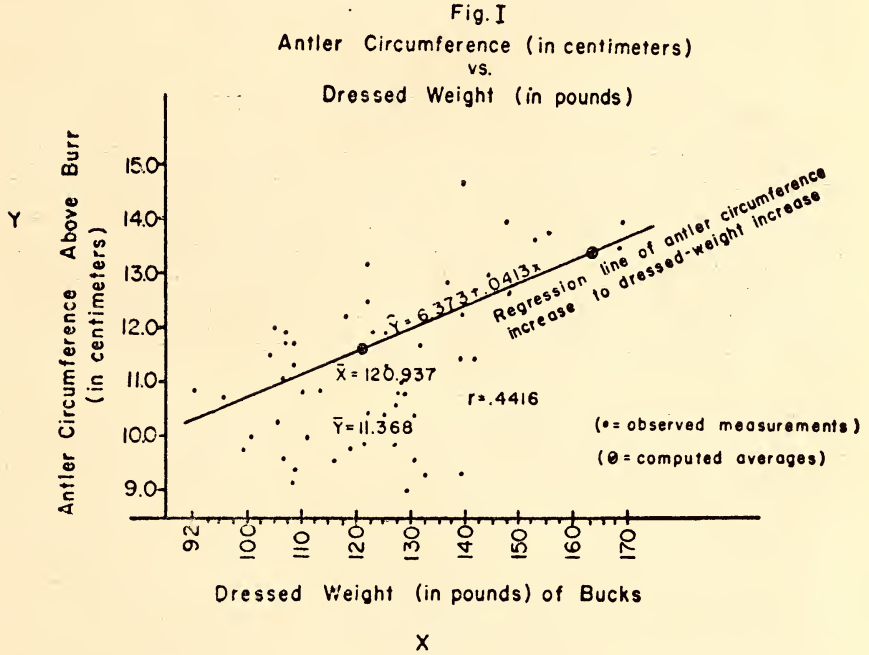
Spread between Tips of Main Beams

Sample Mean (Average Spread)	39·42 (15·50)
Standard Deviation of the Mean	1·21
CI_{99} of the True Mean	36·30-42·55 (14·28-16·75)
Sample Range (Narrowest and Widest Spread)	19·0-70·5 (7·48-27·74)
Standard Deviation	10·44
CI of 99·7% of the True Range	8·10-70·75 (3·19-27·85)
Number of Measurements in Sample	75

Also included in Table 1 are the statistically computed confidence intervals for the means of the measurements. While the averages of the measurements may be determined arithmetically from the samples examined, it does not necessarily follow that the sample average is exactly the same as the true average of all antler measurements. Analysis shows within what limits the true average probably falls. For example the average antler beam length of the antlers measured was found to be 55·89 cm., but statistical analysis of the data shows that the *true* average of all antlers, including the great number not examined, probably falls between 52·11 and 59·66 cm., with less than one chance out of 100 of falling outside of these limits (indicated by CI_{99}).

Analysis of the data also can show the probable upper and lower limits of the measurements of all antlers. Again using the antler-beam length as an example, it may be seen from Table 1 that the shortest antler beam measured was 24·2 cm., and the longest was 80·4. Since only 79 sets of antlers were measured to determine this range, it is reasonable to assume that out of several thousand deer remaining unmeasured some are going to have shorter, and some will have longer, antlers than those examined. Statistical analysis of the sample data indicates that about 99·7% of all bucks on the two islands will have antlers measuring between 17·10 and 94·68 cm. in beam length. Thus we can state that the longest antler length that can normally be found on Molokai and Lanai is probably about 94·68 cm., or 37¼ in.—but of course, there is still a chance that a few rare individuals may exceed this length.

It was noted that antler circumference and beam length seemed to be roughly related to the size of the buck, and these measurements were, therefore, examined graphically and statistically to see if this was truly the case. Examination did show a fair correlation between antler circumference above the burr and the dressed weights of the bucks, and indicated that antlers grow more massive in direct relation to the bucks' increase in weight as demonstrated in Figure 1. Although the general correlation could be computed and shown, individual measurements did not follow the computed average regression line too closely. The correlation of beam length and body weight was very weak and is not illustrated.



It is probable that antler beam circumference, and possibly beam length, are directly related to the age of the buck, getting larger and longer as the buck grows older. Unfortunately the ages of the bucks whose antlers were measured were not known. Until a number of known-age bucks are available, this relationship cannot be determined with certainty. Both food quality and quantity, and heredity are known to influence antler size and could upset the direct relationship between size of body and antler size. Also it could well be that body weight and age of bucks are not closely related beyond a certain point ; hence the weak correlation between antler size and weight.

For those who are interested in the antler measurements of bucks from India and Ceylon, the following will give some comparison :

	Beam Length	Circum-ference	Spread
India—(Lydekker 1898) ..	38¼	4¾	19½ in.
India—(Rowland Ward 1928) ..	40	4½	23¾ in.
Ceylon—(Phillips 1935) ..	36	4	23½ in.
	36¼		19¾ in.

Any buck with antler beams above 30 in. and a basal circumference of over 4 in. can be considered a good one. It would appear from our measurements that Hawaiian deer have heavier and wider antlers than the Indian or Ceylonese deer.

Weights and Body Measurements

There is a persistent misconception among many people both in Hawaii and among tourists who have visited the Islands, that the Hawaiian deer are small, almost tiny. Expressions such as ' small ', ' tiny ', etc. are often heard. How or why this should be is not known ; certainly the axis deer cannot be listed with the largest deer, neither can it be listed with the smallest. They compare favourably on the average with the well-known white-tailed and black-tailed deer of North America, although the extreme weights of bucks of these species exceed those of the axis bucks that we have weighed. However, in view of our lack of a good sample of large bucks from the high forest of Molokai, this discrepancy may not be as large as it appears to be.

Table 2

Average Dressed Weights (in pounds) of Hawaiian Axis Deer

Adult Bucks	
Sample Mean (Average dressed weight)	120·3
Standard Deviation of the Mean	2·23
CI_{99} of the True Mean	114·5-126·1
Sample Range (Lightest and Heaviest Weighed)	74·0-170·0
Standard Deviation	21·32
CI of 99·7% of the True Range	56·3-184·3
Number of Measurements in Sample	92
Spike Bucks	
Sample Mean (Average Dressed Weight)	88·5
Standard Deviation of the Mean	2·16
CI_{99} of the True Mean	82·5-94·6

Graf : Axis Deer

Willie, the hand-raised Fawn.

Left : At 34 weeks old. Antler development well under way. *Right :* At 51 weeks old. Has well developed velvet-covered spikes.

(*Photos : Lyman Nichols*)

Graf : Axis Deer

Willie, the hand-raised Fawn, at 69 weeks old

Willie's antlers were fully mature at 63 weeks. Here, at 69 weeks the swelling neck, sleeker coat, and filling out of the body show the full masculinization of a buck entering the rut. At this age he was mean and aggressive, constantly looking for trouble and dangerous to humans, whom he no longer feared. The lower picture shows him in the typical attitude and posture of a challenging buck, the attitude and expression during ritual posturing between two bucks.

(*Photos : Lyman Nichols*)

Sample Range (Lightest and Heaviest Weighed)	71·0-109·0
Standard Deviation	10·80
CI of 99.7% of the True Range	56·1-120·9
Number of Measurements in Sample	26

Adult Does

Sample Mean (Average Dressed Weight)	70·5
Standard Deviation of the Mean	1·67
CI_{99} of the True Mean	65·0-75·1
Sample Range (Lightest and Heaviest Weighed)	55·0-97·0
Standard Deviation	9·0
CI of 99.7% of the True Range	45·5-97·74
Number of Measurements in the Sample	30

The average dressed weights (with the viscera removed) of the axis deer examined are given in Table 2. 'Adult bucks' here refers to those larger than spike bucks, which are generally referred to as yearlings. From this table it can be seen that the average weight is 120·3 lb. It was found that the average loss of weight in the field dressing was 24%; thus the average live weight of adult bucks is about 158 lb. The computations indicate that the largest bucks may dress out at as much as 184·3 lb., or weigh when alive up to 243 lb., and possibly more in exceptional cases. The heaviest buck examined during the course of this study had a live weight (whole weight) of 215 lb. and, eviscerated, weighed 170 lb.

It should be pointed out here that weights and statistical conclusions are based on deer collected in the dry-land habitat, with one exception —one buck taken from the Molokai wet forest. This buck, compared with a Molokai buck of the same age class and size from the low, dry-land areas, was found to weigh 10 to 12% heavier. Actually the nearest comparable dry-land buck was slightly larger than the one from the high forest. *If* this difference in weight should prove to be a general rule, then we might expect to find bucks that will go as high as 250 lb. dressed weight in the wet forest area. We have had unconfirmed reports from hunters of weighed bucks in this weight range.

It must also be remembered that the deer of these tropical regions do not put on layers of fat as do northern deer. The best-conditioned bucks that we have examined show almost no subcutaneous fat and only a moderate amount of visceral fat. In contrast, northern-climate deer in good condition put on many pounds of fat in the fall, thus adding considerably to the weight of the animal.

Does are considerably smaller than adult bucks, weighing on the average, only about 70·5 lb. dressed. Since they lose about 31% of their weight upon field dressing, a percentage which varies greatly during pregnancy, an average live doe would weigh about 97·8 lb., an extremely large doe could weigh up to 141 lb.

As a matter of interest, the normally unused portions of one buck were weighed separately to determine what part of the animal's weight they represent. It was found that in this case, the viscera (all internal organs) weighed 25% of the live weight ; the hide 7·2% ; the head 6·6% ; and the feet 2%. The forequarters (separated from the hindquarters between the last two ribs as is usually done) weighed 30·2% of the live weight, and the hindquarters 28·3%. The remaining 0·7% of the weight was accounted for by blood loss.

Weights of Lanai deer appeared to be greater than on Molokai, but statistical comparison again showed no significant difference between the two populations.

TABLE 3

AVERAGE BODY MEASUREMENTS (IN CENTIMETRES) OF AXIS DEER
(The numbers in parentheses show the equivalents in inches)

	Average Length	*Sample Range*
Adult Bucks		
Total Length ..	178·1 (70·25)	164·0-207·0
Tail Length ..	30·9 (12·2)	26·0-36·0
Hind Foot ..	41·8 (16·5)	39·0-45·0
Ear Length ..	13·7 (5·4)	12·0-15·0
Shoulder Height ..	93·2 (36·7)	80·0-101·0
Head Length ..	31·0 (12·2)	29·0-33·5
Spike Bucks		
Total Length ..	162·2 (63·8)	148·5-173·0
Tail Length ..	30·1 (11·8)	26·5-36·0
Hind Foot ..	40·2 (15·8)	31·0-44·0
Ear Length ..	13·3 (5·2)	12·5-14·5
Shoulder Height ..	85·4 (33·6)	78·0-99·0
Head Length ..	28·4 (11·2)	24·0-30·5

Adult Does

Total Length	..	155·7 (61·3)	144·0-167·5
Tail Length	..	27·0 (10·6)	20·0-30·0
Hind Foot	..	37·5 (14·8)	35·5-40·5
Ear Length	..	12·6 (5·0)	11·5-13·4
Shoulder Height	..	78·1 (30·8)	70·0-87·
Head Length	..	27·8 (10·9)	24·5-30·0

Various body measurements were also made on deer examined during the study and are presented in Table 3. The total length is the length from the tip of the nose to the tip of the last vertebra in the tail, following the body contours. The tail length is from the tip of the last vertebra in the tail to the junction of the coccygeal and sacral vertebra, and is taken by bending the tail at right angles to the back and measuring from the base to the tip of the tail exclusive of hair. The length of the hind foot is measured from the point of the hock to the tip of the hoof, and the ear length from the notch of the ear (the deepest notch at the inner base of the ear) to the tip. Shoulder height is from the ball of the foot to the mid-line of the back and, though it is slightly longer than the actual standing height, it gives a reasonable approximation of the true height at the shoulder. The head length is from the tip of nose to the notch of the ear. With the exception of the head measurement, which we added for our own convenience, these are standard measurements used in the scientific comparison of animals. They provide a constant standard of comparison which the layman will have little occasion to consider and even less to use.

Glands

The external scent glands of the axis deer are similar to those of other deer. Inter-digital glands are present between the toes of each hind hoof, and are indicated externally by a distinct line of dark hairs. The skin at the opening of these glands is involuted and covered with short, oily hairs, while subcutaneous glandular tissue is abundant. There is a less distinct line of dark hairs between the front toes, but the involuted skin, oily hairs, and glandular tissue are absent or much reduced, indicating a lack of functional glands here. Metatarsal glands are located several inches below the hock on the outside of the metatarsus, or lower hind leg. The glands themselves are small—about three-quarters of an inch long—but are indicated externally by a larger clump of comparatively

long, light-coloured hairs, which are quite apparent against the normally short, brown hair of the leg.

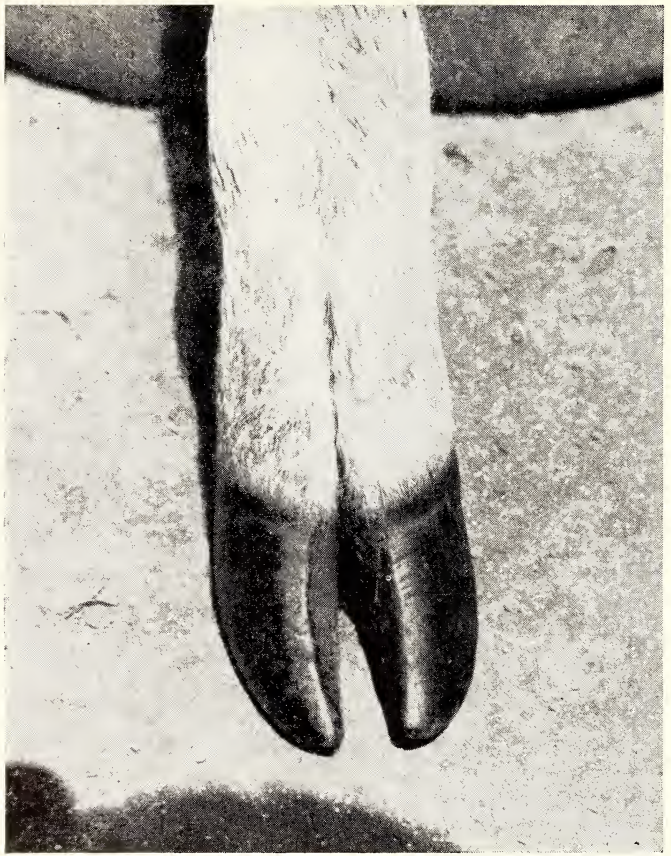
The most noticeable and interesting of the external glands is the infra-orbital gland located just below the inner corner of each eye. This gland normally appears as a mere slit extending from the junction of the upper and lower eyelids. When the deer is excited, however, the gland can be rapidly opened to reveal a large, shallow pouch of nearly the dimension of the eye itself. At the lower, or nostril end, of this gland is a clump of longer oily hairs that are normally folded inwards and enclosed in the slit-like opening. When the gland is flared open, these hairs are rolled outwards, forming an oily tuft at the end of the pouch. This gland appears to be activated by excitement, anger, or other emotional stimuli, and can be opened or closed almost as fast as the winking of an eye. Excitement can be in the form of hunger and anticipation ; when fawns are nursing, or are about to nurse, they become tense with anticipation and their infraorbital glands are flared wide. Or when deer are alarmed, they stand tense and alert, with the glands partially opened.

The glands appear most highly developed in bucks, and appear to be most important when the buck is threatening or challenging another buck, or just stalking around impressing himself with his own importance and toughness. In such instances the glands are opened to their utmost and add considerably to the fierce expression of the face.

Close observation of the captive buck Rudolph, on Molokai, showed that apparently the slightest emotional disturbance or stimulus would cause the glands to open. Obvious stimuli, such as threatening gestures toward the buck or walking close to the fence, caused the glands to flare. Sudden motion towards the buck never failed to bring reaction. Even when standing 10 to 15 feet from the buck, the sudden motion of the hand toward him would cause the gland to open at least partly, and a threatening step forward would usually bring it to full expansion. It was also noticed that even though no threatening gestures were made and the buck had been allowed to become quiet, the gland would at times open partly, sometimes momentarily almost fully, even though no apparent reason was visible.

At this time the antlers were still in velvet, though almost fully developed in size, and the buck's neck was showing some slight swelling, indicating that the emotional state of the rutting condition was building up. Normally, a buck's neck shows no swelling before the antlers are hard, and in North American deer we have never observed neck swelling among bucks still in the velvet. However, a number of axis deer have been observed in the wild state with necks beginning to swell when the antlers are fully grown but still in the velvet. The largest buck collected, with fully grown antlers still in the velvet and slightly rubbery at the tips, showed pronounced neck swelling. This is undoubtedly due to the

Graf : Axis Deer



Feet of Axis Deer

Left : Left front foot. *Right :* Right hind foot

Interdigital scent gland is outlined by dark hairs on hind feet, it does not show on front feet.

(*Photos : Lyman Nichols*)

Graf : Axis Deer

Axis deer, showing infraorbital gland. *Above :* Gland closed, the normal aspect. *Below :* Gland open.

The infraorbital gland, seen here as a shallow pouch in front of the eye, can be opened and closed rapidly under stress of excitement.

(*Photos : Lyman Nichols*)

fact that there is no true sexual quiescence in these deer as there is in northern-climate deer. The physiological condition of the rut, therefore, appears before the antlers are fully hardened and cleaned.

The odour of these external glands is very mild and is a mildly sweetish, musky odour that is not unpleasant. It is hardly noticeable to the human sense of smell except when the glands are held close to the nose. Even old bucks in full rut have little or no odour. There is no comparison with that of a rutting mule deer buck or bull elk.

On damp days, when trailing deer up-wind, they can often be detected as much as 50 yards away by a characteristic pungent odour. This, however, is the odour of the fresh droppings or urine which are almost continuously being deposited by one or other animal in a herd. This odour is somewhat similar to that of the fresh dung of cattle, and is never apparent on the animals themselves.

The genitalia of axis deer are quite similar in appearance to those of other Cervidae, with no significant differences worth recording. The mammaries of the does are equipped with four small teats and two rudimentary accessory teats.

Hoofs and Tracks

The feet of the axis deer are similar to those of other deer of the same size range. The hoofs are hard and black on the outside but tough and rubbery on the ventral surface. Hoofs of the front feet are slightly longer than those of the hind feet, and measure from 4·1 to 6·1 cm. in length along the bottom surface. The outer toe on both front and hind feet is usually slightly longer than the inner one, and all toes taper to a fairly sharp point. Two dew-claws are present above and to the rear of the hoofs on each foot.

The front feet of a number of bucks and does were measured with the idea of comparing them to see if it would be possible to differentiate between the tracks of bucks and does by track size. Both length and width of the hoofs were measured, and the data thus obtained were examined graphically and statistically. The analysis showed that there was no real difference between the size of the hoofs—and hence the tracks—of the sexes. The tracks of a large buck may be told from those of a doe with some chance of correctness if the depth of the track (determined by the weight of the animal) and the placement of the feet can be noted, but not by size alone. The judgment of the factors that go into the making of a track on the ground—the weight of the animal, the hardness of the soil, the speed of movement, the age of the track, etc.—all require such continuous experience that a sportsman of today has little opportunity to acquire the skill of real tracking.

Deformed hoofs appear to be common on the deer living in the rain forest of Molokai where the soil is soft and wet almost continuously, and where there are few rocks in the ground to wear them down. In hooved animals, the outer shell of the hoof grows continuously and is kept worn down by normal abrasion against the soil. Unless driven to it, wild animals seldom wear their hoofs down too much. Horses, however, under domestic use commonly show this type of abuse if worked on hard and rocky soil without shoes. On the other hand, the deer and goats of the wet forest simply do not get enough wear to keep their hoofs worn to normal shape and size.

Goats appear to have more trouble in this respect than deer. This is apparently due to the fact that goat's feet are normally adapted to rocky, mountainous, cliff country, and probably have a faster growth rate. Perhaps they are also harder, and require more wear to keep them in shape. Deer hoofs in the wet areas showed the abnormal growth, but the edges seemed to break off in irregular pieces sooner, indicating that the horn shell is not as tough as, or perhaps is more brittle than, that of goats.

Deer range in some areas overlaps that of feral goats not only on Molokai but also on Lanai, and the tracks of both will be found together. The tracks of the Mouflon sheep (*Ovis musimon*) and the North American pronghorn antelope (*Antilocapra americana*) will also be found in the deer range on Lanai. The goat tracks are usually much more blocky in appearance than those of the deer, being wider and blunter, and giving the impression of a square shape rather than a heart shape, and clear impressions may be readily distinguished from those of deer. However, the hunter must ever be alert to exceptions. On Molokai, particularly in the wet forest areas, tracks were often noted that were very much like those of deer in size and shape, especially the smaller tracks.

Mouflon tracks are slightly blunter than those of the deer and show a somewhat concave outer edge, but the difference is usually apparent only in very clear impressions. Antelope tracks are even more difficult to differentiate from deer tracks, but may appear sharper at the tip of the toe, and may appear more wedge-shaped than those of deer, whose toes have a more convex outer curve and a concave inner curve. There are many variations and exceptions to all these characteristics, associated with many varied conditions.

Voice

One of the most noticeable and interesting characteristics of the axis deer is its voice. It is one of the most vocal of all deer, being rivalled by only a few other Asiatic deer.

There are several fairly well-defined calls uttered by these animals.

The most commonly heard is the ' bark ' of alarm or curiosity, which is a loud, high-pitched ' *Yowp* ! ' that is usually repeated several times. A group of deer seeing something that puzzles or worries them will frequently ' bark ' at it for several minutes or longer while watching intently. After their curiosity has become satisfied, the calling is discontinued. It is used more commonly by does and fawns than by adult bucks, although the latter do ' bark ' when sufficiently aroused by curiosity.

This ' barking ' has been heard over a mile away in the high canyons of the Molokai rain forests, even over the soft noise of drizzling rain ; and on windless days in the dry lowlands, it has been heard from observed deer that were a full mile and a half away.

Besides the common curiosity or ' attention ' bark, there is a short explosive yelp of extreme fright or alarm. This is a short ' *Y-owp* ! ' or ' *Yup* ! ' and is the ultimate in danger signals which all deer within hearing never fail to heed. If a group of deer is suddenly startled and badly frightened, the first one spotting the danger will give this warning yelp, whereupon the whole group, whether or not they too have observed the danger, will take immediate flight without calling. Both bucks and does use these calls, though the calls of the large bucks are slightly hoarser and seem to have a bit more power behind them.

An interesting, and somewhat comical, sidelight to these calls is that the tail gives a spasmodic up-and-down jerk with each ' *Yowp* ! '. It almost appears as if some invisible hand is cranking out the ' *yowps* ' by pumping the tail !

Another call appears to be characteristic only of adult bucks during the rut. Lydekker (1901) describes it as a ' peculiar moaning sort of bellow '. To us it sounds like a low, hoarse modification of the normal call, and may be perhaps described as sounding like ' *yo-o-o-w-w* ', or ' *h-h-a-o-u-u-h* '. It has a low, groaning, forced breathlessness about it that is most difficult to describe, and sounds as though it was being uttered with the last available breath left in the lungs. These calls can be heard at any time of the day, but most often in the morning or evening or at night. Most of them seem to be repeated at intervals of 15 to 20 minutes, though some have been heard to call at intervals of five minutes for a period of some fifteen minutes. The call is not loud, but on quiet days is still easily heard at half a mile. It is an impressive and weird sound and, in the strange world of giant tree ferns and swirling mists of the cloud forest, it is a sound that will long be remembered.

The call appears to be a mating call or, more likely, a call signifying territorial occupation, for bucks with identifiable voices have been heard to call for days from the same spot. A large buck with a herd of does was heard to give this call throughout the mid-afternoon, alternating it with an antler thrashing of kiawe boughs. In the heat of passion the call becomes a moaning roar and, during the excitement of a fight or shoving

contest, bucks often give vent to their rage with a high-pitched, nasal squeal, somewhat like the '*meow*' of an excited house cat.

Young fawns also have several calls with which they summon their mothers. The most common is a high-pitched, nasal '*naya-a-ah* !' similar to the squeal of the bucks, and has a kitten-like sound. Another call begins with a high-pitched, rising whine, and breaks suddenly into a loud raucous squall: '*ee-ee-p-Y-A-AH* !'. Fawns will of course squeal or scream shrilly in fright when caught by predators, or when in pain. Adult deer also will squeal with fright when pulled down by predators or when handled in live trapping, though in the latter case they are not being hurt. Wounded deer have not been heard to utter a sound.

Teeth

The dentition of adult axis deer strongly resembles that of the black-tail deer but can easily be distinguished from it by the two middle incisors, which are very wide and shovel-shaped, with the crowns wider than they are high.

In the lower jaw there are 3 pairs of incisors, one pair of canines (these appear as the outermost incisors), three pairs of pre-molars and three pairs of molars — ten pairs in all. The upper jaw contains no incisors, and in deer a year or more old, no canines. There are three pre-molars and three molars which correspond to their counterparts below. The formula for the axis dentition is:

$$\text{i. } \frac{0-0}{3-3},\ \text{c. } \frac{0-0}{1-1},\ \text{pm. } \frac{3-3}{3-3},\ \text{m. } \frac{3-3}{3-3} = 32.$$

In fawns there is a distinct upper canine tooth on each side, located about midway in the gap between the incisors and first pre-molar. A great deal of controversy has existed over these canines, and whether they are or are not present. Pocock (1943) disclaims their presence, simply because:

> 'They are entirely absent, however, in all the numerous skulls examined in the British Museum.'

This, at least, serves one purpose—to point out the inadequate age distribution of the collection. Fooks (1945) merely adds to the confusion and misinformation by stating:

> 'With reference to Mr. Nolthenius's note on the canine teeth in chital stags (Vol. 45, No. 1, p. 83), I should like to say that after examining a number of chital and sambar for their "tushes" I have only found them in a very rudimentary form and then only in older beasts.'

Fooks's involvement of the sambar as well as his reference to older beasts indicates that he has not examined enough age classes and is confused on the whole subject. Nolthenius (1944) apparently comes closer

Skulls of Axis Deer

Left : Skull of adult buck. *Right :* Skull of fawn, approximately 7 weeks old

In skull of fawn note the well imbedded canine tooth and the absence of canine teeth in the skull of the buck. These teeth, present in all fawns, are shed by the time the animal is one year old and the socket closes, leaving no trace of the former canine teeth. The extra tine above the brow tine in the buck skull is atypical.

(*Photos : Lyman Nichols*)

to the problem, at least in terms of the exception rather than the rule. He says :

> ' No doubt these teeth as found in axis, can only be called rudimentary, they are not solid and fully developed as in the stags of Europe. As a rule they are just under the skin of the upper gums and have not broken through. In a few cases they are visible as small white spots.'
>
> ' They can be lifted out quite easily and rather resemble the thin broken shell of a tiny egg. It is not surprising that the skulls in the British Museum should not show any of these teeth as they are lost at once when the flesh has rotted or the skull has been boiled and cleaned. There is no socket.'

The solution is quite simple. The canines are present in new-born fawns, actually already being present before birth. These canine teeth appear as slim, curved tusks, about one-quarter to one-third of an inch in length. The tooth is imbedded quite firmly at this stage in a very *definite socket.* We have found one skull on Molokai from a fawn so young that the skull bones fell apart, yet the canines were firmly in place in the tiny upper maxilla. There is indeed a socket, and these teeth do not readily fall out when the flesh rots away.

The teeth are quite firmly placed in sockets in young fawns, but gradually loosen as the fawn grows older and usually fall out before the fawn is a year old. Most of them probably are shed by the time the fawn is eight months old. After shedding these teeth, the sockets close up and so are not seen in the adult deer. Occasionally, one or both of these tiny 'tusks ' may be retained by the cartilage of the upper jaw after having come loose from their bone sockets, and are thus found in the gums of the older deer.

Aging Deer

The problem of aging animals by their teeth is not easy, and the determination of the factors by which this can be done is even more difficult in a study of this kind. One needs at least one or two skulls of known age from the various age classes, starting with young fawns and ranging through all adult years. Rarely is this possible. We have only one skull of known age, a 12-month-old buck plus some information on the development from a live deer up to 18 months. Our age determination is based on the order of appearance and approximate time of development judged from the known-age deer.

Temporary premolars are fully present by the time a fawn is a few months old. They can be distinguished by the size and form of the third premolar, which is long and flat crowned but with three distinct cusps or crown areas. Viewed from the outside it appears to have three pillar-like ridges on its side. The first two premolars are shorter and smaller. The permanent molars are added one at a time in the

PLATE XI

Lower Jaws of Axis Deer

2-4 months — The first molar is just beginning to show at this age. The milk-premolars or temporary premolars are all high-crowned with sharp distinct cusp points. The three-crowned 3rd premolar is distinctive up to about the 18th or 19th month when it is shed. The middle or first pair of incisors are about $\frac{3}{8}$ inch wide at the top. The other incisors are about $\frac{1}{16}$ inch wide. Permanent incisors are about twice these widths. Because the middle incisors are much wider at the top than the base, the crown width will decrease with wear.

6-9 months — The first molar is now fully out and the second molar is just beginning to show. The milk premolars are now beginning to show some wear, particularly the 3rd premolar. The middle incisor also may show some wear and may be narrower at the top than in younger deer.

12-14 months — The middle or first permanent incisor is now in place. The width of this permanent incisor is about $\frac{1}{2}$ inch across the crown. The 2nd molar is about half out and the socket of the 3rd molar is now visible as a wide slit in the angle of the jaw behind the 2nd molar. The premolars are now showing considerable wear.

14-16 months — The 2nd and 3rd temporary incisors and the incisiform canines are still present but show considerable wear. The 2nd molar is now fully out. The 3rd molar is still indicated only by the oval slit in the bone behind the 2nd molar. This opening is however, much wider and has advanced forward in the angle of the jawbone. Note particularly the angle and shape of the front part of the jawbone just behind the incisors. This is due to the permanent incisors imbedded in the bone beneath the temporary incisors. When these permanent teeth are all in place the space occupied by them will close up gradually and the jawbone will flatten out and take on the thin flattened shape of deer two years or older. Note also that the third temporary premolar is being lifted by its permanent replacement.

Graf : Axis Deer

Lower Jaws of Axis Deer

For explanation see page opposite

(*Photo : William Graf*)

order of 1, 2, and 3, starting from the front. Determining age is done by using the presence or absence of certain teeth and the degree of development of the various molars, and then finally by the degree of wear of the various teeth.

Hunters, as well as game managers, should be interested in the age of deer they shoot, and the following outline in combination with the illustrations (Plates XI, XII and XIII) will help a great deal in obtaining some estimate of the age of deer. It is admitted that our outline is purely an estimate beyond about 30 to 36 months. It should be pointed out that the wear of teeth may vary because of variable factors. For example, a deer from the dry, coastal area, with little rain, high wind, and consequently much dust and grit blown on the vegetation, will show much greater wear than a deer of the age from the high, wet mountain forests of Molokai, where the vegetation is virtually dustless and is constantly washed clean by daily rains. Replacement ages will be the same within their limits of variability in these two areas. A deer of 30-36 months age with a virtually complete new set of permanent teeth will look much the same from both areas. However, after this the wear can be expected to be much faster in the dry-land deer than in the forest deer of the wet uplands.

Records from the captive buck ' Willie ' show that the middle pair of deciduous incisors were shed the 63rd week of age and replaced eight days later ; the 2nd pair were shed the 65th and 68th week and fully replaced by the 73rd week. No further records were possible after that, but probably all incisors are replaced by the age of 2 years. This information is useful in conjunction with data given for the molar teeth, though most people would have difficulty in determining what is a temporary and what is a permanent incisor.

Age criteria in the illustrations (Plates XI, XII, and XIII) are fairly close up to 36 months. Above four years the aging becomes a matter of judgment and comparison with known-age skulls which we lack today.

Other Ungulate Skulls

Hunters may at times find the skulls of other ungulates, such as goats, mouflon sheep, or pronghorn antelope, in the field on Lanai and Molokai. These are for the most part easily separated from the axis deer. The skull of a buck deer obviously will show at least antler pedicles, the bony, flat-topped, peg-like protrusions rising about 1 to $1\frac{1}{2}$ inches above the surface of the frontal bones. Antlers, of course, easily identify the skull from any other ungulate. On Kauai, where the North American blacktail deer (*Odocoileus hemionus*) has been introduced, this will be the only deer skull to be found, and pedicles are much lower

PLATE XII

Lower Jaws of Axis Deer

18-24 months — All incisors are in by the end of this age-class. The replacement of the 2nd incisor is probably by 18 to 20 months (see text) and the 3rd incisor and incisiform canines between 20 and 24 months. The 2nd and 3rd temporary premolars are in the process of replacement. In the upper specimen (female) the replacement is not as advanced as in the lower specimen (male). The permanent premolar is just visible beneath the three-crowned temporary 3rd premolar in the upper specimen and also beneath the 2nd temporary premolar in the 2nd specimen. In this specimen the 3rd molar is also farther out than in the upper one. There may be a difference in the ages of tooth replacement in sexes. Note the flattening of the mandible behind the incisors as the permanent incisors push out and replace the milk incisors.

30-36 months — All permanent teeth are now present. Note the difference between the permanent and temporary pre-molars, particularly the 3rd pre-molar, which no longer has three cusps. The crowns are all high and the points of the cusps are sharp triangles. The anterior part of the mandible behind the incisors is losing more of the thickened shape of the temporary tooth condition.

4-5 years — Similar to preceding condition. Crowns are still high and the cusps still angular but the points are now rounded off and teeth are definitely showing wear, particularly on the outer side. Note the difference in the appearance of the 1st molar and the 3rd and 2nd premolar. The greatest wear is on the 1st molar and the 3rd premolar.

Graf : Axis Deer

Lower Jaws of Axis Deer

For explanation see page opposite

(*Photo : William Graf*)

than in the axis deer. Also, antlers are readily distinguished. In doe skulls the two middle incisors, with their wide shovel shape, will easily distinguish the axis deer from the blacktail. The males of other ungulates that are found in the area all have true horns ; that is, a bony core rising from the frontal bones, covered with a horny sheath, as in goats, sheep, and antelope. If the horn is missing the bony core will be there, rounded and back-curving in sheep and goats, and straight and flattened at the upper end in the antelope. Most female goats will show this horn core, but smaller. Female deer, female mouflon, and most female antelope have no horn distinction. However, the female mouflon skulls are easily distinguished from doe deer skulls by their general shape. The mouflon skulls are shorter and broader, with a distinct concave or dished outline, while doe skulls are long and narrow with a fairly straight outline from forehead to nose. Doe antelope skulls are similar in general appearance to doe deer skulls, but have very large, heavy eye sockets (indicating their dependence on vision and high eye development) located more to rear—giving them a greater field of vision to side and rear. Antelope also have middle incisors which are narrower than they are long, in contrast to the very wide spatulate middle incisors of the axis deer. Photographs should be carefully examined for other distinctive features.

Faecal Pellets

The fæcal pellets of axis deer assume many shapes typical of other deer, sheep, goats, and antelope, and it would be very difficult to state with certainty that a certain pellet group was that of a deer. The pellets may range in size from one-quarter to three-eighth of an inch in diameter and from one-half to one inch in length, and be deposited separately in a group, or in a solid mass. They often are tear-drop shaped with a dimple in the large end and several indentations on the sides, or else in the shape of cylinders with rounded ends, but may take many forms. They are dark green and soft when fresh, but become dark brown or black and hard with drying.

Goat pellets seldom have the tear-drop shape, and are usually blunt, rounded cylinders, while mouflon pellets are more typically tear-drop in appearance, but less than one-half inch in length. However, the pellets of each species are so variable, that they cannot be definitely identified in all cases by pellet shape alone.

The defæcation rate of one captive buck on a diet of natural food was measured for a period of four days to determine the average number of pellet groups deposited per day. The rate in this case was found to be about 15·5 groups per day.

PLATE XIII

Lower Jaws of Axis Deer

5-6 years — The points of the cusps are showing much wear and are dulled or ground down. The condition of the incisors should be noted. The middle and outer incisors will be still about the same length and the middle incisor is still almost full width. Top specimen shows the first molar partly broken away and other teeth show heavy chipping of the points of the cusps. This animal apparently came in contact with hard, gritty food. Such specimens will still show high crowns but chipped rather than worn points. The upper specimen in this case is undoubtedly older, probably at the upper limit of this age class, whereas the second specimen shown is at the lower limit of its age class.

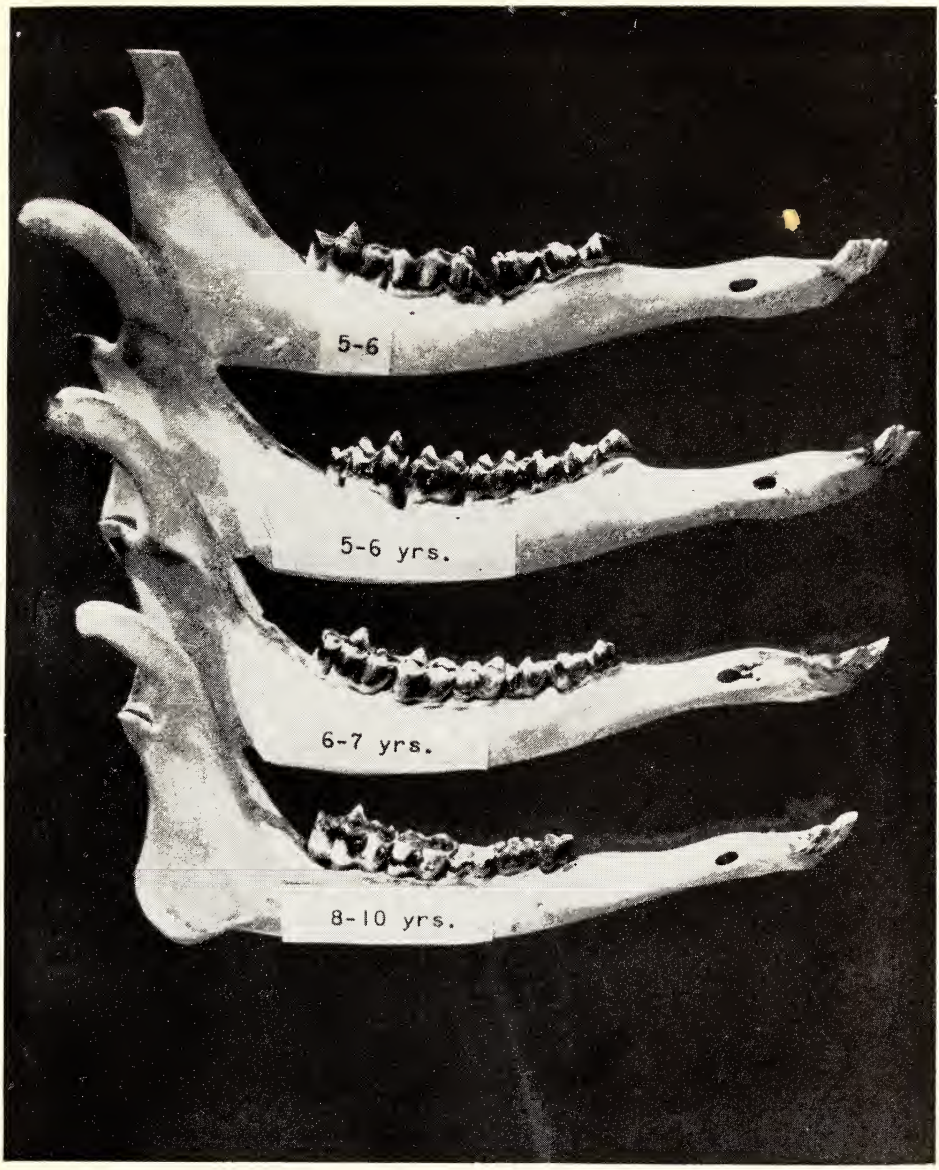
6-7 years — The crowns of all teeth are now well flattened and definitely nearer the gum line. Crowns are reduced about $\frac{1}{3}$ to $\frac{1}{2}$ of their original height and have a fairly flattened appearance. Some evidence of the original triangular pointed cusps is still evident. The first premolar still shows a triangular shape. The incisors show shortening with wear and the outer ones are shorter now than the 1st or middle pair.

8-10 years — All the teeth are now badly worn. The 1st molar is now almost down to the gum-line and presents a concave or cup shape, and even the first premolar is now square topped. The incisors are much worn and the middle incisor in this age-class as in the preceding one will be no wider at the top than in a 9 month old deer. The outer incisors are usually much shorter than the 1st pair of incisors.

Note that the last age-class specimen has only five molariform teeth. The first premolar is lacking. In some specimens the 3rd premolar was missing, a condition that apparently is not uncommon.

All age-classes above 24 months are estimates and ages above 4 years are particularly difficult to judge under variable forage conditions. The examples listed are an average guide to follow but their age may vary depending on conditions.

Graf : Axis Deer



Lower Jaws of Axis Deer

For explanation see page opposite.

(*Photo : William Graf*)

Temperature

The temperatures of four freshly-killed adult deer were taken rectally. These were found to be 101·5, 101·6, 101·2, and 101·2 degrees F. Normal temperature is probably about 101·3 to 101·4. These deer were at rest and were killed instantly. A large buck that had run a short distance was shot but lived about 10 minutes before dying. The temperature taken rectally about 45 minutes after death was 102·7 degrees F.

Senses

All senses are very highly developed in the axis deer. Probably the sense of smell is the most important, but certainly hearing is not far behind in use and importance ; in fact, it is probably equally important, depending on circumstances and conditions. It should be kept in mind by the reader that senses are developed in proportion to the usefulness to the animal. There is too much tendency on the part of sportsmen and popular writers to make hard and fast rules on the basis of general observations.

Both deer and antelope have been observed (Graf 1956) that disregarded their sense of smell, and depended either on eyesight and/or hearing entirely. Under these conditions it was possible to approach to within a few yards with the wind at the observer's back without causing the animal any alarm. Yet in all these cases the animals showed extremely keen alertness to sight and sound.

In deer, normally a forest animal, vision is often greatly restricted and consequently is of little use. Scent and sound are of great importance, and are constantly used. An animal from a dense forest country may at times appear almost blind in its inability to spot an enemy even in the open. Or it may appear quite stupid and remain standing, staring at a man apparently without recognizing him. The answer is quite simply that without scent or sound, by which the animal normally recognizes its enemy, there is no sight recognition of an enemy which the animal may never have seen before. In short, it is unfamiliarity, through a sense by means of which it does not recognize danger, that causes the apparently stupid and unorthodox behaviour of an animal.

In our experience, the senses of smell, sight, and hearing are extremely good in the axis deer. These deer can scent danger that is almost a mile away up-wind from them. They seem to locate food primarily by scent, and it may be that these deer (and perhaps others) are far-sighted, a condition that would not be too strange since the greatest need is to see keenly at a distance. Eyesight at close range, that is, a few feet away, appears to be poor. Beyond a few yards it is excellent. There

is another explanation for this. The captive buck had difficulty in locating food by sight that was in plain view a few inches from his nose. Actually this should not be considered strange since the placement of the eyes—far to the side of the head—is not conducive to locating objects directly under the nose. Eyes so placed are strictly for detecting danger at a distance, not for critical viewing at short range. Critical focus for the purpose of food gathering is of little use to an animal that feeds on the type of food, and in the manner of a deer, and it is quite possible that ungulates' eyes do not focus sharply at very short distances.

Whether deer are colour blind or not, we are unprepared to say. Their eyes are excellent and they can often recognize a man at considerable distance even though he is standing still. This is particularly true on the west end of Molokai where hunting has conditioned the deer to the use of their eyes more than elsewhere. On the east end of Molokai in the high, wet forest, deer showed the typical sight-response of animals not used to using their eyes—as was to be expected in the heavy jungle country and where man is seldom encountered by them.

Hearing is extremely acute, and the ability of the animals to distinguish danger signals from ordinary sounds is at times amazing. Here again it is a matter of conditioning and training. The Molokai west-end deer showed the highest degree of conditioning, the east-end forest deer the poorest.

Gaits

When feeding, the axis deer usually moves along at a slow walk, but it may walk rapidly at times, and occasionally breaks into a trot. When frightened, however, they run with a speed and agility that is surprising. Their run is a low, stretched-out, well co-ordinated flow of motion, with the footwork of a greyhound at full speed, and they can negotiate rocky ground and brush with flashing ease. We have clocked them at 50 miles per hour from a helicopter, but that was ' air-speed ', and the true ground-speed could have been somewhat lower due to head winds. A few observations on Molokai, when deer angled across in front of a jeep racing to intercept them, indicated that they are able to push their speed up to 40 miles per hour for short bursts. However, they tire easily and do not appear able to keep up top speed for long distances, soon dropping back into a slow gallop, then a trot, and finally a walk when pursued steadily, eventually seeking cover in which to hide and rest. This accounts for the ease with which Molokai Ranch cowboys were able to lasso them for the original shipment to Lanai ; they chased them on horseback in relays until the deer slowed enough so that they could catch them.

Leaps of 15 to 18 feet have been recorded for deer in full panic-stricken flight, but these are ' broad-jumps ' not ' high-jumps '. In the

wild, they do not usually jump over obstacles, but prefer to run around them. Captive deer, on the other hand, can soon learn to make high-jumps when necessary, and have been observed to clear a six-foot fence easily from a standing start. Even tiny fawns can bounce over a surprisingly tall barrier. Wild deer, without reason for learning or need to do so, would fail to take even a five-foot fence, preferring nearly always to slip through or under it.

HABITS AND BEHAVIOUR

Normal and Abnormal Behaviour Judgment

In general the behaviour and habits of the axis deer show its relationship to other members of the genus *Cervus* as a whole. However, in many specific details it varies not only from this pattern but varies to a considerable degree in specific habits between each of the islands on which it is found in Hawaii.

Such specific variations are due to the conditions brought on by climate and weather, terrain, and food which may force the animal to adopt behaviour habits that differ from the normal. When abnormal pressure factors are brought to bear upon the animals, one can expect to observe patterns of behaviour that are radically different from the normal. Conversely, when radically different or unusual behaviour is observed, one should look closely to see the cause for such behaviour.

The problem is then to determine what ' normal conditions ' are and what is ' normal behaviour '.

The inexperienced observer, scientist as well as layman, all too often judges by anthropomorphic standards. It is most difficult to avoid doing this, especially when we have nothing else to judge by except our own experiences. This, of course, is wrong. Deer behaviour, or any other animal behaviour, must be judged by its own standards—deer, by deer standards in general, and most specifically by the kind of deer under consideration.

The problem is in knowing what constitutes *normal conditions,* and *normal behaviour.* If we know what normal conditions are, we can come closer to deciding what normal behaviour is. If we do not know this, then we can only accept the behaviour as an expression of the conditions. Also, if the abnormal or unusual conditions persist as a constant situation, then the behaviour must be considered as normal for the conditions. The important point to remember is that varying conditions may create varying habits and that, while many behaviour characteristics are inborn, others can be acquired or varied.

Generally speaking, there is a feeding, herding, breeding, etc. pattern which resembles that common or related to other cervids. Also, in

general the axis deer in India and Hawaii have certain habits in common, but in some respects the axis deer of Hawaii appear to differ not only from their Indian relatives, but show varying habits between the island groups.

It takes a great deal of time in the field observing both habitat and habits to determine what is normal and what is not normal habitat or normal behaviour. Hunters, who spend only a few days a year afield, should keep this in mind. It will help prevent many false assumptions and conclusions and the establishment of so many commonly held dogmas which one finds firmly fixed in the minds of laymen and hunters.

With this in mind let us take a look at the behaviour and habits of deer in Hawaii.

On the whole, there is a degree of gregariousness similar to that in elk and other deer, but not as well developed as in the most specialized groups. They like to be in each other's company, but form only loose aggregations or herds. Feeding is usually during the early and late hours, with regular movements to water during the hot parts of the year. They graze when grass is green and abundant, and browse when grass is scarce, or when browse is particularly palatable or abundant. Groups or herds are matriarchal in nature—i.e. old does generally are the leaders, never bucks. There is evidence of nursery formation among fawns, and there is a well-defined 'signpost' behaviourism in bucks. All these are characteristic of deer in general, but all have their own variations and specific characteristics within or around these basic patterns.

Even as a new-born fawn, the axis deer exhibits characteristics not common to others and which seem to reflect certain adult characteristics to be discussed later. Normally, a new-born fawn shows no fear of man and may be readily approached and even handled. This does not appear to be the case with axis fawns. Those which were encountered, so young that they could only wobble about on rubbery legs, promptly showed every sign of fear and recognition of an enemy, and made every attempt, and quite successfully too, to flee.

Temperament and Alertness

Axis deer, particularly the females, are extremely alert and wary. In their nervousness, they are constantly on edge during the daytime, often jumping up and running from imagined dangers, as well as from real ones. They continually test the breeze, pausing to look and listen for signs of danger, and are thus difficult to approach. The older bucks, however appear to be a bit less alert—or, at least, less nervous than the young bucks and does. When with does, they seem to depend to some degree on the alertness of the does for their own protection.

When alone, they are usually somewhat easier to approach than does if care is taken to stalk them up-wind—the least trace of human scent will put any of them to flight. Young fawns of both sexes, though instinctively alert and nervous, sometimes get carried away by their playing, curiosity, or feeding, and at such times are not as sensitive to the approach of danger as their mothers, who are constantly aware of all happenings in their vicinity. During the night, the nervousness is much reduced and the deer appear to be a little less alert than during the day ; even the does may then be approached fairly easily if wind direction is watched.

This inborn wildness seems to be retained even by deer raised in captivity under close proximity to man. The only exception seems to be in those raised by hand and handled constantly, but even these 'tame' deer will instantly become wild and panic-stricken when frightened by unfamiliar stimuli.

At the Honolulu zoo, the well-fed, well-kept small herd of axis deer will promptly retire to the far end of their roomy paddock at the approach of a visitor. They are rarely found near the outer fence as is commonly the case with other species of deer. This negative reaction is not an accident and has been watched too many times to be mistaken. There is a definite nervousness and watchfulness in the herd when visitors stand in front of the paddock. The does and young bucks in the small herd kept by Mr. Noah Pekelo of Molokai, showed the same behaviour pattern. All of these were born and raised in captivity. Yet the approach of even members of the Pekelo family would cause the animals to run to the far side of the pen, and the approach of strangers would create a wild panic, with animals dashing wildly into the wire fencing of their pen. Only the old buck, Rudolph, raised indoors on a bottle, showed no fear of men, and in fact was exceedingly pugnacious most of the year except when his antlers were shed or still very young and soft.

There appears to be a greater degree of nervousness and wildness demonstrated among wild deer on the Molokai Ranch range than elsewhere. This undoubtedly is due to the extremely heavy hunting that goes on the year round, as well as the type of hunting that goes on in this area, and not in other areas.

This inborn wildness and timidity may also be the reason for this deer's demand for overstorey cover, such as a forest cover. It apparently derives some feeling of security from the partial concealment and shading, yet dislikes the close confinement of dense and continuous cover—there must always be openings or clearings near by, or an open parkland forest.

On Molokai Ranch this affinity for cover was developed and dis-

played perhaps to the highest degree. A typical example that could be observed almost any evening is the following :

A herd of 15 to 20 deer, made up of does, fawns, and perhaps several young bucks and an old mature buck, ventures out of a thicket of kiawes to feed at the edge of an open pasture at the start of their evening's foraging. As they feed out into the clearing, there is the usual pause and quick look up and around for any possible danger. Gradually, as the distance from the forest increases, the frequency with which heads are thrown up increases, there is a gradual but definite build-up in the tenseness and alertness with which the animals move. This changes to outright nervousness as the distance widens to 300 yards or more and, finally, as the distance from cover increases still more, the nervousness reaches a point where there is very little grazing but more looking about and nervous stepping around. This reaches the point where, finally, an animal makes a nervous jump, or jostles another one, which may result in another nervous jump, a startled yelp, and the whole herd breaks into a wild, helter-skelter flight back towards the forest edge.

The speed and panic is high, yet it shows a direct relationship to the origin of the cause for the panic, namely the distance from shelter. As the distance from the forest decreases, so does the panic. The wild racing slows to an easy run, then a trot, and finally to a walk, and comes to a halt near the edge of the forest. Here the group stands around with a bewildered and puzzled look about it that needs only someone to say : ' who started that ? what happened ? ' The animals walk back and forth, peer here and there ; perhaps one gives voice to a shrill ' *ye-e-o-op* ', which may be taken up by another one and is continued back and forth for minutes without anyone really believing anyone else—for these are not really alarm calls which, when uttered lower and sharper, leave no room for doubt in anyone's mind.

Such self-generated flights have been observed many times on Molokai Ranch, where this type of behaviour seems to be most common. One is reminded of a group of young schoolboys out on a ghost hunt to the local cemetery or haunted house—the closer they come to the object, or perhaps the farther from the known security of their car, the more nervous or fidgety they become, until some imagined or misinterpreted sight or sound sets them into flight. There is no doubt that the objectives and minds involved are quite different, but the psychological causes that create the condition and trigger the reaction are the same in both cases.

Another behaviourism that is closely related is one that often occurs in or near open forests, where the deer do not ever get far enough away from surrounding cover to display the spontaneous panic reaction, but which is open enough to make them thoroughly alert. This extra alertness is always manifest whenever they step into a clearing, even a

relatively small one, or thin patchy forest. Under such conditions, either as a result of a real but passing danger or of an imagined one, a deer gives its high pitched alarm bark. This call is clear and distinct and longer than the real alarm call, and might better be termed the 'alert' call. It may evoke a short run which stops after a few half-hearted bounds. After this first moment of alarm, the group stands peering in the direction of the supposed danger. The alarm-giver repeats the call and others, without really knowing what it is all about, may also call. This may go on for several minutes until the whole herd loses its tense attitude. Individuals may wander about in a relaxed and indifferent attitude, now and then throwing up their heads to give a yelp, others answering, until there may be a sort of chain reaction of yelping calls repeated with considerable frequency as the herd wanders about picking at feed or just standing around.

Such a chorus may continue for a considerable period of time following the incident which initiated it and which is always something which has no immediate real threat to the herd. It can be a cow that shows up on the horizon a half mile away, a stray and unidentifiable scent that is picked up momentarily, or a sound, or finally just an imagined danger. Such calling, or 'talking', sessions are so common on Molokai that one is hard put to try to explain the comparative silence of the deer on Lanai. The Lanai deer do, of course, call at times. But even genuine alarm calls are less frequent, while 'talking' sessions, such as those described on Molokai, are even rarer.

Here one could be tempted to say: 'Lanai conditions are more nearly normal. The very limited hunting permits the deer to live a relatively undisturbed life and therefore express themselves in a more normal and natural way.' It is a conclusion which can leave one feeling quite smug and self-satisfied at the ease of solution of the problem—until one becomes acquainted with the deer of the cloud forest of east Molokai. These deer are hunted even less than the Lanai deer. In fact some of these deer may never see a man throughout their lives. They live under almost true wilderness conditions. Yet they are as talkative as their relatives some thirty miles away on the opposite end of the island. Small groups have been observed on distant ridges a half mile or more away, some feeding, some resting, yet now and then at fairly regular intervals one of them, usually an older doe, utters her sharp, clear yelp.

Such calling was a real boon to us while working in the rain forest, both in helping to locate deer for collecting purposes and for observation.

Daily Movements

Phillips (1935) says of the axis deer of Ceylon: 'Except where they have been much shot at and harried they are diurnally inclined and feed in the mornings and evenings ; resting during the heat of the day in the shade of the jungle.' Prater (1935) concurs in this. He says : ' They are less nocturnal than sambar and feed till late in the morning and again in the afternoon, and lie down in the interval in some shaded spot.'

These statements are generally true of the Hawaiian axis deer also. The heat probably influences them more than daylight or darkness. On Molokai during the cool winter months deer could be seen active until mid-morning or even later. With the hotter weather, activity would cease earlier and start later in the afternoon. However even here there were exceptions, and in the protection of the open kiawe forest of the leeward west end, where there was little human activity, deer were often seen feeding and active as late as 10 and 11 a.m. or as early as 2 and 3 p.m. Such activity is, of course, dictated largely by how well-fed and satisfied the animal is. Once the stomach is filled, there is little incentive to move about, and the animal usually lies down to chew its cud and rest.

In this part of the range below Mauna Loa, many of the water troughs—the sole source of water—were well above the kiawe forest, some as much as a half-mile above the main fringe of the forest. Deer began to show up at the edge of the forest just before sunset, occasionally as much as an hour before sunset if the weather was relatively cool. They loitered just within or at the edge of the cover, gradually working farther out as the light fades. None were observed to go to these troughs before it was too dark to see. They gradually wandered uphill to water during the night, feeding, drinking, and then returning to the forest by sun-up. At the first hint of dawn the deer would be heading back to cover. Again, the farther away from the forest, the more hurried the pace, often a trot or even a lope. As they neared the forest, the pace would slow to a leisurely walk, and finally there would again be a period of loafing near the edge of the trees, perhaps some feeding, and at last retirement into cover by 7 a.m. to 8 a.m. at the latest. This retirement from the edge of the forest did not, however, stop all activities. If followed up into the forest, some deer could be found grazing or browsing as late as 9 or 10 a.m.

In Papahaku Forest, a beautiful old-growth kiawe forest that stretches for two miles back of Papahaku beach on the west end of the island, deer were observed active all day during the kiawe-bean season. Beans appeared to reach their peak abundance here in October and November during the study period, and were eagerly sought by the deer. During

the 1957 season, beans were relatively scarce. Food conditions in general were also very poor on the west end, and the forest itself was literally trampled bare by cattle. Only a few hardy lantana shrubs that had reached large size managed to survive under the closed canopy of this forest.

On 5 November 1957, for example, deer were active all day, moving singly and in groups of two to five or six about the forest in search of fallen beans. Cattle and horses also were actively searching for the beans. When a bean dropped within hearing of the deer, they would literally race each other to get to it first. Livestock, particularly the horses, would also respond to the sound of a falling bean, so that competition was high for this food. These beans, like our mesquite beans of the south-west, are high in sugars, with sugar content running up to 25%. The kiawe trees were originally introduced as a supplementary cattle feed. An insect pest that now infects the beans has much reduced the dependability of this crop.

On December 6, a group of 23 deer was observed in the open in a medium-sized forest clearing between 9 and 10 a.m. Generally, however, the Molokai west-end deer cease all activities in the open by 7 to 8 a.m. and do not venture out into the large clearings or fields until 5 p.m. or later.

On the west end, where the water troughs were within the forest and not more than 100 feet from the nearest cover, the deer came regularly in the late afternoons to water. Usually the first individuals would start arriving about 4 p.m., occasionally a few as early as 3 p.m. The main groups and herds would usually drift in after 4 to 5 p.m., always arriving from the side with the best cover. At the main Papahaku trough, they preferred to come in from the east and north-east side which provided good forest cover as well as the shelter of a shallow ravine. This part of the forest is hunted regularly and deer are shot even at the watering place which lies in a clearing some 200 to 250 feet wide.

Deer arrive at the edge of the clearing from the gulch, or north-east side, and spend some time standing and milling around within the edge of the trees. The animals show a great alertness and wariness, not only in general but toward each other. There is a stiff-legged wariness as they mingle ; obviously many are strangers to each other, or at least not regular associates. Drinking is done singly or in small groups. Usually one individual, often a doe, will approach the trough warily, tail raised stiffly ; her gait is measured and halting and as she nears the trough, her neck stretches farther and farther out towards it. By the time she is at the trough she is literally leaning forward, reaching for the edge with her nose. In this way, standing as far back as possible, she drinks ; she may leap back once or twice and re-approach the trough again ; drinking is hurried and often not completed in one operation.

These water troughs swarm with honey bees during the dry season ; many fall in and float or swim about in the water so that not only is the air swarming with hundreds of bees, but often there are almost as many in the water as in the air. This buzzing swarm of bees is no doubt an annoyance to the deer and perhaps a cause of alarm and fear.

After one animal has approached the trough, others become more venturesome, though usually only in small groups. The rest may mill about behind these, stepping warily around each other with stiffly erect tails, like so many strange dogs. Calling may start and may be carried on for a time, simply ' talking ' back and forth, both by animals in the clearing and others coming in.

A most interesting feature of the behaviourism around the watering troughs is the deer's reaction to the fencing, and particularly the gates, around the troughs.

The Papahaku troughs, as well as a number of other troughs on the west end, were situated in a fenced cattle corral. These corrals were usually rectangular or square and about 200 to 300 feet across ; the fence, usually made of smooth strands of wire and wooden posts, presented no problem to the deer. The gates, 15-20 feet wide, were always left open. Such fences and gates made it possible to control the use of water by cattle as well as to corral cattle at the water trough.

It was most interesting to note that deer never used the gates at a number of these fenced water troughs on the west end though these troughs were used daily throughout the dry season by hundreds of deer. In every case deer crawled under or through the fence, no matter how inconvenient, rather than go through the gate. These troughs were checked for tracks on numerous occasions throughout the dry season, and not once were tracks found entering or leaving through the gate. A coincidence ? It is difficult to explain such a coincidence when numerous tracks were to be found going through the fence near the gate, not once but consistently on successive nights.

On Lanai, deer generally remained under cover during the daytime and were rarely seen moving about in the open until just before sunset. An hour or so before sundown they would begin to emerge from their daytime resting places, and would be seen browsing and grazing along the edges of the coverts. There, as on Molokai, they are hesitant and nervous when first leaving their protective cover, but as darkness approaches they become bolder and work farther and farther from the thickets and onto the open ridges and hillsides. Since the best cover there, as on Molokai, is usually along the coast or in the gulch bottoms, the evening drift is predominantly uphill towards the open ridge tops. This is particularly noticeable along the northern coastline where the deer may move uphill two or three miles from the kiawe forests before the night is over, with a climb of perhaps 500 to 1000 feet in elevation.

Where the dense and attractive coastal forest is not present, the deer may spend the day at fairly high elevations wherever cover is available, so that the evening feeding is just on the near-by open ridges rather than up-slope. It is possible that this upward movement may be towards the zone or elevation in which nightly dews fall and thereby provide more moisture in terms of succulence as well as water on the grass.

There is no comparable movement on Molokai except that described for the leeward shore water troughs, which are situated well above the forest line at altitudes up to 1000 feet. East of Mapulehu on Molokai, and still on the leeward side, there is some movement of deer down from the cooler higher elevations into the lowland kiawes where water troughs are located. This is an area where the trade winds and the cooler moisture conditions of the east end make themselves felt. There is a higher open forest in some sections here, and deer prefer to rest and feed at the higher elevations and come down to water at the coastal troughs.

Along the eastern coast of Lanai, at the base of the big ridges leading down from Lanaihale, the evening drift is the reverse of that along the western, northern, and north-eastern coasts. Here many of the deer spend their days in the lower ends of the gulches and move down into the coastal forests in the evening and at night to feed.

Feeding goes on throughout the night, either continuously or intermittently between short periods of rest. They seem to become much more confident after dark, perhaps feeling better protected by the cover of darkness, and are not nearly so prone to take to their heels over disturbances. They calmly feed out onto open slopes that they would not normally set foot on during the day, and where their range adjoins the pineapple fields on Lanai, may wander out onto the dirt roads along the edges of the fields, picking at weeds made succulent by farm irrigation. Occasionally a few work into the cultivated fields for a quarter of a mile or more from the nearest brush along the edge.

On Molokai, there was no activity observed on the roads into or along the edges of the pineapple fields. The difference may be due to a greater reluctance on the part of Molokai deer to leave cover for any distance beyond the maximum 300 to 400 yards, but more probably is due to the combination of fences along the edges of the pineapple fields and the distance below these fences to reasonable forest cover.

As daylight approaches, the deer that have been feeding on the open ridges on Lanai begin to move slowly downward again, feeding as they go, while generally working their way towards the cover of the forest or dense brush in the gulch bottoms. By some two hours after sunrise, there is rarely a deer in sight in the open, though of course some exceptions to this occur and animals may occasionally be observed moving about even at midday. The majority drift into the heavy brush along the inland fringe of coastal kiawe forests or into the dense brush or forest

that lines the sides and bottoms of many of the gulches. Where the coastal forest is not available, they move into such patches of cover as are suitable for protection and shade. As on Molokai, the deer on Lanai continue to browse and graze along after reaching cover, or just dawdle along or stand round doing nothing. When they find a suitable place, they bed down to spend the day, resting and chewing their cud. These periods of rest may be interspersed with short feeding periods. Resting animals rarely remain bedded continuously for a long period of time, but usually get up to stretch, turn around, or move about a little, bedding down again after a half hour or so in the same or a different spot.

Individual deer appear to be fairly regular in their daily feeding rounds if undisturbed, and if the weather remains the same. For example, a small herd occupying the lower fringes of the eucalyptus forest behind Lanai City would move out of the forest regularly each evening along a similar route and spend the night feeding in an abandoned, weed-grown pineapple field, the open hillside, the fields between the town and the forest, or occasionally out on the golf course. In the early morning they would return slowly to the forest where they spent the day. Once their route and timetable was established, they could be found almost at a given time and place with a fair degree of certainty. Deer with distinctive markings in other areas have also been observed to follow roughly the same circuit day after day if undisturbed.

Resting

During the night between periods of feeding, axis deer frequently bed down to rest and chew their cud. Because of their confidence in the protective cover of darkness, they lie down wherever they happen to be without seeking cover. The use of a spotlight at night shows small groups of deer scattered over the hillsides and flats, with some feeding and others lying down, often right out in the open.

In the morning, after they have reached cover, many deer spend some time just loitering under the trees before seeking their day-beds. These loafing areas are usually found within a grove of good-sized kiawe trees surrounded by a screen of smaller growth which protects the interior of the grove from observation. They are marked by well-trampled, and usually, bare ground, buck-rubbed tree trunks and branches, and large amounts of droppings. Some deer lie down in these spots and spend the day resting and picking at what forage is available there, but most soon wander away to search out more favourable bedding sites.

Preferred spots for beds are generally in the shade of kiawe trees, large klu bushes, or wiliwili trees, though some just lie down at the base of a large rock screened by a little shrubbery. On Molokai where there is always an abundance of kiawe cover, it was noted that deer liked to

pick flat benches on the sides of gulches or slopes. In areas where the kiawes are widely spaced, the trees are wide-branching with branches reaching almost to the ground. Such trees provided favourite resting spots, the deer crawling under the low-hanging branches and bedding down on the clear ground underneath. In the rain forest, deer were observed bedded in open pockets on the sides of canyons. Here, however, the grass was so high that a deer lying down was almost invisible.

Beds may be on ridge tops where cover is available, but more often they are on the edges, slopes, and bottoms of the larger gulches, where, if disturbed, the deer can reach other cover in a few leaps, or run down or across the gulch putting it between themselves and the source of danger.

Beds appear to be picked for comfort as well as concealment and safety ; on hot days shaded beds will be used, while on cool days deer will often lie in beds open to the warmth of the sun. The beds are often situated on the lower or down-hill side of a clump of bushes or trees under the rim of a gulch, where there is a good view of the country below.

Since deer, like other ungulates, tend to turn their back to the wind, one might be tempted to conclude that deer pick their beds with a down-wind view in order to be able to see danger in front as well as to scent it approaching from the rear. However, one can find almost as many cases where there is no correlation between the way in which the animal lies and its ability to foresee danger. Sites on the sides of hills or canyon walls generally present a good view downhill, and if the wind happens to be at the animal's back from across the top of the gulch—as it often is on certain parts of the islands where the tradewinds blow across the gulches at an angle—then it might appear that the deer possess a judgment and sagacity which such animals are not likely to have. With a change from the normal tradewinds, the wind and view would often be from the same direction, thus offering no particular advantage of scent to the deer's usual bedding site.

If there is a slight slope to the bed, the deer lies with its head in the direction of the higher part of the bed and with its back to the slope. This is a natural position which even a man will take under these conditions. Where the benches were wide enough, or on ridge tops, there was no uniform direction of facing except to turn the back to the wind if it was particularly strong or cold.

Day-beds are frequently used over and over again by the same or other deer, and are often worn bare of vegetation from continuous use. While lying in their beds, they nibble at any forage within reach on the ground or overhead, so the sites are usually picked clean.

Axis deer always lie down by folding their forelegs under them first, then their hindlegs. They get up on their hindlegs first when arising. They can rise and be running so rapidly when frightened that it seems they are almost exploded out of their beds and into full stride. Nor-

mally, however, they get up slowly, arch their backs and stretch their legs luxuriously, and then move off.

When lying down, they usually have their legs folded under them in readiness for quick flight, but they sometimes roll over onto their sides with legs extended in complete relaxation. Their resting attitude is one of dozing rather than sound sleep, and the head is often partially erect even though the eyes are closed and the animal appears sound asleep. Even while dozing, the ears and nostrils are attuned to sound and scent, and they are wide awake in an instant at any sign of danger.

An interesting note about the bedding habits of these deer is that bucks frequently urinate in their beds while lying down. Their rate of excretion is slow enough to let the urine soak into the ground rapidly, forming a very small wet patch and hardly contaminating the coat at all. Does have never been seen to do this, so if a fresh bed is found with a wet spot in it, it is almost certain to have been that of a buck—a point worth remembering by the hunter.

Effects of Weather on Daily Movements

The daily feeding and resting movements as described are typical for normal, clear dry weather with little or moderate wind. On Lanai in the dry-land habitat, a rainy day will change the pattern and the deer will tend to remain under cover instead of coming out in the open in the evenings and early mornings to feed. The rain does not seem to bother the deer particularly ; captive deer lie or stand in rain with no appearance of discomfort and only seek shelter if it rains very hard. Nonetheless, they are rarely seen in the open during, and for perhaps a day following, rain.

In the cloud forest habitat of east Molokai, rain is an almost daily occurrence and there is no escaping it. In fact, deer and goats have been observed to move into the open during drizzles and fogs to escape the drip from the trees. There is neither a daily or seasonal movement here, nor other movement within the home range for food and shelter.

A heavy wind also seems to keep the deer under cover, particularly those ranging the comparatively open brushy slopes away from the coastal forests of large kiawe trees ; they tend to move and feed in the shelter of tree-clumps and brush-patches in the gulleys, and are not seen as abundantly in the open during the normal feeding hours. The wind itself may cause no discomfort, but they appear much more nervous and ' spooky ' during a strong blow and perhaps remain closer to cover for this reason. Strong wind dissipates odours rapidly, creates a constant sound of rattling branches, and puts all vegetation in motion, thus making danger much harder to detect. It is possible that the deer realize their senses are not as effective under these conditions,

However, on west-end Molokai there was no noticeable difference in the behaviour (nervousness) of the deer under such conditions, perhaps because they are constantly keyed-up to their highest pitch due to heavy hunting.

On cool or overcast days, the morning feeding periods last longer and the evening periods commence earlier. The deer move about more during these periods and feed longer than they do on hot mornings and evenings when they seek shade earlier and leave it later.

Foggy weather, while rare in the dry-land habitat, is common in the wet forest and just below it. Under these conditions, deer may be encountered feeding in the open at a much later hour than on clear days. On Lanai, if the fog persisted, the deer living in the lower fringes of the cloud forest often remained out, moving and feeding as long as it lasted, perhaps spending much of the night bedded down. However, on Molokai during the time which we spent on the high north-eastern open ridge in the rain forest, deer were gone from the open ridges as early as dawn on the drier slopes. Likewise, they were abroad all night long, judging from their frequent calls all around camp, and from the tracks on the trails ; and this during the nightly rains and fogs. In the rain forest where the collecting of specimens was done on both clear days as well as many rainy foggy days, there was no consistency of activity. Deer were sometimes encountered in the open during the clear days as well as in fog and rain. Likewise, during many rainy and cloudy days, deer did not appear in the clearings until late afternoon.

The stage of the moon, while not a weather condition, also seems to affect the daily movements to some degree. During full moon, feeding is heavier at night when visibility is relatively good, and the deer take cover earlier in the morning and leave later in the evenings. The reverse takes place during the dark of the moon.

Seasonal Movements

On Molokai the only seasonal change was not of movement, but rather one of activity as it was affected by water and food. With the rainy season, food and water becomes abundant and the deer are not obliged to travel to the tanks for water. Food is abundant in the open kiawe forest as well as on the open ridges. Concentrations of deer disappear from some areas near favourable feeding places—such as sections of forest with a good bean crop. They are then somewhat more uniformly distributed throughout the forest areas. Perhaps, if anything, there is less movement and activity than during the dry season. There is, of course, not even this change in activity within the rain forest.

On Lanai, as on Molokai, there is no great seasonal variation in temperature. The seasonal variation is one of rainfall and, with it, of vegetation and surface water. On the north end during the summer and

fall, when the weather is normally dry with only an occasional shower, many deer move to the upper ridges and some even move up onto the north end of the central plateau, where they spend the entire day bedding in whatever cover is to be found. They are probably seeking more succulent vegetation than that to be found at the lower elevations. Although there is plenty of green feed throughout the range all year, the almost nightly dewfall at the higher elevation may itself be the cause of the movement.

With the first heavy rains of late fall, the deer almost immediately move down to the lower elevations, where they remain throughout the rainy period and for some time thereafter. During this period of time, the deer have choice food and water within the forest cover they prefer, and so remain in it.

Sometimes during the winter there are long periods between rains and the lower elevations again dry up. When this happens, the upward drift of deer again occurs just as it does in the late spring after the main rainy season. These ' seasonal ' movements are not really shifts of the entire north-end herd, but rather a spreading of the herd during the dry periods. Although many deer do move into the high elevations, others remain on the coast and in the intermediate country. Wet weather concentrates nearly all of the population in and near the lower forests.

This spreading and retracting of the herd in relation to the weather cycles is noticeable primarily in the population occupying the north-western, northern, and north-eastern slopes of the island, where there is moderate to heavy forest at the lower elevations. The forest attracts the deer because of its favourable cover, food, and water when conditions are favourable.

There appears to be no major upward movement along the eastern coast in dry times, possibly because of unfavourable food and cover conditions higher up, but more likely because water is available along this coast all year in the form of sump-units, seeps, and a few pipe-line troughs all within the heavy forest.

Along the southern and western slopes there is no coastal forest to hold the deer during the rainy season. Here they occupy all parts of the slopes the year round. The most noticeable change in activity is that during the wet season there is less use of the pineapple field margins than during the dry season. We see, here as elsewhere, that water is the critical factor that, along with cover, determines and controls the movements of the deer, both daily and seasonally.

Water Use

During the dry season, when natural water is scant, deer inhabiting sections of the islands where artificial water units are available make heavy use of these units. It is not known definitely how often individual deer

must drink, but indications are that in hot, dry weather they need to drink at least every day or two. Water units were visited with a frequency that indicate daily use and possibly more often. In the dry north-end range of Lanai, where no artificial units are available at present and where long trips are necessary to get to the few coastal springs, seeps, and potholes, they probably drink less frequently. A captive deer was able to get along for several days without drinking water, even in hot weather, as long as green forage was plentiful, but would use water every day if it was available. However, this deer would pass up water for days at a time if the weather was cool and heavy dews occurred. His water consumption, measured over a 26-day period of mixed hot and cool weather, averaged 2·5 pints (1·18 litres) per day—this was for a 120-pound deer.

On Lanai, in the dry north-end habitat, deer may have to make trips of up to five miles in order to reach water, though most of them travel much less than this. The ones that spend their summer at the upper elevations apparently obtain most of their water requirements from dewfall, with only occasional long trips to the coastal watering spots. However, those in the lower areas probably must water daily. One buck was collected in this habitat that had a damaged stifle joint which limited his movements severely. Although he was in an area of abundant forage and the wound in itself was not serious, he was extremely emaciated and weak due to the fact that he was unable to make the long journey necessary to get to water, and apparently had been without it for days.

In this dry area of Lanai, which incidentally contains the largest part of Lanai's deer herd, the deer make use of any potable water that they can find. This includes one or two freshwater springs found on the beach at high-tide level, brackish water seeps in the mouths of several gulches just behind the sand beach, and the several rain-water potholes which last all year only in Kaapahu Gulch on the north-western slope. They even wade out into the shallows on the reef and apparently drink salt water occasionally. Actually they are probably drinking brackish water where fresh water seeps up through the salt water in places on the reef. Such freshwater springs in the salt water are well known on Molokai, and both cattle and deer used them in days past, though apparently not to any great extent today. To what extent cattle or deer can use pure salt water is not known, but an observation made on Molokai is worth noting in this respect.

On 19 January 1957, seven of the Molokai Ranch Santa Gertrudis bulls were observed on Papahaku Beach. These were a group of young bulls, perhaps two-year-olds, that were often seen in each other's company as a bachelor group. The seven bulls walked out across the beach from the direction of the Papahaku water trough, and on reaching the water, each walked into the surf and tasted the brine. Several apparently swallowed some water. One bull waded knee deep into the surf

and drank continuously, just as if he were drinking from a freshwater trough. It was estimated that he drank at least a gallon and a half or two gallons of water judging by the length and steadiness with which he swallowed water. Drinking time lasted approximately half a minute, possibly longer. No ill effects were noted either then as the animal wandered away with his companions, or later as they were seen in the vicinity of the water trough. There was no need for any of the animals to drink salt water ; all tried it and several drank at least two or three swallows, while one drank deeply. A water trough was available within 400 to 500 yards. January is in the rainy season, and there was no dry, hot weather that might force an animal to drink salt water. Deer quite commonly wander out on the beaches. Do they drink salt water ? How often and how much do they drink ?

On Lanai the artificial water units are heavily used during the dry periods. At these units they show their characteristic suspicion and nervousness even though they must have watered there many times before, and it is interesting to watch them approach. They approach with utmost caution and hesitancy, often running off for a short distance for no apparent reason several times during the approach, then nervously returning. Once they have reached the water, the fear seems to subside and they drink with relative calm. When a group approaches the water unit, one or two will often be bolder than the rest and approach the unit first, while the rest fidget about a short distance away. When they see the 'advance guard' drinking safely, the rest will then move in confidently.

If the water unit is overflowing onto the ground and forms a puddle, the deer prefer to drink out of the puddle rather than from the trough. While at the water unit, they frequently dawdle for some minutes, taking a drink, walking around or shoving for position, and then returning for another drink. They usually leave a water unit, particularly one that is in the open, by a different route from the one by which they approached.

On Lanai there appeared to be no set time for watering ; they would visit the troughs or natural watering places at the beginning of the evening feeding period, or at any time during the night, or during the early morning before bedding down for the day. Occasionally they would come to water during the daytime but this was uncommon. On Molokai in the forest cover, the most common watering time appeared to be late afternoon and early evening, although deer continued to arrive long after dark. Papahaku trough, which was located in a heavy forest, was watched on many days and occasionally all night long. A few deer could be expected to arrive at all times of the day. These were usually singles often a doe with a fawn, sometimes a buck. Apparently these were unattached animals that had missed the normal crowd and just came in as it suited them. The big press around the trough would be from four o'clock until just after dark. By ten o'clock at night, there would be

only a few individuals about. Dawn would see a resurgence of activity, apparently many of the animals returning for another drink after a night of feeding. At the troughs well away from any cover, such as several below Mauna Loa Heights on the lee side and some on the west end, deer were never seen at the troughs during midday and, as already described elsewhere were usually gone by sun-up. Likewise, their approach here was reluctant and slow before sundown, and all drinking appeared to be done during the night, although exceptions undoubtedly did occur here also.

As soon as good rainfalls provided natural potholes of fresh water in the gullies, the deer on Lanai abandoned the artificial units and the less palatable beach supplies, obtaining their water from potholes, and rarely visited the other sources until the potholes had again dried up. They prefer to drink from muddy, stagnant pools of natural rainwater in the cover of the gulch bottoms, rather than from the clear, fresh water of the artificial troughs. Even the troughs in Maunalei gulch, which are in a dense kiawe forest, are rarely used during the wet season.

On the west end of Molokai the rainy season also brings an end to the use of water troughs by deer. The rainy season usually starts with torrential rains that turn the gulches and gullies into torrents. These flow only for a short time, the best ones for perhaps a week or so. Then the gulches are again dry. The water-holding quality of this area is extremely poor and pools of water are scarce. In a few of the deeper, larger gulches good pools of water remained over a period of several months during the main part of the rainy season. These, however, are so few that it was easy to check them often for deer use. Not one instance of use by deer was noted during the entire rainy season of 1957-58. The soft silt and mud around the pools made checking very easy and, although tracks were on several occasions found near the pools, it was obvious that the deer had only walked by the pool but had shown no interest in the water. At this time, also, no tracks were found around the water troughs. It is obvious that, in this area at least, all water requirements were being obtained from the fresh green vegetation available at this time. Rumen contents in specimens collected at this time in this area showed a very high water content—25-50% by volume—obviously more than enough to satisfy the deer's water requirements.

The water pools in the gulches dried up long before the lush green vegetation declined so that, by the time the vegetation no longer supplied the water needs of the deer, these pools of water were no longer available. As the vegetation dried up, there was a gradual increase in use of the water troughs. A similar pattern of water use was noted for the cattle in this area.

Phillips (1935), in speaking of the Ceylon axis deer, has this to say of its drinking habits : ' It generally drinks daily, towards midday, and

in dry weather is usually to be found in the vicinity of water-holes and tanks between the hours of 10 a.m. and 1 p.m.'

Trailing

When travelling to and from feeding grounds and watering sites, the deer follow well-used trails that form a network throughout their range. The feeding movements are random, without necessarily following trails but, when travelling from place to place, they usually follow trails if it is at all possible. This system of trails on Lanai reaches its greatest development in, and just above, the coastal kiawe forests, where they form a complete lacework covering all parts of the area. The trails become less numerous towards the upper limits of the range, where they lead more definitely from one point to another rather than wandering in all directions as they do in the forest. Usually trails follow available cover, crossing open areas at their narrowest points, but some cross large expanses of open grassland when leading from one feeding ground to another, or to water. They frequently follow contours of the land, but may go straight up and down steep ridges, and there is usually a series of trails in the bottoms of the gulches. Trails are particularly noticeable at watering sites where they converge from all directions.

In the Molokai rain forest range, the vegetation is so heavy and profuse, and the deer density so low, that trails are few and faint at best. Where they are noticeable at favourite crossing points, they are usually short and faint, and quickly vanish once the deer leave the crossing point.

On the west-end where cattle use is heavy, deer use the cattle trails as well as their own. On the south-west side in the quite heavy cover, trails are indefinite and show only along steep slopes or on points where deer must follow a favourable bit of terrain. Above the forest, the trails quickly converge into the cattle trails to the water troughs. It was noticed that, when leaving the forest, deer tend to drift in a loose group until well up the hill towards the trough before actually forming a trail group. Likewise, when leaving the trough, the group stayed on the heavy cattle trails only for a short distance over the roughest part of the terrain. Then they quickly spread out in a loosely grouped formation on the broad grassy ridge top for the last quarter of a mile or so down to the forest, feeding hastily or just trotting and walking as they hurried back to cover.

On the broad, open flats on the south-west part of Molokai Ranch, there were definite deer trails leading to the nearest water troughs. These were used for the specific purpose of reaching the watering site. Most were used by small groups of deer, some of which travelled up to three miles to reach water. They could not be considered heavily-used

trails since they were generally used only at night for a two-way trip by the several groups of deer that used each trail.

Well-used trails are usually trampled bare of vegetation, forming narrow ribbons of naked soil through grassland parts of the range. Within the dense forests, where the ground cover is scanty at best, they merely form beaten pathways across the nearly bare ground. Trailing appears to be the major form of range damage caused by deer on Lanai at present. This is more apparent than real, except in a few areas of concentration of small size where the ground is trampled bare. It is most common on the loafing grounds, usually within a clump of trees, where the deer may congregate and mill around. It is by no means serious. There is little evidence of erosion being caused by trailing, since most of the deer range is in an area of low rainfall. On the wet rain forest range it would take many times the present deer population to show any noticeable effect on the soil or vegetation.

On Molokai Ranch, in the area of the leeward forest below Mauna Loa, most of the forest is not used by cattle, which are excluded by fences which extend along the fringe of the forest for a considerable distance. In other parts, cattle stay above the main forest, or use only the upper edge because of the location of water troughs. Here one can see an interesting contrast between the effect of the cattle and that of the deer. Below the cattle-use area, deer trails are faint and ill defined at best ; grass is knee high in the open forest. Above the forest, the land can best be characterized by the scarred erosion gullies, erosion sinkholes, heavily tramped cattle trails, and all the other symptoms and signs of land abuse.

Home Range

Because of the poor success in capturing and marking wild deer, our information on the size of the home range and extent of movement of these deer is very limited. However, a few distinctively marked deer were observed over and over again in a relatively small area. They remained in an area of approximately a quarter of a square mile, if one can exclude the occasional long trips to special feeding areas or watering troughs. During the dry season, when seasonal movements to the upper elevations occur on Lanai, the deer appear to establish a home range within a fairly small area at this higher elevation ; most do not move back to the lower slopes for resting after feeding on the upper slopes. A few, however, may make these daily movements of several miles for water, returning to favourite resting grounds afterwards. In these cases, probably much of the feeding is actually done in these favourite areas also.

Deer residing in the sections where seasonal ' migrations ' are not necessary — such as the herd occupying the eucalyptus forest above

Lanai City — spend most of their daytime activity in an area not over one-quarter of a square mile. Their nightly foraging, however, may take them up to a mile and a half from the daytime resting areas.

Effects of Human Activity

Throughout most of Lanai's deer range, human activity is usually limited to the daylight hours. Since deer spend most of the day under cover, little effect upon their normal activities and movements has been noted. Where their range includes well-used roads, or where it adjoins the plantation, they simply move away from the disturbed portion during the time of human activity, returning at night after activity ceases. Some merely seek out the best cover at hand and wait out the disturbance if it is not too severe or too close. The small herd living just above Lanai City commonly feeds right next to a number of homes throughout the night, disregarding the barking of dogs (providing these are chained), talking, lights, and other human activities. At daylight they move back into the forest where it is quiet.

When people move directly into the deer range, the reaction is much the same as that noted near the roads and pineapple plantation. Deer frightened away by campers during the day will frequently return after dark and go about their normal activities regardless of the camp, merely remaining a discreet distance away. They often come to within 100 yards of camp and spend long periods barking in curiosity at the camp fire.

Hunting, of course, does affect the normal activities of the deer. If the hunting is light, such as one or two persons collecting a specimen now and then, the disturbed animals leave the area hastily but apparently return again at night. Heavy hunting will cause the animals to flee in all directions and, if it continues, will keep them on the move all day, forcing them into long flights from which they may not return for several days. Many seek out the heaviest cover they can find, wherein they spend the day in hiding rather than leave their home area, while others run back and forth, circling, if possible, in order to remain in country they know. Where hunting goes on continuously, as on Molokai Ranch, many people believe the deer herds move out of the area entirely for the duration of the hunting. If this were true, the west-end range would long ago have been cleared of deer. Observations show that the vacating of a particular area is only temporary and that actually most deer do not leave, but merely keep to the dense cover during the day. Where areas have been thoroughly driven and most of the deer moved out, they return again at night. Papahaku forest on the west coast was hunted every weekend, and often during the week, during the winter of 1957-58 ; yet within 24 hours after the hunt, often within a few hours, deer could be found in the forest if one cared to leave the roads to look about. The type of road

hunting usually practised here does not take the hunters into the dense thickets ; they do not see as many deer as at other times and assume that the deer have moved out.

Deer can be moved out, of course, and axis deer are particularly susceptible to driving. On Molokai Ranch it was often the practice to send a number of drivers into Papahaku forest on the south end ; these would fire ' scare shots ' as they went and this type of driving would often move deer in large numbers out of the area of the drive. These would return, usually the next night.

As a rule axis deer are sensitive to human activities during daylight hours and either leave the area temporarily or withdraw to dense cover. During the night they will put up with a remarkable amount of harassment before abandoning a choice feeding location. Attempts to keep them out of alfalfa and pineapple fields at night by means of patrols, firecrackers, gunshot, lights, and acetylene exploders have been, for the most part, futile. Shooting them at a safe range with a shotgun loaded with skeetshot was the only means found effective for keeping them away, and even after this treatment many would return in a few hours. Although nervous and fearful of the least disturbance during the day, they appear to feel completely secure and safe under cover of darkness.

Gregariousness and Herding Instincts

True herd formation, on the order of that of the North American elk or the European red deer, does not take place with the axis deer. There is, however, the rudiment, or the beginning, of such a herd formation. The axis deer does not appear to have a strong herding instinct and a group feeding or moving together will often scatter and go their own way when disturbed. Even when undisturbed, various individuals and small groups commonly leave a larger group and drift off on their own, to feed or seek resting places. This was commonly reflected in changing numbers and compositions of groups that regularly came to drink at certain water troughs. One morning one might see 40 animals, the next only 25, and the next 30 ; sex ratios and age classes would be equally as varied. This is quite in contrast to many herds of elk, sheep, and pronghorn antelope which we have observed, and in which numbers and individuals may remain very constant throughout the year except for adult males, which join the herds during the breeding season.

Gregariousness is there, and they like the company of others of their kind. It is common for small groups to rest, feed, or travel together. Single deer or small groups frequently leave their bedding spots and drift together to form larger herds while feeding. When left behind, individuals will hurry to catch up with the main group.

A captive buck, raised alone from infancy, would follow his master like a pet dog, apparently enjoying his companionship, though he would not hesitate to run off alone if frightened. Another pair of fawns, also raised by hand almost from birth—but together—were inseparable and were most unhappy if not together. These two also seemed to enjoy their owner's companionship, but to a much lesser degree than the one raised alone. The behaviour and actions of deer raised in captivity must be interpreted with caution, however, for there are many influences under such conditions not found in the wild state. Captive conditions may bring about expressions which would never be developed under wild conditions, although, in this case, the desire for companionship seemed apparent—at least for young deer.

Herd Composition and Size

The basic unit of the herd appears to be the family group, usually composed of an adult doe, her yearling fawn, and her new fawn, if she has one. If the yearling is a buck, he may leave his mother and strike out on his own as his first spike antlers mature, but it is not uncommon to see several spike-antlered bucks remaining with a group of does and fawns. The yearling does apparently remain with their mothers until their own first fawns arrive, and in some cases even after they are nursing their own young. An old doe, with a distinctive white chevron on her neck, was seen several times in the company of another doe, apparently an yearling, which also bore the same unusual mark. Both does had small fawns, one of which was similarly marked.

The larger groups may be made up of several of these family units, which may join together temporarily for companionship when feeding, travelling, or resting. Herd composition and size often change during the day and single animals may band together for a short period of time on good feeding grounds, on trails to and from feeding and watering grounds, or on favoured loafing grounds, later breaking up to go their own way. It is not uncommon to see an older buck or two moving temporarily with the doe-yearling-fawn group. These, however, usually do not remain long with them unless one of the does happens to be in season.

Except during and just after the peak breeding season, most of the mature bucks tend to seek solitude or form ' bachelor ' groups of two or more animals. This is particularly noticeable on Lanai when many of the bucks are ' in the velvet ' during the late winter and early spring months. During that period, they are often seen in such bachelor groups, or alone, and rarely with doe-fawn groups. During the peak breeding season, and for a while thereafter, the bucks join the doe-yearling-fawn herds, and groups of all ages and sexes may be seen to-

gether. But here again, the composition of the groups is not necessarily constant, since many of the bucks shift from one group to another in search of receptive does.

Due to the fact that some breeding goes on at all seasons of the year—even though the peak rut is in late spring and summer—this sexual segregation is not nearly so clear cut as it is with other temperate-climate big game. A few bucks may be seen with the doe groups at any time, probably following those females that occasionally come into season during other than the main breeding months. This situation is even more confused on Molokai, where the almost constant hunting pressure disrupts what would be the normal group behaviour pattern on less-disturbed Lanai, and causes the sexes to mix in a more random manner throughout the year.

Harem-gathering and herding by large bucks is not common with the axis deer, although occasionally a large old buck will do so to a limited degree. Even during the breeding season, the bucks are more or less outsiders in the groups and, although they may be the physical masters because of their size and aggressiveness, are rarely the herd leaders. Although leadership, like other phases of the herding instinct, is poorly developed in the axis deer, what there is of it appears to be of a matriarchal type. An old doe is usually the initiator of such action as she may influence, and often is the one to warn of danger and lead the escape, although she is probably acting as an individual rather than as a deliberate leader.

There is no basis for the commonly held belief that bucks are the leaders of the herd, or that they will protect the does and fawns from danger. When danger threatens and a group takes flight, it is rarely a buck that leads them off, but rather an old doe. The larger bucks usually follow last or run off by themselves, abandoning the others. Not only do they not protect the does and fawns, but big bucks frequently bully them, use the does when they can, and leave them to shift for themselves at the first sign of danger unless it happens to be convenient to follow them in flight.

Altogether, the herd organization and behaviour pattern is a primitive one, with poorly developed habits and characteristics of organization or specialization.

In size, the herds on Lanai usually number about seven to eight deer or less, although some are occasionally seen with ten or more. Larger herds are more common on Molokai, where 15 to 25 were commonly seen. There, one herd of 97 was observed. This was apparently made up of a number of smaller groups that left a feeding area at the same time over the same route, thus forming a large herd while travelling, but splitting up again on reaching the resting grounds. There is no justification

for the ' herds of 200 ' or even more that one often hears about.[1] Such herds are often reported on Molokai Ranch, but apparently are largely the figment of wishful thinking by those who have never been there, or someone who has driven through the area and has seen perhaps 20 or 30 deer dashing away in all directions among the kiawe bushes and trees. Such a sight appears most impressive and is quite likely to look like ' 200 ' deer to the inexperienced and impressionable viewer—especially several days later when the experience is being recounted to an equally impressionable and wishful audience.

Hunting pressure, both on Molokai and Lanai, may cause the temporary formation of larger-than-normal herds. Small groups and individuals, running back and forth to escape hunters, may join together in common flight for short periods, giving rise to the ' large herds ' often reported. Also, these large herds may be composed mainly of does, fawns, and young bucks, leading to the belief among hunters that mature bucks are scarce or ' shot out '. Actually, bucks in general, especially older and larger bucks, tend to be more phlegmatic, perhaps through longer experience, and are consequently less prone to panic and run about. These may hang back in heavy cover and hide while the hunting is going on. Thus, they may be overlooked during the hunt, but soon show up after the hunting is over and conditions return to normal.

In the rain forest of Molokai, the largest groups observed numbered five, a typical group consisting of an old doe, a younger one, two yearling does, and a 16- to 18-month old spike buck. Other groups of two to three and four were the rule.

Prater (1935) has this to say of numbers and activity :

> ' They are seen in herds of ten to thirty, which may contain two or three stags ; but assemblages numbering several hundred have been met with. They do not shun the proximity of villages, enter cultivations and frequently associate with many forest animals, particularly monkeys. They are less nocturnal than sambar and feed till late in the morning and again in the afternoon, and lie down in the interval in some shaded spot.'

Apparently the Hawaiian axis deer have not changed much, for there is little that we can differ with in this regard. Perhaps the Hawaiian deer are not quite so tolerant of other animals, but then there are few with which to get acquainted. The feeding in India seems a bit late in the day, but then again as we have seen, there is some variation even between Molokai and Lanai.

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[1] Mr. E. R. C. Davidar, The Nilgiri Wild Life Association, at p. 682 of Vol. 61 of this journal publishes a photograph of a ' herd ' of axis deer, which he estimated as consisting of more than 500 individuals.—Eds.

Curiosity

Unusual occurrences or objects, if not recognized as immediately dangerous, excite the strong sense of curiosity (or anxiety) in the axis deer. When they see something they don't understand, they stare at it intently, with neck stretched out, ears up, tail up, and all muscles tense and ready for immediate flight if necessary. If nothing 'dangerous' happens they will watch for some minutes, barking their '*yowp*!' of curiosity or mild alarm, then begin to approach guardedly, or to circle downwind to get the object's scent. While approaching or moving about for better views, they are as tense as tightly wound springs, lifting each leg quickly and nervously. They usually raise their front legs high and stamp each forefoot down hard, as though to ensure a solid footing for a quick flight—however, quite possibly such an action telegraphs a warning sound to other deer, — or could it be a threatening gesture?

A group of deer attempting to satisfy their curiosity in this manner form a picture of tense concentration, high-strung fear barely concealed by burning curiosity. The least disturbance or sound will cause the group to scatter like wind-blown leaves. If the sound or disturbance is minor and does not appear dangerous, they will often stop after a few leaps and again begin the cautious approach. Finally, their curiosity satisfied, they almost immediately forget their concern and begin again their normal feeding. One or two may keep a close watch on the strange object as they move off, and occasionally one will return for a second or third close inspection.

Usually, an observer standing motionless in view of a group of deer will hardly be noticed as long as he is motionless. A quick movement will focus every eye upon him. If the movement is not repeated, they soon forget their fears and resume their normal activities. Repeat the movement a time or two and one will soon circle downwind to get the scent, whereupon there is a startled '*yup*!' and one and all vanish in a drumming of hoofs.

The reader must not get the impression that standing motionless will always conceal him from recognition. Experienced individuals do learn to recognize the human form—and vehicles. This is particularly true on the much-hunted west-end of Molokai. In the picturesque and beautiful Papahaku forest, a parked jeep, even though carefully backed into what was considered a most favourable position for blending concealment, was recognized as dangerous, and produced instant flight when the deer were still 60 to 70 yards away. Likewise, the observer was readily recognized even though completely motionless. Association and conditioning is the primary factor here.

Older bucks in a group will usually stand quietly in the rear, watching intently but not approaching, allowing the does and younger spike bucks

the opportunity—and possible danger—of discovering the nature of the object or occurrence. These old-timers are satisfied with watching from a safe distance or, if alone, perhaps by circling downwind at a safe distance. If they do not determine the nature of the strange object by a few minutes of staring, they usually slip quietly away rather than risk a closer approach.

Curiosity will sometimes get the better of them, however, and they will react in much the same manner as does and younger bucks. A group of deer, including a beautiful, full-grown buck with polished antlers and swollen neck, several smaller bucks, and a dozen or so does and fawns, was stalked for photographs as they fed near a clump of kiawe trees on Lanai. When within about 50 yards of them, the observer —who had crawled on his stomach through the grass and low brush— carefully raised himself and set up camera and tripod. These movements were made while partially screened by brush, and were made with great care ; furthermore, the observer was dressed in a camouflaged parka to help break up his outline. While he was setting up, the deer became aware of the slow, guarded movements, but were unable to recognize the form as being human, or for that matter, as anything else of immediate danger.

Their curiosity was intense, however, and they began the typical nervous pacing, all the while staring at the unknown object with necks stretched and tails raised, and uttering their 'alarm' bark back and forth. The big buck, who had been standing back in the cover of the trees and watching quietly, finally could stand it no longer, and he, too, moved out with the others to bark and to stare with neck stretched and raised to its utmost. After a number of photographs had been taken, the building tension grew too much for them and the whole herd whirled and vanished in the forest.

People are often tempted to ascribe greater sagacity to the large bucks but, although they may certainly be somewhat wiser than young animals because of more years of varied experience, their actions may also be due to other factors than true intelligence. The males, particularly the old males, of most members of the deer family are not of the same temperament as females or young males. There is by the very nature of maleness, especially mature maleness, a greater degree of stability, self-assurance, and what may pass for better judgment but may only be less excitability.

Energy and alertness are largely directed towards one goal—breeding activities—and are expended in this direction. A great deal of energy and aggressiveness must be available to accomplish this in the type of rutting behaviour found in the members of the deer family, more in some than in others, true, but a great deal in all. This also calls for what we, for lack of better knowledge, call a more phlegmatic nature between

breeding periods. Such a condition is not compatible with an excitable, nervous disposition.

A buck that stands quietly and does his viewing of a suspicious object from a distance without a great to-do may be no more stupid, or for that matter any smarter, than his nervous sisters. Also, he will probably learn just as much. Likewise, it is doubtful that he is deliberately letting his females and junior members do the dangerous work for him. Not having the nervous temperament of the females and younger animals, he is usually content to do his viewing from where he is.

Three captive fawns raised on Lanai all showed strong curiosity about their surroundings. Their fear of humans, at least of certain individuals that they knew, had largely been overcome. Their true character was readily observable and was not hidden or modified by the factors that influence the life of a deer in the wild.

All three closely examined everything within reach, particularly in relation to edibility. Almost every object had to be sniffed, licked, and, if chewable, chewed though not necessarily swallowed. Strange objects in the pen were always approached and examined, even though some nervousness and fear may have been expressed at first. Strange animals were likewise subjected to intense examination, though much more guardedly.

Two small goat kids were placed in a small pen adjoining the fawns' pen for two days. The fawns, which had never seen a goat before, were at first very hesitant and remained as far away as they could but, shortly after dark the first night, they approached the kids with the usual mixed fear and curiosity. After 'stalking' carefully up to within 15 feet of the goats, they stopped. The next hour was spent in barking at the goats while examining them from this 'safe' distance, all the while exhibiting the usual signs of deer curiosity: head stretched as far up and forward as it would go, ears forward, eyes staring, nostrils flared and searching, tail held rigidly up and flared wide, and forefeet stamping as they slowly stalked stiffly back and forth. At the end of this time, the fawns apparently decided that the kids were probably nothing to fear, but not really to be trusted. They then moved off to another part of their pen and settled into their regular routine of grazing and resting, keeping some distance away from the goats, but hardly looking their way again.

Reaction to Fright

When deer are watching something because of curiosity, but are unable to satisfy themselves that it is harmless, the tension may build up to the breaking point and they may jump into hasty flight. If they

are not too frightened, they may stop after a few hundred yards after putting some cover, such as a ridge, gulch, or large clump of trees, between themselves and the danger. However, if thoroughly frightened they usually run for a half-mile or more before seeking cover in which to stop.

One of the most interesting aspects of flight in these instances is their orientation to the wind while fleeing. They will almost invariably run into the wind if it is at all possible to do so. So strongly established is this safety orientation that they will frequently run into the wind even when it involves the risk of passing closer to the object of their fear. For example, groups of deer have on many occasions been observed to circle close by, or angle towards an observer, the object of their fear, in order to run into the wind ; yet there was ample room to run in any one of several other directions that would have taken the deer away from him. On several occasions deer actually overran the observer, i.e., they passed on either side within a few feet of him when actually they could more easily have avoided the danger by taking the opposite direction or several other directions, all away from him.

This commonly observed display is probably not only an instinctive orientation, but is also related to the habit of these deer to panic easily. The instinctive reaction to wind direction is there and, when sudden fright occurs, they may panic so suddenly that they automatically take the direction into the wind even when it is to their disadvantage. Such witlessness under conditions of sudden fright is quite striking in comparison with many other ungulates.

When danger threatens, or a deer is suddenly surprised, it usually utters a single startled yelp of warning. This sound, a short, sharp '*yowp*!' is uttered only once and is almost always heeded, resulting usually in instant flight by all within hearing. This can be well illustrated by the actions noted during another photographic stalk, this time of a buck that was heard calling from a ridge-top in the kiawe forest below Mauna Loa, Molokai.

A careful approach brought the photographer to within 60 yards of the buck—a superb specimen in full breeding condition in the midst of a group of does, fawns, and lesser bucks which were spread out among the trees. These were resting and dozing while the 'master buck' kept repeating his rutting call and horning a kiawe limb. The observer, partly concealed behind a tripod and movie camera, was quietly running off film when the buck stepped out from under his tree and walked towards the camera, completely unaware of man's presence.

As he stepped into the open about 40 yards away, the sight of the camera and tripod and whatever showed behind it, and possibly the quiet hum of the camera motor, struck his senses. The pop-eyed astonishment, but, unfortunately, not the startled squawk of alarm, was

clearly recorded on the film, as was also his lightning-quick about-face and disappearance into the thickets. There was no hesitating, no curiosity, and no second-looking here.

When thoroughly frightened, deer rarely stop for a second look, but keep running at full speed until well away, and only then stop for a brief look back ; more often, they simply slow down but keep on going until they feel safe. Bucks, possibly because of their less excitable nature, occasionally stop for a second look if they are not certain of the cause of the alarm.

Both bucks and does will tire quickly after the initial all-out blazing burst of speed and drop to a slow run and then a trot, occasionally stopping to make a check on the pursuit or danger. As they become exhausted they seek cover in which to stop to hide and rest, leaving it reluctantly if closely pursued, only to dive into other cover.

The axis deer do not lie as closely as do the blacktail, mule deer, or white tail deer. Only occasionally will they lie so close that one can pass but a few yards away. However, when exhausted and very frightened, they may take refuge in very dense cover, if it is present, and refuse to move so long as they remain undiscovered. When dogs got into the experimental range-pen where two does were penned and killed one of the deer, the 15-acre pen was combed with 14 drivers to remove the dogs left in the enclosure. This enclosure, roughly rectangular, contains a heavy rain forest cover of ferns, shrubs, and trees over about one-half of the area. Two drives, one lengthwise and one crossways, with 14 yelling, brush-beating boys netted two dogs, but no deer. It was assumed that both deer had been killed by the dogs and that one probably was killed in the heavy brush where it was difficult to see. However, a few days later the doe turned up safe and sound in the pen. She had obviously crawled into one of the many heavy thickets, overgrown with the almost impenetrable staghorn fern, and let the drivers pass by.

Does are especially prone to panic and, when cornered, or when they think they are cornered, or when very badly frightened, they may go completely to pieces in blind panic, running into objects in their way, or over cliffs, injuring or killing themselves. Once panic grips them, they run until it leaves them or, if they cannot get away, they run back and forth into whatever barriers are present, battering themselves until they drop from exhaustion or injury. Under these conditions they frequently die from shock. If caught by man or dogs, their panic wells up in loud bawls of abject fear ; otherwise they run in silence.

Cornered bucks will try every means of escape, including charging their tormentor in an effort to gore and overrun him. Unlike the does, they are not as likely to lose control of themselves. When all hope is gone they may lie down and sulk, waiting for an opportunity to escape

or fight. The Lanai investigator was very nearly gored by a buck on Molokai which was discovered tangled in some light field telephone wire. One end of the wire was thoroughly tangled in the buck's antlers, while the other end was snagged in a clump of kiawe trees ; thus the buck was on a 50-foot line like a trout on a hook. When approached, he ran into the grove of trees to the limit of his line. When he was further pursued, he immediately whirled and charged at full speed with antlers lowered. Quick footwork saved the day by inches, though the investigator was flipped over by a trailing loop of wire. The buck was soon subdued by means of a drugged dart, ear-tagged, and released.

As already stated, the deer become more confident after dark and do not take fright as easily or readily as during the day, nor do they permit fright to overcome them as easily. Even the scent of humans may cause them to run off only a few yards before stopping. They apparently depend heavily on the protection of darkness rather than on flight, and feel secure. Noises and actions that would send them into a panic during the daylight may startle them at night, causing them to run off for a short distance before stopping, but will only rarely put them into wild flight.

When attempts were being made to frighten them from the pineapple and alfalfa fields at night by means of acetylene ' cannons ', firecrackers, and gunshots, they soon became accustomed to the noise and would all but ignore it. Often they were spotlighted with a powerful light while rifle shots cracked over their heads and into the brush around them in attempts to drive them away. The usual reaction was to jump and fidget at the first few shots, then to move off a short distance, and finally, if the shooting continued, to trot over a ridge or into a ravine out of sight, all the while showing obvious reluctance to leave. The same actions during the daytime would bring on a wild and immediate flight.

Even under normal conditions, when not attracted to some choice location by food (such as under drought conditions which were involved in the cases mentioned), they nevertheless are more reluctant to leave the area of disturbance at night, but do so in a relatively calm manner, compared with daytime behaviour. When spotlighted, they do not usually 'hold' as well as do some of the other deer species, but fidget about nervously, attempting to get out of the blinding glare. Once out of the light, they soon settle down unless very badly frightened by close approach of a human, or by the sting of a drug-laden dart hitting them. At this they will immediately run and keep going until out of sight in good cover. This is the main reason why this method of capture has so far failed ; once they are hit and really scared they do not hesitate to leave the area at full speed, night or day.

This paradoxical behaviour of the deer by day and night may not be

as easily explained as it appears to be. To say that the deer 'realize' they cannot be seen and feel secure is easy, but an analysis of this simple explanation leaves much unanswered. How can the deer know they cannot be seen? If they themselves can see well, as is indicated by their freedom of movement at night, then they must also see man and his activities at night. On the other hand, if their security lies in not being seen, then our assumption that they see well must be false. For the only way that a deer could feel that it was not seen (to be hidden) is not to see well itself. It has no knowledge of how well we see, but only of how well it sees. The answer may well lie somewhere between the two extremes.

We ourselves do not rush about at night because of our limited vision. The same is probably true of the deer. While there is little doubt that deer and other ungulates see quite well at night, the visual acuity may well be relatively short and, while the animal may see very well within reasonable limits which would enable it to get around with ease and to forage for its food (keep in mind a highly developed sense of smell, vibrissae to help in tactile sensing, and sure footwork), it may actually be operating in a visual field that is not very large. In other words, rather than feeling altogether secure, it may simply be more reluctant to go barging about in a world in which its own vision and perception is much more limited than during the day. Be this as it may, there is apparently some feeling of safety at night which leads it to wander into areas which it would not enter during daylight. Our knowledge of the night vision of wild animals is extremely limited, and we need to know much more before we can analyze their night time behaviour correctly.

There is another possible explanation for the lack of continued fear over loud noises during the night, and the use of exploding devices, gunfire, etc., may be the wrong method entirely for scaring deer during darkness. It has already been pointed out that when sense perception is not associated with a known danger, then no fright reaction will result from the sense stimulation. We assume that since deer do run from sounds of gunshots during the daytime, they will react similarly at night. Under cover of darkness, and with the possible inhibition of visual senses, deer may simply accept the repeated explosions of carbide exploders and guns as a natural phenomenon, such as thunder, rather than related to man. Deer readily become accustomed to dynamiting and similar continuing activities. During the daytime there is no difficulty in keeping deer out of crop areas such as the case mentioned because they can see that man is associated with the disturbance. It should be possible to do so at night by providing the right stimulus and sense association to produce the desired reaction.

Swimming

Axis deer swim well when forced to do so but, in Hawaii at least, they do not enter the water by choice. Several have been encountered on the shore where they were trapped between the sea and impassable cliffs, perhaps having fallen into this situation or driven into it by feral dogs. None of these was observed to attempt to swim out of their predicament; they would walk back and forth disconsolately, looking for a way up the cliffs. Perhaps others, not discovered, have saved themselves from starvation by swimming to freedom voluntarily. At any rate, when attempts were made to free those that were discovered trapped, they readily entered the sea and swam strongly away. One, at least, was drowned by being caught between a sheer rock ledge and the pounding surf while attempting to regain the shore. A few reports have been received of others seen swimming off shore but no details of the circumstances are known.

Play

Wild fawns have frequently been observed playing wild, carefree, running and butting games, and all three captive fawns showed a strong desire to play when well fed and secure from danger. Play takes the form of leaping back and forth, wild, zig-zagging runs through the brush, and mock head-butting fights. The captive fawns frequently chased each other around until they were panting from the exertion, and seemed to enjoy the 'game'. Male fawns apparently prefer the butting games, while the females prefer the running games of 'tag'; although both sexes will engage in some of each.

Both captive male fawns enjoyed playing butting games with their owner; this consisted of butting his outstretched hand, arm, or foot as rapidly and as hard as they could, alternating the actual butting with a comical, high-jumping, back-and-forth dance, somewhat like a boxer practising his footwork. As they grew older the play became rougher and, by the time 'Willie', the first fawn, developed his spike antlers, the owner was hard put to keep up with his play. After Willie's spike antlers matured and hardened, his playfulness began to give way to aggressive anger and he became too dangerous to rough-and-tumble with.

While playing, the tail is held up with the hair flared out, presenting a striking white 'flag', and the infra-orbital scent glands are frequently opened wide in excitement. This play, besides being an enjoyable means of using up excess energy, undoubtedly also serves as valuable training for the fawn's future life by hardening muscles, teaching foot-work for running and jumping, and preparing the young bucks for their adult battles.

Adults of both sexes have occasionally been observed to engage in similar games, though such instances do not appear to be common, especially among older animals. Several times, particularly during cool mornings or evenings, does have been seen chasing each other wildly in play, and, once, a spike buck and a doe engaged in a game of tag, including some mild butting and shoving, apparently all in a spirit of play. Spike bucks, with both mature and velvet-covered antlers, commonly engage in mild sparring contests with each other, apparently more in playfulness than in anger.

Older animals appear to lose their 'sense of humour' and not only refuse to play, but intervene in the game of others if they come too close and annoy them. On one occasion, two fawns were seen chasing each other merrily around the brush. Their play took them near an old doe, which was browsing on a klu bush; as the fawns ran by her, she whirled, charging at them with forefeet striking and teeth reaching, immediately breaking up the game. On several other occasions, mature bucks jabbed with their antlers at small fawns that played too close, or that came up to sniff them in curiosity.

Social and Territorial Behaviour

The aggressive and bullying nature of the bucks becomes evident when they are still fawns and increases as they grow older. The two captive fawns that were raised were inseparable friends; even so the little buck did not hesitate to butt the doe out of his way to get at preferred food or to keep her from getting petted when he wanted the attention. As bucks grow older and develop spike antlers, they become even more aggressive and frequently use their weapons to bully and shove does that get in their way.

The relationship between males of various ages in the axis deer appears to be one of rather primitive and unspecialized development compared with that of other cervids with a highly specialized and well-developed herding characteristic.

In the axis male there is the normal aggressiveness and antagonism that is common to males, but it is far less segregated in terms of age classes and seasons. This shows up in the very generalized year-round breeding cycle and potency of the bucks, as well as the much milder antagonism and animosity that bucks show towards each other at all stages of their relationship to each other and to the does.

The general attitude of bucks of various ages and stages of antler development follows a pattern that is not unusual or unexpected in such animals. Larger animals dominate smaller ones, and older animals dominate younger ones. Hard-antlered bucks generally dominate those in the velvet, although here social order may assert itself when a large

old buck in the velvet comes up against an immature buck with hard spike antlers. The authority of habit and the size and years will give the older buck right of way over the younger one even though the 8- to 10-inch needle-sharp spike antlers could be a most potent weapon for the young buck. This is all as is to be expected. Within these general rules there is, however, a good deal of variation as well as an over-all tolerance of adult bucks towards the younger ones and each other in general that is not observed in cervids of more modern groups.

Spike bucks commonly engage in shoving and sparring contests with each other, many of a playful nature, but others in a more serious tone. These sparring matches begin when the antlers are still in the velvet, indicating that they are not as tender as is sometimes believed, though they do appear to 'pull' their punches to some degree at this time. These spike bucks often give the appearance of being the most aggressive of all ages, since they commonly may be seen stalking around with their hair all bristled up, challenging any other buck near-by. They approach each other, stalking stiff-legged like two strange dogs, pawing the ground, and hooking at brush; then may come a contest as they put their heads together and begin to shove back and forth. Such battles usually end in a draw, and both contestants quit almost as though on a signal and resume their feeding. Sometimes there may be several of these contests going on at one time in a group of bucks, and at times even a three-way match.

Such behaviourisms are usually accorded the most common interpretation of the simple expression of aggressiveness or simply competitive animosity. However, in many cases there may be quite complex underlying aspects of social structure and organization, varying in degree of development and significance.

This underlying social structure is the 'territorial and signpost' behaviour pattern. We have already mentioned the home range. This is the area in which the animal feeds and lives. Within this, or perhaps overlying this, there may also be a territory which the animal will defend against encroachment by others of its kind or, if not defended, at least it is not invaded actively by others. The first would appear to be the more primitive, the latter the more developed and specialized. In the case of an undefended or ' psychological ' territory, it would have to be carefully and definitely marked out with recognition signposts which could and would be recognized by other individuals. In its highest development, these signposts would have to have an intimidating effect in the absence of their marker for the greatest effect and usefulness. The making of signposts, i.e. the activity itself, may also have an intimidating effect on a potential invader or competitor.

Most members of the deer family show this territorialistic behaviour to some degree. Observers have recognized it in some form, usually

without a knowledge of its significance. In most cases little is ever said about it, and for that matter, very little is known about most of our deer in this respect. One of the best developed territorial behaviourisms is that of the Roosevelt elk, with its interesting and highly ritualized and spectacular signpost habits (Graf 1956). Others (Lindsdale 1953, Darling 1936, *et al.*) have recorded signpost behaviour, with either no comment on its real significance, or without recognizing its significance.

As a rule, a well-developed signpost habit indicates a well-developed territorial habit and a complex social structure. The axis deer shows some of these to a degree, mostly weakly developed and not highly organized. Its signpost habits, though well developed are only moderately organized so far as any apparent benefits are derived. However, this may only be our lack of understanding and interpretation.

There appears to be no territorial segregation of herds, and as already described, the herds are rather loosely organized and not too stable in composition and numbers. Animals do have an area in which they prefer to stay and where several, perhaps a family group, are found ; one could speak of these as a herd home range. Throughout these areas there will occur 'signposts' with varying frequency. This signpost is an inverted V mark made by scraping the ground with the forefeet. It will invariably be found at the base of some small plant—a small ilima or a lantana bush or even tall weeds. The characteristic 'marker' plant is never large—usually with a stem not over pencil diameter, often much less. The plants are usually not more than 18 to 20 inches high, and often are solitary ones out in the open. Sometimes the end of a low-hanging branch of a tree may be used.

The buck, and only bucks have been observed in this act, walks up to a 'marker', lowers his antlers, and brushes them through the twigs with a back and forth motion, sometimes with an up-and-down swing. After the antler-brushing, there is a careful nosing of the twigs brushed, that is running the nose carefully over the effected twigs as though inspecting them by scent. This may be done five or six times; then he scrapes the ground alternately with each front foot several times, then brushes his antlers through the twigs again. The whole procedure may be repeated four or five times at one point or only once or twice. The buck may then move on to another point ten or fifteen feet away and repeat the process.

As many as six to ten of these signposts have been found in a distance of 75 to 100 feet—apparently made as the buck wandered along ; others have been found scattered at random within a radius of 30 to 40 feet. They are often most common around the loafing and resting areas. All were found on ridge tops or on flat areas, some on feeding areas ; the latter were apparently made during the feeding period. One buck was observed to stand on his hind legs and brush his antlers through the twigs

of a kiawe tree. Most interesting here is the fact that this buck and most others observed in this act were in the velvet or were young bucks, usually spikes or two-pointers, that is bucks in their first and second sexual cycle. One is tempted to say this is the ' non-combatant ' group and most likely to benefit from this expression. However, this may be putting it in anthropomorphic terms.

The ' inspection ' of the ' marker ' behaviourism is also often carried over to the more commonly observed horning, or fighting of trees and shrubs. After horning an object, the buck often ' inspects ' the object with his nose by carefully running his nose over the horned area. ' Willie ', the pet buck on Lanai, would always do this after one of his bouts with a post or shrub. This would appear to relate at least some of the horning and fighting of trees and shrubs, and even the ground, to the signpost behaviourism although the scrape marks are omitted. Some of this behaviour is, on the other hand, only a form of ' punching bag ' fight practice.

In the axis deer, where bucks start brushing antlers in the vegetation and twigs while still in the velvet, the picture may become even more confused. The reason may be due to the fact that these deer are sexually potent throughout the year, regardless of antler or neck condition.

In the case of the spike bucks' threatening and sparring behaviour as described above, there may be more involved than simple animosity. Behaviour has been observed which takes on a uniform and ritualized posturing. It varies only slightly from that already described. Young bucks in the velvet display it more often than others. In this case, two bucks approach each other, back slightly arched and body held stiffly, neck bowed and head held low and with chin tucked in, ears flat. The tail usually, but not always, is held stiffly erect or cocked to one side. The bucks approach each other to within about 3 feet, facing, but several feet to one side of each other. In this position each one scrapes with alternate strokes of the front feet, forming the typical inverted V mark. There are usually 3 to 4 strokes in this scraping. The bucks may then circle around each other in the same relative position, walking in this same humped-back pose, with neck bowed, dorsal hair erected, and chin held in, so far as walking will permit this. The pace is stiff and with slow-motion deliberateness, almost like that of fixed mechanical figures. After circling slowly and deliberately, they may stop and again scrape the ground several times, then circle again. This may go on for four or five minutes after which the bucks will withdraw, and wander about only to come together again later and repeat this process.

The V marks are, of course, numerous at such points, but are not to be confused with those made in relation to some ' marker ' plant as described above. These latter are readily recognized by the uniformity of shape and without the trampling over them. They are located

Graf : Axis Deer

'Sign post' mark made by axis buck. The 'marker plant' can be seen to the left of the apex of the scrape mark

(Photo : William Graf)

individually and almost always with the apex just in front of some small shrub plant, or clump of weeds which will show unmistakable signs of having been worn by the brushing of antlers through it.

These behaviour patterns should be kept in mind when reading of, or observing, the various patterns of behaviour that we have described here. What may appear to be a simple antagonistic or fighting behaviour may have an underlying social behaviour origin with some significance which we do not yet fully or correctly understand. What goes on in the mind of an animal, and how this mind and its processes work, is even less understood than the outward manifestations which we observe.

The behaviour of the spike bucks described earlier may be a variation of the formal posturing ritual, and the posturing undoubtedly has some relationship to the ' signpost ' performance. The psychological effect of such rituals and performances is that they may avoid active conflict, or may minimize it—expression of feeling and accomplishments may be attained in this way and thus reduce, if not eliminate, the necessity for active bodily conflict. It may be a process of ' debate ' or of ' cold war '.

It must be remembered that in other deer, where there is a definite seasonal breeding cycle with a quiescent period, the usual animosity and aggressiveness towards each other disappears in the male ; likewise it becomes much more exaggerated during the rutting period. In the axis deer, breeding in both males and females continues during all times of the year and males are, in effect, in the rut regardless of other physiological factors involved. If the male axis deer were to display the same degree of aggressiveness and animosity throughout the year as the elk or the red deer, he would probably be reduced to a complete physical and nervous wreck. A more moderate and milder social relationship is therefore the rule. The continuous breeding condition nevertheless influences the behaviour throughout the year.

Spike bucks, therefore, will try to take on a larger buck and, while the old bucks are generally intolerant, they make no effort to go out of their way to pursue or overcome these young upstarts. The youngsters quickly learn that the old-timers are better armed and not very playful. There are exceptions to this, which illustrates the very nature of the more tolerant relationship. For example, a spike buck was observed to engage a much larger buck, perhaps three years old and of medium size with fully developed antlers. The match obviously was strictly in play with good-natured fencing and sparring and mild pushing. However, as the pushing increased, the weight of the bigger buck quickly proved to be too great for the youngster, and he was pushed back. As the younger one gave way there became apparent a rapid change in the attitude of the bigger buck, so that as he advanced his aggressiveness became more and more pronounced. Instinctively stimulated by the winning forward movement, the big buck suddenly drove forward with full force, almost

driving the small spike buck to the ground. The spike, however, instantly realized his disadvantage and turned sideways, letting the big buck slide by and so disengage himself. As soon as the youngster dodged away, the larger buck calmly walked off.

These two bucks engaged in this play several more times, usually without the larger one taking advantage of his size and weight. Only when the small buck gave way would the big buck's action build up into a forceful aggressive drive. Had the small buck failed to break off the action instantly, the larger buck probably would have built up such a vicious aggressiveness that he would undoubtedly have gored the smaller antagonist, even though the action started as play. Most of the younger and smaller bucks stay out of the way of the very large mature bucks, who are usually ill-tempered and intolerant.

The older males do occasionally engage in 'friendly' shoving matches, but usually they keep out of each other's way, bristling as they pass but stepping wide of each other. They have learned not to ask for trouble unless they really mean it. Several shoving contests have been witnessed between large-antlered bucks in the velvet, but these appeared to be merely practice sessions, with both contestants putting their antlers together slowly and gently before pushing. In one of these matches, the shoving got a bit rough and apparently sparked that instinctive anger so near the surface in these engagements, whereupon the two bucks, both in the velvet, reared up on their hind legs and boxed vigorously with their forefeet.

The bucks are in breeding condition throughout the year ; however, the psychological and certainly the physiological peak of the rut is reached only during a part of the year, corresponding to the seasonal appearance of the rut in other deer. This can be spoken of as the ' true rut ' in the axis deer. During this period the buck's neck is swollen, his antlers are hard and his ego is at its peak as is his aggressiveness. During this period, serious fights do take place, but no death-duels have been observed, nor have we found any dead bucks that have been killed by fighting. That the battles sometimes are quite rough is attested to by the scars and cuts about the neck and head of bucks examined, and one buck had a half-inch of antler tip embedded in the thick fibrous connective tissue under the skin of the neck, apparently with no ill-effect.

To fight to the death requires both an aggressive desire and a defensive willingness over some common ground or reason. In the Rocky Mountain elk and its relatives, this reason is the harem, and only the defence or pirating of a harem can bring on a fight to the death. This is lacking in the axis deer. There are no fixed or acquired harems to fight over as a rule ; there is no definite territory to defend, or if it is defended it is done psychologically. Consequently, any fight simply stems from male animosity and whatever degree of anger that may flare up sponta-

neously. An ordinary fight can at times flare up into a real heated battle that generates its own energy, though this is rare. The fights, though sometimes ferocious, appear to end as soon as one buck discovers he is being out-fought, whereupon he quickly gives up and moves off, with the winner not following up—for here there is no reason to follow up just as there is nothing to gain by staying in the fight when losing. In this respect the fights resemble those between bachelor bulls among elk—not serious, just sparring jousts, sometimes very rough but never vicious. In contrast, those fought over a harem are all out, vicious fights with no quarter given or asked, and often end in serious and fatal injuries.

It is interesting to watch the aggressive behaviour of a group of bucks just before the main rutting season, when they are still travelling together in bachelor groups. Although no actual contact between animals may take place, and they remain warily out of reach of each other, each appears to be carrying a 'chip' on his shoulder, daring one of the others to knock it off, but secretly hoping that no one will. If strange bucks approach the group, all will bristle up and stalk stiff-legged about in the usual threatening attitude, the newcomer advancing slowly in the same manner. As they mix, there may be some shoving and sparring, or they may just threaten and bluff each other for a few minutes before again settling down to feeding in relative peace. Their action here, as was also noted around the watering troughs and at other meeting places, reminds one of a group of strange male dogs approaching each other.

The threatening attitude of the axis buck is most interesting and is a most ferocious-appearing display. The hair on the neck and body is raised as in a fighting tomcat, making them appear larger, the tail is partly raised and held cocked sideways with the hair flared, heads are tilted partly sideways and the chin is tucked in, antlers jutting. Their face wrinkles up, with the lips curled back in what can well pass for a snarl. Then, with scent glands spread wide open with the inner tufts of oily hair sticking out on each side of their face, ears laid back, and eyes rolling up wildly, they begin to stalk back and forth slowly and threateningly with legs held stiffly and hind-feet dragging the ground at each slow step, all the while giving forth low hisses with each breath. This display may last some minutes before actual contact is made, if at all, and may include pawing the ground with front feet and hooking at brush or grass with the antlers.

This aggressiveness, though reaching its climax during the peak breeding season, is by no means limited to it. Larger bucks, when carrying mature polished antlers, regardless of the time of the year, are in their physiological rut. These bucks, certainly know their superior position and do not hesitate to bully smaller bucks, does, and fawns when they wish to. Their presence during a time other than when a majority of other bucks also are in this condition, places them at an even greater

advantage over other bucks which have their antlers in various stages of growth and in the velvet.

Aggressive behaviour is not nearly so pronounced among does and is rarely observed; they appear to get along in relative harmony most of the time. At times one will become annoyed by the actions of another whereupon she will strike with her front feet or bite, rarely butting with the head. The captive doe-fawn occasionally vented her spleen on her companion, or the owner's dogs, by running up and quickly grabbing a mouthful of hide and hair and giving a sharp tug. The dogs, especially, appeared to be much more wary of this approach than they were of the playful butting of the buck fawn.

Co-operation

The only observed indications of co-operation among axis deer have been limited to reciprocal licking of the head and neck, usually by two does. Pairs of does have several times been observed to stand facing each other while vigorously licking each other over the head, neck, and shoulders. It is not known whether these were unrelated females or whether they were mother and yearling daughter. The latter is perhaps more likely, since mothers frequently lick their fawns all over, with fawns licking their mother in return. When the captive fawns were being scratched about the head and neck—which they greatly enjoyed—they returned the favour by licking the arm of the person scratching them ; this appears to be an instinctive action between mother and fawn—and perhaps between any individuals. It is, in fact, possibly the explanation for the mutualness of this act. In other words, it may be a way of saying ' scratch me please ' ; that is, by initiating the licking of a certain part of the neck, or head, or other part of the body, the animal can in turn get its own part licked. Horses do this regularly ; the Roosevelt elk (Graf 1956) does likewise. In these cases, the interesting thing is that the initiator of the act gets the same corresponding part of his anatomy 'scratched'; if he nibbles or licks the right side of the neck, he in turn gets the same spot on the right side of the neck nibbled or licked. It appears to be a simple way of getting a job done without much explaining or complex communications.

Another type of co-operation which occurs, possibly involuntarily, is a form of ' baby sitting ' by does with young fawns. This is well known among other deer and also other ungulates. On several occasions one doe has been seen with two or more small fawns, although only one appeared to be her own. Later, another doe or two would join the single doe and the does and fawns would move off together, the indication being that the extra fawns had been left in the 'care' of the first doe. This could be unintentional, of course, since does often travel in

groups and, while the fawns are resting, one or more of the does may leave the group leaving her fawn just as she would when alone. Thus, the fawn is left in the company of the other does until its mother returns. Fawns that leave their resting place during the absence of the mother will then, of course, join the other fawns and does near-by.

Deer and Fences

Although physically capable of executing high jumps the axis deer, by inclination and its normal running and moving habits, is not a high-jumper. They rarely jump over a fence which lies in their line of travel, preferring to slip through or under it. Though physically capable of easily clearing a four-foot fence, they nearly always follow it until they find a spot where they can crawl under or slip between the wires. Where fences are found on their range, their trails invariably lead to places where they can go under or through the fence. When hard-pressed, they will run up to these crossings and dive under or through the fence with hardly a break in stride. Captive deer can sometimes be held within a six-foot fence of woven wire, but if badly frightened they will jump over it.

The important point here, from a fencing standpoint, is that a five- or six-foot fence would keep deer within a wild range, except for an occasional rare individual that might have special inclinations for high jumping. Deer do not jump fences just to be jumping. Such activity takes special effort and, unless there is some reason or enticement, they do not do so. On the open range, if one wanted to confine these deer to a certain part of the range, this could undoubtedly be done with a five-foot hog-wire fence. At special points, where a jump possibly might be made easier by the terrain, a single strand of barbed wire above the fence should be sufficient to discourage such attempts. Close confinement will force animals to attempt acts that they normally do not attempt.

Behaviour towards Other Game Species

Only on Lanai is there an opportunity for the axis deer to encounter other species of big game than the wild goat. When the pronghorn antelope were released on Lanai, several encounters between the antelope and the deer were observed. These encounters occurred during the early morning as the deer were moving downhill towards cover after a night of foraging higher up. As the two groups discovered each other, they would stop and stare intently with great curiosity mingled with fear. The deer would move a few steps and stamp their feet as they do when uncertain. The antelope would instantly wheel and run off

a few yards, snorting and flaring their 'powderpuff' rump patches, then stop and stare and then begin a slow and cautious advance toward the deer. This behaviour would be repeated each time the deer moved —the antelope running when the deer moved, the deer freezing when the antelope dashed off—until the tension finally built up to the point where the deer would break and run off, with the antelope hesitantly following. In all cases observed, the deer were the first to give in to fear and run away. Later, as they became accustomed to the antelope, they would feed calmly near them with only occasional signs of nervousness.

The ranges of these two species overlap only slightly, so encounters between the two are not too common except among those few deer living within the overlapping areas.

Mouflon sheep, introduced on Lanai several years earlier, occupy the same range as do the deer and meetings are not infrequent. Several such encounters have been witnessed, but only after the two species had been together for some time and had grown used to each other's presence. The deer would regard the mouflon with mild alarm and curiosity as they approached each other, perhaps stamping their feet, lifting their tails, and giving a few barks of alarm. The mouflon paid little attention to the deer, feeding along calmly, and the deer would soon get over their own apprehension and return to feeding, both groups intermingling in harmony.

The range of the wild (feral) goat on Lanai lies above that of the deer for the most part, and the two species are not commonly seen together. On the few occasions when they have been seen to meet, they appeared not in the least concerned about each other and went about their business calmly, each more or less ignoring the other. Both goats and deer have been on the island for many years, and have had ample time to learn that each is harmless towards the other.

On Molokai, wild goats and deer are found occupying the same range in the east-end rain forest. No opportunity was had to observe meetings between the two. Undoubtedly they do at times come together but probably avoid each other. Goats are by nature phlegmatic and calm, not given to excitable behaviour. The deer undoubtedly exhibit their usual nervous and excitable nature that is so characteristic of them.

Deer occupying ranges where they would never encounter goats would probably act much as they did when first seeing the antelope at the first meeting with these strangers. The two captive fawns were much concerned when two small goat kids were placed in a pen adjoining theirs, and did not get over their nervousness in the two days that the goats remained. If the goats had been kept for a few more days, the fawns would probably have overcome their fear completely.

Unfortunately, up to this time no observations have been made of

any of these competing species meeting at a water hole, where competition for a common need would be strongest. It would be interesting to see which would dominate, or if they would drink together. The latter is most unlikely in view of the highly nervous nature and complete timidity of the deer and the fact that they do not drink when cattle are at the troughs. This also would place them last on the list so far as any dominance is concerned, a position the goats or mouflon are much more likely to take in view of their generally stable and relatively calm nature.

Cock pheasants have been observed to wander within a few feet of deer, with neither pheasant nor deer paying any attention to the other.

Reaction to Domestic Animals

There is no domestic livestock on Lanai at present, with the exception of a few privately owned saddle horses. These are pastured in areas out of the general range of deer habitat, so no opportunity was had to observe reactions between these animals on Lanai. On Molokai, however, deer share common range with both cattle and horses. Horses are in the minority and encountered only over a very small part of the range. In most cases observed, the deer always showed their generally suspicious and nervous character and preferred to remain aloof from the cattle and horses. At times they have been seen to mingle with cattle and horses particularly on choice feeding areas.

In Papahaku Forest when the ripe kiawe beans were falling, cattle, horses, and deer were found together in the same area. However, the deer avoided close approach to the cattle and horses. At the water-trough, deer quickly vacated the near vicinity and permitted cattle to take over. In areas well removed from cover, they appeared very reluctant to come in very near troughs being used by cattle and would often hang back several hundred yards.

On the far west end of the island where cattle were very common on the deer range, cattle were tolerated but avoided. Close approach, such as even 5 or 10 yards, was not observed, the deer usally moving away as cattle approached within 20 to 30 yards. In some of these areas, it was noticed that the approach of cattle through the forest, even though open forest, was almost always certain to alarm and put deer to flight. The deer seemed to feel most sure of their neighbours where they could keep them under full view and clearly see what was coming and what they were doing.

In one instance, a herd of 15 to 16 deer, consisting of does, fawns, and several bucks of various ages, was observed feeding on a low ridge at sundown. A lone range cow came wandering over the ridge, and although this was in an area where cattle were common, the deer all

stopped and showed a great deal of concern, barking and staring intently and anxiously at the cow. An inexperienced and new observer would have concluded from their action that this was the first cow the deer had ever seen. These deer stopped their feeding, which had been in the direction of the cow, and finally retreated. The cow never got closer than about 150 yards. It should also be mentioned that this herd of deer had come up out of Papahaku Forest where they had daily contact with cattle and had undoubtedly associated, and even perhaps competed with cattle for the kiawe beans. This again illustrates the unpredictable nature and extreme nervousness and timidity of these deer.

Above Halawa Valley on the east end, there are a few wild cattle that still roam the lower part of the range inhabited by deer. They have been observed to associate side by side with no apparent discord. In one instance, an old cow was observed entering a small clearing in a remote part of the forest, shortly to be followed by a doe and then a fawn about six months old. The doe, perhaps 25 to 30 yards from the cow, was not concerned, but the fawn was nervous and suspicious of the cow and hung back until the cow left. In the one instance where a saddle horse was used as a 'blind horse', that is by means of which it was hoped to be able to approach deer for close observation, the ruse did not work. The deer bolted at the first sight of the horse. This was close enough to Papahaku Forest, where horses were often near the water tank, so that these deer undoubtedly had seen horses at some time in the past.

Deer in Captivity

Three fawns were raised by the Lanai investigator to obtain data on fawn development and behaviour. They were all captured when very young and raised on a bottle in a pen encompassing his yard. One, Willie, was raised along until he was about 18 months of age, whereupon he was sent to a zoo. The other two, Pepper, a male, and Squeekie, a female, were captured in the summer of 1960 when only a few days old and were hand raised to approximately five months of age, when they too were sent to the zoo.

Willie was raised without the company of his own kind, but in close company of humans and two pet dogs; he quickly became very tame. Up to the time he was about three months old, he was not penned but was allowed to roam at will, spending the nights in the washroom with a pet mongrel and a German short-haired pointer dog. He wandered about the yard nibbling at vegetation and resting in the shade of the trees during the day, occasionally following the dogs off on their neighbourhood forays but always returning at bottle-time. He quickly

learned his name and would come running when called. He always enjoyed his owner's company and attention, and liked being petted and played with. He was afraid of most strangers at first, and particularly of children. He was insatiably curious about all happenings around the place, tried to eat anything remotely edible, and especially enjoyed getting into the house at every opportunity where he would beg scraps in the kitchen, nibble papers, clothes, and cigarette butts, and generally make a nuisance of himself. All in all, however, he was an affectionate, playful, and very interesting pet while young.

The other two fawns were raised together and this had a tendency to keep them somewhat wilder, though Pepper was also affectionate and playful. The little female, Squeekie, never showed the desire for human company exhibited by both bucks; she would come readily in answer to her name for her bottle and would submit to some handling, but otherwise made no attempt to attract attention or show affection. Neither of these fawns showed the close friendship towards the dogs that Willie did, and both were much more afraid of strangers. Nevertheless, both were playful and attractive pets.

As Willie grew older and began raiding the neighbour's flower gardens, it became necessary to pen him in. However, the pen was not too substantial at first and he escaped several times. Usually he would return by himself, but once he was found several miles from home, apparently having tried to track his owner's jeep through the pineapple fields. This was not unexpected since he would become very upset when his owner would drive away, and would attempt to follow the vehicle. Another time he was gone for 11 days and, as was discovered, had joined the herd of wild deer inhabiting the forest edges above Lanai City. This occurred after his spike antlers had matured, and the mating urge first appeared. The owner finally located him feeding with some other deer several miles from him, and when his name was called he came trotting like a lost dog. The others, of course, fled. Then he followed the jeep home, and appeared happy to be back in his pen. During his freedom he had obviously tangled with some larger bucks and had found that he was neither as big nor as tough as he believed, and had gotten a few scars in the bargain for his pains.

As his antlers matured and he began to lose the velvet, Willie showed the normal characteristics of a maturing buck and—what can be expected of all male deer in captivity—he began to get decidedly aggressive and antagonistic and dangerous towards anyone entering his pen. This is characteristic of buck deer raised as pets; they lose their fear of humans and, when they reach their first breeding season, become pugnacious and dangerous, and will continue to be that way from then on. The captive deer, Rudolph, owned by Mr. Noah Pelelo Sr., was raised much as Willie and was kept in captivity until he was 11 years old. His

pen could be entered only when his antlers were newly shed or still very young. As soon as they had reached near full size, he would immediately charge anyone standing near the fence, even though his antlers were still soft enough to tear and bleed near the tips. During his captivity he put two men in the hospital with serious antler wounds. It is well to remember this.

In the wild, bucks are never dangerous towards man under normal circumstances but, once tamed and without the overpowering fear of man, the natural instinctive antagonism and combativeness are turned towards the nearest object at hand. People are not recognized as friends, but as antagonists, and no distinction is made between men and women. Once a buck attacks a man there is no discouraging him, and few have any chance of winning out against the brute strength and implacable rage of a buck with the battle lust upon him. A full-grown buck is more than a match against a man; it takes the most powerful of men to handle even a yearling buck, and then it is not certain that he will escape uninjured. We know of several instances of men killed by penned deer, and the keeping of male deer is most inadvisable. They make interesting and beautiful pets when young, but become exceedingly dangerous when they grow up. It is, therefore, wiser to refrain from raising them unless for reasons of study and research.

Although all three fawns were raised in close association with humans and they all became reasonably tame, they never lost their natural nervousness and instinct for survival. Sudden or unusual occurrences would make them fly into a panic, causing them to run wildly back and forth in the enclosure, leaping into the fence in their efforts to escape. When in such a state, they seemed almost blind to obstacles, running into anything in their way. This appears to be typical of axis deer when badly frightened, and the fawns plainly showed how quickly and thoroughly their instincts would overcome the thin veneer of tameness.

Fawns, raised in captivity by their own mothers (who themselves may have been hand-raised or captured in the wild) and which have a minimum of handling and attention, never become tame. These fawns remain as timid and shy as the wild deer. The deer belonging to Mr. Pekelo have already been referred to in this respect. His buck, Rudolph, was reasonably tame and not easily frightened. The does and fawns would fly into a complete panic when approached by strangers, charging blindly and repeatedly into the walls and fences of their shed and pen often injuring themselves. These are deer that have spent their whole life in captivity in quite close association with humans, but because they were not individually hand-raised on a bottle like Rudolph they never overcame their natural fears.

The axis deer, raised for several generations in the Honolulu Zoo,

respond in the same way. They tend to remain at the rear of their enclosure when visitors are watching, and are continuously nervous and watchful and never get completely used to people. Paul Breese, Director of the Zoo, states that they are the most nervous and excitable of any of the wild animals he had handled.

Handling Captive Deer

Axis deer, whether wild caught or 'tame', that must be handled for weighing, tagging, etc. are a problem. They can put up a terrific fight and must be subdued by force ; however, if handled too roughly they may die on the spot from shock. The best method found so far is by means of nets ; two or three men can carry a large net into a trap or pen, herd the deer into it one by one, and wrap them up rapidly and with relative ease with little chance of injury to either party. They can then be weighed, tagged, and handled without hurting themselves and, what is most important, apparently without suffering from shock.

Tranquilizing drugs have been used with some success in helping to handle axis deer. It was found that Thorazine, injected intramuscularly at the rate of 0·5 mg. per pound, calmed one buck and one doe to some degree, making them much easier to work with. The drug Librium has been tried several times on the captive fawns, but has shown little effect other than to make them weak and wobbly without calming them in the least. The dosages tried have been orally administered up to a rate of about 2·3 mg. per pound of body weight. More work is needed before the success of these and other drugs can be determined, but they appear to promise an easy way to reduce the self-inflicted injuries and death from shock when handling captive axis deer.

REPRODUCTION AND DEVELOPMENT

Breeding Cycle

The breeding and fawning season of the axis deer in Hawaii, as in other parts of the world, is not limited to a clear-cut season of the year. Blandford (1888-1891), Lydekker (1898), Prater (1935), and Phillips (1935) all mention the irregularity of the fawning and antler-shedding in the Indian axis deer.

The indefiniteness and direct contradiction of these writers indicates how little is known today about the Indian axis deer. Recent extensive correspondence with various members of the Indian Forest Service, the Zoological Survey of India, and private individuals who kindly undertook to check some of these matters for us confirms the fact that the axis deer there has no regular breeding and antler-shedding season though, as in Hawaii, there appears to be a peak season. It is of interest

to note that a temperate climate does not affect the cycle of these deer. Whitehead (1950) states that the axis deer in England breeds at all seasons of the year, and that 'the majority of calves would appear to be dropped between Christmas and Easter'. Heck (1935) has the same to say about the axis deer in Germany.

It was not possible to determine with absolute certainty all the factors related to the breeding cycle and its various phases both in bucks and does. However, in general it can be stated that fawns are produced at all seasons of the year with a peak fawning period from about the middle of November to April. Likewise, antlers are dropped at all times of the year, but the peak period of dropping corresponds roughly to the early part of the fawning season. Peak antler-maturation and breeding or rutting activity occur from about April to August, though breeding by any mature buck can take place at any time of the year regardless of the stage of antler development in which he may find himself.

Just as there apparently is no inhibition of breeding ability during the antlerless period in a buck, there apparently is no inhibition of the estrus cycle of does by lactation. The indication is that a doe may come into breeding condition within a few months after having given birth to a fawn which she will be nursing. These two factors must account for the irregularity or non-seasonal breeding of these deer. The fact that this does not alter even in temperate climate indicates an inherent physiological characteristic and not something that is caused by the tropical climate in which these deer are normally found.

In a temperate or northern climate, the young of deer must be born in the spring to survive. This is ensured through a mechanism where the breeding cycle is inhibited in the female during lactation or simply through a regularly spaced cyclic estrus period to ensure coincidence with the season. A similar cyclic quiescence in the males further ensures this coincidence with the seasons. In the axis deer the bucks can breed at any season of the year, and does apparently have a repeated estrus period with such frequency that no definite breeding season will become established.

The acclimatization of true temperate zone deer, such as the European red deer and others, in a climate where the seasons do not coincide with their own breeding cycle will result in an adjustment of the breeding cycle to fit the season. This is the situation in south-temperate New Zealand where the seasons are the reverse of the natural range of many of the deer introduced there. The north-temperate climate animals now have a breeding season just the reverse of those in the north-temperate zone. (Donne 1924, Wodzicki 1950).

We have no explanation for the failure of the axis deer to adjust itself to climatic conditions even in such unfavourable climates as England and northern Europe, other than that offered.

Temperature in Hawaii does not vary greatly; however, there is definitely a seasonal rainfall variation, and in this respect the main fawning season or peak corresponds to the season of maximum rainfall. In India, the best information that we have been able to obtain indicates that the fawning peak falls somewhere between August and February; however, there is some conflict of information on this. The consensus of information indicates that there is at least a weak correlation with the monsoon or wet season there also. The indication is that the coincidence of these seasons and the fawning peak may be just that—a coincidence rather than an adjustment of the cycle to the climatic conditions which happen to be favourable. If this were not so, then the seasons should have had a profound influence on the breeding and fawning activity of these deer in the cold temperate climates where they have been introduced.

Favourable climatic conditions, whether temperature or moisture and food or all of these, will of course have an important effect on the survival of young animals. This in turn may tend to group the arrival of most of the fawns during these favourable months. As will be seen later, bucks apparently shed their antlers with great regularity. It would be most interesting to know whether does have any regularity of recurring pregnancy—it would appear not at first glance; however, we do not have enough data to be certain. The breeding cycle in Hawaii may be just a carry-over from that originally developed in India. The median dates of the varied information received from India would fit our season close enough.

It will be interesting to see what change, if any, takes place in the reproductive habits of the newly introduced pronghorn antelope over the years. This species has a well-defined breeding and fawning season which does not coincide exactly with optimum conditions in Hawaii.

Antler Development

Closely associated with the rutting season is the development of the bucks' antlers; in fact, rutting activity begins with maturation of the newly-developed antlers, and the beginning of the major rutting season may be determined by discovering the period when most of the bucks shed the 'velvet' from their new-grown antlers.

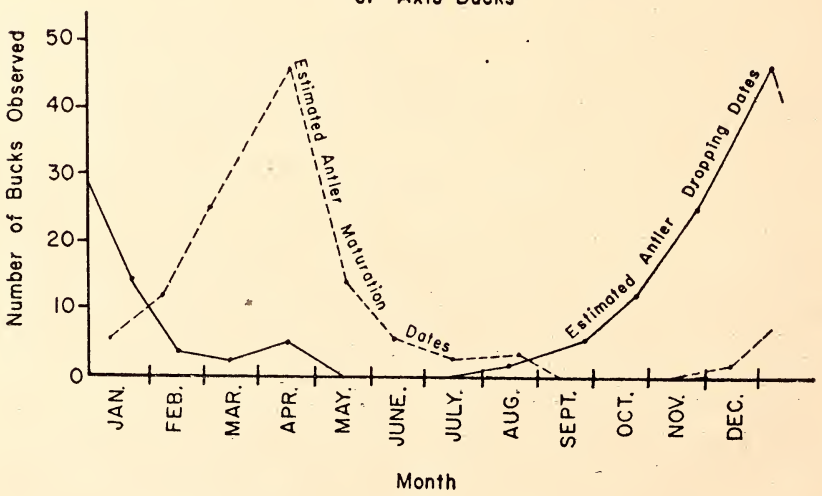
During the course of the present study, close watch was kept on the captive buck, Rudolph, on Molokai, in order to determine the length of time required to grow a set of antlers. This old buck was very consistent from year to year in dropping his old antlers and developing his new ones. The first two years he was checked he dropped his antlers on the same date, January 7; the next year he missed this by only one day, dropping them on the 8th. In the first year, the antler scars on

the pedicles were completely healed over and new growth was evident 17 days after he dropped his old ones. The second year, it took only eight days. The antlers were mature, and began peeling or shedding on May 18th both years. Thus it took 132 and 130 days respectively, or a little over four calendar months, for new antlers to become completely developed after the loss of the old ones, which he carried for nearly eight months.

In order to arrive at the approximate period when most wild bucks shed the velvet from their antlers, the antler-dropping dates were estimated for all bucks observed in the velvet for two years. The state of their antlers was compared to the observed growth-rate of the penned buck, and by working backwards, the approximate dropping date was obtained. This data is plotted graphically in Figure II, which shows the estimated month in which each buck dropped his old antlers. Assuming that antler development in most bucks roughly follows that of Rudolph, taking a little over four months for completion, the corresponding curve to show antler maturation dates was also plotted in Figure II. These two curves indicate that the majority of axis bucks drop their old antlers in December each year, and that most of the new antlers are mature by April.

Fig. II

Estimated & Known
Antler Dropping & Maturation Dates
of Axis Bucks

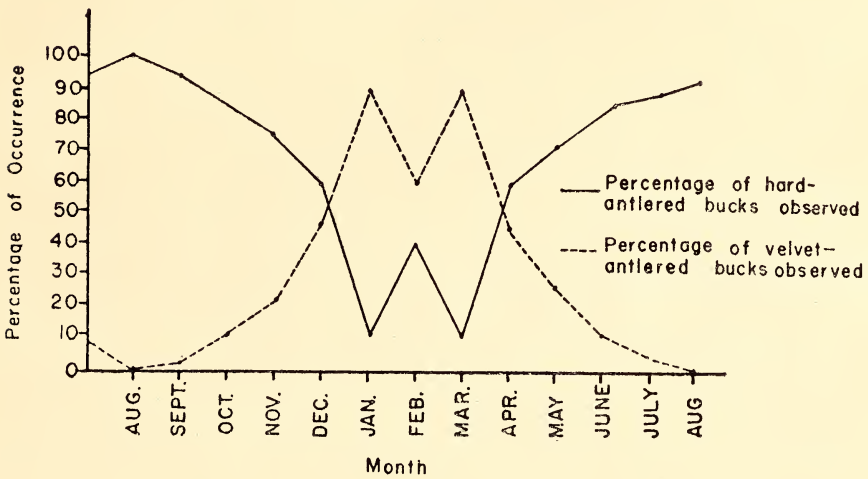


In order to corroborate these two periods, the curves shown in Figure III were constructed by plotting the percentage of occurrence of all bucks observed each month with hard antlers versus all seen with

antlers in the velvet. The curves show a sharp drop in bucks seen with hard antlers in December and a sharp rise in April, again indicating that the majority drop their antlers in early winter and develop new ones by mid-spring. It must be remembered, however, that although the bulk of the bucks follow this pattern, many are 'out of phase', and some may be seen in any stage of antler development at any time of the year. It is not at all uncommon to see a few bucks that have

Fig. III

Antler Condition By Percentage Of Occurrence And Month



just shed their old antlers, or that are in the velvet, during the summer, or bucks with mature, polished antlers during the winter.

After they have lost their old antlers and while new ones are developing, most of the bucks travel together in bachelor groups apart from the doe-fawn groups, although they may occasionally mix with these while feeding. A few of the older stags may even become solitary, keeping apart from others of their kind. Bucks in this state appear to realize the loss of their armament, and become even more shy and nervous than usual. They stick close to cover and keep out of sight as much as possible, taking to their heels more readily when alarmed.

When the antler is dropped, the surface of the pedicle is left raw and open and may bleed slightly. This 'wound' is quickly covered with a soft, greyish blue skin, and in one to two weeks new growth in the form of a slight knob is noticeable. While the antlers are growing—which they do from the tips, not the bases—they are covered with a thick, soft skin, which has a coat of fine, short, velvet-like hair, giving rise to

the term 'velvet'. This protective skin contains a well-developed circulatory system which provides blood and nourishment to the growing bone beneath. Damage to this skin or velvet while it is still functional causes severe bleeding and, if the damage is sufficient to impair circulation to the growing tip of the antler, malformation or stunting may result. It is not uncommon to see bucks with clubbed or twisted antlers, probably resulting from injury while they were developing.

Such injuries are not hard to visualize since many bucks engage in mild to moderately rough sparring contests while their antlers are still developing. As their velvet-covered antlers begin to mature, the bucks' confidence and belligerence returns, and signs of antagonism are exhibited. Several weeks before Rudolph's antlers were fully mature, and while they were still soft enough near the tips to bleed when struck, he began jabbing and gouging them on the fence in his efforts to attack onlookers.

At this stage of their antler-development, the bucks reach their best physical condition and build up an abundance of visceral fat. With the final maturation of the antlers, their necks begin to swell; the skin over the sides and upper portion of the neck becomes thick and tough, and a thick, subcutaneous layer of connective tissue develops in this area. The neck muscles become enlarged, providing the protection and strength needed for the more strenuous battles to come.

When the antlers reach full maturity, circulation in the protective skin is much reduced or decreases altogether and the skin dies, drying into a fibrous, paper-like covering. As it dries and splits, it peels down and off the antler in long shreds and strips. The process is fairly rapid so that in a period of several days the buck may be left with tangled strands of this dried skin hanging from his antlers and over his head and face. Some bleeding may occur from parts of the skin not completely dried, but it is minor and merely stains the antlers to varying degrees with the brown of dried blood.

The common assumption that bucks remove the velvet by rubbing the antlers on shrubs and trees is not entirely correct. Actually, the velvet comes off naturally and without help, though, obviously, the rubbing that does occur will help to remove it even though rubbing may not be done for this purpose. At the time when the velvet is drying and beginning to peel, an instinctive desire to rub their antlers arises, perhaps being encouraged by itching as the velvet dries, but more likely by the excess energy of the fully-awakened rutting urge. The bucks begin to spend numerous periods in thrashing small trees and brush with their antlers, sometimes calmly and deliberately, sometimes in apparent rage. Such rubbing does help to remove shreds of velvet—though not deliberately—and also stains the antlers more fully, as well as covering them with bark fragments and other debris.

Breeding Ability and Pregnancy Rate

Although the outward signs of the rut are most apparent in the period following the maturation of the buck's antlers, which for most of the bucks is in late spring and summer, and although most of the breeding takes place during this period, bucks apparently are able to breed successfully at any time of the year. Several observations have been made of wild bucks breeding receptive does after the bucks have dropped their antlers. The pet buck, Rudolph, was recorded as successfully impregnating a doe two days after dropping his antlers on January 7th, over eight months after he actually began his rutting season.

A number of bucks were collected in various stages of antler development, ranging from those that had just lost their antlers, through those with partly developed antlers in the velvet, to bucks with polished antlers but apparently past the peak of the rut. Microscopic examination of the reproductive tracts revealed that mature and active sperm were plentiful in all cases, indicating that the animals could impregnate a receptive doe at any time of the year, regardless of outward appearances.

Bucks without antlers, or in various stages of velvet, do breed with does not uncommonly as our own observations show. It would seem reasonable however that, where bucks with hard antlers are present, these would do the breeding in most cases, since they would have no difficulty in fending off their unarmed rivals from a receptive doe.

Little has been learned about the sexual activity and the estrus cycle of the axis does. They appear to be receptive to the buck for only short periods of their estrus cycle, not unlike other deer. They apparently go through several estrus cycles annually, though how many is not known definitely. From the little evidence that we have, it would appear the great majority of does are bred the first time they come into heat on reaching sexual maturity, and thereafter are bred as they come into season after the birth of each fawn.

The only observations so far available by which we can estimate the length of the doe's estrus cycle were made on a pair of captive deer. The buck was observed to mount the doe on September 19th, then again on December 9th and December 16th. The September 19th act can be considered as an unsuccessful breeding. The second two dates, however, present several possibilities. Either the buck forced himself on the doe prematurely, that is before she was actually in full estrus, which might be possible under pen conditions, or the axis deer has a long heat period. In any case, the December 16th breeding was successful and the doe became pregnant. No more mounting of the doe was observed after this date. The time lapse between the first and second breeding was 81 days, and between the first and third 88 days. Since our records in

these cases depended on the observations of the owner of the animals, one can only make assumptions as to the estrus cycle. If the doe went through regular estrus cycles between the first breeding attempt and the last one, one could, on the basis of a 27-30 day estrus cycle of similarly sized deer, assume that she had gone through three cycles between September 19 and December 16 or, if no other estrus periods occurred, then it is possible that the axis deer may have an estrus cycle of approximately 85-90 days, which is not too likely. Since we do not know whether the doe was kept separated from the buck between the first and third breeding (normally the practice by the owner) this remains pure speculation. It is a field that needs more study and observation.

Records of the time-lapse between parturition and re-impregnation of axis does are also scarce. Those obtained from the zoo showed that the four does observed again became pregnant four, four and one-half, seven, and nine months after giving birth to fawns. There is a strong indication that does often become pregnant even sooner than four months after giving birth. One doe collected had a fawn with her that could not have been more than 3 months old. This doe was carrying a 25 mm. fœtus, which can be estimated at about 50 days of age. She was from the wet rain forest, where food conditions are at their best, and the fawn can be considered to have made a maximum growth. Thus, by the most liberal estimate based on dry-land growth, breeding must have occurred here only one and one-half months after parturition, and possibly even sooner.

Another young doe, which could have been no older than 14 months according to her teeth, was found to be nursing a fawn while she was carrying a fœtus which was about 80 days old. This means that she was bred the second time at about eleven and one-half months of age. Subtracting the approximately seven to seven and one-half month gestation period of her nursing fawn from this age, indicates she was bred the first time at four to four-and-a-half months of age—and this with no time lapse between giving birth to her first fawn and being bred again. Assuming one-half to one month between parturition and re-breeding, she would have had to be only three to four months old at her first breeding. Thus, it appears that the interval between parturition and re-breeding could have been only one month at the most, and probably less, since it is highly unlikely that she could have been successfully impregnated before she was three or four months old. Even this age must be an exceptional minimum for sexual maturity.

Ten other does were found to be both pregnant and lactating. According to the age of the fœtuses carried, they had been pregnant from 2·3 to 6·1 months approximately, or an average of 3·6 months for the 10 animals. Since it appears that fawns are normally weaned between four and six months of age (and probably closer to four months)

and these does were still nursing un-weaned fawns, the maximum interval between their giving birth and becoming re-impregnated must have been between about 1·7 to 3·7 months, with one of them possibly becoming pregnant almost immediately after giving birth.

In all probability, the average axis doe in the wild becomes pregnant again about four to five months after giving birth. If they did not average this time lapse but took from 16 to 17 months, more barren does would have been found among those examined, and if the lapse averaged longer or shorter than four or five months or 16 to 17 months, the peak fawning season would have changed over the years, probably levelling out by now to a constant monthly birth rate. For example, if a doe became pregnant on January 1, she would give birth approximately on August 17. Then, if she again became pregnant two months later in the middle of September, her next fawn would be born about the first of May the following year. If fawning and breeding dates of the population as a whole varied in this manner for a number of years, the fawning season would not continue to form a peak during the winter months as it does, but would be scattered almost evenly throughout the year, or form peaks at random seasons. Since the breeding and fawning peak seasons are obvious and apparently constant, such an interval between parturition and re-impregnation must be the average case for the herd as a whole, even though a number of animals vary from this average to quite a degree.

Where forage is good, as it is over most of Lanai and parts of Molokai, axis does probably average almost one fawn every 12 months. Two fawns produced successively in the same year as stated by Lydekker (1898) is, of course, out of the question due to the length of the gestation period. A total of 152 sexually mature does were examined for indications of pregnancy and lactation. This included the laboratory examination of ovarian scars, as well as gross examination for obvious fœtuses and the presence of milk in the mammaries. Of this total, it was found that 103 does were pregnant, 27 were pregnant and lactating, 14 were lactating only, and only 8 were neither pregnant nor lactating. Thus, 144 were either pregnant—and so would give birth within the next seven-and-a-half—or had already given birth within the past six months or less (most fawns are weaned before they are six months old, and probably by the time they are four months old). This indicates a yearly pregnancy rate of about 95%. Thus, it seems safe to say that one could expect about 90 to 95% of the sexually mature does in the herd to produce fawns annually. Judging from the herd increase rate under the present ideal conditions on Lanai, the indicated birth rate is probably not far from correct.

Breeding Behaviour

With the maturation of the bucks' antlers, the rutting period begins in earnest. Antlers are struck and rubbed against trees and brush with the utmost zeal, and at times the bucks act as if they are actually 'fighting' a tree. They jab and shove viciously while dancing around and pawing the ground, apparently using the tree as an imagined enemy. Favoured rubbing spots are young kiawe trees under four or five inches in diameter, but almost any tree, including large ones, may be rubbed and gouged from time to time. Antler-rubbing is frequently violent, and young trees so attacked may be completely girdled of bark and killed, while older trees receive deep scars. Bucks approach each other with more than the usual belligerence, stalking about and threatening, and fights are commonplace. The fights, though rough, are usually short and end as soon as one contender realizes that he is losing, the winner rarely pushing the attack.

During this period, some of the bucks appear to wander restlessly from herd to herd, seeking receptive does. While wandering about, the larger bucks at least, can occasionally be heard calling their hoarse, drawn-out challenge, usually in the late afternoon or evening. To what extent these calling bucks are transient is not known. In the high forest of Molokai, at least, there is an indication that these 'roaring' bucks are calling from a 'fixed' territorial area.

As a doe comes into heat, she is quickly located by one or more bucks, and followed intently until the heat period is over. Although several bucks may be following her, the largest quickly asserts his dominance, and the others follow at a discreet distance, hoping for an opportunity but not daring to approach too closely. If one is bold enough to come too close to the doe, the dominant buck makes a quick rush at the interloper with antlers lowered. This is usually enough to send the smaller buck back to a respectful distance. The dominant buck does not appear to mind the other bucks hanging around, and wastes no time on them as long as they do not try to interfere or come too close.

If the doe is not quite ready to accept the buck, she often leads him a merry chase, keeping just out of his reach and trotting ahead, nibbling a bite here and there until the buck is almost up to her, then trotting off again. The buck follows her, walking, trotting, or even running after her in his frustration.

When the doe is ready for breeding, she will permit the buck to come up to her, indicating her readiness by urinating and lifting her tail frequently. The buck reacts by smelling and tasting the urine, raising his head with extended upper lip curled back in the typical ungulate gesture. He then proceeds to lick her genitals, flanks, and head, often jabbing her lightly with his antlers. This pre-coital courtship may go on for some

minutes before the buck actually tries to mount the doe. When he does so, she frequently will move out from under him, making him repeat the courtship several times while he grows more and more eager and frustrated. His antler jabs become more forceful as his desire mounts, until the doe finally gives in completely and copulation occurs. It is apparently repeated as often as the buck is able and as long as the doe remains in heat. When she loses her desire, the buck will leave her and go off to seek another.

Only rarely has a larger buck been observed to actually herd several does in a harem, remaining with them while he keeps other bucks away. The more common practice is to stay with a single doe coming into heat and leave her after breeding to find another one, perhaps in another group. On the few occasions when herding was observed, the buck used his antlers to keep his does from straying from the group, and appeared to move the group in whatever direction he chose by herding and jabbing.

Although bucks lose some weight during the extended rutting season from the exertions, they show no aversion to feeding at this time, and browse hastily and sporadically while pursuing the does, with long feeding periods in between. Most of the breeding activities take place during the usual feeding periods in the evening, night, and early morning when the deer are normally on the move. Even during the peak of the rutting season, they continue to seek heavy cover and rest during the major part of the daylight hours. Many of the older bucks leave the doe-fawn herds and groups during the day, and seek solitude for the resting periods, joining them again in the evening.

By late summer most of the smaller and medium-sized bucks' necks have returned to their normal size—somewhat heavier than that of the does, but not noticeably swollen as they are during the beginning of the rut. The necks of the larger bucks also shrink somewhat, but they remain fairly heavy until after they lose their antlers, after which they become even more reduced. As the summer progresses, the ardour of the rut drops off and less fighting and threatening is noticed. The bucks remain with the doe-fawn groups for the most part, but appear to get along with each other with less hostility. Does coming into heat periodically throughout the off-season are bred, but the outward signs of the rut are not nearly as feverish as during the late spring and early summer. During the fall, many bucks begin to drift away from the herds of does and fawns and again take up their bachelor life, although a few bucks may always be found with does.

Gestation

Only one definite record was obtained of the gestation period of axis deer during the study. In this case, the elapsed time between the last date of breeding—and probable date of conception—and the date of

parturition was 229 days, or a little over seven-and-a-half months. There is undoubtedly some variation in this period, but it will probably not vary more than a week or two either way. Rough correlation was obtained by the length of time between the start of the peak breeding season in April and the start of the peak fawning season late in November, or about seven-and-a-half months.

Growth of the Foetus

Axis does normally carry only a single fœtus ; none so far examined has contained more. Only one record has been obtained of twin births, and that from a zoo deer. Mrs. Marie Palit, of Ranchi, India, in a personal communication states that she has had the opportunity to observe a great many does killed on large estates as a result of extermination drives. She was personally interested in examining them for pregnancy because the pregnant does were not acceptable as food. As an example, one such shoot brought in 47 deer, 38 of which were does, many pregnant. In her letter dated 2-11-1960, Cobwebs, P.O. Nehal, Ranchi, India, she states : ' I myself have never seen multiple fœtuses, nor have I seen single does with more than one fawn at heel '. Twins, of course, are possible but undoubtedly are quite rare in this species.

A number of fœtuses were obtained from field collection and from hunter-killed deer ; these were all weighed and measured. One specimen of a known-age fœtus was obtained from a captive doe. Her breeding date was recorded and, upon her accidental death, the fœtus was collected, at which time it was 108 days old and weighed 250 grams. Three of the other fœtuses appeared to be fully developed, and at least two of the does were obviously ready to give birth within a day or two. Their mammaries were fully developed and their vulvas were swollen. The third would probably also have been born shortly. If we accept the 229 days as average gestation period, this is the approximate age these fœtuses would have to be given.

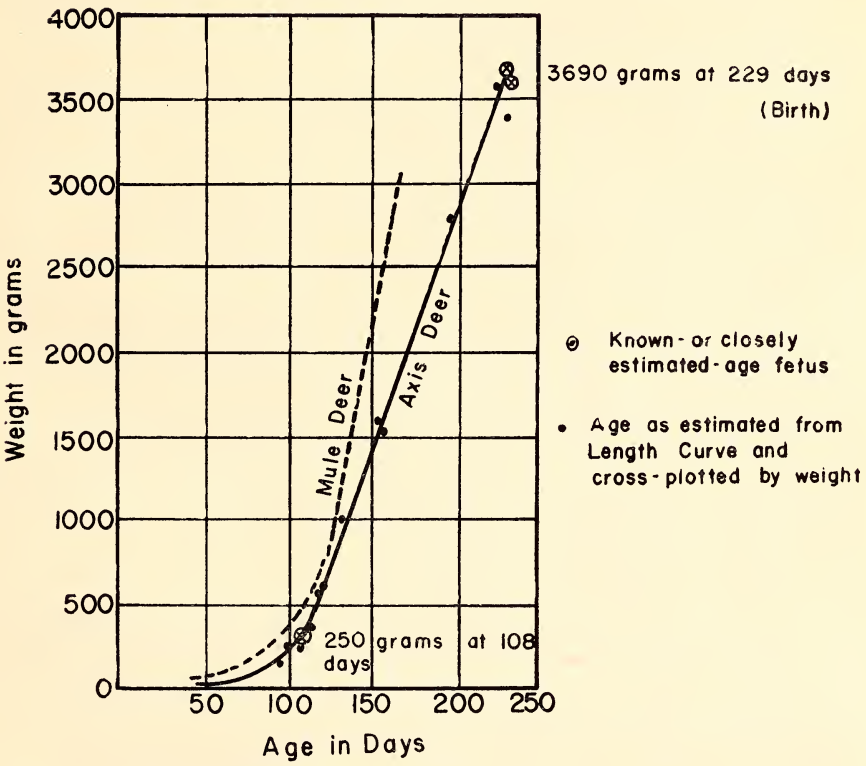
Hudson & Browman (1959) determined the weights by age of a number of known-age mule deer fœtuses, and the data were plotted into a curve in Figure IV to illustrate the increase in weight by age in days for this species. By using the weights of the heaviest of the three estimated-age term fœtuses of axis deer and that of the one known-age fœtus, a similarly shaped curve was constructed to show the increase in weight by age of axis fœtuses. This curve, also shown in Figure IV, *was constructed by eye for best fit and resemblance,* and is solely an estimate of the true average growth curve but, as will be shown, is probably fairly accurate.

The length, by age, of the mule deer fœtuses was also determined by Hudson & Browman, the length in this case being the distance from the

crown or forehead to the rump. The crown-rump length was used if the head was still bent downwards, and the forehead-rump length if the

Fig. IV

Constructed Fetal-Growth Curves
of Mule Deer & Axis Deer
by Age in Days & Weight in Grams

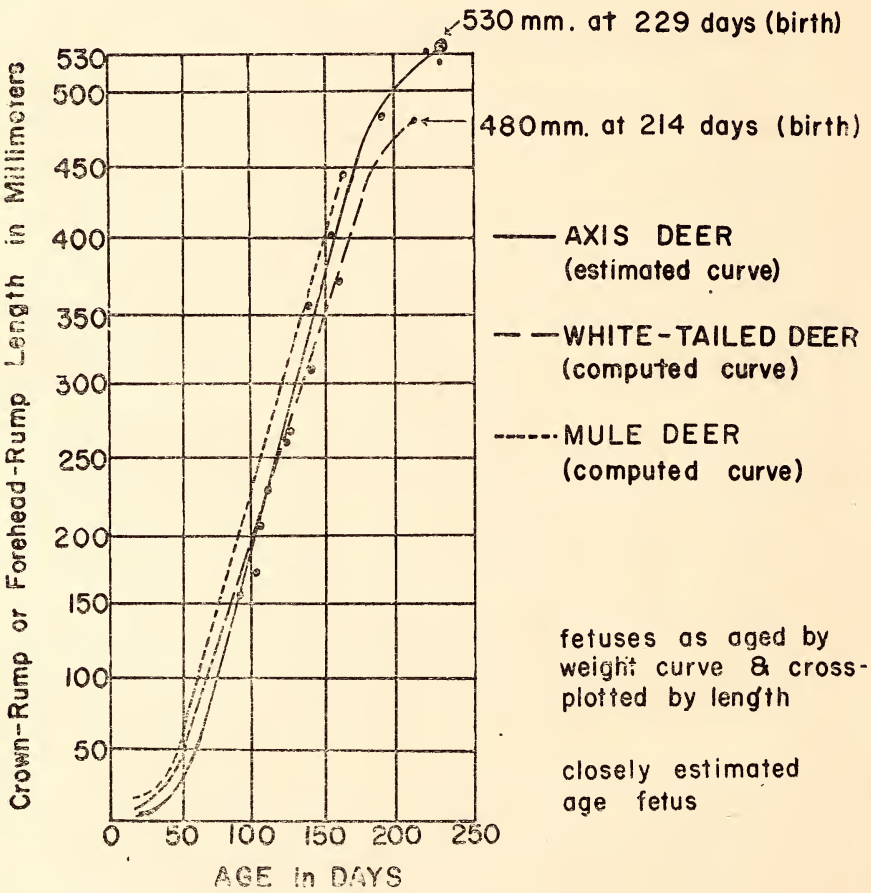


head was straightened as the fœtus grew older. The data were plotted in a curve (Figure V) to show the increase in length with age in days of mule deer fœtuses. Similar data for white-tailed deer fœtuses were obtained (Thompson 1958) and plotted in Figure V. The curves overlap almost perfectly over most of their length, though that for the mule deer was not carried out until the age at birth due to lack of data. A similarly-shaped growth-curve for the axis deer was constructed using the length of the heaviest full-term fœtus as the assumed length at 229 days of age, and shaping the curve to take into consideration the lag in early development as indicated by the one known-age fœtus. Unfortunately, the length

of this fœtus was not obtained ; the specimen was lost before being measured due to a freezer malfunction. This estimated curve is also illustrated in Figure V.

Fig. V

Constructed Fetal Growth Curves of White-Tailed, Mule & Axis Deer By Age in Days & Length in MM.



The fœtuses obtained were then aged according to each of the curves so constructed ; the resulting ages by weight and by length agreed quite closely. These ages were then cross-plotted on the two curves ; in other words, the estimated ages according to the weight curve were plotted on the length curve by length, and the estimated ages by length were plotted on the weight curve by weight, in order to see whether the curves agreed with each other and were therefore constructed in the proper shape.

This cross-plotting is also shown in Figures IV and V, and indicates that the two curves are in close agreement and therefore are probably designed about right. More data will be needed in order to check on their accuracy but, until it is forthcoming, these curves will have to suffice for the aging of axis deer fœtuses.

The following list of physical characteristics may help obtain the approximate age if scales or tape measure not available :

Age	*Characteristics*
Less than 100 days ..	No hair present, no skin pigmentation visible, metatarsal glands not visible.
110 days ..	No hair present, no skin pigmentation visible, metatarsal glands visible as white spots on hind leg below hock.
130-140 days ..	A little hair developing on chin, and eyelashes evident, skin pigmentation barely visible, metatarsal glands very apparent, nose dark grey.
150 days ..	Hair fairly plentiful on eyes, nose, and chin, only ; pigmentation more visible ; nose black ; hooves black and formed ; teeth present only as cartilaginous lumps.
160 days ..	Hair appearing all over, especially on head, tail, and rump ; pigmentation very plain ; nose and hooves black ; teeth still not formed.
200 days ..	Fully haired and developed ; incisor teeth starting to protrude through cartilage.
220-229 days ..	Fully developed ; incisor teeth completely formed ; appears the same as a newborn fawn.

Sex Ratio of Foetuses

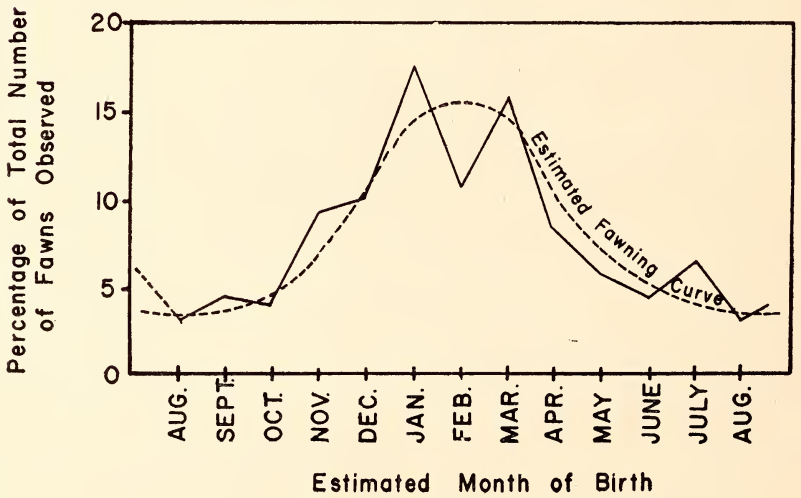
A total of 68 fœtuses was examined from pregnant does that were collected or brought into hunter checking stations. Of these, 39 were male and 29 were female, giving a sex ratio of approximately 1·3 males to 1·0 females. This sample is quite small, however, and, although it may actually indicate the true sex ratio of fawns at birth, it is believed that the true sex ratio is probably close to equality with perhaps a slight preponderance of males. For the purposes of calculation, a sex ratio at birth of 1·0 to 1· 0 will be assumed until further information is available.

Fawning

Observations in the field showed a peak fawning season which started during late November and which continued through March. Although the peak period was obvious, it was possible to see some young fawns during any month of the year. In order to confirm this winter peak, most fawns observed in the field were roughly aged by comparing their sizes to those of the captive fawns at various ages, and the approximate month of their birth determined. In addition, the future birth dates were computed for all fœtuses examined, and the birth dates determined for a number of captive fawns. This data was plotted graphically in Figure VI by the number of births during each month. The resultant figure

Fig. VI

Known & Estimated Birth Dates of Fawns
By Percentage of Occurrence



clearly points out a fawning peak during the winter months from November through March. According to the data obtained, about 61% of all fawns are born during the five months from late November through March, and 39% during the remaining seven months from April through October.

Since the aging methods by which the majority of birth dates were obtained are admittedly not very accurate, the picture as presented in Figure VI is not precise, but is used merely to indicate the approximate annual fawning cycle. Field observations lead to the belief that it is fairly indicative, though possibly showing the peak season commencing

a little early ; it actually appears to start in late November or early December rather than in early November.

The major fawning season as shown helps to confirm the major breeding season as discussed earlier. Subtraction of the seven-and-a-half months gestation period from the beginning and end of the fawning peak points to a breeding peak from April through August.

Parturition

Although no actual births have been observed, a number of does have been seen that were obviously just about ready to give birth. Most of these were alone, having sought out some spot of good cover such as a dense patch of brush or small clump of trees high on the side of a gulch where visibility was good and approach difficult. They appeared very reluctant to leave these chosen sites, and seemed to be waiting for their time, moving but little. Others have been seen with nearly new-born fawns in similar sites, and also alone. Thus it appears that when their time is near the does leave their yearling fawns, if any, and their companions, and seek privacy in some well-protected spot in which to give birth to the fawn.

Fawn Development

The newborn fawns are kept well-hidden by their mothers, who make them lie down by nosing them on top of the head. Small fawns can hide in almost any small patch of weeds, brush, or grass, and easily remain hidden by stretching flat. They seem to have an instinctive desire to hide in this manner when very young, and remain for hours in this position while the mother remains near-by or goes off to feed. Periodically, the doe returns to nurse her fawn but, otherwise, she stays somewhat apart from it and may go off for an hour or two to feed with other deer. The result of this isolation of the fawn not only permits the doe to feed normally but cuts down the possibility of attracting a predator to her fawn by her presence. Predators, either instinctively or from experience, methodically search areas where isolated does are encountered.

Small fawns can be induced to assume this flat hiding position by stroking them on the head, whereupon they lay their ears back, stretch their necks and heads out on the ground, and make themselves as flat and invisible as possible. The ears soon come up, however, and resume the continual swinging and searching movements that are rarely stopped for the rest of their lives.

When very young, the fawns apparently have little scent to give away their presence ; several times dogs have been seen to pass right beside hidden fawns without noticing them. Another possible protective

mechanism is that for their first few days their eyesight appears weak. Thus they would not be as likely to see some real or assumed danger near-by, become frightened, and jump out of their hiding place to run, thereby giving themselves away. They normally lie where their mother has left them, refusing to move unless practically kicked out. Since they are so hard to see while they remain still and hidden, and since they apparently are very difficult to locate by scent, their best possible protection is to remain right where they are and allow the danger to pass by. If they do become frightened by the near approach of danger, they may jump up, run a few yards, and then duck into whatever cover is present and lie down again to resume hiding. When the doe is near-by when danger threatens, she will run off alone, leaving the hidden fawn, and apparently trying to attract the danger to herself by making her flight obvious.

When the fawn is badly frightened as when caught by a dog or men, for example, it will squeal its high-pitched mewing call or give a loud, raucous call of terror. This will bring the doe to it on the run if she is within hearing, where she will 'flutter' about nervously if the danger is human, or attack savagely with tooth and hoof if a dog is present. Does can be made to reveal their hidden fawns by imitating a fawn call ; as soon as the doe hears it, she will run to the fawn to see if all is well.

In more peaceful times, the fawns apparently call quietly when they are hungry, for does have been seen to suddenly throw up their heads to listen, then trot over to a hidden fawn to nurse it. All of the captive fawns would call repeatedly for their milk if it did not arrive on time.

For the first two or three weeks of their lives young fawns are kept almost constantly hidden by their mothers, and are thus rarely observed. After they are several weeks to a month old, they are allowed to accompany their mothers while feeding and are more frequently seen, though they still spend long periods resting in hiding. As they grow older, they accompany their mothers constantly in their movements, nibbling on forage and playing with other fawns, nursing whenever the mother will stand still long enough.

Nursing is always a time of excitement for the fawns ; they stretch to their utmost, tense as little springs, their tails go up with hair all fluffed out, and their small infra-orbital scent glands are flared wide open. They suck with vigour until the milk stops flowing, whereupon they butt the udder savagely with their nose, tug and yank the teats, and sometimes strike sharply with their fore foot. A large fawn may give its mother quite a beating if she does not supply enough milk or supply it fast enough, though, if the fawn gets too rough, the doe may reach around and nip it or kick it. A large fawn when butting this way, may lift its mother's hind feet off the ground by the force of the push.

It is not known how often fawns nurse during the day, but it is probably fairly frequent since the doe's udder is not large. As the fawns grow older they demand more milk and must nurse more often. A two- or three-month old fawn can consume a large quantity of milk in a surprisingly short time. The captive fawns at this age could drain a nine-ounce baby bottle through a nipple in less than 30 seconds, and would take 18 ounces three times a day, all the while trying for more. Nursing periods observed in the wild have been short, with the doe moving off after only 10 to 15 seconds, but these have been daytime observations and nursing might last longer under cover or in darkness.

Actually, it appears doubtful whether milk is an absolute necessity beyond nine weeks and is not more or less a luxury which the fawn takes as long as possible.

All three of the captive fawns raised began picking at green forage at about one week of age, and were eating it in quantity by five weeks. By five-and-a-half weeks, their faeces had hardened into typical pellet form from the consumption of vegetation ; before that age it was soft and viscous. As their consumption of greens increased, they began regurgitating and chewing their cud during resting periods. By three months all were eating sufficient forage to provide ample nourishment had their milk supply been cut off, though they still relished and sought milk daily.

Actually neither the capacity nor the desire for milk of bottle-fed fawns is an indication of the amount or the length of time that a fawn will get milk in the wild state. It is doubtful whether a wild doe could come anywhere near producing 54 ounces of milk per day, though the captive fawns showed they were more than willing and able to take it. As the does' milk supply becomes inadequate, the fawn must make up the food lack with adult food. The hardening of the faeces into typical adult pellets gives some clue to the age when the fawn becomes capable of existing entirely on adult food. A wild fawn weighing 40 pounds or about 12 weeks of age, was found to be subsisting almost entirely on adult food, though a small amount of milk was found present in the rumen. In all probability fawns of even younger age subsist largely on vegetation and, while undoubtedly milk is acceptable, it is probably not necessary.

In the wild state, few fawns over four to five months old have been seen nursing. There is little doubt that these were being over-indulged and were getting more than they needed. The proof that such over-indulgence does occur was the observed instance of a yearling doe, as large as her mother, which was still nursing ; she had to get down on her knees to do so. Such instances are, however, rare.

The fawn, Willie, was not weaned until he was six months old because it was not known whether his daily forage was sufficiently balanced to properly nourish him. However, after weaning, he showed practically no decrease in weight gain, and therefore, could undoubtedly have been

weaned several months earlier. The other two fawns were still getting milk at five months of age, mainly in an effort to keep them tame and easy to handle, but could have been weaned much sooner.

The question of weaning time and at what age a fawn is capable of being self-reliant from the food standpoint is important. Many well-meaning but uninformed people claim that fawns will starve to death if the does are shot during either-sex hunts. This is true, of course, if the fawns are too small ; however, if the season is held at a time when most of the fawns are several months old there is little likelihood of this occurring. No difficulty has been had over this question in Hawaii, but it comes up constantly on the mainland. There, in temperate climate deer, where fawns are usually 4 to 5 months old by the time the hunts are held, such arguments are ridiculous to say the least. It should also be remembered that if the food supply is so poor that the young fawn starting out on its own, that is 9 to 12 weeks old, cannot survive, then it is highly improbable that the doe will be able to supply it with enough milk for it to survive. Milk, after all, is not produced by wishful thinking and sentiment—it takes food to produce it, in fact considerably more food than the milk that will result from it.

The doe frequently licks her fawn over the entire head, neck, and body, particularly at nursing time ; at this time she also licks it vigourously about the anal region. This not only keeps the fawn clean, but apparently helps it to defecate ; the captive fawns, when very young, tended to become somewhat constipated unless stroked about the anus with a warm, moist cloth. While the licking is going on, the fawn commonly reciprocates by licking its mother about the head. This habit is kept up apparently as long as the fawn remains with its mother, though to a lesser degree as the fawn grows older. It is not unusual to see a doe and her yearling fawn licking each other about the head and neck.

It is interesting to note that fawns under a month or so of age do not like to urinate when in the open but wait, if possible, until they are in a sheltered and quiet spot. The captive fawns would invariably wait until they were allowed into the house, where they would move into some quiet spot where they felt secure and protected before urinating. The buck fawns commonly waited until they were lying down, then would urinate in their bed and remain lying in it with no apparent discomfort. The doe fawn was never observed to do this.

Before weaning, fawns show little interest in drinking water and, in fact, did not seem to know exactly how to go about drinking it. They sniffed and sometimes licked at the water, but did not drink it. As their milk consumption dropped off and finally stopped altogether, they quickly learned to drink and made frequent use of water when it was available.

Physical Development

The senses of newborn fawns do not appear to be very acute, with the possible exception of hearing. This may, however, be more a matter of developing use rather than an actual lack of the sense. Lack of familiarity with objects may also give false impressions of the acuteness of a sense, as has already been explained in the discussion of the adult senses. In a precociously born animal such as deer, one would expect all faculties to be reasonably well developed at birth, though a lag of a few days may be the case here.

The sense of smell, or its use certainly, develops rapidly and they become very interested in various odours within a few days after birth. It is difficult to judge how well this sense is developed but, in view of its importance, one would expect it to be among the best developed.

Eyesight appeared to be relatively poor in the pet fawns, except at close range, and did not appear to become much strengthened until these fawns were about one month old. Before that, they were constantly running into various objects during play, seemingly unable to discern them until they were almost touching them. After a month or so, however, eyesight use improved until vision was very good at all ranges.

Two observations were made on newborn—or almost newborn—wild fawns that indicate that vision is possibly better than that observed in the captive fawns, and so may negate the theory of poor eyesight being a protective mechanism in very young deer. At least in these two cases, the fawns were able to recognize the close approach of danger and reacted promptly. One of these was discovered in a dense stand of kiawe second-growth near the beach. The fawn was discovered wobbling about near an old windfall, amidst a welter of debris of limbs and rotten wood. It appeared to be but a few hours old, barely dry, had the gaunt and un-co-ordinated appearance so common to new fawns, and was swaying and wobbling about in a most uncertain way. It would bump into twigs and fall over every small obstruction. It appeared quite helpless. Certainly it had never seen a man, nor had it had any experience with one. No one besides the observer had been near this remote spot for weeks.

The snapping of a large twig when the observer was still some 10 yards away, brought the youngster's head around with a jerk. Its ears had lost their dejected droop and were up and alert, the eyes were bright and clear and they obviously focused on the intruder, showing all the startled amazement and fright of a surprised adult under the same circumstances. There was only a moment's hesitation as the observer advanced, confidently expecting the youngster to drop flat and try to make itself invisible. However, its instant pivot away had all the speed and dash of a full-grown deer—except that it ended in an ignominious heap as the plucky youngster tripped over a twig; however, it quickly scrambled

to its feet and made off, tiny white tail held high, and even managed to clear a few miniature logs like a steeple-chaser, giving a good imitation of things to come. In spite of many falls and tumbles, it did better than the observer in the close cover and escaped after a spirited chase.

A second fawn, a few days later, appeared slightly older but still was weak and very wobbly on its legs when seen. The doe was with it and a very slight warning was given so that the fawn,whether voluntarily or on signal from the doe, dropped flat. The doe fled, but even though a very cautious approach was made, the fawn did not stay put but scrambled up when a few feet separated it from the observer. In spite of the fact that every tuft of grass tripped the youngster, its speed was still good enough to elude its pursuer, although in the more open area it was possible to tire it enough to cause it to lie down and remain long enough to allow approach for a few pictures at a distance of 15 to 20 feet.

The interpretation of wild animal behaviour and habits is one of the most difficult and uncertain of all scientific endeavours in wildlife work. This is why we so often say 'it appears to be', or 'the indication is', rather than concluding that something 'is' thus and so, particularly when the interpretation involves few observations. Consequently, the best we can say is that vision during the first few days of an axis deer fawn's life appears to be comparatively weak when judged by the behaviour of the captive animals and the stumbling escape of the two wild ones observed, but could be better than believed when judged by the wild fawns' obvious recognition of approaching danger and immediate reaction. It is probable that the use of eyesight develops much more rapidly under the stress of wild conditions than it appeared to develop in the captive fawns while in the comparative peace and quiet of their pen. Vision may become quite acute in wild fawns in a much shorter time than the several weeks it seemed to take the tame ones.

Eyesight was depended upon much less by the pet fawns at close range than was scent in the search for food titbits. A cigarette butt, for example, which was a choice item for these deer after they were several months old, could be spotted easily when flipped into the pen, and they would trot up to it eagerly. As they approached it, however, they would track it down by scent even though it was in plain sight, apparently preferring to trust their noses rather than their eyes when dealing with food.

The infra-orbital scent glands, which appear to play an important part throughout their lives in expressing emotion, are barely developed at birth, forming a small, shallow slit below the eyes, and are incapable of movement. Within a few weeks, these glands develop sufficiently to become controllable, and when the fawn is excited, particularly at nursing time, they are spread open into shallow, hairless pockets. As the fawn grows older, these glands become larger and, in the bucks at least, begin to secrete a small amount of waxy substance which adheres to the

tuft of inward-growing hairs in the lower corner of the gland. Under excitement, the glands are flared wide open and the waxy hairs rolled outwards. These glands do not appear too important in the life of the does and, although they are present and controllable, they do not develop to the extent as they do in bucks, nor are they used as much. During early life, these glands are stimulated when the fawns of both sexes are under excitement, but use declines with maturity in the does, while becoming important as a secondary sexual character in the maturing bucks. The metatarsal and interdigital glands are present at birth and appear to be fairly well developed, though becoming larger and more pronounced as the fawn grows. Since they have little noticeable odour to the human nose at any age, it is hard to tell whether they are functional at birth, or just when they become functional.

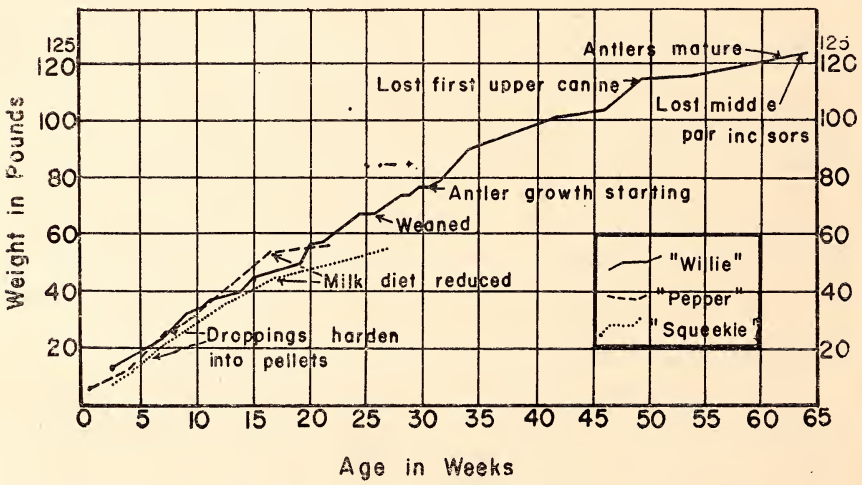
Muscular co-ordination develops rapidly in fawns, and they are able to move about a short time after birth, though they spend most of their time resting when very young. A few hours after birth they can run for short distances, but still appear weak and wobbly on their feet. Within three weeks, they are running and leaping with ease and agility. At six weeks of age, Willie could jump over a five-foot barrier from a standing start with no sign of real effort ; he would stand on his hind legs, give a jump, and sail gracefully over. Frequent running, leaping, and butting games strengthen the young muscles rapidly and increase agility, and by three or four months of age, fawns are strong enough to put up a real battle in the hands of a grown man. The power in the hind legs of a 40-pound, three-month old fawn is amazing, and it can deal out a large assortment of cuts, scrapes, and bruises when being handled. By the time they are old enough to be seen with their mothers while feeding—at about one month of age or less—they can easily keep up with the adults in flight over rough and brushy ground, and often lead the escape, out-distancing older deer for short distances.

The coat of newborn fawns varies somewhat in shade and texture, but is usually thick and fluffy with a generous woolly undercoat, and lighter in colour than that of adults. The spotted pattern is completely developed at birth, though not quite as distinct as in later life, and apparently remains the same throughout life. Both sexes have the little black whorls of hair on their foreheads, marking the spots where the male's antlers will later develop. The faces are more or less a uniform brown without the distinctive black markings common to older bucks. As the fawns grow to maturity, they lose the woolly undercoat and the fluffy appearance, and the coat becomes lighter in weight and sleek. It usually darkens somewhat over the brown parts, thus setting off the white spots more distinctly. The coats of buck fawns become even darker than those of the does in most cases, with the black facial markings and the charcoal neck shading becoming pronounced by about one year of age.

The captive fawn, Willie, was kept until he was about 18 months old, and was weighed periodically until he was about 64 weeks old, at which time he became too difficult to handle without resorting to roping and tying him—an experience which threw him into a complete panic and partial shock. The weights obtained have been plotted in Figure VII in graphic form by age in weeks. In addition, a few notes of interest are included in this growth chart so that they may be easily correlated with his size and age. It may be seen that weight increase was fairly constant before he was weaned, but gradually slowed up after this time. Since he was fed on ample diet of natural forage plus a supplement of corn, which kept him fat and sleek, it is believed that his weight increase by age is reasonably representative of that of a healthy wild buck on good range.

Fig. VII

Axis Deer Fawn Growth Rate
By Weight & Age



The weights of the other two fawns which were raised were also taken regularly and are included in Figure VII. The increase rate of Pepper, the male, followed that of Willie closely, while that of Squeekie, the female, lagged behind as would be expected since the full-grown weight of does in much less than that of bucks. In fact, her growth rate is probably behind that of a normal doe fawn, since she was starved for nearly a week just after birth, and consequently might be somewhat retarded in her rate of weight-gain.

When fawns are born, there is a yellowish white cartilage-like extension attached to the tip of each hoof, which is present on the hoofs of the

fœtus in all cases. This soft extension is worn off with the first few steps, leaving the fawn's small hoofs black and shiny. As the fawn grows, the hoofs grow out continuously like fingernails, being worn off at the tips and sides from abrasion with the ground. When the newborn fawns' hoofs harden, a small annular ridge is formed on the hard surface where it meets the hairline; this ridge progresses down the outside surface of the hoofs as they grow, and is easily visible. By the time the pet fawns were about 20 to 21 weeks old, this ridge had reached the tips of the hoofs and disappeared through wear. Although the disappearance of this small ridge probably varies somewhat in individuals, depending on the hoof growth rate, it could be used as a rough method for determining the age of fawns that still retain it, and would indicate that those without it are probably at least five months old.

Little could be determined from the captive fawns about the development of their molar teeth, due to lack of proper equipment for handling them and holding their mouths open. They seriously objected to anyone poking about in their mouths as was proven by several well-chewed fingers. However, a record was kept of the development and replacement of the incisiform teeth of the one fawn, Willie, until he was shipped off at the age of 73 weeks. When born, all fawns have a full complement of six lower incisors and two lower incisiform canines, plus the two upper canine ' tusks ' discussed earlier. All these teeth are temporary or milk teeth, and are eventually lost and replaced with permanent teeth, except the two upper canines which are not replaced. In appearance these teeth all look almost identical with the later permanent teeth except somewhat smaller ; the middle pair are much wider and asymmetrically spade-shaped, while the others are progressively narrower and weaker in appearance.

At 49 weeks, Willie lost one of his upper canines ; the other loosened, but was held by cartilage until his 65th week, when it too was lost. This demonstrates the variability of at least superficial shedding in these teeth and may account for many mis-statements in literature. At 63 weeks, he shed both of the large middle incisors at the same time. These were replaced by permanent ones, fully grown within eight days and, except for the difference in size, it would be difficult to tell these from the temporary ones. The second pair were shed at 65 and 68 weeks and replaced by the 73rd week, at which time one of the third pair was shed. The other one and the two lower incisiform canines were still present when Willie was shipped away at this time. These teeth were probably all replaced by permanent teeth before he was 24 months old ; unfortunately, no more records were possible after shipping him off to a zoo.

Sexual Development

Unfortunately, the captive female fawn was showing no indication of sexual maturity by the time she was shipped off at about five months of age. It is possible that we would have seen some sign of awakening sexual desire had she been with a mature buck, but such was not the case. As shown in an earlier chapter, a number of young wild does were examined for indications of present and past pregnancies, and these examinations indicated that axis does may reach sexual maturity while still very young.

The ovaries of seven doe fawns, estimated to be between six and nine months old, were examined ; one was definitely pregnant, five had ripening Graafian follicles—showing that they could soon become pregnant, and only one had no mature follicles. Four others examined, which were estimated at 12 to 14 months of age, were found to be pregnant, and two of these were lactating as well, showing that they had already given birth to fawns. Only one fœtus was available for aging from the two that were both pregnant and lactating, but it was approximately 80 days old, showing that this animal must have become pregnant no later than at about eleven-and-a-half months of age. If we allow no time between her giving birth to her first fawn—which she was still nursing—and again becoming pregnant, and subtract the seven-and-a-half gestation period from this birth date, this doe must have become pregnant the first time at about four months of age, and possibly less since there must have been some time interval between parturition and re-impregnation.

Ten others, which were estimated from their tooth development to be from 14 to 16 months old, were found to be pregnant and, although none was presently lactating, four had ovarian scars which probably indicated earlier pregnancies ; in which case, they must have first become pregnant at about four to six months old. A number of other somewhat older does were also found to have probably become pregnant for the first time when they were between five and twelve months old.

It is quite obvious, then, that at least some axis deer females reach sexual maturity before they are six months old, while many, if not all, reach this stage by the time they are one year of age. This, of course, is under ideal range conditions ; sexual maturity might be greatly delayed if forage quality is low.

Buck fawns begin to exhibit some very early signs of sexual awakening at about five months, when they begin attempting to mount doe fawns of about their size. Probably they are not actually capable of breeding until their first antlers are nearly mature. Willie's antlers first began to develop when he was 30 weeks old, and were fully mature at 65 weeks, when the velvet was first shed. At about 60 weeks, he started showing

signs of sexual excitement and the approach of his first rut, becoming mean and aggressive. This attitude increased as his antlers matured and his neck began swelling, and was accompanied by frequent periods of masturbation, starting at the age of about 63 weeks. He was, no doubt, perfectly capable of successful reproduction at this age, and possibly before. It was noted earlier that several spike bucks between one and two years old were examined and found to have a plentiful supply of mature and vigorous sperm present.

In the development of secondary sexual characteristics in bucks, the most apparent is antler growth. Up until they are some seven months old, the only signs of future antler development are two small whorls of dark hair on the forehead, also present on females. After that age, small bumps form under these marks, rapidly enlarging to form the antler pedicels from which the spike antlers themselves will grow. The pedicels will be covered with normal hair, while the growing antlers are covered with the fine soft velvet already described.

Young bucks enjoy playing butting and shoving games long before the start of their first antlers, and even while the antlers are still developing under their velvet engage in mild shoving contests. Not until the antlers have hardened and the velvet dried, do they commence the violent tree-rubbing and fighting, however.

As the antlers reach maturity, the other secondary sexual characteristics become prominent, including belligerence, swelling of the neck, threatening facial expression, and full development of the infra-orbital scent glands, which play a large part in making the face appear fierce when they are opened wide. The darker coloration over the neck, and the black facial markings of the mature buck also may become apparent at this time. Before the antlers begin growing and the facial markings appear, it is difficult to distinguish between the sexes at a casual glance ; however, buck fawns generally have a more masculine appearing head, even when very young, with a convex or relatively straight slope from forehead to nose-tip, while young does have a more concave slope and a proportionately shorter muzzle. The female's eyes appear somewhat larger and more protruding than those of bucks, and their bodies are slimmer and of lighter construction. By the time the doe fawns lose their dish-faced, short-muzzled appearance, the bucks of equal age are developing antlers, and sex differentiation is no longer a problem.

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Reviews

1. A ZOO MAN'S NOTEBOOK. By Lee S. Crandall in collaboration with William Bridges. pp. viii+216 (22×14 cm.). Several monochrome photographs. Chicago & London/Toronto, 1966. The University of Chicago Press, Chicago & London/The University of Toronto Press, Toronto. Price $4·95/37*s*.

Having spent all his working life in a zoo and having enjoyed every moment of it, the author is well qualified to speak with authority. His book takes the form of short notes about animals as inmates of zoos, with occasional references to their biology or their life in the wild. It is based on the author's earlier publication *The Management of Animals in Captivity*, which was intended for professional zoo keepers and is therefore packed with details. The necessary adaptation was made by the author's collaborator.

It is interesting to get an inside view of the many problems zoo authorities have to deal with and the many mishaps, some amusing and some serious, and the many disappointments they meet. An obvious problem is diet. It must have been a bold imagination that devised a successful diet for the ant and termite eating Giant Anteater: milk, eggs, and chopped meat, with cooked cereal and codliver oil. And we are told of a Giant Anteater at the Cincinnati Zoo that devoured newborn mice with relish!

Various methods have been tried at different zoos to exhibit during zoo hours the nocturnal inhabitants of the rodent house. The most successful is the 'red light room' of the New York Zoo, with the cage walls painted red and lit with red fluorescent tubes. Once visitors' eyes have adjusted to the light, visibility is good and they can watch the rodents moving about actively and apparently unconscious of the presence of visitors.

Beavers are interesting exhibits but difficult inmates. They were confined within an iron fence and a concrete wall which was believed to reach down to the underlying bedrock, but an exploring beaver discovered an unprotected gap, the first intimation of its discovery being the cutting down of trees outside the fence. When the gap was closed and the beavers once more confined within the fence, the problem was to prevent their building activities from flooding the enclosure. This was managed for a time by means of an

outlet some distance upstream of the beavers' dam so situated as to keep the water at the desired level. This failed because the accumulation of silt raised the level of the outlet area and prevented the drain off, and the beaver colony was finally closed.

No one would think of the Hyena as a lovable creature, particularly the Spotted Hyena of Africa. A young hand-reared specimen at San Diego, however, became a popular exhibit in the Children's Zoo. When, later, it was sold to the New York Zoo and the Director was reported in the papers as having described hyenas in the wild as skulking scavengers there was a howl of protest from the children in San Diego and, according to a story wired to the New York papers, the children were contributing money to a fund for repurchasing the hyena. The Director hastily retrieved the position by issuing a statement that *this* hyena, far from being a skulking scavenger, was 'the nicest, friendliest, gentlest, most intelligent hyena' he had ever seen.

By the way, the author speaks of hyenas as scavengers, relying for their food on the kills of bolder carnivores. A different account has recently been given by Dr. H. Kruuk who has been observing Spotted Hyenas as part of the Serengeti Research Project. The majority of the hyenas observed feeding were eating hyena-killed animals, most of which appeared to have been animals in good health. In fact, according to Dr. Kruuk the evidence suggests that the lions in the Ngorongoro Crater live largely on hyena-killed prey.

Interesting items relating to the biology of the animals occasionally occur. One such relates to the birth of pups to a Cape Hunting Dog. Preparatory to the birth the male was separated from the expectant mother. When the first pup was born, the female picked up the pup and leaped excitedly against the partition separating her from her mate. When the male was admitted about an hour later, he went directly to the pup and licked and mouthed it for a time but it was dead. The pups that followed received no further attention from their mother; each was carefully cleaned by her mate, and then was picked up by her and carried to the nest box. Once this duty had been completed she drove the male away from the compartment and compelled him to keep at a distance.

Another relates to that wonderful swimmer, the California Sea Lion. At birth it cannot swim, and the first baby born in the zoo died of drowning. A baby born subsequently was carefully screened off from the pool. But two days after its birth the mother herself took the baby to an island in the pool. Every now and then the baby tumbled into the pool but the splash invariably called the

mother to the scene and she tossed the baby back on the island, while her mate looked on helplessly. This particular baby was rather backward and did not learn to swim till it was about eight weeks old. Another baby however was swimming freely when it was only 13 days old.

Unlike the Sea Lion, the hippopotamus baby at birth was dropped unceremoniously into the water and swam at once. About half an hour later it scrambled on to one of the steps and was promptly pushed back into the water by its mother. Two hours later the mother was seen lying on her side in three foot deep water with the calf quietly nursing under water.

The book is illustrated with numerous photographs.

D. E. R.

2. CHAPTERS ON THE HISTORY OF BOTANY IN INDIA. By I. H. Burkill. pp. xi+245 (16×25 cm.). 2 maps and 4 plates Calcutta, 1965. Botanical Survey of India. Price Rs. 5·50.

These chapters were published in the form of separate articles in the *Journal of the Bombay Natural History Society* in five separate volumes from 1953 to 1963. With some alterations in Chapters 1 & 7, they are now republished in book-form by the Botanical Survey of India, Calcutta, in view of the intrinsic interest of these articles to Indian Botany. The object of the publication is very laudable and the Botanical Survey has rendered valuable service by making this interesting history available in one volume at such low cost.

The history refers to the whole of the Indian sub-continent of pre-independence days and includes also Burma and Ceylon. The history begins with the work of Garcia da Orta of the 16th Century and ends with the first two decades of the 20th Century. It covers the period before Agharkar's 'Progress of Botany during the last 25 years' (Ind. Sc. Cong. Ass., Calcutta, 1938) and Maheshwari and Kapil's 'Progress of Botany during the last 50 years' (Ind. Sc. Cong. Ass., Calcutta, 1963).

Burkill's Chapters contain many names of those who made significant contributions to Indian Botany either by encouraging or promoting botanical studies in India. The importance of local or contemporary political factors are significant to any progress and

they are very well brought out in the most unobtrusive manner by the author. This reviewer is not aware of any other work where the historical perspective of contemporary affairs—men and matters—in relation to botanical development in India is brought out so well. The critical assessment of earlier works (e.g. Ainslie's) and the definition of 'United Brothers' are given more authentic meaning. We learn here that in the development of Indian Botany, 7 French soldiers, 3 Dutch administrators, 4 Danish missionaries besides many British and German civil servants and medical-men took part. The influence of great teachers at Edinburgh and the men of authority at Kew was obviously very great in those days. The story of discovery of tea in Assam and its subsequent cultivation there makes very interesting reading.

Botany of the present day in India has developed in much greater dimensions than what is embraced in these chapters and many Indian botanists have made noteworthy contributions which could be seen in the accounts by Agharkar and Maheshwari. The publication under review describes a period of about 300-350 years before the present century when the development of Science in India had not taken place at all and Indians played a minor role. These chapters form a very good and authentic document for a future illustrated history of Botany in India and is by far the best historical account of Indian Botany giving an insight into the development of Botany in relation to contemporary affairs and into the character of the men who shaped them.

P. V. Bole

3. THE WEALTH OF INDIA: A DICTIONARY OF INDIAN RAW MATERIALS AND INDUSTRIAL PRODUCTS. RAW MATERIALS. Vol. VII: N-Pe. pp. xxvii+330+viii (27·7×21·5 cm.). 9 plates and 140 text-figures. New Delhi, 1966. Council of Scientific & Industrial Research. Price Rs. 30.

This volume takes one step further the Council of Scientific and Industrial Research's Encyclopaedia of the 'Wealth of India'. Like its predecessors it deals in great detail with the topics raised. In particular it carries interesting and well documented articles on Tobacco (*Nicotiana*), Rice (*Oryza sativa*), Oysters, and Opium (*Papaver somniferum*)—though, unfortunately, considerable portions are too technical for the layman.

One makes exciting discoveries as one thumbs through the pages, for instance that the Balsa tree (*Ochroma pyramidale*), made so familiar by the famous Kon-Tiki adventure, has found its way to India. It is grown in plantations at Kannoth in Wynaad Forest Division and Top-slip in South Coimbatore Forest Division, and on a small scale in a few other places. The wood, which is the lightest of commercial timbers, is used as sandwich material in certain parts of aircraft, and also in gliders and sea planes. It makes rafts, floats, life buoys, and other life saving equipment and, being a good heat insulator, is used for lining refrigerators, auto-truck bodies, and holds of ships. Besides, it is a sound deadener and is useful for ceilings and partitions. With its resiliency, strength, and smooth soft surface it is an excellent shock absorbing material and it even serves as a substitute for cork and may be used for cigarette tips.

The scientist in charge of the publication apologises for the slow rate at which the successive volumes of the work are being published. Having regard to the thoroughness of the scrutiny that is being made of the literature, a certain amount of delay is inevitable; it is good to know that attempts are being made to keep it as low as possible. The illustrations are clear and well chosen. A valuable work of reference.

D. E. R.

4. EVOLUTION AND MODIFICATION OF BEHAVIOUR. By Konrad Lorenz. pp. 121 (22×14·6 cm.). London 1966. Methuen & Co. Ltd. Price 25*s*.

Professor Lorenz's long essay is an important contribution to the 'nature-nurture' controversy, much of his sophisticated argument representing the ethological orientation to this problem. This is not an easy book to read. Polemic in tone, oblique in reference and often obscure in style it is nevertheless a study that merits serious attention from the advanced student of behaviour. Moreover it gives an insight, usually denied the non-German reading specialist, into the particular cast of Lorenz's philosophical approach to biological problems. The study is based upon an earlier contribution 'Phylogenetische Anpassung und adaptive Modifikation des Verhaltens, *Zeitschrift Tierpsychol*, **18**: 139-87', published in 1961.

Lorenz has written the book with two main intentions. Firstly, to 'prevent the discrediting of a concept which . . . . is indispensable

to an ethological approach'—namely the concept of the 'innate'. Secondly, he asserts the validity of the deprivation experiment as an analytical tool in the investigation of behavioural ontogenesis. The argument is thus directed against the views of an anti-ethological school of thought voiced by a limited number of American psychologists whose approach to animal behaviour stems from a different historical groundwork from that of Ethology. Lorenz particularly attacks the view that the description of behaviour as being either innate or learned is not useful since one can be defined only by the exclusion of the other and, secondly, the view that much so called innate behaviour may be due to *in utero* learning.

Lorenz's defence, in general, is an effective one. He attacks his adversaries on their weakest ground—knowledge of comparative ethology. Repeatedly he produces examples of complex behaviour patterns occurring for the first time without evidence for any learning process being involved in their determination. His use of invertebrate examples greatly strengthens his case.

The argument is based on a definition of the 'innate' and the 'learned' in terms of 'the provenience of the information which is the prerequisite of behaviour being adapted to environment'. Either a behaviour pattern has been subject to the natural selection of genetic mechanisms and has thus arisen in phylogeny, or else it has been selected through processes of learning, such as reward reinforcement, during an individual's lifetime. Furthermore, learning must itself be based upon the prior natural selection of physiological mechanisms responsible for learning ability. No one will deny the distinction between phylogenetic adaptation and phenotypic modification in the field of morphology—the distinction in behaviour study is no less meaningful. No biologist is likely to disagree with Lorenz in his sound argumentation on these points.

A number of ideas in the book do merit, however, a more critical appraisal. Firstly, Lorenz tends to gloss over the historical origins of the quarrel. While he admits inadequacies in the views of earlier ethologists—among whom he was pre-eminent—it was these very views with their nativistic assumptions that called forth criticism not only from Lehrman, a physiologist-psychologist in America, but also from ethologists in Europe—notably Kennedy and Hinde. An understanding of the controversy depends upon an adequate digestion of these viewpoints. However, Lorenz's most persistent adversaries—and those he particularly challenges here—drew their inspiration from a very narrow branch of psychological investigation—the 'behaviourist' school, based on studies of classical and operant conditioning in a

very limited number of species. Although work of this kind, rigorously operational in execution and theory, has made a major contribution to problems of behaviour adaptability, the authors concerned are neither geneticists nor evolutionists. Their tendency to promulgate general theories of behaviour based on brilliant experimentation of extremely narrow range is ludicrous to those of broader biological background and acquaintance with behaviour in many phyla. Nevertheless most such authors—including Hull—have left room for the innate even if it was called the 'unlearnt' and described in terms of simple reflexes. It is perhaps surprising that Lorenz is so alarmed by recent expressions of this viewpoint. Not many ethologists would be in doubt about its limitations.

Secondly, Lorenz attacks a number of his fellow ethologists for their understandable caution in using the term 'innate' for complex behaviour the ontogenesis of which is far from being understood. Furthermore he objects to views that suggest a 'mixing' of 'phylogenetic adaptability and learning' in accounting for much complex behaviour. This is curious since many of his own descriptions show how learning and innate responses have become interwoven in the development of an individual's complex adaptive behaviour. There seem to be major semantic difficulties here. One does not perceive easily what Lorenz implies by 'mixing' and 'permeability'—especially when one relates the arguments to the cases he quotes approvingly. No ethologist is in doubt about the existence of adaptedness or intends to 'shed' his biological knowledge. Operational analysis of behaviour nevertheless remains a valuable tool in certain fields of research.

The deprivation experiment remains, as Lorenz emphasises, a valuable method of disentangling the sources of information on which a given behaviour complex is based. Nevertheless it is likely to become a crude tool in the near future. Recent research, particularly with rodents and primates, shows clearly that the factors bearing on behavioural development are of great complexity. The unravelling of the genetic instructions guiding the appearance of behaviour is itself in need of analysis and may well include intrinsic 'teaching mechanisms' such as the heart-beat conditioning of the chick's head movements suggested by Kuo. Although Lorenz may care to include these under his category of innate it remains clear that a phenomenon of a different type than simple biochemical decoding is involved. Lorenz's approach tends to obscure the significance of these distinctions and thus to prevent the researcher asking the revealing questions. Lorenz appears to have developed a rigid attitude towards the 'innate' that springs from an over-inclusive definition. To say

that the information controlling a behaviour pattern is phylogenetic in origin is not an explanation of the developmental process. There are certainly many subtle processes involved the classification and interrelations of which demand exacting analysis. Jensen is right to point out that a dichotomy of classificatory terms into 'innate' and 'learned' will not help in the solving of this problem. Multifactorial causation demands forms of analysis more sophisticated than the simple deprivation experiment.

A curious feature of Lorenz's thinking is his reference to 'English-speaking ethologists' as if these were an especial breed holding distinctive views. One wonders how these gentlemen should be distinguished from Dutch speaking ethologists or American-English speaking ones. Perhaps Professor Lorenz would prefer them all to be German-speaking? The truth, of course, is that Ethology is not to be categorised on a linguistic basis nor do ethologists form cliques or schools along nationalistic lines. Research in Animal behaviour is undergoing rapid expansion at present and disciplines formerly separated by broad academic divides are coming into closer contact. The semantic difficulties this engenders will provoke distrust in some but may in general be welcomed. Ethology has done much to broaden the narrow confines of comparative psychology while those trained in the 'behaviourist' tradition have much to teach ethologists in methodology and experimentation. The electicism of British, American and Dutch workers may draw the wrath of the Father of Ethology upon them but this will not prevent the development of an increasingly fascinating debate.

J. H. C.

Miscellaneous Notes

1. A NOTE ON THE URIAL, *OVIS ORIENTALIS* GMELIN

Only scanty information is recorded in the revised second edition of Prater's BOOK OF INDIAN ANIMALS regarding this wild sheep, and in view of this it seems worthwhile to record a few of my own observations. In March 1962 I obtained a young male Urial which had been captured in the Suleiman range of Baluchistan. It was about thirteen months old at that time and has now attained maturity giving valuable information on horn growth and dentition as indicators of age and development in this species.

Contrary to what Stockley (1936) states at p. 123 in STALKING IN THE HIMALAYAS AND NORTHERN INDIA, horn growth is very rapid in the first two or three years. Thereafter it slows down rapidly and probably ceases altogether after the sixth year.

When I obtained my pet it still had eight milk teeth in the front of its mouth but the first pair of centre incisors erupted by October, and the third or outer pair by the 39th month. The outer incisors, erupted at 48 months.

The rate of growth of the horns is as follows:

HORN MEASUREMENTS

Date	*Length in inches measured over outer curve.*	
5-9-1962	12½	} Both horns equal in length.
20-4-1963	17	
16-9-1963	21¼	
	Tip of one horn splintered off.	
24-5-1964	23½	24¾
6-8-1964	25½	27¼
1-4-1965	27½	27½
22-11-1965	27½	28
20-8-1966	28	29

Breeding Habits. It is believed that the rut starts in September, and since shikaris have often seen rams pursuing ewes and fighting with each other up to mid-October, it can be considered to last from six to eight weeks. Jerdon (1874) in THE MAMMALS OF INDIA gives the gestation period as from four to seven months, but Prater (op. cit.) states that it is not known but must presumably be between four to six months. Observation on my pet indicates that some mating could easily take place by late August. The head keeper at Lahore Zoo recalls Punjab Urial breeding successfully some years

ago and states that the gestation period was six months. This man is, however, illiterate and has no written record. My animal as far as I can estimate was born in early February, whilst an Urial lamb captured last year for Lahore Zoo from the Salt Range was born in late February. On such flimsy evidence I would consider the gestation period to average 180 days (compared with about 150 days average in domestic sheep). It is certainly more than five months and less than seven months according to what I can learn from questioning local shikaris who live in areas where Urial occur and who have had ample opportunity to observe them in their natural state. The majority of young are born during February and March both in Baluchistan and the Salt Range. Earlier records state that twins are not uncommon. Information from local shikaris has to be treated cautiously and I have no first hand evidence. However, in the Kirthar Range where Urial and Sind Ibex (*Capra hircus*) occur together, all the local Shikaris believe that the Urial never has more than one offspring while the Ibex generally has two unless the Monsoon rains fail altogether in which event few breed. Similarly, in Chitral, where Markhor (*Capra falconeri*) and Shapu occur on the same mountain ranges, I have been told by local shikaris that the Markhor generally bear twins and the Shapu single offspring. It appears therefore, that twins are probably rare and single offspring more usual with this species.

My Urial reached sexual maturity at three years of age. In September 1963 when I estimated its age at 32 months, its testes were hardly developed. Its facial (lachrymal) glands were not noticeable nor its behaviour unusual. In September 1964 it showed marked restlessness and agitation; butting the sides of its pen, with a noticeable discharge from the lachrymal glands. Its testicles were well down and evident.

During the rutting season rams often chip and splinter off huge chunks of their horn in their head-on collisions.

Miscellaneous Observations. Many writers have commented upon the extreme wariness of this animal. It possesses a keen sense of smell as well as acute eyesight and probably depends at times upon its acute hearing as well. I have often been impressed by the immediate reaction of my pet to movement of men as far as 300 yards away and who were in fact largely concealed by bushes and not visible to me. It is well known that Urial keep contact with each other by scent from the inguinal, as well as the foot glands. The latter consists of very small circular orifices in the bare skin inside the fold or crack which extends from the front of the hoof into the

pastern. I have not detected any very noticeable smell from foot glands, but infer that their scent must be acute.

In the spring and early summer my Urial is relatively silent and the lachrymal glands appear dry. But from early August these facial glands start to exude a sticky substance which stains the cheeks, and from late August, with increasing intensity into September, he frequently calls. Other writers call this sound a bleat, I would prefer to describe it as a rather throaty low pitched '*Me-errrh*' sound. I have never heard their whistling alarm call.

There are two moults in the year. In March the longer winter hair comes off in ragged patches, starting first with the lower flanks. The animal feels the irritation and rubs itself against rocks and projections. The beard and ruff partly moulted become much shorter in the summer. In early August the new winter coat begins to grow as well as the more luxuriant chest ruff. The pelage is at this time brilliant, becoming light chocolate in colour. Just behind the withers, there is a faint vertical area of blacker hairs. The hairs, both in winter and summer, are very pithy and in texture like those of the Musk Deer. An adaptation perhaps against the extreme variation in day and night temperatures in the environment in which they live, as they have virtually no under-wool, even in their winter coat.

The Urial in its wild state, though wary, exhibits certain rather foolish traits. For example, if a small scattered group is suddenly fired upon they invariably converge together into a tight flock, and then pause to look around for the source of danger, generally thereby affording a second chance for slaughter to the unscrupulous hunter. They display a great curiosity for any unidentifiable noise or sight and it is possible to lure small bands closer by imitating their call. They are highly nomadic in habits and a small herd will suddenly desert a particular mountain range where they had been regularly observed for months, presumably in search of fresh feeding ground.

Present Status and Distribution. Three races occur:

Ovis orientalis vignei Blyth 1841. Known locally as the Shapu. This is the large race inhabiting the inner Himalayan ranges and is greyer in colour and generally bears a more scanty ruff than the lowland races. Its horns rarely describe a full circle and are often more prominently ridged than those of the Salt Range race. Extremely scarce around the perimeter of the main valley of Gilgit it only occurs on the right bank of the Chitral river and has become rare due to over-shooting. It is, however, fairly plentiful in Baltistan, and Ladakh.

Ovis orientalis blanfordi Hume 1877. Known locally as the Gad. It is clear from specimens which I have seen that this race intergrades with the Salt Range race and indeed I feel that there is no clear distinction between the two. It extends right down to the Mekran sea coast in Las Belas and even close to Karachi near Gadap and in the Thana Bula Khan Hills of Southern Sind. In the north it extends up to the Isa Khel Range in the former North West Frontier Province. Though it used to be well known around Peshawar, even forty years ago, it now appears to have been totally exterminated in all regions of the former North West Frontier Province except the extreme south-west. On the Sind-Baluchistan border it still occurs in considerable numbers in the Kirthar Range and in Baluchistan there are several herds in the Takhi-I-Suleiman area. A small herd still survives in the Chiltan reserve near Quetta, and it is quite numerous near the Afghan border in the Takhu Range. I would say that it is in no danger of extermination in these areas. With due caution for the many exceptions, which no doubt occur, my observations indicate that *Ovis orientalis blanfordi* to be longer legged and lighter in bone (more 'gazelle-like') than the Salt Range race. Also its horns have more prominent corrugations, are less massive at the base, and describe a more complete circle.

Ovis orientalis punjabiensis Lydekker 1913. Known locally as the Urial, this animal is more familiar to sportsmen. I have examined nine different captive specimens, including six rams, all from the Salt Range. They were heavier in bone and more stout limbed than *Ovis orientalis blanfordi* and the rams often had horns which were comparatively smoother and set at a wider and straighter angle to the skull than the Baluchistan Urial.

Although there are still a few herds in the Kala Chitta Range and the eastern part of the Salt Range up to the Attock Hills I would say that this race is much persecuted and in real danger of extermination if unrestricted shooting continues. It is certainly almost unknown in the hills around Rawalpindi and Jhelum where it used to be quite plentiful thirty years ago.

In closing I should like to reiterate that many of the above observations are based on the comments of others and I have only noted here those aspects that seemed to be reasonably reliable.

ROBERTS COTTON ASSOCIATES LTD.,
KHANEWAL, W. PAKISTAN, T. J. ROBERTS
September 11, 1966.

2. BEHAVIOUR OF CHITAL *AXIS AXIS* (ERXLEBEN)

In the tidal forests of the Sunderbans there used to be (and, I believe, still are) large herds of Chital deer. The predominant areas are however in East Pakistan now. When I was a probationer, in charge of a Range (1942-43), we could see deer as we liked. At almost every turn of the creek (particularly bigger ones) one could come across herds of Chital numbering anything from a dozen to more than 100, on the banks exposed at low tide. The interesting part was that few stags could be spotted as they would run into the forests at the approach of a motor launch, but the fawns and does would not run away. I remember taking small motor launches as close as 3 to 4 feet of them and yet they would not budge. In fact they would come forward to meet the launch. If, however, one approached them in a dinghy, the entire herd would disappear into the forest. This we associated with the poachers who normally came in country boats and did indiscriminate shooting.

In the Sunderbans, the deer are also known to follow troops of Rhesus monkeys to feed on the leaves and fruits dropped by the monkeys. In fact it was a standard method to mimic the chatter of monkeys to lure deer. If imitated by someone adept in the art, and accompanied by shaking and shedding of branches, leaves and fruits, the deer would arrive within minutes. I have witnessed it time and again.

I kept a pair of fawns as pets in the Sunderbans and I remember that whenever at breakfast, we started peeling bananas, both the fawns would make a bee-line for the table apparently attracted by the scent of the banana which they could get from beyond several rooms.

WRITERS' BUILDINGS,
CALCUTTA-1,
WEST BENGAL,
June 23, 1966.

K. C. ROY CHOUDHURY
Chief Conservator of Forests (Offg.)

3. RAVENS AND BROWN BEAR

Many times when stalking big game in the Himalayas, I have seen Ravens in parties of 2 to 4 give away the presence of Brown Bear. The bear while digging for grubs is followed by the Ravens and after it moves on they pick up the grubs left by it.

Last month a friend of mine, while trying to photograph Markhor, saw a Brown Bear stretched out and four or five Ravens pecking at

its head and body. Thinking that the bear was dead he approached close to it and threw a stone. To his great surprise the bear was very much alive and angry and after a few very loud woofs ran off. I am sure that the Ravens were picking ticks off the bear. In Markhor areas there are hundreds of ticks, and when stalking Markhor, one has to go through a thorough de-ticking after returning to camp in the evening. I am sure the Brown Bear was enjoying the Ravens pecking away at the ticks.

NEDOU'S HOTEL,
GULMARG, SRINAGAR,
KASHMIR,
June 28, 1966.

COL. H. NEDOU

4. THE IDENTIFICATION OF THE EGGS OF THE INDIAN HILL PARTRIDGES OF THE GENUS *ARBOROPHILA*

There are four species of Hill Partridge in the Indian Himalayan region. The Common Hill Partridge, *Arborophila torqueola*, occurs in temperate forest at higher altitudes from 4,000 to 10,000 ft. and over. The Rufousthroated Hill Partridge, *A. rufogularis*, occupies lower zones from about 2,000 to 8,000 ft., while the Whitecheeked Hill Partridge, *A. atrogularis* is present from the plains level up to 5,000 ft. The fourth species, the Redbreasted Hill Partridge, *A. mandellii*, is rarer than the other three and has been recorded from 1,000 to 8,000 ft. (Ripley 1961).

The eggs of these species in the collection of the British Museum (Natural History), which have been assembled from various sources, give the following size ranges—*A. torqueola*, length 43·5-45·5, breadth 33·3-33·7 (3 eggs measured; Whistler [1919] quoted a c/9 taken near Simla as having length 42·5-46, breadth 32·5-34); *A. rufogularis*, length 41·5-42·8, breadth 29·5-31 (19 eggs measured); and *A. atrogularis*, length 35·5-38·8, breadth 27·6-29·5 (17 eggs measured), all measuements being in millimetres. No eggs of *A. mandellii* were available.

These species vary in size and one can obtain some index of this from the wing-lengths. The following measurements were made—7 females of *A. torqueola* 138-146; 7 females of *A. rufogularis* 125-134;3 females of *A. atrogularis* 126-129; 3 females of *A. mandellii* 128-131. The males are consistently larger than the females in the first three species, but in *A. mandellii* the sexes are similar in size.

In view of the above differences in wing-length between the species involved one might expect some consistent differences in egg-size such as that quoted above, since this is usual in closely related species.

The egg-measurements given above conflict with those published by E. C. Stuart Baker (1935) and based on eggs in his collection which is now in the British Museum (Natural History). Baker claimed a complete overlap in egg-size. This is due to the inclusion of clutches which appear to have been wrongly identified. In addition some of Baker's clutches seem to be of composite origin. A clutch of eggs of *A. rufogularis* taken by C. Primrose at Kurseong, Bengal (B. M. reg. no. 1952. 11. 49) is accompanied by Primrose's original data slip on which an original clutch number of two eggs has been altered to a four. Only two of the eggs in the group of four bear Primrose's pencilled setmark, and it must be suspected that two clutches have been combined to make a clutch of four eggs. The clutch of seven eggs of *A. atrogularis* mentioned by Baker as the upper limit of clutch size in that species, consists of three large eggs with a rather tapering shape, three large and more rounded eggs, and one small egg. The first six are of a size more typical of *A. rufogularis* and are inscribed '18 May 1909' and the small egg is inscribed '18 May 1920'. Baker stated that he took this clutch himself and trapped the female on the nest, which he describes.

There are other anomalies in the dating of Baker's eggs. A clutch of six eggs of *A. rufogularis* (B. M reg. no. 1952. 11. 60), stated by Baker to have been collected on 27th May 1904, contains one egg inscribed 27.5.04, one inscribed 27.5.24, and four which appear to have been originally of the latter date but in which the 2 of the figure 24 has been altered to an 0 which still retains the tail of the figure 2. Similar alterations occur in two other clutches (B. M. reg. no. 1952. 11. 56-57).

There is therefore evidence that Baker's material is not completely reliable and it has been necessary to try and discriminate between authentic and unreliable material and to compile new data from the former. Although ultimately new field-work will be needed to confirm our conclusions, from the material available the following measurements, considered to be more accurate data, have been compiled.

A. torqueola (13 eggs measured): average 43·6×33·3; max. *44·7*×33·7, 43·2×*33·8*, min. *42·4*×*32·2*.

A. rufogularis (91 eggs measured): average 39·9×30·3; max. *43·8*×31·1, 39·1×*31·9*; min. 40·6×*28·3*, *37·6*×30·2.

A. atrogularis (42 eggs measured): average 37×28·3; max. *38·8*× 27·5, 36·5×*29·7*; min. *35*×27·3, 36·9×*27·1*.

The Museum has no authentic eggs of *A. mandellii*. Baker had a clutch of four eggs (B. M. reg. no. 1952. 11. 40) sent to him by Macdonald 'with remains of a skin which shows beyond doubt that this is a Hill Partridge either of this or a very closely allied race.'. This indicates that Baker was not certain of the identification, and while *A. mandellii* is closest to *A. rufogularis* in body size the four eggs would be large even for *A. torqueola*, measuring 44·2×34·7, 44·2×35, 42·6×33, 44·8×34·6.

BRITISH MUSEUM (NATURAL HISTORY),
CROMWELL ROAD,
LONDON S.W. 7,
September 2, 1966.

C. J. O. HARRISON
S. A. PARKER

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5. THE EGG-LAYING OF THE KOEL, *EUDYNAMYS SCOLOPACEA* (LINNAEUS)

In 1962 Dr. Sálim Ali, while going through the manuscript of my House Crow paper (Lamba 1963) commented regarding parasitization by the Koel: 'Is the koel's egg laid at any particular stage of the crow's clutch, i.e. after the 1st, 2nd, 3rd, or 4th egg of the crow? Ever in a newly completed empty nest?' At that time I was unable to deal with the points raised as I had not paid attention to this particular aspect during my studies on the nidification of the House Crow.

After my transfer to Poona in June 1964, I was able to pick up the threads of my studies on the breeding habits of the Koel, *Eudynamys scolopacea* (Linnaeus), in and around Poona, After making careful observations on scores of nests of *Corvus splendens* Vieillot and *Corvus macrorhynchos* Wagler, (the two species in whose nests the Koel normally lays) over a period of three breeding seasons during 1964-66, I find myself in a position to throw a little light on the subject.

In twenty-one nests of *C. splendens* in which a Koel managed to lay during the course of the present study, sixteen times she laid her first egg after the crow had laid her first, thrice after the crow had laid two, and twice after the crow had laid three of her eggs. In all the three nests of *C. macrorhynchos*, the Koel laid after the first egg had been deposited by the crow.

The maximum number of Koel eggs found in a single crow's nest was observed to be three, though previous workers sometimes came across as many as seven (Jacob 1915), eleven (Abdulali 1931), and thirteen (Baker 1934).

I have not, so far, come across an instance of a Koel's egg being laid in a newly completed but empty crow's nest, although as many as two (Cardew in Hume 1890: 396) and eleven (Abdulali 1931) Koel's eggs and none of the crow's have been observed in a crow's nest in the past. I shall be extremely grateful to any reader who would be kind enough to inform me if he comes across a Koel's egg in a freshly constructed but empty crow's nest.

ZOOLOGICAL SURVEY OF INDIA,
WESTERN REGIONAL STATION,
1182/2, F. C. ROAD,
POONA-5,
July 27, 1966.

B. S. LAMBA

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6. OCCURRENCE OF THE BROWN FLYCATCHER (*MUSCICAPA LATIROSTRIS* RAFFLES) IN THE GIR FOREST

In March this year while bird watching at Sasan, Gir Sanctuary, in the company of Yuvaraj Shri Shivrajkumar of Jasdan, we saw a brown and inconspicuous bird which was identified as a Brown Flycatcher by the Yuvaraj. The previous Monsoon had been very poor and almost all the Nullahs were bone-dry. Most of the birds seen by us, including the Brown Flycatcher, were concentrated around

a small pool of ten to twelve sq. ft. area beneath the shade of great trees in the otherwise dry bed of Kapuria River, some four miles from Sasan Rest House. As far as I am aware this species has not been recorded earlier from the Gir.

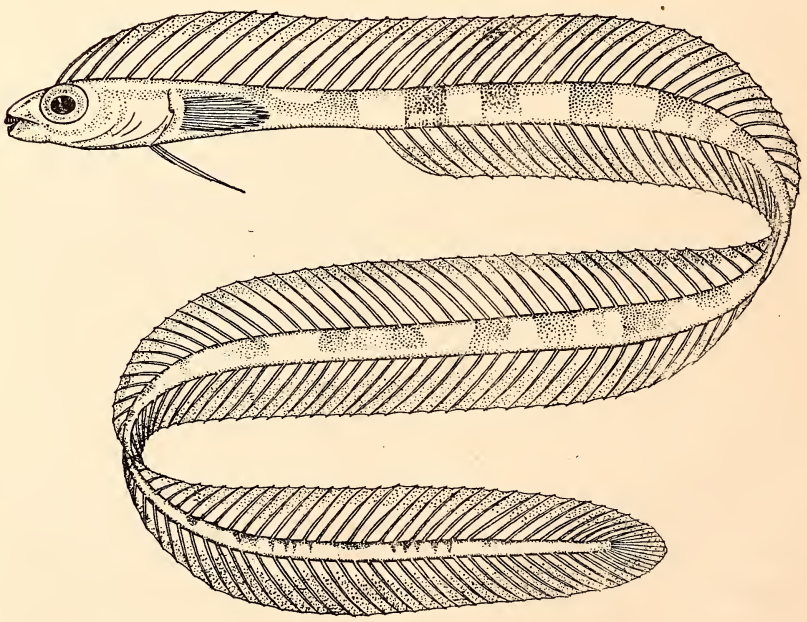
3, Kamar Villa,
Opp. Mahendra Ghat,
Morvi (Saurashtra),
July 21, 1966.

LALSINH M. RAOL

7. ON A RARE BLENNID FISH *XIPHASIA SETIFER* SWAINSON FROM THE MADRAS COAST

(*With two text-figures*)

In September 1965 the junior author made extensive collections of fish from the Madras coast and also visited the fish markets in Madras to examine the fish catches brought to them. At Royapuram market on 11 September he procured an eel-like fish which appeared very curious and interesting. On his return to Calcutta the fish was



Text-Fig. 1. Lateral view of *Xiphasia setifer* Swainson.

identified in the laboratories of the Zoological Survey of India as *Xiphasia setifer* Swainson.

Swainson (1839) named the fish from the illustration of it given by Russell in his DESCRIPTION AND FIGURES OF TWO HUNDRED FISHES COLLECTED AT VIZAGAPATAM ON THE COAST OF COROMANDEL (1803). Jerdon (1851) in his account of the fish observed: 'I one day procured two specimens of this curious species of *Gymnotus*, which Swainson has named from Russell's figure, which however is very defective. Its tail ends in a long filament, and the dorsal and anal fins are much higher than is there represented.' Day (1878) based his description mainly on Russell's figure but his illustration, which shows the presence of a long caudal filament, was taken from a drawing in Sir W. Elliot's collection (Day 1878, p. 337). The species was not represented in the Zoological Survey of India collections.

In the circumstances related it was considered worthwhile to give a detailed description illustrated with drawings made from the present specimen, which measures 288·0 mm. in length:

Xiphasia setifer Swainson

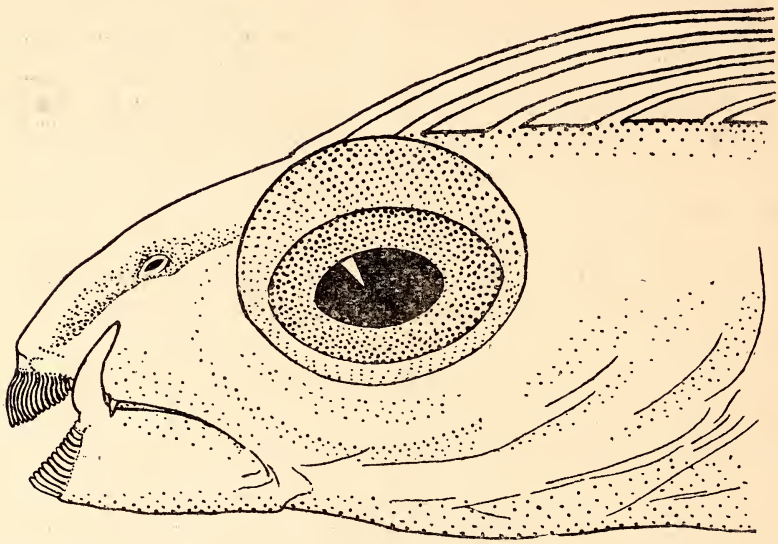
D. 121 A. 107 P. 13 V. 3 C. 9

Body exceedingly elongate; depth 36·0 in total length, head 13·1; eye 3·14 in head length, equal to snout. Interorbital space flat slightly more than half diameter of eye. Mouth terminal, slightly oblique, cleft reaching up to anterior border of eye. Upper and lower jaws with a row of rather long, feeble, incisiviform teeth and posterior canines. Canines on lower jaw sharply pointed, curved inward and fitting into a groove-like structure on palate. Canines on upper jaw smaller. Gill openings small vertical slits about size of eye, situated at base of pectorals. Dorsal commences above front margin of eye, anterior rays as long as head without snout. Anal commences below 17th dorsal ray, distance between its origin and tip of snout 5·8 in total length. Both fins broadly united to caudal. Pectoral rounded, equal to posterior part of head. Ventrals with the middle rays produced slightly longer than pectorals. Lateral line indistinct. Colour yellowish-grey with about 26 distinct brown crossbands on body. Dorsal and anal fins black, pectorals and ventrals yellowish-grey.

Distribution. Tropical Indo-Pacific extending from East Africa to Japan and Australia through India and Indo-Australian Archipelago.

Remarks. There is no elongated caudal filament in the present

specimen though Jerdon (1851) noticed caudal filaments in his two specimens from Madras. Smith (1953) mentions the presence of



TEXT-FIG. 2. Lateral view of head of *X. setifer* showing the teeth and origin of the dorsal fin above anterior margin of eye x 6.

caudal filaments in the African specimens, whereas the specimens from the Indo-Australian Archipelago (De Beaufort & Chapman 1951) do not have any. The presence or absence of caudal filaments may be a secondary sexual character and unless a larger number of adult specimens are examined nothing definite about it can be concluded. The black markings on the dorsal fin seen in the case of specimens from the Indo-Australian Archipelago (De Beaufort & Chapman 1951) are absent in our specimen.

According to Day (1878) the fish grows to about 14 feet. Ordinarily it is not known to grow more than 2 feet in length though Smith (1953) in his account of the fish observes: '. . . pearl divers of the tropical Pacific describe an eel-like creature several yards long much like this species. This they fear greatly, as it is said to attack with great ferocity, and once the great fangs are buried in a man he cannot escape and drowns.'

ZOOLOGICAL SURVEY OF INDIA,
CALCUTTA,
February 11, 1966.

A. G. K. MENON
P. C. VARMA

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8. TWO NEW SPECIES OF TRICHIURID FISH FROM WALTAIR[1]

(With a plate)

So far, four species of Trichiurids have been recorded from Indian waters: *Eupleurogrammus intermedius* (Gray), *E. muticus* (Gray), *Trichiurus lepturus* Linnaeus, and *Lepturacanthus savala* (Cuvier) (Day 1876; De Beaufort & Chapman 1951; Prabhu 1955; James 1959). Tucker (1956) has given the synonymy of these four species. In the course of studies on the biology and biometry of the Trichiurids of Waltair Coast, two new species have been observed, one under the genus *Trichiurus* and the other under the genus *Lepturacanthus*.

Trichiurus russelli sp. nov.

Holotype. A fish, 419 mm. total length, from Waltair, Andhra Pradesh. Holotype deposited in museum of Department of Zoology, Andhra University, Waltair.

Description. Based on 30 specimens 257-465 mm. total length. D. III, 126-131; A. i+I, 100-104; P. I, 10; V. 0; Vert. 146-149.

Body proportions variable; depth 12·92-15·29; head length 7·14-8·20; post-anal length 1·48-1·55; length from snout to origin of dorsal 10·69-12·51 in total length; snout length 2·87-3·17 in head length; diameter of eye 1·55-1·81 in snout length; length of pectoral 1·60-1·96 in depth. Dorsal and pectoral fins not pigmented. Origin of anal below 33-36 dorsal rays. Caniniform teeth in both the jaws barbed. Silvery in colour.

[1] Communicated by Dr. T. S. Satyanarayana Rao.

Occurrence. This species is caught off Waltair in boat seines and gill nets. It was first noticed on 16 April 1962 when 12 specimens of this species were obtained along with 26 specimens of *T. lepturus*. Another 18 specimens were obtained during the course of 1963. The maximum size obtained was 465 mm. and the minimum size 257 mm.

Diagnosis. Until now only one species, *lepturus*, has been described under the genus *Trichiurus*; it has a world-wide distribution in the warmer waters (Tucker 1956; Rosa 1957) and has been considered as a 'variable species' (Tucker 1956). There is no doubt that in addition to *T. lepturus*, a second species is present. The salient characters of *T. lepturus* and *T. russelli* sp. nov. are compared in Table 1.

TABLE 1

COMPARISON OF THE SALIENT CHARACTERS OF *T. lepturus* AND *T. russelli* SP. NOV.

No.	Character	*T. lepturus*	*T. russelli*
1.	Anal origin below dorsal rays	37-38	33-36
2.	Colour	Burnished or dull silvery	Pure silvery
3.	Pigmentation on fins	Three-fourths of dorsal and pectoral fins pigmented	Not pigmented
4.	Depth in total length	10·87-20·17	12·92-15·29
5.	Head length in total length	6·17- 7·68	7·14- 8·20
6.	Diameter of eye in snout length	1·62- 2·11	1.55- 1.81
7.	Length of pectoral fin in depth	1·23- 1·40	1·60- 1·96
8.	Post-anal length in total length	1·51- 1·67	1·48- 1·55
9.	Distance from snout to origin of dorsal in total length	8·87-10·74	10·69-12·51
10.	Dorsal fin rays	III, 128-132	III, 126-131
11.	Vertebrae	164-157	146-149

Named in honour of Patrick Russell who about one hundred and sixty years ago recorded over two hundred species of fishes from Visakhapatnam.

Lepturacanthus serratus sp. nov.

Holotype. A fish, 357 mm. total length, from Waltair, Andhra Pradesh. Holotype deposited in museum of Department of Zoology, Andhra University, Waltair.

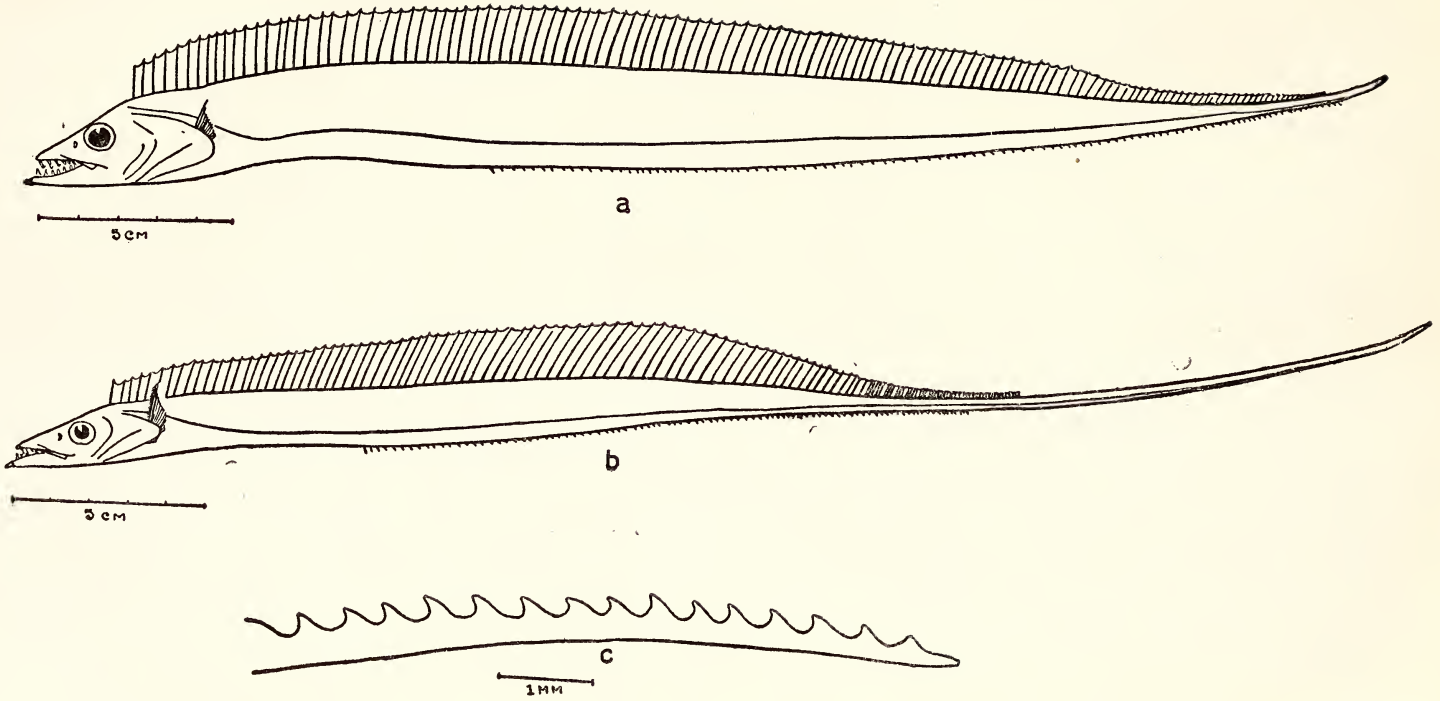

FIGURE. **a.** *Trichiurus russelli* sp. nov. From holotype ; **b.** *Lepturacanthus serratus* sp. nov. From holotype ; c, Camera lucida diagram of first pectoral spine of *L. serratus* sp. nov.

Description. Based on 164 specimens, 109-512 mm. total length. D. IV, 120-125; A. i+I, 86-97; P. I, 10; V. 0; Vert. 178-188.

Body proportions variable; depth 21·25-33·06; head length 9·09-10·63; post-anal length 1·29-1·66; length from snout to origin of dorsal 8·33-16·38 in total length; snout length 2·58-2·88 in head length; diameter of eye 1·93-2·25 in snout length; length of pectoral 0·87-1·05 in depth. The second anal spine is not dagger-shaped as in *L. savala*, and is shorter. The outer edge of the first pectoral spine (plate fig., c) is serrated, the number of serrations increasing with length of fish. Post-anal region is filamentous. Origin of anal below 34-35 dorsal rays. Caniniform teeth in both the jaws barbed. Silvery in colour.

Occurrence. This species occurs in the commercial catches at Waltair from July to December in boat seines and gill nets. The maximum size obtained was 512 mm. and the minimum size 109 mm.

Diagnosis. Superficially the new species resembles *L. savala* (Cuvier), which is the only species hitherto recorded in the genus *Lepturacanthus*. The salient characters of the two species are compared in Table 2.

TABLE 2

COMPARISON OF THE SALIENT CHARACTERS OF *L. savala* AND *L. serratus* SP. NOV.

No.	CHARACTER	*L. savala*	*L. serratus*
1.	Anal origin below dorsal	35-37	34-35
2.	Second anal spine	Prominent and dagger-shaped	Comparatively short
3.	Pectoral spine	Not serrated	Serrated
4.	Depth in total length	12·80-29·01	21·25-33·06
5.	Head length in total length	7·59- 9·84	9·09-10·63
6.	Diameter of eye in snout length	2·08- 3·00	1·93- 2·25
7.	Length of pectoral fin in depth	1·00- 1·70	0·87- 1·05
8.	Post-anal length in total length	1·32- 1·50	1·29- 1·66
9.	Dorsal fin rays	IV, 106-112	IV, 120-123
10.	Anal spines	i+I, 76-82	i+I, 86-97
11.	Vertebrae	166-179	178-188

James (1961) recorded a wide range in the number of rays in the dorsal and anal fins and in the number of vertebrae of *L. savala*; the present observations, however, indicate that this may have been due to the fact that he was unable to isolate the new species from *L. savala*. He did observe the serrations on the first pectoral spine, but assumed that this feature occurs 'in some individuals of *T. lepturus*

and *L. savala*'. It may be questioned why such a distinctive character should occur in some individuals only, and that too of two species which do not even belong to the same genus. The present studies indicate that the serrations on the pectoral represent a specific character of *L. serratus* sp. nov.

Paper chromatographic studies also show differences between these two new species and the other recorded species. Details will be published elsewhere.

ACKNOWLEDGEMENTS

The authors express grateful thanks to Prof. P. N. Ganapati for providing excellent facilities and for encouragement. The work was carried out during the tenure of a Research Training Scholarship of the Government of India, by one of us (VT).

DEPARTMENT OF ZOOLOGY,
ANDHRA UNIVERSITY,
WALTAIR,
April 23, 1966.

S. DUTT
V. THANKAM

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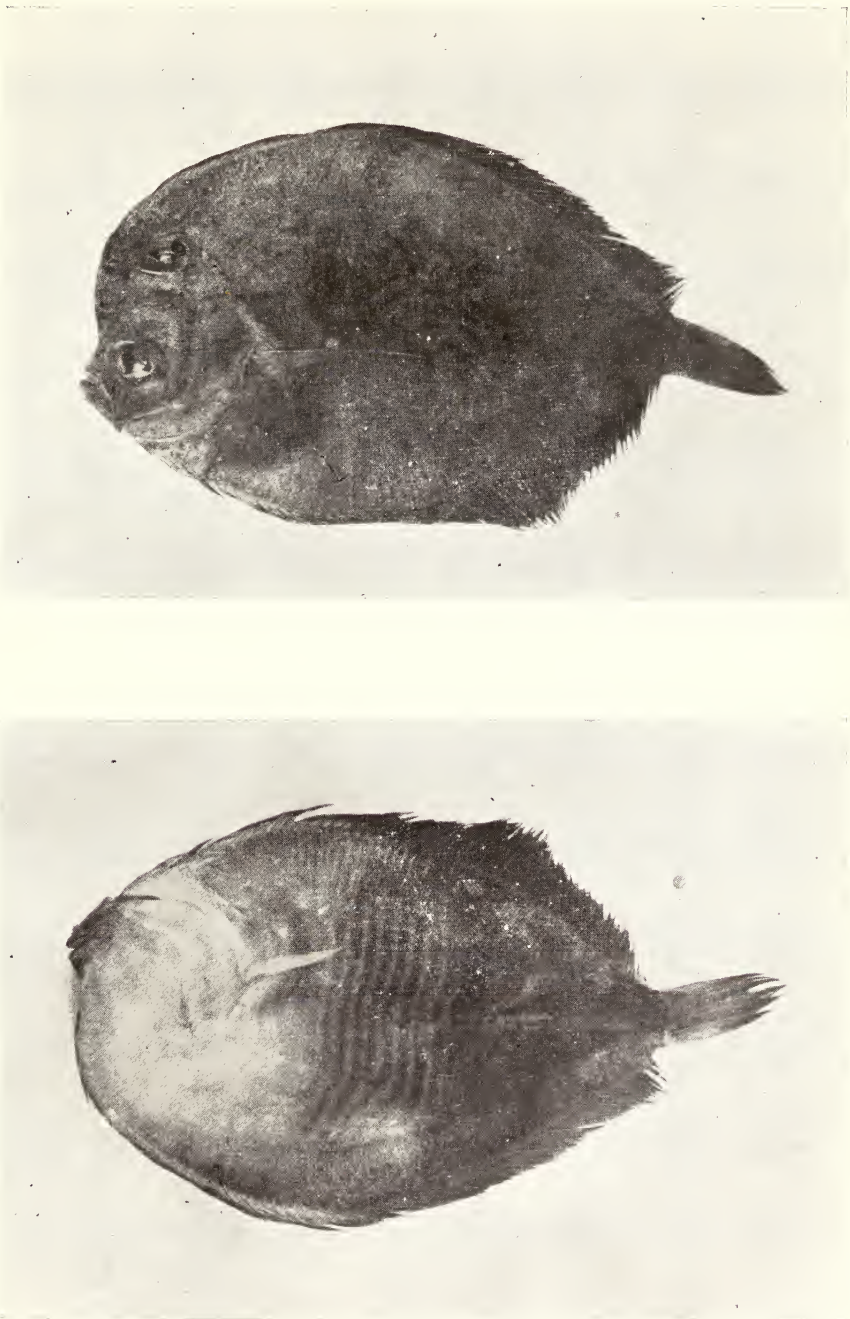
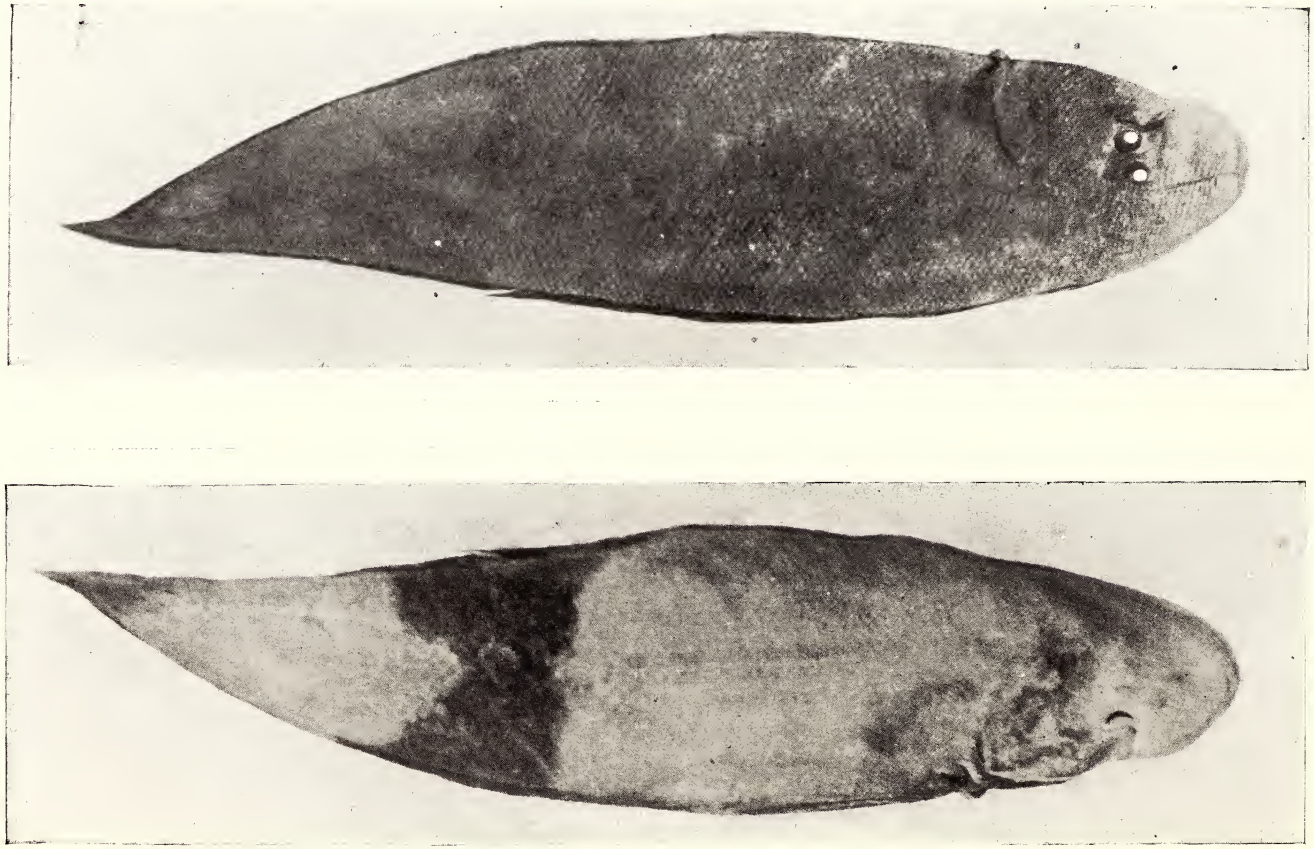
9. AMBICOLOURATION IN TWO SPECIES OF FLATFISHES FROM MADRAS

(*With two plates*)

Ambicolouration or pigmentation on the blind side in flatfishes is known to be associated with the tendency to regain bilateral symmetry (Norman 1934). In India two instances of ambicolouration in flatfishes have been reported; in the 'Pan Sole' *Brachirus pan* (Hamilton) by Jones & Menon (1950), and in the Oriental Sole



Ambicolourate specimen of *Bothus ovalis* (Regan).
Above : View of the ocular side ; *Below* : View of the blind side



Ambicolourate specimen of *Cynoglossus lida* (Bleeker)
Above : View of the ocular side ; *Below* : View of the blind side

Brachirus orientalis (Bloch & Schneider) by Pradhan *et. al* (1962). Both species belong to the family Soleidae. The present note records ambicolouration in a bothid and a cynoglossid flatfish from Madras.

On 18 July, 1966, I brought a collection of flatfishes from the Mandavelli Market, Madras, which included three species, *Pseudorhombus tricellatus* (Bloch), *Bothus ovalis* (Regan) and *Cynoglossus lida* (Bleeker). Among these there were two ambicolourate specimens belonging to the last two species.

The ambicolourate specimen of the Oval Flounder, *Bothus ovalis* (Regan) (plate I) measuring 119 mm. in total length is normal on its ocular side, whereas the blind side is divided into an anterior banded region and a uniformly coloured posterior region. Anteriorly from snout to a length of 41 mm. it is white, as in normal specimens, but there is an extension of dark pigmentation near the base of dorsal and anal fins. Following this, is a banded region extending over a length of 23 mm., starting from 35th dorsal and 17th anal rays to 52nd dorsal and 32nd anal rays. The 5th band does not reach the dorsal fin so that there is a fusion of the 4th and 5th white bands a little above the vertebral column. The rest of the blind side is uniformly black, the caudal base being a little paler.

The ambicoloured specimen of the Shoulder-spot Tongue-Sole, *Cynoglossus lida* (Bleeker) (plate II) measuring 162 mm. in total length is also normal on the ocular side. On the blind side there is a dark brown patch extending from 88 to 111 mm. from the snout and widening a little towards the dorsal and anal fins. The rest of the blind side is white as in normal specimens.

ACKNOWLEDGEMENT

My thanks are due to Shri S. Vijayaraghavan for the photographs.

ZOOLOGICAL SURVEY OF INDIA,
SOUTHERN REGIONAL STATION,
MADRAS-4,
July 22, 1966.

T. E. SIVAPRAKASAM

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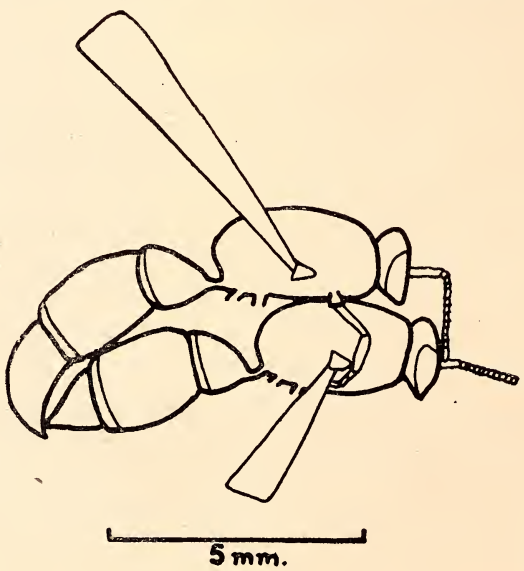
10. SEXUAL BEHAVIOUR IN SOLITARY EUMENID WASPS

(With two text-figures)

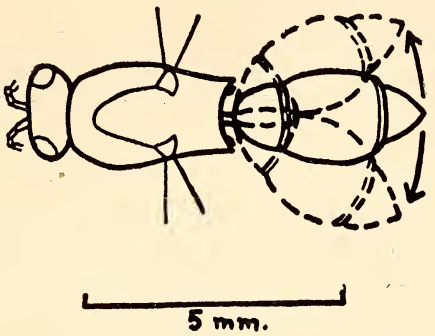
Wasps of *Stenodynerus miniatus* (Sauss.) build mud tubes on walls. The similar squatter wasps of the species *Subancistrocerus sichelii* (Saussure) exploit both natural cavities and mud cells built by other wasps. In Thailand, Iwata (1964) found them in cells of a species now classified as belonging to *Stenodynerus* by J. Van der Vecht and Jayakar & Spurway (1966) have perhaps found it in cells of *S. miniatus* itself. They have been observed resting in hollow bamboos, and nest boxes which are provided.

On four occasions apparent mating has been seen. On 23 August 1963, this was observed on cells of the *Stenodynerus* sp. built between 18 May and 3 June, 1963 from which no specimens were collected. As no wasps were seen on this nest between 22 June and 19 August, it is conceivable that the wasps seen on 23 August belonged to *Subancistrocerus sichelii* (but see Jayakar & Spurway 1966). These also were not captured. On 6/10 and 7/10/64 the wasps observed had emerged from the nest boxes and were preserved, while on 13/8/65 it was performed by two wasps who were certainly *Stenodynerus miniatus.*

On 23 August, when first seen at 09.24 a.m., one wasp was riding the other, as in Fig. 1. At 09.29, the ♂ (assumed to be the one on top) started fluttering his wings. Their genitalia then made



contact for about 3 secs., then separated. The male then started moving his abdomen rhythmically sideways through an arc of about 60° (Fig. 2). With each sideways movement, he stroked with his abdomen the tip of the female's abdomen (see Fig. 1), and at



the same time, fluttered his wings and tapped the female's head with both his antennae. At 09.30, the fluttering of the wings alone discontinued. At 09.35, though the abdominal movements continued, the antennal movements stopped. Abdominal movements ceased at 09.37. From 09.38 to 09.42, the female walked about. The cycle was repeated several times and the times are given below. (The movements were roughly 3 beats to a second.)

09·45 .. contact of genitalia and fluttering by female—start of rhythmic abdominal, antennal and wing movements ;
09·46 .. wing movements stopped ;
09·50 .. antennal movements stopped ;
09·53 .. abdominal movements stopped—♂ fluttered with his antennae held vertically down.
10·02 .. contact of genitalia—rhythmic movements of abdomen, genitalia and wings started ;
10·03 .. wing movements stopped ;
10·05 .. ♂ fluttered briefly ;
10·07 .. antennal movements stopped ;
10·10 .. ♀ moved, ♂ fluttered ;
10·11 .. abdominal movements stopped.
10·12-10.13 .. — ♂ fluttered several times while ♀ walked about.
10·20 .. contact of genitalia—rhythmic abdominal, antennal and wing movements started ;
10·23 .. wing movements stopped ;
10·27 .. antennal movements stopped—♂ flutters ;
10·29 .. disturbance by a mosquito flying near them—abdominal movements stopped—♀ moving about, ♂ fluttering occasionally.
10·37 .. contact of genitalia with ♂ fluttering—rhythmic movements started ;
10·39 .. wing movements stopped ;
10·43 .. antennal movements stopped ;
10·44 .. ♂ flutters while ♀ walks about ;

10·45 .. abdominal movements stopped.
10·46 .. ♂ flutters while ♀ walks about.
At 10·52, another wasp of the same species came out of one of the cells, was approached by the copulating pair, and withdrew.
10·55 .. contact of genitalia—rhythmic movements started ;
10·57 .. wing movements stopped ;
10·59 .. ♂ flutters several times ;
11·01 .. ♀ moves—antennal movements stopped—some fluttering ;
11·02 .. abdominal movements stopped— ♀ moved— ♂ fluttered ;
11·10 .. contact of genitalia—rhythmic movements started ;
11·14 .. wing movements stopped ;
11·15 .. ♂ fluttered.

At 11.15, the wasp from the cell emerged and re-entered twice, causing the copulating female to walk off the nest onto the wall. The male then dismounted and flew away, and at 11.16, the female flew away. Table 1 summarises these data.

TABLE 1

Cycle	Period in minutes				
	A	B	C	Total	D
1	1	5	2	8	8
2	1	4	3	8	9
3	1	4	4	9	9
4	3	4	2	9	8
5	2	4	2	8	10
6	2	4	1	7	8
7	4	—	—	—	—
Mean	2.0	4.2	2.3	8.2	8.7

A=Beginning of rhythmic movements to stopping of wing movements.
B=Stopping of wing movements to stopping of antennal movements.
C=Stopping of antennal movements to stopping of abdominal movements.
D=Stopping of abdominal movements to beginning of next cycle (i.e. of A).

On 6/10/64, two wasps emerged from nest box 4, cell III (called 4. III). These cells were sealed by wasp *S.s.* 7 on 11/9/64 in the house of my colleagues R. Mangipudi and H. Pulugurtha in Bhubaneswar. The cell (width 3/16″, length 1½″, volume 0·442 cc.) had been partitioned by the mother into two sub-cells. The nest box was put into a covered glass jar to trap the emergences, and the wasps, when first seen at 10.28 a.m., were one on top of the other as described before. At 10.34, 10.43 and 10.51, rhythmic movements similar to those described above were performed by the male, who

dismounted at 11.04. On the next day, of 3 emergences from cell 4.IX (the same size as 4.III), the male was riding one of the females at 12.10 p.m. and dismounted at 12.20. In the latter two cases, no contact of the genitalia was observed, and it is possible that the wasps had been disturbed enough to alter their behaviour.

The nest on which similar mating behaviour was seen on 13/8/65 was built by a female of *Stenodynerus miniatus* (Jayakar & Spurway 1966). The nest was started on 20/7/65, and by 13/8, she had completed the building of three cells, two of which were sealed. At 09.09, a pair was seen copulating on the nest, and there was an emergence hole in the mouth of tube I. The male was performing the abdominal movements described above. Very soon after, the male dismounted; the female then went to the mouth of cell I, then pecked at the ♂, who flew away. At 09.14, the female was captured, etherised, marked, and then released. Her subsequent history has been published (Jayakar & Spurway op. cit.).

No similar behaviour has been seen in any other species of wasp observed here, though mounting and riding have been observed in *Eumenes emarginatus conoideus* (Gmelin). The latter were deliberately put together in a jar. It is interesting that the wasps considered in this paper copulated immediately after emergence, and that there is thus a high probability of brother-sister mating and possibly son-mother mating. Iwata (1953) has seen copulations in *Eumenes decoratus* Smith and *E. fraterculus* Dalla Torre, and he has also seen males visiting places where females collected mud, and this suggests that females at least sometimes copulate after they have started building.

I am grateful to Dr. van der Vecht of Leiden for determining the species of the offspring of the female marked on 13/8/65 and of another individual from the relevant nest box, probably also the offspring of *S.s.* 7, and to Dr. K. Iwata of Hyogo for criticising a draft of this paper.

GENETICS AND BIOMETRY LABORATORY,
BHUBANESWAR 3, S. D. JAYAKAR
ORISSA,
August 23, 1965.

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11. GENITALIA AND OPISTHOMERES OF THE EARWIG, *ANECHURA HIMALAYANA* SINGH

(*With three text-figures*)

The original description of this species *Anechura himalayana* Singh lacks description of genitalia and opisthomeres. The present paper is a study of its genitalia and opisthomeres. The author (1965) has pointed out that as genitalia is very confusing in the family Forficulidae the opisthomeres are of great use in separating the members of this group.

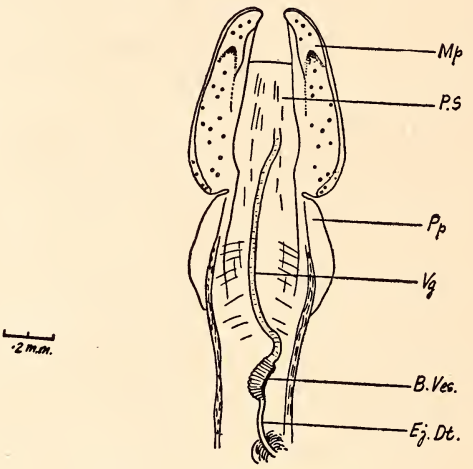

Fig. 1. Male Genitalia

B. Ves.— Basal vesicle ; Ej. Dt.—Ejaculatory duct ; Mp.—Metaparameres ; P.S.—Preputial sac ; Pp.—Proparameres; Vg.—Virga.

Genitalia (Fig. 1)

The genitalia are of Anechurine type. Metaparameres (Mp.) elongated, parallel-sided with broad base and a little narrow rounded apex; *c.* ·74 mm. long and ·18 mm. wide in the middle. Connected to the broad proparameres (Pp.) by a small hinge which is far less well-developed than in the lower group protodermaptera, though better chitinized than other structures of the genital armature. Proparameres feebly chitinized and true base of the segment difficult to distinguish. Space between proparameres and up to about three-fourths near the apex of the metaparameres occupied by the long median unpaired penis-lobe (preputial sac). Preputial sac (P.S.)

c. ·22 mm. wide in the middle and directed forwards. Chitinized virga (Vg.), enclosed within the preputial sac, *c.* ·89 mm. long and ·03 mm. wide nearly throughout its length. Connection of the virga with the reniform basal vesicle (B.Ves.) prominently elbowed, a very characteristic feature of the subfamily *Anechurinae*. Basal vesicle strengthened by chitinous parallel-linings *c.* ·19 mm. long and ·08 mm. wide in the middle. A short ejaculatory duct (Ej.Dt.) arises from the posterior end of the basal vesicle.

Opisthomeres (Figs. 2 & 3)

The opisthomeres are very interesting because they contain all the three clearly defined segments. Burr (1915) described the male opisthomeres of only two species, *Mesochelidura bolvari* Borm. and *Anechura bipunctata* Fabr., for the subfamily *Anechurinae*. He pointed out that the opisthomeres of these species lack the third segment or plate, the telson. Therefore, the opisthomeres of *Anechura himalayana* Singh give a new example in the subfamily *Anechurinae* in having all the three well-developed plates, the pygidium, metapygidium, and the telson, closely fitted as if it were a single structure.

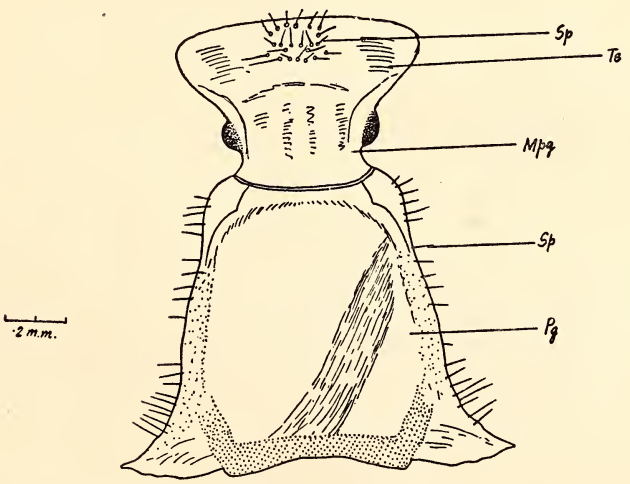

Fig. 2. Male Opisthomeres

Mpg.—Metapygidium; Pg.—Pygidium; Sp.—Spine; Te.—Telson.

Male· Pygidium (Pg.) is the largest plate and is more than one and half times longer than the metapygidium and telson combined;

c. ·95 mm. long, 1·24 mm. broad with ·44 mm. narrow apex and provided with a group of lateral spines (Sp.). Metapygidium (Mpg.) closely fitted with the pygidium, constricted near the base and has a pair of bulges near the centre of the lateral sides *c.* ·34 mm. long, ·44 mm. broad at the base. Telson (Te.) an elongated fan-like structure, *c.* ·21 mm. long, ·46 mm. broad at the base and ·73 mm. at the apex, bearing a group of spines (Sp.) in the centre of the apex and surrounding the apical portion of the metapygidium.

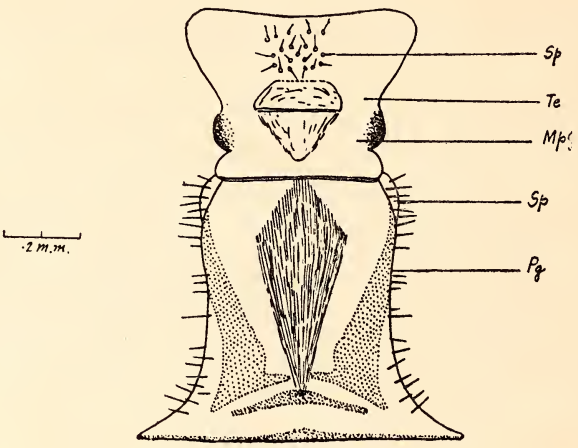

Fig. 3. Female Opisthomeres

Mpg.—Metapygidium ; Pg .—Pygidium ; Sp.—Spine; Te.—Telson.

Female: Opisthomeres similar in shape, shorter than that of male. Pygidium (Pg.) *c.* ·68 mm. long, ·84 mm. broad and ·43 mm. narrow apex. Metapygidium (Mpg.) somewhat different from male and about ·24 mm. long, ·43 mm. broad at base and ·14 mm. at the apex. Telson (Te.) about ·17 mm. long, ·41 mm. narrow at the base with ·56 mm. broad apex which is slightly concave.

Thus the above study supports the placing of *Anechura himalayana* Singh in the subfamily *Anechurinae*, by Santokh Singh (1955).

Summary

The structures of the genitalia and opisthomeres of *Anechura himalayana* Singh are described for the first time. The opisthomeres in having all the three well-developed plates namely the pygidium, metapygidium and telson form a new character for the subfamily *Anechurinae*.

ACKNOWLEDGEMENTS

I am grateful to Dr. H. N. Baijal, PH.D., F.A.Z., Zoology Department, Agra College, Agra, for guidance and encouragement during the present work; to Dr. Santokh Singh, PH.D., F.R.E.S., School of Entomology, St. John's College, Agra, for placing the present collection at my disposal; to Principal Dr. M. Ray, D.SC., F.N.I., and Dr. C. P. Singh, PH.D., F.L.S., F.A.Z., Head of the Department of Zoology, Agra College, Agra, for laboratory and library facilities, and to the Ministry of Education, Govt. of India, for the scholarship award.

DEPARTMENT OF ZOOLOGY,
AGRA COLLEGE,
AGRA,
March 26, 1966.

V. C. KAPOOR
Research Scholar

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12. NEW PENTATOMID HOST RECORD FOR HYMENOPTEROUS EGG-PARASITES *ANASTATUS COLEMANI* CRAWF. AND *ASOLCUS* SP.

Anastatus colemani has been known to parasitise eggs of pentatomids besides those of Dictyoptera and Lepidoptera. In India, this eupelmid has been recorded from the eggs of the pentatomids *Tessaratoma javanica* (Mehra & Kapur 1955) and *Degonetus serratus* (Krishnamurthi & Usman 1954). Records of scelionid parasites from the eggs of pentatomids, from India, refer to *Microphanurus* sp. from eggs of *Eurydema* sp. (Chatterji & Rahalkar 1958), *Microphanurus indicus* from *Plautia fimbriata* (Narayanan & Kaur 1959), *Hadrophanurus* sp. from *Bagrada cruciferarum* (Narayanan *et al.* 1959) and *Telenomus latisulcus* (=*Microphanurus priapus*) from *Chrysochoris purpureus* (Swaminathan & Madhavan Nair 1962).

In the present investigation, both *A. colemani* and *Asolcus* sp. were observed in the field to oviposit inside the eggs of *Placosternum*

dama Fab. which is a new host record for these parasites. Batches of host eggs collected from the field were kept under observation in the laboratory to assess the degree of parasitisation and survival percentage of the host. Eggs escaping parasitisation could be distinguished by the reddish brown streaks visible through the chorion, as parasitised eggs changed from green to black through a stage of light brown coloration.

P. dama is commonly seen on the slender branches of the banyan tree in a number of places around Madras, though all the eggs in the present study were collected within the college campus. The parasites make their appearance in late October and are seen in the field till March of the succeeding year. During 1964-65, these parasites were collected together during all the five months. *Asolcus* sp. predominated in the process of parasitisation. During 1965-66, however, *Asolcus* sp. was not seen in the field till it emerged from the host eggs in the middle of January.

During this period, nevertheless, the number of host eggs parasitised by *A. colemani* did not increase to any appreciable extent.

TABULAR ANALYSIS OF HOST AND PARASITE SURVIVAL DURING 1964-66

	1964-65	1965-66
Total No. eggs collected	678	1,156
No. eggs from which *A. colemani* emerged	165 or 24·3%	316 or 27·3%
No. eggs from which *Asolcus* sp. emerged	269 or 39·7%	275 or 23·9%
*No. eggs from which *Tetrastichus* sp. emerged	..	24 or 2·0%
No. eggs parasitised but from which no emergence took place	90 or 13·3%	16 cr 1·4%
Mortality per cent in parasitised eggs	— 17·2%	— 2·5%
No. eggs hatch d (Unparasitised)	143 or 21·1%	516 or 44·6%
No. unparasitised eggs which failed to hatch	11 or 1·6%	9 or 0·8%
Mortality per cent in unparasi ised eggs	— 7·1%	— 1·7%

* This parasite was determined through the kindness of Mr. R. G. Fennah of the Commonwealth Institute of Entomology, London.

The parasites were also successfully reared in the laboratory to study their biology, sex ratio and fecundity. Details of these studies will be published elsewhere.

The author is grateful to Dr. C. S. W. Muesebeck of the U.S. Department of Agriculture, Maryland, and to Dr. I. H. H. Yarrow

of the British Museum (Nat. Hist.) for determining the material sent to them. He also expresses his sincere thanks to Mr. K. S. Ananthasubramanian for the help received during this study, and to the authorities of the Loyola College for laboratory facilities.

DEPARTMENT OF ZOOLOGY,
LOYOLA COLLEGE,
MADRAS-34,
April 27, 1966.

B. N. RAMAMURTHI

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13. FIRST RECORD OF THE FAIRY SHRIMP *BRANCHINELLA KUGENUMAENSIS* ISHIKAWA IN GUJARAT STATE, NORTH INDIA

On the 13th October 1956 the writer collected four fairy shrimps in a rainwater pool near the mission school compound in Ahwa, headquarters of the Dangs District, south Gujarat. These specimens were sent to Manchester College (U.S.A.) in 1958, where general classification as *Branchinella* was made by Dr. William R. Eberly of the Department of Biology.

After noting Dr. K. K. Tiwari's (1958) article on a new species of *Branchinella* from Sambhar Lake, Rajasthan, the writer concluded that this catch of fairy shrimps was significant. Therefore the matter was reported to the Bombay Natural History Society for guidance. Upon their suggestion the fairy shrimps were returned to India, where they were identified by the Zoological Survey of India, Calcutta, as *Branchinella kugenumaensis* Ishikawa.

Linder (1941) mentioned seeing two males of a *Branchinella* form from Madras, India, preserved in the British Museum, London, and

remarked further that this species *Branchinella kugenumaensis* was previously known only from East Asia. Thus the presence of this species in Gujarat is an interesting record. It was formerly recorded by Linder (op. cit.) in Madras, by Sanjeeva Raj from Madura (1952), and by Tiwari in Rajasthan (1965).

402, N. Wayne St.,
North Manchester, Ind.,
U.S.A., 46962,
August 8, 1966.

E. M. SHULL

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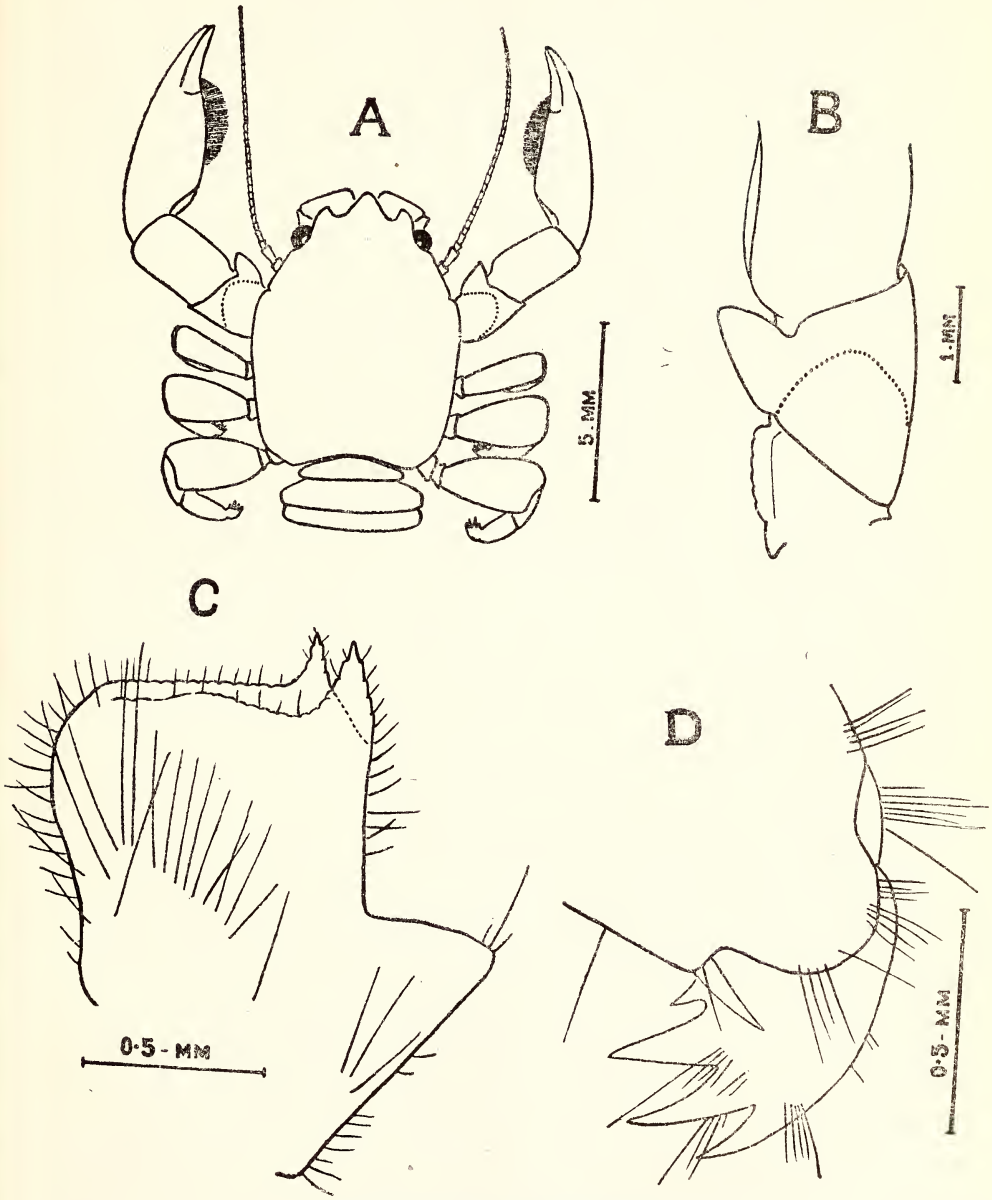
14. ON THE OCCURRENCE OF *PORCELLANELLA PICTA* STIMPSON (DECAPODA : ANOMURA) IN THE GULF OF KUTCH

(With a plate)

Records of the genus *Porcellanella* from Indian waters are *Porcellanella picta* (Stimpson) from Rameswaram Island by Henderson (1893) and from Gulf of Mannar by Sankarankutty (1961), *Porcellana gaekwari* (Southwell 1909) from Gulf of Kutch on which Gravely (1927) remarked 'the biunguiculate feet of which clearly place it in the genus *Porcellanella*', and *Porcellanella haigae* (Sankarankutty 1963) from Gulf of Mannar.

In June 1965 the author collected a number of porcellanid crabs found as commensals on a Sea Pen *Ptereoides* sp. from the intertidal zone of the mud flat on the south-western side of Dabdaba Island (69° 11′ 36″ E., 22° 22′ 10″ N.) in Pindara Bay, Gulf of Kutch. These porcellanids were identified as *Porcellanella picta* Stimpson thereby extending the distribution of this species to the Gulf of Kutch and first record of the species from the west coast of India.

Each host (*Ptereoides* sp.) harboured from 7 to 10 of these anomurans. In all 87 specimens were examined of which 37 were



Porcellanella picta Stimpson

A. Female, *B*. Ischium and merus of cheliped, *C*. Basal antennular segment, *D*. Dactylus of walking leg.

males, and of the remaining females 22 were ovigerous. The carapace lengths of the males ranged from 3·15 to 5·6 mm. and of the females from 3·2 to 8·0 mm. The smallest ovigerous female measured 4·43 mm. long and 3·57 mm. across the widest part of the carapace. The frontal lobes of the specimens in the collection showed minor variations in respect of their relative sizes and shape, more or less in the same way as reported by Sankarankutty (1961) in the case of the Gulf of Mannar specimens. Regarding the spinules of the dactyli of the walking legs, though as a rule the second proximal was the largest a few specimens were found in which the second and third spinules were subequal. The first spinule (proximal) was found to be appreciably smaller than the fourth in all the specimens. The variations from type were mostly confined to younger specimens.

In the nature of the spines on the inner distal margin of the basal antennular segment these specimens differed from the Gulf of Mannar specimens. In the Kutch specimens the spines are close-set overlapping slightly at the base and the inner one is the stouter. This feature was found quite consistent in all the specimens in the collection.

The author gratefully acknowledges the help of Dr. D. S. Johnson and Dr. C. Sankarankutty in examining the specimens and confirming the identification.

MARINE BIOLOGICAL RESEARCH
STATION, OKHA, R. RAMANANDAN
August 3, 1966.

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15. NOTES ON A COLLECTION OF BARNACLES FROM THE EAST COAST OF INDIA

(With five text-figures)

Introduction

This paper lists 30 species of Cirripedes from the inshore areas of Porto Novo, and Mandapam-Krusadi island region collected during the course of faunistic surveys in May and September-October 1960 by the authors for the Zoological Survey of India. All the thirty species are new records for the localities as indicated in the Table. In addition, *Balanus hoekianus* Pilsbry, 1916, is redescribed briefly since the previous description of this species from a single lot is inadequate. Notes on *Chthamalus malayensis* Pilsbry, 1916, and *C. challengeri* Hoek, 1883, recorded for the first time from the Bay of Bengal, are also given to facilitate easy identification.

Table

List of Species

Name of species	No. of specimens	Localities	Z.S.I. Reg. No.
Family Lepadidae			
1. *Lepas anatifera indica* Annandale	8+4	Porto Novo & Pamban bridge	C 4495/1
2. *Lepas anserifera* Linne	6+6	-do-	C 4496/1
3. *Lepas pectinata* Spengler	7	Gulf of Mannar	C 4512/1 & C 4514/1
4. *Conchoderma virgatum* (Spengler)	1	Krusadi island	C 4499/1
Family Trilasmatidae			
5. *Trilasmis minuta* (Gruvel)	8+2	Porto Novo & Palk Bay	C 4505/1
6. *Trilasmis kaempferi* (Darwin)	4	Krusadi island	C 4506/1
7. *Trilasmis amygdalum* (Aurivillius)	4	Porto Novo	C 4506a/1
8. *Octolasmis tridens* (Aurivillius)	22+12	Porto Novo & Palk Bay	C 4507/1
9. *Octolasmis warwickii* Gray	36+4	Porto Novo, Pamban Bridge & Palk Bay	C 4511/1 & C 4513/1
10. *Octolasmis grayii* (Darwin)	34+1	Porto Novo & Krusadi	C 4502/1
11. *Octolasmis lowei* (Darwin)	20	Porto Novo	
12. *Octolasmis cor* (Aurivillius)	52+64	Porto Novo & Gulf of Mannar	C 4515/1
13. *Octolasmis nierstraszi* Hoek	1	Krusadi island	C 4503/1
14. *Octolasmis angulata* (Aurivillius)	48	Porto Novo	C 4503a/1

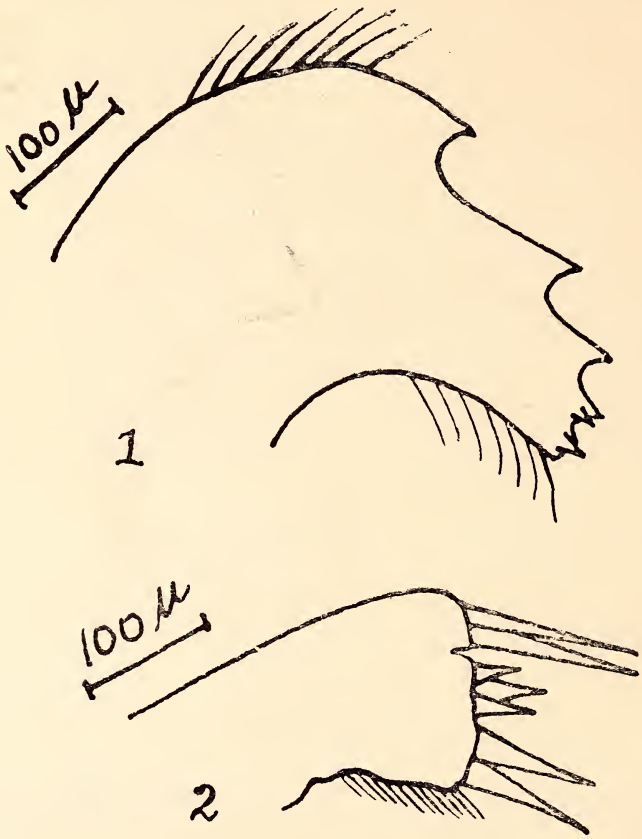
Name of species	No. of Specimens	Localities	Z.S.I. Reg. No.
Family Balanidae			
15. *Balanus tintinnabulum tintinnabulum* (Linne)	3+3	Porto Novo & Mandapam	C 4491/1
16a. *Balanus amphitrite communis* Darwin	64+30	Porto Novo & Gulf of Mannar	C 4486/1
b. *Balanus amphitrite variegatus* Darwin	62	Mandapam, Gulf of Mannar & Pamban Bridge	C 4484/1 C 4481/1 C 4492/1
c. *Balanus amphitrite venustus* Darwin	3	Pamban Bridge	C 4488/1
d. *Balanus amphitrite cirratus* Darwin	11	Gulf of Mannar	C 4482/1
17. *Balanus sinnurensis* Daniel	11	Porto Novo	C 4170/1
18. *Balanus calceolus* Darwin	2	Krusadi	C 4493/1
19. *Balanus tenuis* Hoek	3	Pamban Bridge	C 4483/1
20. *Balanus amaryllis* Darwin	2	Gulf of Mannar	C 4485/1
21. *Balanus ciliatus* Hoek	1	-do-	C 4487/1
22. *Balanus hoekianus* Pilsbry	2	Porto Novo	C 4487a/1
23. *Balanus longirostrum krusadiensis* Daniel	6+6	Porto Novo & Palk Bay	C 4481/1
24. *Acasta sulcata spinosa* Daniel	2+2	-do-	C 4510/1
25. *Chelonibia testudinaria* Linne	1	Gulf of Mannar	C 4494/1
26. *Chelonibia patula* Ranzani	6	Gulf of Mannar	C 4490/1
27. *Chelonibia caretta* (Spengler)	2	-do-	C 4498/1
Family Chthamalidae			
28. *Chthamalus stellatus* (Poli)	48	Gulf of Mannar, Mandapam & Pamban Bridge	C 4500/1 C 4501/1 C 4504/1 C 4508/1
29. *Chthamalus challengeri* Hoek	5	Pamban Bridge	C 4497/1
30. *Chthamalus malayensis* Pilsbry	4	-do-	C 4509/1

Balanus hoekianus Pilsbry, 1911

Shell and opercular plates white, subcylindrical with triangularly ovate orifice. Compartments solid, without pores and without radii. Parietes solid, not distinctly ribbed, with no chitinous cuticle and no hairs. Alae smooth with oblique upper margins and peritreme deeply serrate. Rostrum largest compartment, externally indistinctly rugose longitudinally, internally with tripartite sheath. Carina strongly concave; lateral compartment triangular with well-developed ala. Carino-lateral plate narrow, recurved and with bipartite sheath. Basis thin, transparent, calcareous at the edges only. Scutum thick, twisted at the apex, marked with fine growth-striae externally; with short and well-developed articular ridge. Articular furrow narrow, shallow but distinct. Adductor ridge discernible only faintly. Tergum small and thick; scutal margin concave, carinal margin short, strongly convex; spur long and narrow, separated from scutal margin by nearly its

own width; articular ridge high and massive, articular furrow wide but not deep; depressor crests short but sharp.

Mandible (Fig. 1) with four teeth. Maxilla I (Fig. 2) with a notch below the upper two large spines.



Figs. 1 & 2. *Balanus hoekianus* Pilsbry, 1911
1. Mandible; 2. Maxilla I

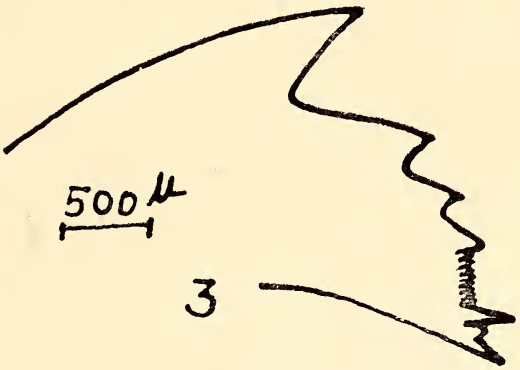
This is the first record of this species from the Indian Ocean.

Chthamalus challengeri Hoek, 1883

This species has been previously recorded from the west coast of India (Bombay) by Bhatt & Bal (1960). Other records are from Red Sea, Colombo, Malay Archipelago, and Japan.

The largest specimen in the collection has a carino-rostral diameter of 5·5 mm. and a lateral diameter of 3 mm. Shell conical, almost rounded with large orifice. Colour bluish gray. Compartments

smooth, delicate, easily separable from one another and from surface of attachment. Radii narrow, but well developed. Scutum with prominent articular ridge and a narrow adductor. Lateral depressor muscle pit indistinct. Tergum wide above, narrow below; upper free portion prominently laminate. Articular ridge strong with wide furrow. This species is easily distinguishable from *stellatus* by the well-developed adductor ridge of the scutum, the short articular ridge with the characteristic tapering lower end. Mandible (Fig. 3) with lower extremity bearing three conspicuous points. The mandible of *stellatus* is also figured (Fig. 4) for comparison.



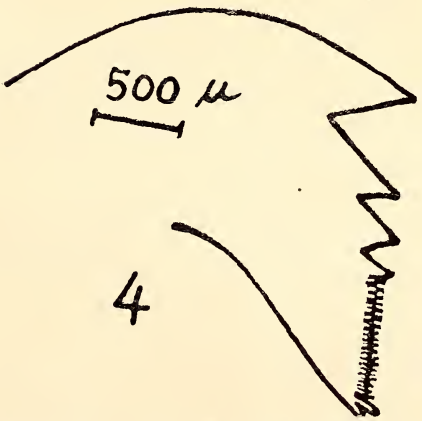


Fig. 3. Mandible of *Chthamalus challengeri* Hoek 1883
Fig. 4. Mandible of *C. stellatus* (Poli) 1791

Chthamalus malayensis Pilsbry, 1916

1916. *Chthamalus malayensis* Pilsbry, p. 310
1931. *Chthamalus malayensis* Broch, p. 55
1938. *Chthamalus malayensis* Nilsson-Cantell, p. 31.

This species has been previously recorded from Akyab, Arakan coast, Burma, Indian Ocean, and Malay Archipelago. This is the first record from the Bay of Bengal.

The specimens in the present collection agree well with the descriptions of *C. malayensis* given by Pilsbry (1916) and Nilsson-Cantell (1938). Opercular valve corroded externally. Scutum with articular ridge very prominent in the middle; adductor ridge short. Tergum triangular, narrow at the lower end and broad above. Mandible (Fig. 5) bears four teeth, with the third and fourth bifid. Six small teeth occur between the fourth tooth and the lower spines. Front margin of Maxilla I is irregular. Terminal segments of cirrus II without large-toothed spines. Cirrus IV bears four pairs of spines on the front margin of the segments.

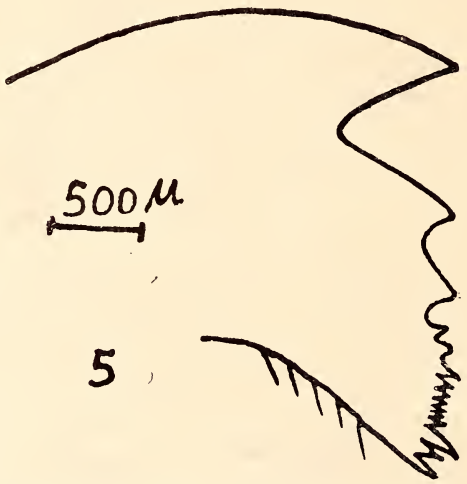


Fig. 5. Mandible of *C. malayensis* Pilsbry 1916.

This species can be distinguished from *C. challengeri* and *C. stellatus* by the presence of coarse teeth below the fourth tooth of the mandible.

ZOOLOGICAL SURVEY OF INDIA,
CALCUTTA,
January 29, 1966.

A. DANIEL
P. K. CHAKRABARTI

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16. A NOTE ON *GNAPHALIUM PEREGRINUM* IN NORTH AND NORTH-WESTERN INDIA

Gnaphalium peregrinum Fernald in Rhodora 45: 479, 1943; Munz. & Keck, Cal. Fl. 1259, 1959; *G. purpureum* auct. pl. non Linn.

Materials kept under the name of *Gnaphalium purpureum* in the Herbarium of Forest Research Institute, Dehra Dun (DD), and Herbarium of Northern Circle of Botanical Survey of India, Dehra Dun (BSD) did not match with sheets of *Gnaphalium purpureum* Linn. from countries other than India housed in DD. On closer scrutiny all the Indian specimens of BSD & DD turned out to be *G. peregrinum* Fernald, which is similar to *G. purpureum* Linn. in many respects. The two taxa can be distinguished as follows:

Lower leaf surface closely white-pannose, the subappressed hairs tightly enmeshed; involucre densely woolly at base only; head 4-6 mm. long ... *G. purpureum*

Lower leaf surface loosely villose-lanate; involucre almost completely covered in wool except the tip; head 3-4 mm. long ... *G. peregrinum*

Specimens examined: UTTAR PRADESH. Agra, *Jameson* s.n. (DD): *C. L. Malhotra* 13577 (BSD). Ambara (Kheri Dist.) *Inayat* 22259 a-c (DD). Aurangabad (Bulandshahr), *N. P. Singh* 19458 (BSD). Balawali, *Sarin* 5036 (BSD). Chandpur, *C. L. Malhotra* 20241 (BSD). Dehra Dun, *Duthie* 1782 (DD); *Gamble* 24031 (DD); *S. K. Malhotra* 18532 (BSD); *N. P. Singh* 31302 & 31693 (BSD). Etawah, *C. L. Malhotra* 13537 (BSD). Garhwal, *C. L. Malhotra* 2748 (BSD).

Khurja (Bulandshahr), *N. P. Singh* 25564 (BSD). Mahoba, *Bhattacharyya* 21008 (BSD). Mussoorie, *Saxena* 1391 & 1473 (DD).

ORISSA—*Mooney* 3745 (DD).

PUNJAB—Badopal, *N. C. Nair* 25928 (BSD). Hissar, *V. J. Nair* 21539 (BSD). Jhabua (Rewari), *N. C. Nair* 20714 (BSD). (BSD). Mahendragarh, *N. C. Nair* 20596 (BSD). Sampla, *N. C. Nair* 20012 Talwandi, *N. C. Nair* 345 (BSD). Yumunanagar, *N. C. Nair* 25284 & 26394 (BSD).

I am thankful to the authorities of the Forest Research Institute, Dehra Dun, for Herbarium facilities.

BOTANICAL SURVEY OF INDIA,
76, LOWER CIRCULAR ROAD, N. C. NAIR
CALCUTTA-14,
September 19, 1966.

17. ADDITIONS TO THE FLORA OF GUJARAT

Chlorophytum borivilianum Sant. & Fern. J. Bombay nat. Hist. Soc. 52: 896-900, 1955, t. 1.

Perennial herbs with fascicled root tubers. *Leaves* all radical, 8-22×0·7-1·8 cm., linear-lorate or ensiform, spreading horizontally or recurved, glabrous, acute, with hyaline margins. *Flowers* 3-3·5 cm. across, white, in clusters of three, in a raceme.

Occasional on hilly slopes at Ahwa, Dangs forest (*BS* 1178), profusely flowering in June, growing with *C. tuberosum* Baker. It is a new species described by Santapau & Fernandes.

Dyschoriste dalzellii (T. Anders.) O. Kuntze, Rev. Gen. Pl. 486, 1891; Cooke, Fl. Pres. Bombay 2: 362, 1906; Santapau in Univ. Bombay bot. Mem. 2: 31, 1951 & Fl. Purandhar 98, 1958.

Occasional in shade along hedges on the outskirts of the forest or in undergrowth of the dense forest at Malegam, Dangs forest, in December 1965 (*BS* 753, 805).

For Gujarat it is reported for the first time from Dangs forest. Cooke (2: 31, 1908) records *D. erecta* (Burm. f.) O.K. (=*D. depressa* Nees) from Dangs forest but not the present plant.

DEPARTMENT OF BOTANY,
SARDAR PATEL UNIVERSITY, G. L. SHAH
VALLABH VIDYANAGAR, B. SURYANARAYANA
GUJARAT STATE,
September 15, 1966.

18. NEW PLANT RECORDS FROM ERSTWHILE BOMBAY STATE III

(With two plates)

During the course of intensive floristic studies in the Ratan Mahal and surrounding hills, Panch Mahal District, Gujarat State, the following plants were collected. While studying them in detail in the laboratory and the library, their distribution was found to be interesting. The determination of the specimens has been confirmed by the National Herbarium, Calcutta and Royal Botanic Gardens, Kew. As far as could be ascertained from the available literature, the plants are new records for Bombay State.

A more detailed description of some of the plants listed below is given with a view to supplementing the scanty information available in the works on Indian flora. It is hoped that the illustrations and field notes may help workers on floristic studies in this part of the country and adjoining regions to determine the distribution of these plants.

Polycarpon tetraphyllum Linn. Syst. ed. 10, 881; Hook f. Stud. Fl. Brit. Isles. 63; Gamble, 46.

Annual, glabrous, slender, sub-erect herb. Leaves 7-15 mm. in opposite pairs or whorls of four. Stipules very small, narrowly triangular, acuminate, scarious. Inflorescence a much branched dichasium. Flowers 2-4 mm. in diameter, shortly pedicellate; sepals with broad white scarious margins; petals white, narrowly oblong; stamens 3-5. Capsule ovoid, about equalling the calyx. Seed brownish finely papillose (Plate I).

Flowering and fruiting: August-October.

Herbarium specimen *Bedi* 3048 (19.8.62) & (10.10.62)

The plants grew on moist soil near Dhanpur tank and Dhanpur village. The plant is rare and restricted to the plains on the northern part of Ratan Mahal hills. It has been mentioned as an introduced weed by Gamble in the Flora of the Presidency of Madras. In the Flora of the British Isles this species is mentioned as a rare and local plant of sandy and waste places in Cornwall, south Mediterranean region and central Europe, but widely introduced elsewhere.

Millettia auriculata Baker in Fl. Brit. India 2: 108, 1876; Brandis For. Fl. 138; Gamble 1 :227.

A large woody climber. Leaflets 7-9, glabrescent, 10-25×5-12cm. Flowers in axillary racemes near the end of the branches; corolla

pale-yellow, densely covered with soft hairs on the outerside; standard distinctly auricled at the base on both sides of the claw. Pod hard, 8-20×2-5 cm. covered with brown velvety tomentum. Seed dark brown, rounded and compressed (Plate II).

Flowers: July to September. Fruits: October to March.

Herbarium specimen *Bedi* 775, 2729, 2806.

Fairly common on the hilly forest slopes between Kanjeta and Pepargota. Rarely noted on the plains north of Panam valley. Ganjam, Vizagapatnam (south India); Rohilcund and Kumaon to Sikkim; also on Parasnath in Bihar.

Dioscorea pubera Blume, En. Pl. Jav. 1: 21, 1827; Prain & Burk. in Ann. Royal Bot. Gard. Calc. 14: 402, t. 143, 1938; Burk. Fl. Males. I, 4(3): 333, 1951. *D. anguina* Roxb. Fl. Ind. 3; 803, 1832 excl. ref. Rumph.; Fl. Brit. India 6: 293.

Tuber cylindric. Stem twining, round, without prickles. Leaves more often alternate than opposite, cordate, entire with hyaline margin, 5-7 nerved, with many transverse veins between them, lower surface permanently pubescent, upper sub-glabrous. Larger leaves up to 40×50 cm. (It has the largest leaves of all the dioscorea of this region). Flowering axis densely pubescent. Male spikes 2-5 cm. crowded on long peduncles.

Flowers and Fruits: September to November.

Herbarium specimen *Bedi* 3202, 3203, 3204 (1.10.62).

A few plants noted twining over shrubs and small trees on the slopes of a hill along the banks of a stream at Nalwani near Kanjeta. Restricted in distribution, not common.

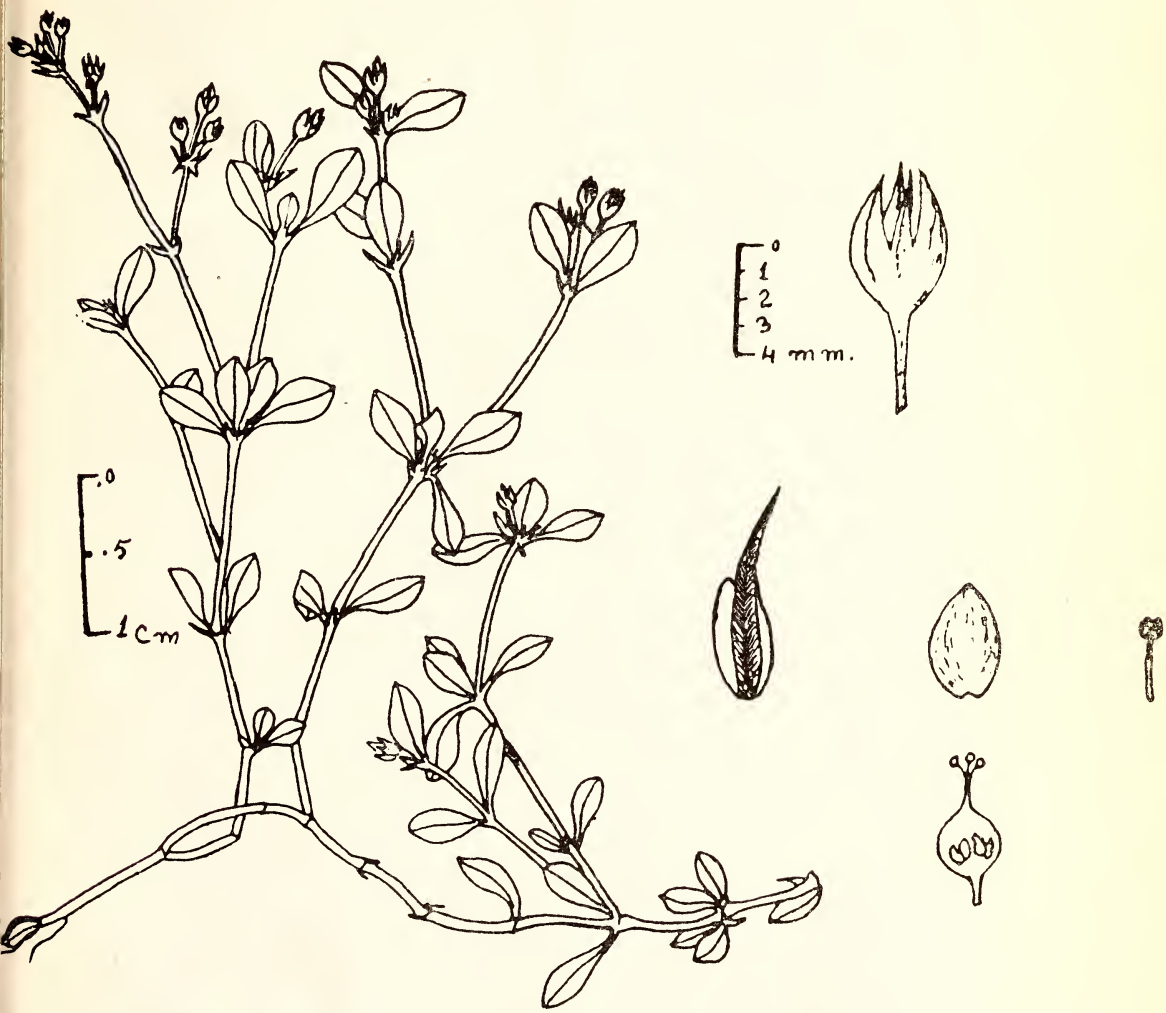
Chota Nagpur; North and East Bengal; South-east Asia; Malaysia; Sumatra (West Coast), Java.

The tubers are edible and are boiled several times before use. The junior author, on a number of occasions had the opportunity of enjoying a dish prepared from the tubers by the local Bhils.

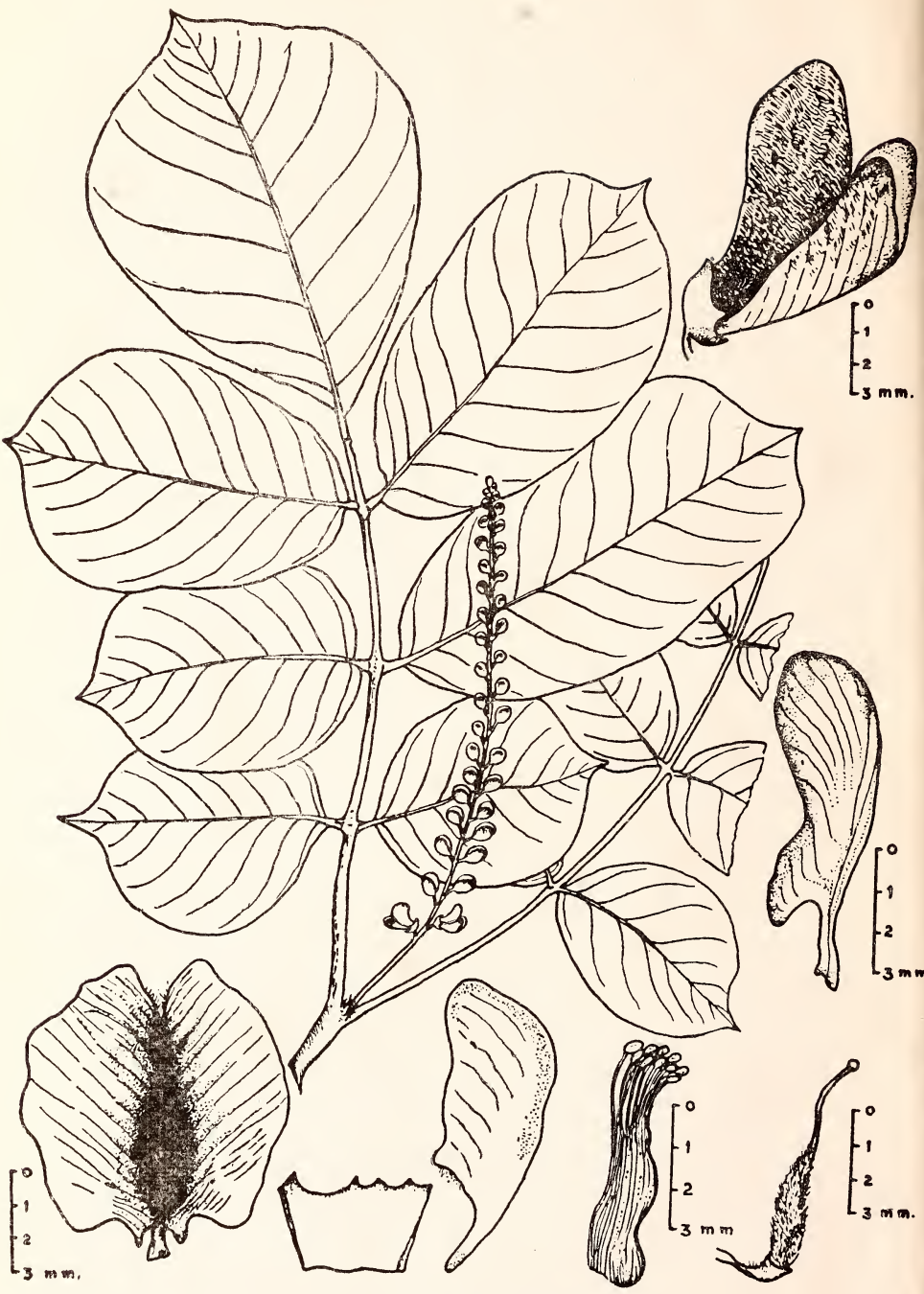
Commelina suffruticosa Blume, Enum. Pl. Jav. 1 : 3, 1828; Fl. Brit. India 6: 374, 1894.

A much branched, glabrous, erect or ascending herb, arising from a short rhizome. Leaves ovate-lanceolate 10-20×2-6 cm. base narrow, sessile, pubescent. Sheath 1-2 cm. hairy near the mouth, auricled. Spathes shortly peduncled, ovate-cordate 1-2 cm. long. Racemes simple 6-10 flowered. Petals white or with light bluish tinge. Capsule bilobed, 2-celled, obovate, pedicellate. Seed one in each cell, ellipsoid, rugose, ash coloured or brown.

Flowers and Fruits: July to September



Polycarpon tetraphyllum Linn.



Millettia auriculata Baker

Herbarium specimen *Bedi* 1601 (17.8.60), 2760, 2788.

This species is fairly common amongst grasses, near streams and other moist localities, in the forests of hill slopes near Banvaro and Pepargota.

From Nepal, Sikkim and Bengal to Central India and the Malay peninsula.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. G. Taylor, Director, Royal Botanic Gardens, Kew, England and the Curator, National Herbarium, Calcutta, for confirming the determination of the specimens. The junior author is thankful to his colleague, Shri S. D. Sabnis.

M.S. UNIVERSITY OF BARODA,
BARODA,
September 17, 1966.

A. R. CHAVAN
SURINDER J. BEDI

19. CONTRIBUTION TO THE GENUS *RUBIA* L.

(*With two plates*)

The taxonomic study of *Rubia* Linn. (Rubiaceae) of India and adjoining countries, as represented in Indian herbaria, has been undertaken by the authors. The present paper embodies some important results of this study on (1) *Rubia aitchisonii* Deb et Malick, sp. nov. (2) *R. cordifolia* L. var, *cordifolia* f. *strigosa* Deb. et Malick, f. nov. and (3) *R. albicaulis* Boiss. var. *stenophylla* Boiss. f. *infundibularis* (Hemsl. & Lace) Deb et Malick, comb. et stat. nov.

1. **Rubia aitchisonii** Deb et Malick, sp. nov. (Plate I).

Affinis *R. floridae* Boiss. a qua tamen differt foliis elliptico-lanceolatis, marginibus arcte aculeatis, pedicellis longioribus.

Suffrutex 6-9 dm. altus, valde ramosus, ramis brevibus, caule inferiore lignoso, terete, cortice squamoso, partibus juvenilibus quadrangularibus, internodiis brevissimis. *Folia* simplicia, 24-27×2·5-5 mm. sessilia, elliptico-lanceolata, coriacea, arcte aculeata ad margines, ad apicem acuta, ad basin attenuata, pinnatim nervosa, nervis 4-5. *Inflorescentia* axillaris et terminalis cymosa, pedunculis longis, quadrangularibus, aculeatis. *Flores* viridescenti-lutei, 5-6×3-3·5 mm.

pedicellis 6-10 mm. longis, quadrangularibus, tenuiter aculeatis. *Calyx* penitus circumdat ovarium, eique adhaeret, aculeatus. *Corolla* 4-5 mm. longa, laciniis 5 vel 6, oblongis vel oblongo-lanceolatis, ad apices mucronatis. *Stamina* 5 vel 6, epipetala, filamentorum parte libera 0·25-0·5 mm. longa, antheris 0·5-0·75 mm. longis, oblongis, bilobis, dorsifixis. Discus annularis, tenuis, circumdans styli basin. Ovarium biloculare, 1·25-1·5×1·5-1·75 mm. ovulis singulis in unoquoque loculo fixis septi basi; styli bini, 0·75-1 mm. longi, uniti; stigmate globoso.

Typus, *J.E.T. Aitchison 338 A*, lectus ad Badgis in Afghanistania die 29 aprilis anni 1885 et positus in CAL; paratypus, *J.E.T. Aitchison 338 B*, lectus eodem loco, die 20 maii 1885 positus in DD.

Rubia aitchisonii Deb et Malick, sp. nov.

This is allied to *R. florida* Boiss. differing in elliptic-lanceolate leaves, closely prickled margin of leaf and longer pedicels.

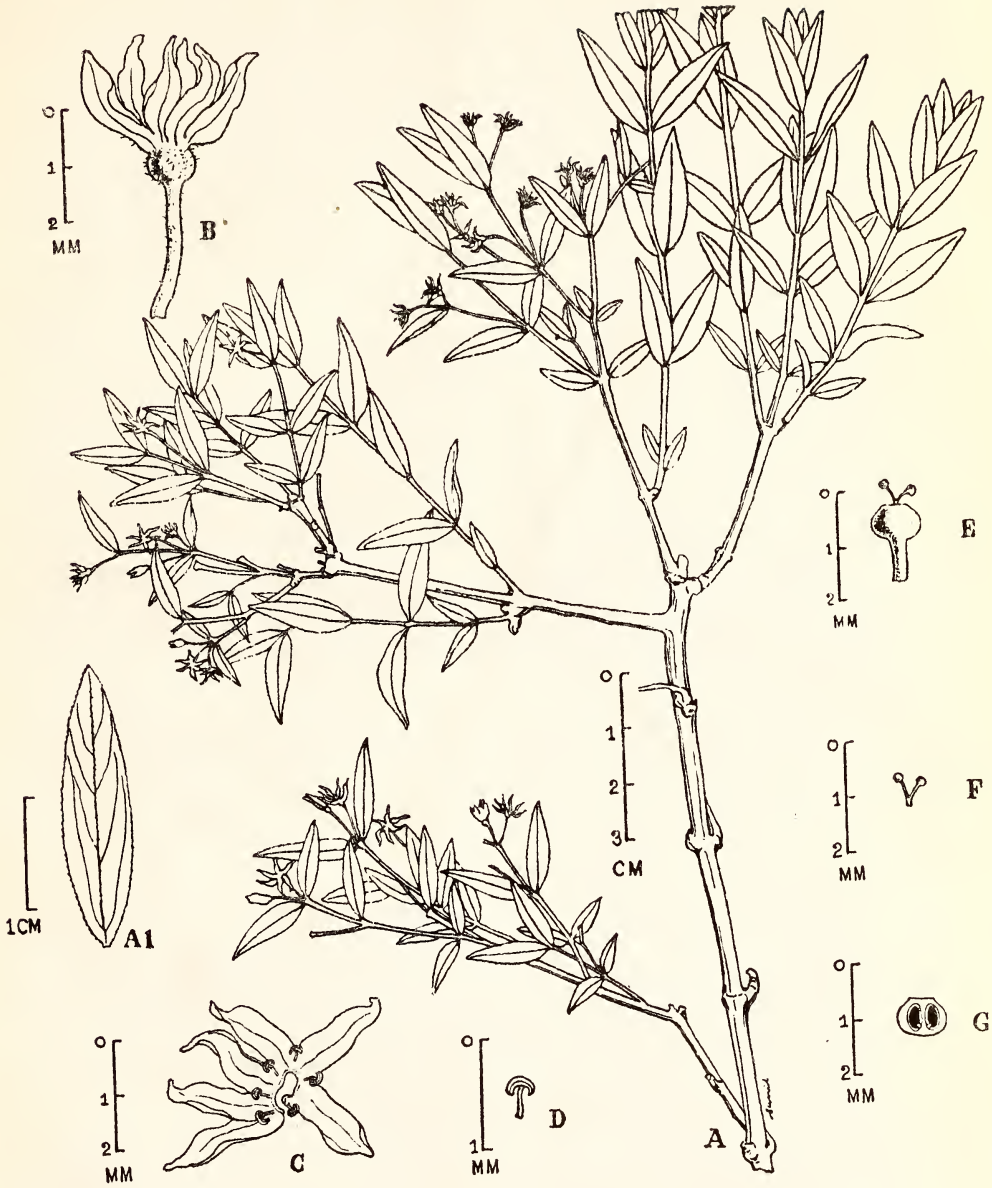
Undershrub 6-9 dm. in height, much branched; branches short, lower part of the stem woody, terete, bark scaly, young parts quadrangular; internodes very short. *Leaves* simple, 24-27×2·5-5 mm. sessile, elliptic-lanceolate, coriaceous, closely prickled at the margins, acute at the apex, attenuated at the base, pinnately nerved, nerves 4-5 obscure, prickly. *Inflorescence* axillary and terminal cymes; peduncles long, quadrangular, prickly. *Flowers* greenish-yellow, 5-6×3-3·5 mm.; pedicels 0·6-1 cm. long, quadrangular, thinly prickly. *Calyx* completely enclosing the ovary and adherent to it, prickly. *Corolla* gamopetalous, 4-5 mm. long, lobes 6 or 5, oblong or oblong-lanceolate, mucronate at the apex. *Stamens* 6 or 5, epipetalous, alternating with petals, free portion of the filaments 0·25-0·5 mm. long, anthers 0·5-0·75 mm. long; oblong, bilobed, dorsifixed. Disk annular, thin, around the basal portion of the style. *Pistil* bicarpellary, syncarpous; styles 2, 0·75-1 mm. long, united; stigma globose. Ovary 1·25-1·5×1·5-1·75 mm. 2 celled, ovule one in each cell, attached to the base of the septum.

Type, *J.E.T. Aitchison 338 A*, collected from Badgis, Afghanistan, on 29 April 1885 is preserved in Central National Herbarium (CAL); paratype, *J.E.T. Aitchison 338 B*, collected from the same place on 20 May 1885, is located in the herbarium, Forest Research Institute (DD).

2. **Rubia cordifolia** Linn. var. **cordifolia** f. **strigosa** Deb et Malick, f. nov. (Plate II).

Differt a forma typica foliis utrimque strigosis, praesertim secus nerves in pagina inferiore, caulibus et petiolis hispidis.

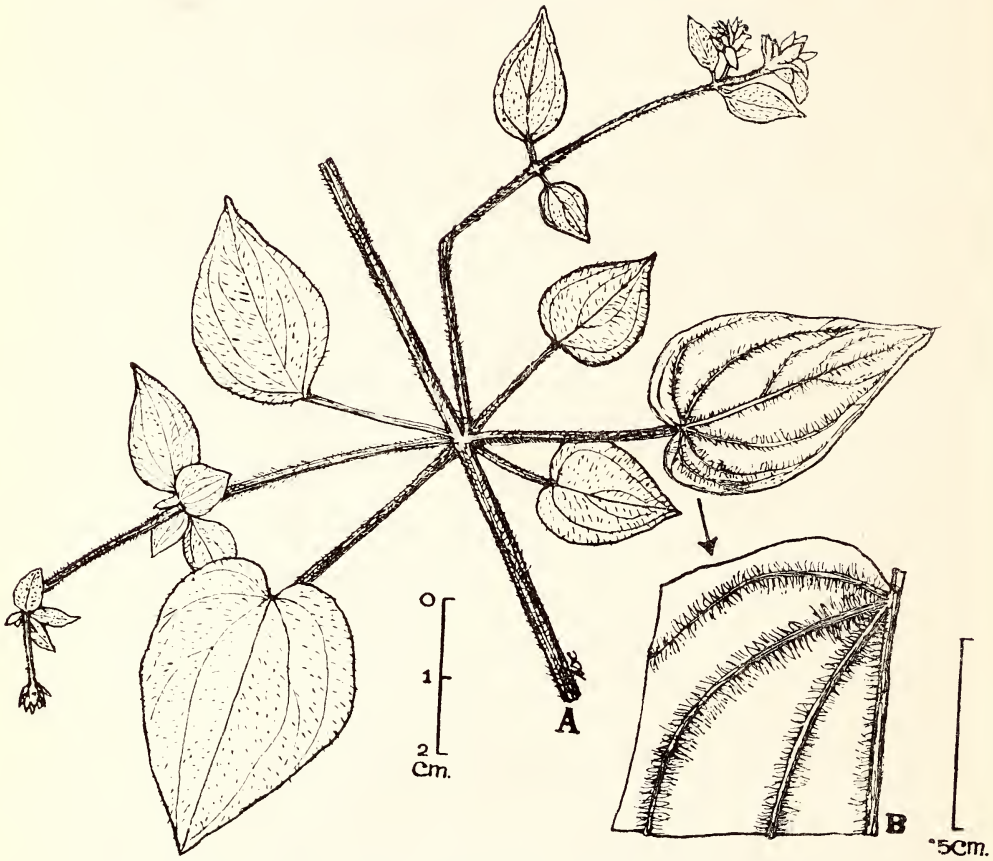
Deb : Genus *Rubia*



Rubia aitchisonii Deb et Malick, sp. nov.

A. portion of flowering twig ; A1. undersurface of the leaf ; B. flower ; C. corolla and stamens opened out ; D. stamen ; E. pistil ; F. style and stigma ; G. l. s. of ovary.

Deb : Genus *Rubia*



Rubia cordifolia Linn. var. *cordifolia* f. *strigosa* Deb et Malick, f. nov.

A. portion of branch ; B. undersurface of leaf.

This differs from the type in having the leaves strigose on both surfaces, more so along the veins underneath and also in hispid stem and petiole.

Type, *G. King 482 A-C* (CAL: A-holotype; B-C isotypes) collected from Taesieu Doom, Chumbi, Bhutan, on 17 June 1884; paratypes, *G. Panigrahi 16006 A & B* (A-CAL; B-ASSAM) collected from Jegaon to Poom, Kameng F.D., NEFA, on 21 May 1958.

Distribution: Bhutan and North East Frontier Agency.

3. **R. albicaulis** Boiss. var. **stenophylla** Boiss. f. **infundibularis** (Hemsl. & Lace) Deb et Malick, comb. et stat. nov.

Basionym: *R. infundibularis* Hemsl. & Lace in Journ. Linn. Soc. 28: 324. 1891; Parker, For. Fl. Punjab 283. 1918; Koe & Rechinger, Symb. Afgh. 4: 138. 1958; Kitam. Fl. Afgh. 369. 1960.

This is allied to *R. albicaulis* Boiss. var. *stenophylla* Boiss, differing from it in having slightly longer pedicels and slightly larger flower with longer style. Probably this is a long-styled form of the former. But the materials at our disposal are not sufficient to prove the phenomenon conclusively. That is why it is reduced and retained at the status of a form, instead of merging it outright with the type.

Type, *J. H. Lace 3945, 3870,* collected from Ziarat, Baluchistan and preserved in the Central National Herbarium (CAL) is designated here as Lectotype; *J. H. Lace 3945, 3870,* collected from the same locality is preserved in the industrial Section, Indian Museum, Calcutta.

Distribution: Afghanistan, West Pakistan, Baluchistan.

Acknowledgements

The authors record their deep gratitude to Rev. Dr. H. Santapau, S.J., F.N.I., Director, Botanical Survey of India, Calcutta, for Latin descriptions of the new taxa and suggestions to improve the manuscript. Thanks are also due to Sri Kedarnath, Officer-in-Charge, Botany Branch, Forest Research Institute, Dehra Dun, for sending the specimens of *Rubia* located there for our study.

Central National Herbarium, D. B. DEB
Calcutta, K. C. MALICK
June 4, 1966.

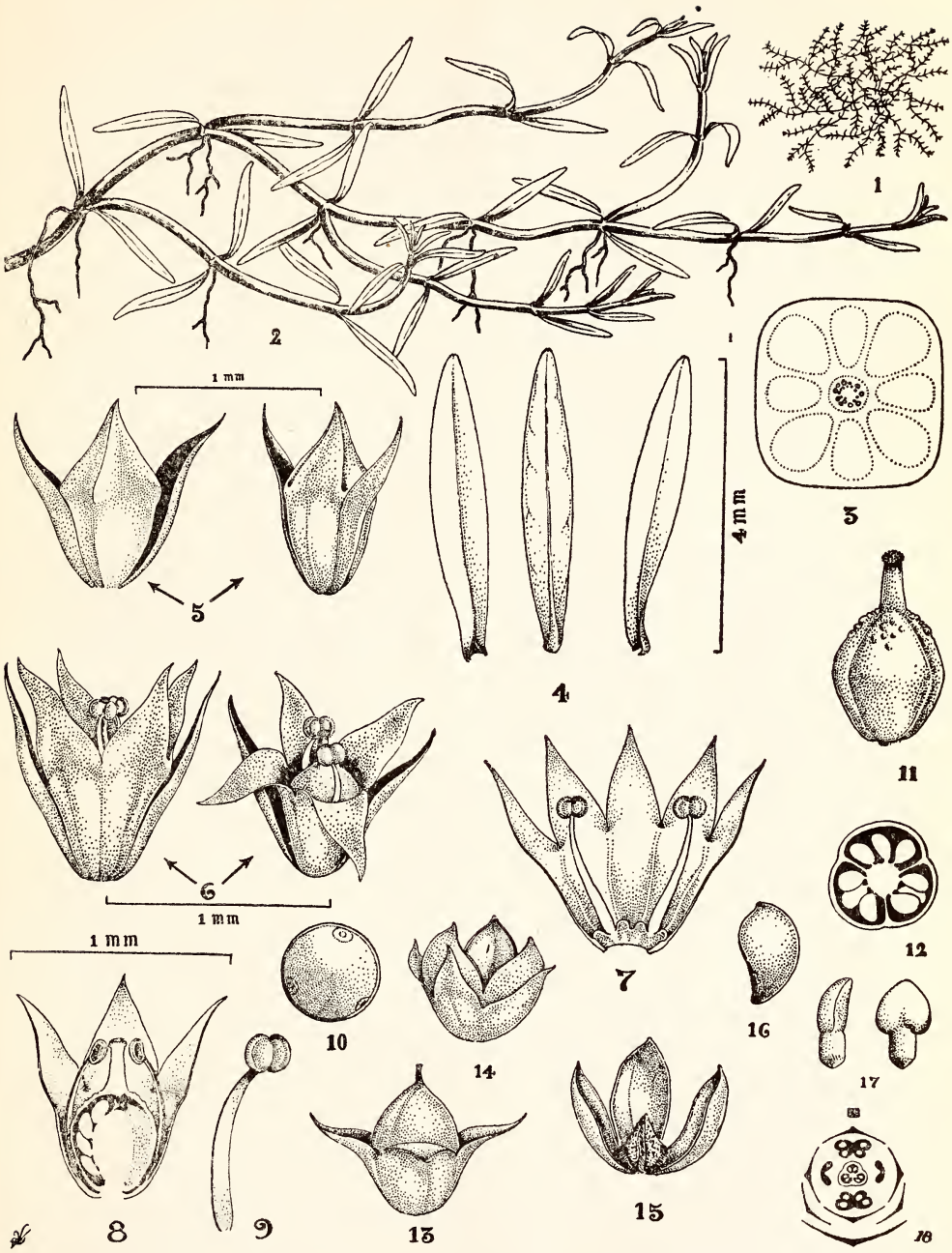
20. A NEW RECORD FOR *AMMANIA PYGMAEA* KURZ FROM SOUTH INDIA

(*With a plate*)

Ammania pygmaea Kurz described by C. B. Clarke in J. D. Hooker's FLORA OF BRITISH INDIA 2: 568, has been recorded from different places in north India, such as Chota Nagpur, Khasia Mts., Rajamahal Hills, and Botanical Gardens, Calcutta. In peninsular India, it has not been recorded south of N. Kanara. The following description and sketches are based on fresh specimens of this species collected in September 1963, from Palghat, Kerala State, and identified through Kew Herbarium.

Ammania pygmaea Kurz

Very small, delicate, prostrate, annual herb (fig. 1); spreading as pinkish-green felt, to a diameter of 2-5 cm. on water-soaked soil, or as grass-green patch, 6-10 cm. in diameter, in very shallow water in paddy fields. *Stem* slender, pinkish or greenish, profusely branched, rooted at nodes, with 4-angled internodes about 5 mm. long (fig. 2). *Leaves* simple, sessile, opposite decussate, exstipulate, about 5 mm. long, less than 1 mm. broad, linear-oblong; base concave, pinkish, with minute, lateral, purple, gland-like outgrowths; midrib pale pink, linear, ending in a pink dot at the minutely truncate apex of lamina and slightly raised on lower surface; venation reticulate, indistinct (fig. 4). *Flowers* solitary, axillary, sessile, about 1 mm. long, bracteolate, hermaphrodite, actinomorphic, perigynous; *bracteoles* two, lateral, subulate, pinkish, as long as sepals or slightly shorter (figs. 5, 6). *Calyx* of 4 free, triangular, acute, pink, valvate sepals, arising from the rim of pinkish hypanthium without accessory teeth or prominent ridges (fig. 7). *Corolla* absent. *Androecium* of 2 free stamens arising from near the base of hypanthium, shorter than sepals, equal to the level of and bending towards the stigma; filaments white, subulate; anther short, white, 2-lobed, 4-celled, lobes semi-circular, introrse (fig. 9). *Pollen* minute, white, spherical, smooth, thin-walled, with three, circular, convex germpores (fig. 10). *Staminodes* two, minute, pink, equally or unequally bilobed, alternating with filaments (fig. 7). *Gynoecium* superior; *ovary* inconspicuously trilobed, rarely bilobed about 0.5 mm. long (figs. 11, 12), white or pinkish, often with wart-like epidermal cells near top; imperfectly trilocular, rarely bilocular, with



Ammania pygmaea Kurz

Fig. 1, Habit, diagrammatic ; Fig. 2, Branch ; Fig. 3, C. S. of stem, diagrammatic ; Fig. 4, Leaves ; Figs. 5-6, Flowers, bud and open ; Fig. 7, Hypanthium—opened ; Fig. 8, V. S. of flower ; Fig. 9, Stamen ; Fig. 10, Pollen ; Fig. 11, Gynoecium ; Fig. 12, C. S. of ovary ; Figs. 13-14-15, Fruit ; entire and opened ; Fig. 16, Seed; Fig. 17, Embryo, side and surface view ; Fig. 18, Floral diagram.

few anatropous, ascending ovules on swollen, axile placenta; *style* short, columnar, with pinkish or greenish, microscopically papillose, capitate stigma. *Fruit* about 1 mm. long, slightly exserted from dried up calyx, pinkish, splitting septicidally into three, rarely two, valves separating from the central placenta (figs. 13, 14, 15). *Seeds* about 12-15 per fruit, nearly obovate, dorsal side convex, ventral side caved in, light amber coloured, smooth, shining, non-endospermous (fig. 16). Testa brittle; embryo white, slightly bent; cotyledons two, fleshy, nearly circular; radicle obtuse (fig. 17).

Note: Presence of staminodes is a feature which this species shares with some species of *Rotala* and the allied *Hydrolithrum*; but reduction in number of stamens is not very common in related species. This reduction is not a disadvantage to the plant, as the bending of filaments brings the anthers in contact with stigma and ensures self-pollination. Plants being very small and prostrate, and flowers inconspicuous, neither wind nor insects could be of much help in pollination. But proximity of anthers to stigma ensures self-pollination, by direct contact or even through capillary water.

Plants have been collected from two localities, about 40 km. apart. Only a few plants were seen at both places. At Palghat, they appeared exactly in the same spot, in a garden, in successive years. It was noted that plants reached flowering stage within a fortnight. But in spite of this quickness of growth and high viability of seeds which lie dormant in very dry soil for the major part of the year, the plant has poor competitive qualities. In both localities, plants were found on open soil only. Thorough search of the weeded area around did not reveal more plants. It seems that this species, though managing to survive, is incapable of competing with other species and getting distributed amidst them.

ACKNOWLEDGEMENT

We are very thankful to the Director of Royal Botanic Gardens, Kew, England, for confirming our identification of the species.

GOVT. COLLEGE,
PALGHAT,
October 10, 1965.

R. VASUDEVAN
V. P. K. NAMBIAR

21. A FEW ADDITIONS TO THE FLORA OF PAVAGADH

The flora of Pavagadh hill, Gujarat State, has attracted the attention of a number of botanists. Many papers have so far been published. Very recently, Shah & Inamdar published their 'Further contribution to the Flora of Pavagadh near Baroda, Gujarat' (*J. Bombay nat. Hist. Soc.* **62**: 279-284) based on a day's field work in the area.

A further exploration of the area has revealed the presence of the following plants, which have escaped the notice of earlier workers.

Cleome chelidonii Linn. f.
Noted on the banks of a pond near Machi.
Bedi 3965, 3966; 20-10-64.

Desmodium neomexicanum A. Gray
Bedi 3868, 3869, 3879; 20-10-64.

Atylosia scarabaeoides Benth.
Noted along a path and as a forest undergrowth near Machi.
Bedi 3955, 3956; 20-10-64.

Lobelia heyneana Roem. & Schult.
Along the track leading to Machi.
Bedi 3986, 3987; 20-10-64.

Anisochilus eriocephalus Benth.
Bedi 3907, 3908; 20-10-64.

Cyperus squarrosus Linn.
On loose, gravelly soil at the foot of hills.
Sabnis 180; 22-8-58.

Cyperus esculentus Linn.
On banks of temporary puddles in the plain at the foot of the hill; not very common.
Sabnis 184; 27-8-58.

Cyperus iria Linn.
Sabnis 181, 182; 22-8-58.

Fimbristylis dichotoma (Linn.) Vahl
On the banks of streams in the forest at the foot of the hill.
Sabnis; 27-8-58.

DEPARTMENT OF BOTANY,
M.S. UNIVERSITY OF BARODA,
BARODA-2,
August 15, 1966.

A. R. CHAVAN
S. J. BEDI
S. D. SABNIS

Gleanings

Observations on the Spotted Hyena (*Crocuta crocuta* Erxleben)

In an *ad interim* report on observations on Spotted Hyenas (*Crocuta crocuta*) made as part of the Serengeti Research Project, H. Kruuk dispels the generally held belief that hyenas are primarily scavengers and, at best, kill only weak or young prey. Of 1082 hyenas observed feeding, 82% were eating hyena-killed prey and the evidence so far obtained points to most of the prey being animals in good health. In fact, there is good evidence that the lion population in the Ngorongoro Crater live largely on prey killed by hyenas. It was found that in the day the proportion of hyenas feeding on non-hyena-killed prey is greater than at night. This may have given rise to the popular belief.

He estimates the hyena population of the Ngorongoro Crater (area 100 square miles) at about 420 adults and finds that it is arranged in eight 'clans', each of 10-100 adults. Each clan has its 'range' with, usually, one communal den-site. It feeds within the limits of the home-range and defends it against intrusions by members of other clans. Males may wander beyond the range limit, but the females seem to confine themselves to it.

While the clan system occurs in the larger area of the Serengeti Plains (7,000 square miles), there is also a considerable migratory population which follows the wildebeest (*Connochaetes taurinus*) herds in their annual wanderings. Further, there is evidence of the existence of a third category, the 'commuters', who have their dens in one place throughout the year and from there make excursions, sometimes lasting several weeks and covering as much as fifty miles out, to areas where the wildebeest are to be found.

H. Kruuk: Clan-system and Feeding Habits of Spotted Hyenas (*Crocuta crocuta* Erxleben). *Nature*, 19 March 1966. Vol. **209**, pp. 1257-58.

Roadside Survey of Rhesus Monkeys in West Bengal

In a survey of Uttar Pradesh, the majority (406/638) of rhesus groups were found by observers (three, one of them driving) who moved along roads by motor car. In a similar survey (three observers and one professional driver) of the major areas of West Bengal

covering 1451 miles of road, only 9 monkey groups were seen, about 1 in 160 miles against an average of 1 in 10 miles in U.P. The difference in results was probably attributable to the difference in roadside habitats, W. Bengal with its moister climate having more extensive roadside vegetation than U.P. Roads passing through dense vegetation or hilly areas are not suitable for roadside survey. With further information acquired by forest hikes and verbal enquiry from knowledgeable persons the opinion is expressed that rhesus monkeys were formerly more abundant in W. Bengal and that the main rhesus populations have been driven to the forests, the last refugium in this area of dense human population.

1964, Charles H. Southwick, Ajoy Ghosh and Charles D. Louch *J. of Mammalogy* **45** (3): 443.

The Hagfish (see Text-figure on the opposite page)

The worm-like Hagfish, of which some twenty-four species occur on the ocean bottom in the temperate latitudes, is an animal of amazing flexibility. It can tie itself in a knot, and come untied by crawling through it. This capacity is useful in three several ways. It furnishes the purchase necessary for tugging at tough food. Aided by a defensive coat of slippery slime, it enables the hagfish to slip through the grasp of an enemy. And finally, when the slime becomes an encumbrance that interferes with comfortable breathing, it wipes off the slime by passing the body through a knot. There are other peculiarities, such as one nostril, four hearts, no jaws, no stomach. The method of reproduction remains a mystery though, as long ago as 1864, a prize was offered by the Copenhagen Academy of Science for its solution. An interesting account of a Pacific Ocean species, *Eptatretus stoutii*, appears in the *Scientific American*.

David Jensen, in *Scientific American*, February 1966.

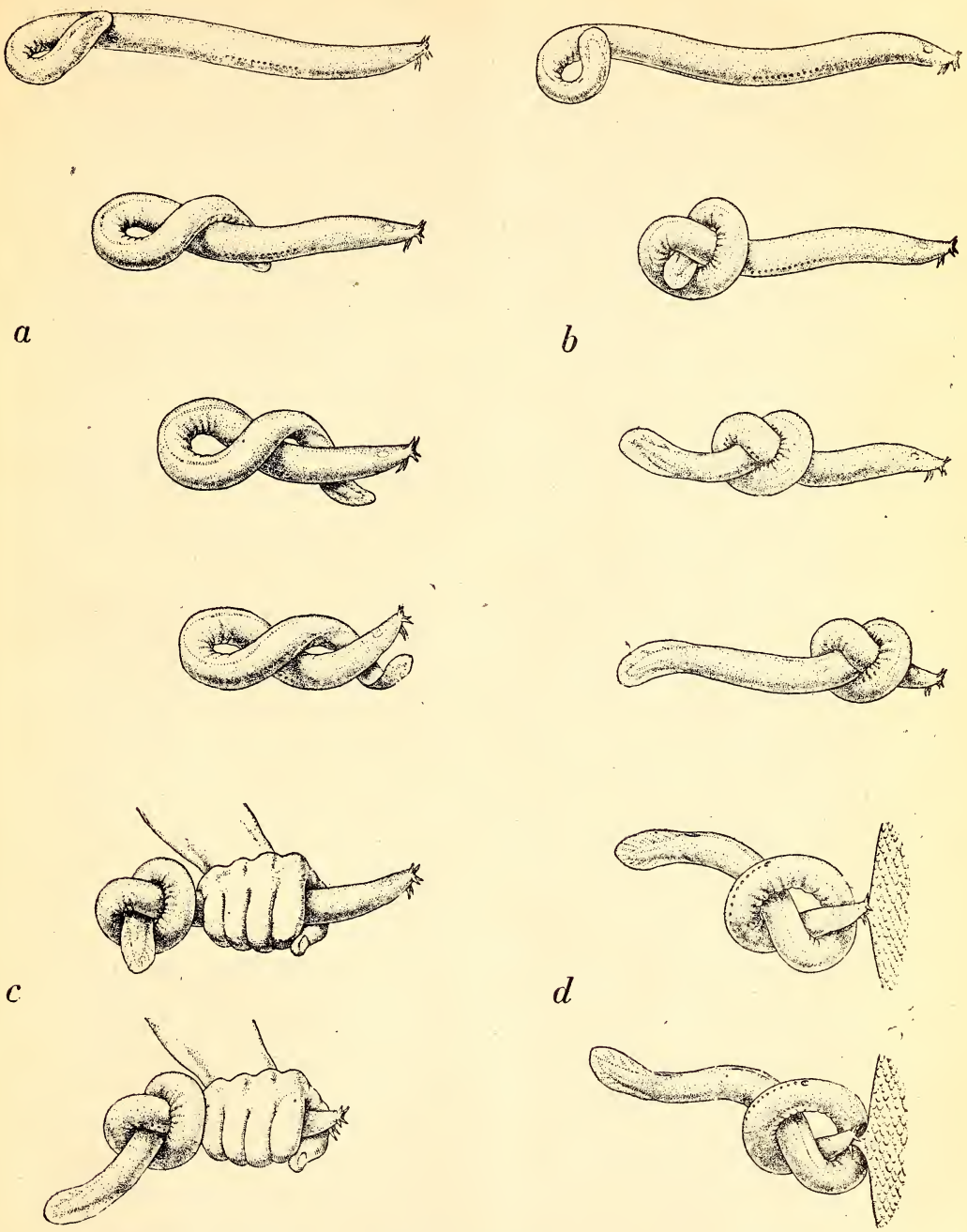
Sooty Tern (*Sterna fuscata*) 150 miles inland

G. Harrison records the recovery on 21 April 1966 of a Sooty Tern (*Sterna fuscata*) exhausted to the point of death, at Lujeri in the Mlanje District, Malawi *c.* 16·00 S. 35·45 E. The bird appears to have been blown there by strong winds.

G. Harrison: A Sooty Tern *Sterna fuscata* in Malawi. November 1966, *Bulletin of the British Ornithologists' Club*, Vol. **86**, No. 8, p. 160.

Identification of hair and feathers in the gut and faeces of carnivores

A short note by Messrs. D. R. Patil and P. N. Chaudhari in our issue for December 1965 glances at the possibility of using differences



The Hagfish

a. The hagfish can curl itself into odd configurations ; *b.* It removes slime from its body by passing itself through a knot ; *c.* It uses this movement to escape capture ; and *d.* to obtain the purchase necessary to tug at tough food.

Courtesy : David Jensen, and the Editor, *Scientific American*

in the structure and pigmentation of bat hair for determining its origin. In *Journal of Zoology* Mr. M. G. Day tells how he tackled a similar problem when analyzing the gut and faeces contents of stoats and weasels, Britain's smallest carnivores. The principal contents were fragments of mammalian hair and bird feathers bones and teeth if present were usually too small for identification. A key for the identification of the hair to genus level was worked out by examining hair from mammals likely to form the prey of these predators. It was based on cortical scale pattern, type of medulla, and cross-section shape. The feathers found were usually the bases of the coverts. The diagnostic features of barbules in this portion, namely the size, shape, and distribution of the nodes, were found to be unaffected by digestion and weathering; they formed the basis of a key for identification down to the main bird orders.

M. G. Day: Identification of hair and feather remains in the gut and faeces of stoats and weasels. *Journal of Zoology*, February 1966, Vol. **148**, pp. 201-217.

Breeding cycle in rabbit fleas

In *Scientific American*, Miriam Rothschild describes how rabbit fleas have geared their reproductive cycle to that of their hosts. The fleas are normally attached to the ears of the rabbits and, unless the host becomes pregnant or they transfer to a pregnant female or one with new-born young, they will neither mature nor mate. The temperature of rabbits' ears rises during mating; this excites the fleas on both rabbits and they can be seen hopping back and forth between the mating pair. In female rabbits ovulation follows mating and within a few hours sex hormones are released into the blood. This is the signal for the fleas to attach themselves firmly to the skin of the doe. Ten days before the young rabbits are born there is a rise in the level of corticosteroids in the blood of the expectant mother. It is at this stage that the eggs of the fleas begin to develop. By the end of the hosts' pregnancy the flea eggs are ripe. The fleas also defecate at shorter intervals, and the dried blood-spots later provide the iron essential for the development of the flea larvae. From the mothers the fleas migrate onto the young. It has been shown that the same corticosteroids as in the mothers are present at high levels in one- to seven-day old rabbits. They also have high levels of 'growth hormone', somatotropin. The fleas feed voraciously on the baby rabbits, mate, and lay eggs in the nest. After about 12 days they return to the mother. When she becomes pregnant again a new cycle begins.

All fleas do not show similar breeding cycles; the rat flea for instance is not dependent on its host's hormones. But many cycles remain to be investigated, and it seems unlikely that this is an unique vertebrate host-insect parasite relationship.

Miriam Rothschild: in *Scientific American*, **213** (6) December 1965, pp. 44-53.

Tamarisk trees as a protection against forest fires

The cutting of fire lines, i.e. strips cleared of combustible material, is the ordinary protection against forest fires. This has two great disadvantages. Firstly, it is costly as the lines have to be cleared annually. Secondly, it removes soil-binding vegetation. Y. Waisel & J. Friedman of the Department of Botany, Tel-Aviv University, therefore, suggest as an alternative the growing of protective lines of *Tamarix* trees, the litter of which has a high mineral content and is saturated with the salty drip from the trees, with the result that it ignites with difficulty and, even when it is lit under laboratory conditions, the flame does not spread and dies out almost immediately after the removal of the source of ignition. The authors note that *Tamarix* trees are to be found in a large variety of regions, and are easy to grow and rapid in growth.

Y. Waisel & J. Friedman: The use of tamarisk trees for the restriction of fires. *La'yaaran*, Vol. **15**, No. 3, September 1965.

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