THE WILSON BULLETIN

A Quarterly Magazine
of
Ornithology

GEORGE A. HALL
EDITOR

ORNITHOLOGICAL LITERATURE EDITOR
PETER STETTENHEIM

Volume 85
1973

Published
by
THE WILSON ORNITHOLOGICAL SOCIETY

-W

The Wilson Bulletin

PUBLISHED BY THE WILSON ORNITHOLOGICAL SOCIETY
WEST VIRGINIA U. · MORGANTOWN, W. VA.

VOL. 85, NO. 1 MARCH 1973 PAGES 1–112

THE WILSON ORNITHOLOGICAL SOCIETY

FOUNDED DECEMBER 3, 1888

Named after ALEXANDER WILSON, the first American Ornithologist.

President—Pershing B. Hofslund, Dept. of Biology, University of Minnesota Duluth, Duluth, Minnesota 55812.

First Vice-President—Kenneth C. Parkes, Carnegie Museum, Pittsburgh, Pennsylvania 15213.

Second Vice-President—Andrew J. Berger, Dept. of Zoology, University of Hawaii, Honolulu, Hawaii 96822.

Secretary—James Tate, Jr., Laboratory of Ornithology, Cornell University, Ithaca, New York 14850.

Treasurer—William A. Klamm, 2140 Lewis Drive, Lakewood, Ohio 44107.

Elected Council Members—Elden W. Martin (term expires 1973); Robert D. Burns (term expires 1974); Harvey I. Fisher (term expires 1975).

Membership dues per calendar year are: Active, $8.00; Sustaining, $15.00; Life memberships, $200 (payable in four installments).

THE WILSON BULLETIN is sent to all members not in arrears for dues.

THE JOSSELYN VAN TYNE MEMORIAL LIBRARY

The Josselyn Van Tyne Memorial Library of the Wilson Ornithological Society, housed in the University of Michigan Museum of Zoology, was established in concurrence with the University of Michigan in 1930. Until 1947 the Library was maintained entirely by gifts and bequests of books, reprints, and ornithological magazines from members and friends of the Society. Now two members have generously established a fund for the purchase of new books; members and friends are invited to maintain the fund by regular contribution, thus making available to all Society members the more important new books on ornithology and related subjects. The fund will be administered by the Library Committee, which will be happy to receive suggestions on the choice of new books to be added to the Library. William A. Lunk, University Museums, University of Michigan, is Chairman of the Committee. The Library currently receives 104 periodicals as gifts and in exchange for *The Wilson Bulletin.* With the usual exception of rare books, any item in the Library may be borrowed by members of the Society and will be sent prepaid (by the University of Michigan) to any address in the United States, its possessions, or Canada. Return postage is paid by the borrower. Inquiries and requests by borrowers, as well as gifts of books, pamphlets, reprints, and magazines, should be addressed to "The Josselyn Van Tyne Memorial Library, University of Michigan Museum of Zoology, Ann Arbor, Michigan." Contributions to the New Book Fund should be sent to the Treasurer (small sums in stamps are acceptable). A complete index of the Library's holdings was printed in the September 1952 issue of *The Wilson Bulletin* and newly acquired books are listed periodically.

THE WILSON BULLETIN

The official organ of the Wilson Ornithological Society, published quarterly, in March, June, September, and December, at Morgantown, West Virginia. The subscription price, both in the United States and elsewhere, is $10.00 per year. Single copies, $2.50. Subscriptions, changes of address and claims for undelivered copies should be sent to the Treasurer. Most back issues of the *Bulletin* are available (at $2.50 each) and may be ordered from the Treasurer. Special prices will be quoted for quantity orders.

All articles and communications for publications, books and publications for reviews should be addressed to the Editor. Exchanges should be addressed to The Josselyn Van Tyne Memorial Library, Museum of Zoology, Ann Arbor, Michigan.

Second class postage at Lawrence, Kansas, U.S.A. 66044

PRINTED IN U.S.A. Allen Press, Inc., Lawrence, Kansas 66044

THE WILSON BULLETIN

A QUARTERLY MAGAZINE OF ORNITHOLOGY
Published by The Wilson Ornithological Society

Vol. 85, No. 1 March 1973 Pages 1–112

CONTENTS

General Notes

DEDICATION

Volume 85 of *The Wilson Bulletin* is dedicated to Charles H. Rogers and Alexander Wetmore who in 1973 will have completed 70 years of membership in The Wilson Ornithological Society.

Male Okinawa Woodpecker. Painting by Albert Earl Gilbert.

HABITS, RELATIONSHIPS, AND CONSERVATION OF THE OKINAWA WOODPECKER

LESTER L. SHORT

THE Okinawa Woodpecker (*Sapheopipo noguchii*) or Noguchigera as it is known in Okinawa and Japan, has long interested me because of problems concerning its relationships (Yamashina, 1941; Hachisuka and Udagawa, 1953; Goodwin, 1968; Short, 1969), and because it has been considered rare for several decades (Yamashina, op. cit.). It is little known, and some reported information (e.g., the view that the woodpecker may be crepuscular, Hachisuka and Udagawa, 1953: 212) is misleading or erroneous. I made a brief visit to Okinawa from 3 to 9 February 1972. Proceeding to the inland wooded hills in the northern part of the island, I spent five days seeking the Okinawa Woodpecker. Despite almost constant rain the visit proved fruitful, for I observed the Okinawa Woodpecker, assessed the availability of its habitat, and noted (Short, In press) other woodland birds. These observations offer limited information, but are supplemented by information from local inhabitants, from locally produced movies depicting nesting and other habits, and from abundant evidence of foraging activity by the woodpeckers (see below).

Okinawa, situated at 128° E, 26° 30′ N, marks the southern end of the continuous chain of northern and middle Ryukyu Islands, all within 80 km or less of one another, extending northward the 540 km to Japan (Kyushu, the southernmost main island). Okinawa extends 100 km from southwest to northeast, and averages only 11 km (3 to 29 km) wide. Its 1175 km^2 area is about equally divided between the relatively flat, densely populated southern section, and, connected by a narrow "waist," the hilly, sparsely inhabited northern section. Virtually all the remaining forests on the island are found in the north, inland from the coast except at the extreme north end, near Hedo (where Mount Hedo, 248 m, is situated). The extant undisturbed (Fig. 1) forest probably amounts to no more than 1500 ha, distributed on five mountains (Yonaha, 498 m; Ibu, 354 m; Iyu, 449 m; Nichime, 420 m; and Hedo), and in tiny patches interspersed, often on steep slopes, in second-growth forests and cleared areas in the hills connecting these mountains. The Okinawa Woodpecker is confined to the discontinuous undisturbed forest patches.

This report is offered in the hope that it will contribute to the preservation of this distinctive woodpecker, the total population of which I estimate to be 20 to an unlikely maximum of 60 pairs. Some of the comparative information concerning other genera of woodpeckers is drawn from results

Fig. 1. Forest habitat of Okinawa Woodpecker on upper slopes of Yonaha Mountain, elevation 440 m. Except for sporadic wood-cutting and wood-gathering, the forest is natural, and comprises part of the small Yonaha Mountain Preserve. Picture taken 8 February 1972.

of field studies of species representing all but two genera (West Indian *Xiphidiopicus, Nesoctites*) of the Picidae. Published information is cited below, but results of my 1972 Asian woodpecker studies are in the preliminary stage of preparation for publication.

LIFE HISTORY

About 23 cm in length, the Okinawa Woodpecker in the field appears dark brown with a pale yellow bill which is conspicuous even in the dense, dark understory of the forest it inhabits. At close range under favorable light conditions an observer notices several small white marks (bars) in the outer primaries, and its dull reddish back (and crown of the male; females have a brown crown). Its calls, described below, and its habit of wing-flicking when calling attract attention to it. The Okinawa Woodpeckers that I saw reminded me of a dark, pale-billed Gray-headed Woodpecker (*Picus canus*). At least five and possibly as many as eight individuals were observed, one in the area southwest of Mount Ibu on 5 February, and the others on the slopes of Yonaha Mountain on 6 to 8 February.

FIG. 2. Workings of Okinawa Woodpecker. A well-hacked limb of a live tree in which a male had been foraging.

Foraging Sites.—The Okinawa Woodpecker forages mainly near the ground in various dead or live trees and bamboos, in stubs, and on moss-draped fallen logs and debris littering the forest floor. It does not feed on the ground in the manner of the ant-foraging flickers (*Colaptes* spp.) or Green Woodpecker (*Picus viridis*), but frequents the bases of trees and stubs, and hops about on fallen logs, and debris amid dense low bushes. Occasionally it perches on the ground, or hops across a small area of open ground near logs, to gain a more favorable position for feeding. In areas occupied by the Okinawa Woodpecker numerous dead stubs are encountered, bearing deep, pitted excavations as large as 3 to 4 cm long and 1 to 4 cm wide (Fig. 2). Over 90 percent of these workings are within 5 m of the ground. The tiny Japanese Pygmy Woodpecker (*Picoides kizuki*), which I did not observe on Okinawa, is the only other picid on the island, and it could not be responsible for such large excavations (see Foraging Modes). The foraging sites of *Sapheopipo noguchii* clearly indicate its dependence upon the diminishing, undisturbed natural forest of Okinawa, that is, moist forest (Fig. 1) with large trees (some dying, providing foraging and nesting sites), accumulated fallen trees, branches and other debris, and undergrowth.

Foraging Modes.—Foraging of the Okinawa Woodpecker during early

February, 1972, was by excavating, tapping, probing, and flicking aside of rotten wood (see Short, 1970, for terminology). Rotting stubs, logs, and even rotten sticks 2 or 3 cm in diameter lying on the ground are used, and if the wood is well rotted it literally is hacked apart leaving (on logs or the ground) a mound of loose wood particles. The gouges in rotten stubs mentioned above are obvious signs of the Okinawa Woodpecker's excavating habits, but it chisels smaller circular or rectangular holes in live trees and bamboos. Observations at other times of the year are needed, but the numerous workings observed indicate that the foraging modes described here are those generally used throughout the year. An excavating bird directs its bill toward the bark, moderately spreads and appresses its rectrices, and with great force delivers blows with the bill straight downward or laterally at an angle. The noise thus produced is less than might be expected, probably because the rotten wood is moist (rain fell during all but two periods of observation) and soft. At times several taps or even a single peck yielded an item of food (only cicadas have been cited as its food by Yamashina, 1941, but various boring insects probably comprise most of its diet), but extensive excavating often was necessary. Occasionally the woodpeckers probed the bill into rotting wood or crevices in the bark of trees. Bursts of bill movements effectively like digging were noted when a bird foraged on very rotten logs; already broken wood is scattered about by lateral or backward swipes of the bill. This method also is employed in piles of mosses and debris at the bases of vines and bushes, where I observed individuals foraging for up to 45 minutes, probing, excavating, and "digging." One male flushed from the undergrowth then flew to a stub and foraged by probing and excavating for one-half hour there and at two nearby stubs, all between 2 and 4 m above the ground. I watched several birds carve deep, pitted excavations in less rotten wood below such stubs. The preference of the Okinawa Woodpecker for rotten wood suggests that the health of live trees and stage of disintegration of dead trees are of greater significance to foraging woodpeckers than is the species of tree represented. I did note, however, that they shunned coniferous trees, although most conifers accessible to the Okinawa Woodpecker in the area visited were exotic, plantation trees. The foraging modes and sites, and the general deportment of the Okinawa Woodpecker while foraging are very like those of the Southeast Asian *Blythipicus rubiginosus*, although the latter forages much less frequently on small logs or debris actually on the ground (pers. obs.).

Long Call.—I was fortunate to hear ten distant Long Calls (see Short, 1970) of this woodpecker. Only one call was tape-recorded and that too poorly to illustrate herein. The individual notes are clear, whistled *pee* notes closely resembling those in the comparable call of *Picus viridis*, *P. canus*, *Blythipicus rubiginosus,* and *B. pyrrhotis* (pers. obs.). The call is characterized by an irregular delivery of notes, which were rendered at rates of 5 to 12 notes per sec, varying even within the same call. One call continued with pauses for 6 sec. Notes are from 2.8 to 3.2 kHz in frequency with little variation within an individual call. The comparable call of *Picus viridis* is of lower frequency (1.5 to 2.2 kHz), and the irregularly delivered notes are rendered in short series. The similar-sounding but longer notes of the Long Call of *Blythipicus rubiginosus* descend progressively (as do those of *B. pyrrhotis*) from about 3.2 to 2.8 kHz within an individual call, and the series are not as long as those of *Sapheopipo noguchii.* The Long Call presumably is the territorial "song" of the species, and at the time of my visit (prior to the breeding season) it was heard much less than was drumming, which may overlap functionally with Long Calls.

Call Notes.—I heard two distinct one-note calls, which probably vary in function (localization call, alarm call, other agonistic function?). Neither was tape-recorded in the field, but I was able to copy on tape some examples of both calls from the soundtrack of a motion picture, through the kindness of Mr. Katsu Moriguchi. The movie depicted an adult Okinawa Woodpecker feeding young at a nest in 1971 (the forest at the nest site has since been cleared!). One call note is a sharp, whistled *whit* (Fig. 3), rendered when the bird appears disturbed by the close approach of an observer. The Whit Call is a high-peaked, mechanical note, appearing on a sonagram as an inverted U, but with a carry-over beyond the U. Its main frequency range is between 2 and 4 kHz, but a faint component peaks above 8 kHz. The note is 0.15 to 0.20 sec in duration. These calls resemble closely the Pit Call of *Blythipicus rubiginosus,* and *Picus canus* also has a similar call (pers. obs.). The second call, heard more commonly than the Whit Call in February, is a variable Kup Call, rendered *Kyu-kyu*; *Kup, kup, kup*; and *Kyu-kyu-kup* in my notes. A call sounding like this was copied on tape from the film soundtrack, and analysis shows it to consist of a single note, or a series of notes individually appearing on a sonagram much like a Whit Call note but without an extension beyond the inverted U. These notes also are loudest at a higher frequency (3 to 4 kHz) than the Whit notes. The Kup Call closely resembles, and may be a ritualized development of the nestling Pip Call (see below). Compared with a Pip Call note, a Kup note is louder, more intense overall but especially at a higher frequency (3 to 4 kHz versus 2.5 kHz in Pip notes), and the notes are delivered irregularly in short series or singly, rather than regularly in long series as are the Pip notes of nestling Okinawa Woodpeckers. *Gecinulus viridis* and *Blythipicus pyrrhotis* give series of notes similar to Kup notes, but the intensity of the notes is great in higher

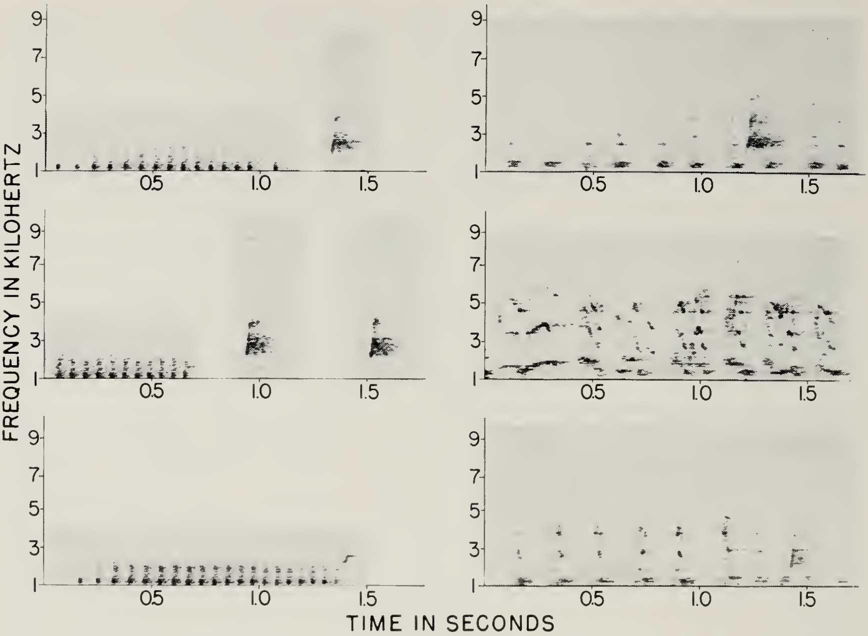


FIG. 3. Sonagrams of some vocalizations and instrumental signals of the Okinawa Woodpecker. Upper left: the shortest of the long or usual drumming bursts (note temporal variation of initial and terminal elements), followed by a Whit Call note. Center left: a short drumming burst, followed by two Whit Call notes. Lower left: a typical long drumming burst. Upper right: weak nestling Pip Call with adult Whit Call appearing (taller note) toward the end. Center right: nestling Kyaa Call (see the paired tendency of the elements, and variation from note to note). Lower right: Kup Call series with low Whit Call (last tall note); the next to last tall note is somewhat intermediate between a Kup and a Whit note (compare Kup Call with nestling Pip Call, upper right). All right sonagrams made from vocalizations in soundtrack of movie by K. Moriguchi. Sonagrams were made using narrow band filter on Kay Electric Sound Spectrograph machine. Please note that drummings are at 0.5 kHz less than shown in the figure.

pitched harmonics rather than in the fundamental tone which is emphasized in the Kup Call of *Sapheopipo noguchii.*

Nestling Calls.—I was not present on Okinawa during the nesting season, but copies were made of vocalizations on the soundtrack of Mr. Moriguchi's movies of nesting Okinawa Woodpeckers (see above). These included a great number of nestling calls, permitting analysis of these vocalizations, which generally resemble those of nestling *Picus* sp., and are less complex than are the calls of nestling flickers (*Colaptes,* Short, 1972). Two distinct nestling calls (Fig. 3) recorded are the Kyaa Call and the Pip Call. The latter call seemingly is rendered at intervals, especially when the nestlings are agitated or sense the presence of an adult nearby. The Kyaa Call replaces the Pip Call when adults are in close proximity to the nestlings, and especially is uttered by the young as an adult approaches to feed them. The Pip Call consists of very uniform notes delivered in long series, and are uttered from very softly to very loudly. There is a distinct tendency, evident in most calls, for a pairing of notes within series, and the call may be called more accurately a Pip-pip Call. Each note with its harmonics covers a great frequency range (0 to 7 or more kHz), but the intensity is great only at about 2.5 kHz, and to a lesser extent at 1.2 kHz. Above 3 kHz the components are weak, and above 5 kHz they are extremely weak. The notes are rendered at from 6.8 to 7.6 per sec. Each note appears on a sonagram as a simple inverted U approximately 0.07 sec in duration. The Kyaa Call bears some resemblance to the Pip Call in that the notes basically have an inverted U shape, and they are repeated regularly in series, which may be short or long. However, the notes are usually paired, a pair effectively comprising a single component note of a series, and they are variably long notes. Even a component element of a double *Kyaa* note is twice the duration of a *Pip* note, and full double notes are as much as five times (0.35 sec) the duration of a *Pip* note. The fundamental at 1.2 to 2.0 kHz, and the first two harmonics are intense, and higher frequency harmonics are weaker. Some notes peak sharply over 1 kHz, with a slight drop between the elements of the double-notes; other, longer notes are more horizontal, showing a gradual rise to the highest frequency, but not a sharp peak. A few double notes have very sharp peaks, and it is the elements of these which, except for their higher frequency, most resemble *Pip* notes. Longer, horizontal *Kyaa* notes resemble notes of the Long Call of *Blythipicus* sp., and *Pip* notes resemble single note calls of *Picus canus*, and notes occurring in series of *Blythipicus pyrrhotis*, *B. rubiginosus*, and *Gecinulus viridis*.

Drumming.—This instrumental signal was heard intermittently, mainly between 07:00 and 09:00. Up to three bursts per minute, continued for five minutes were heard on the mornings of 7 and 8 February. Such drumming bouts followed periods of 10 to 30 minutes without drumming. Drumming consisted of short bursts of 7 to 14 individual taps, and long bursts of 15 to 21 notes. Seven recorded short bursts (Fig. 3) of drumming lasted 0.40 to 0.87 sec, averaging 0.629 sec. With an average of 10.43 taps per instance of drumming the short drumming bouts were delivered at a rate of 14.5 to 18 notes per sec, varying from bout to bout but being quite regular within a bout. Long drumming episodes (Fig. 3) proved more regular from instance to instance (16 recorded long drumming bouts lasted 1.00 to 1.22 sec, averaging 1.11 sec, and they averaged 17.6 notes per bout delivered at a rate of 15.45 to 17.21 taps per sec). However, within a long burst of drumming the first two to six notes usually were delivered at a slower rate than those notes following them. Occasionally there was a similar slowdown in the last two or three notes, and, in two cases there was a break of 0.08 to 0.1 sec in the middle of a bout. Short bursts of drumming tended to initiate, or to terminate a series of long drumming episodes. Consecutive long drumming bouts generally resemble one another closely. For example, in one series of five bouts the consecutive bouts lasted 1.05, 1.04, 1.05, 1.06, and 1.05 sec. The first four of them each contained 17 notes, whereas the last, and terminal bout of this particular series, contained but 15 notes. Compared with the drumming of *Picus canus* (recorded in Austria, Summer 1970), that of *S. noguchii* consists of generally shorter bursts rendered at a slower rate (*P. canus*—19 to 21 notes per sec), and the drumming is less regular.

Nesting.—The Okinawa Woodpecker nests in April and May (Yamashina, 1941; Hachisuka and Udagawa, 1953; H. Arakaki, pers. comm.). Several old nests of this species were known to Messrs. Arakaki and Moriguchi, and I saw other holes undoubtedly excavated by *Sapheopipo noguchii.* These were 3 to 9 m above the ground in large trees or stubs (diameter 25 cm or more). A woodcutter working on the slopes of Yonaha Mountain at my direction cut down a stub in which an old nesting cavity was located. The stub was in a cleared area, and the nest had been active about seven years prior to my visit, when the forest was more extensive. The stub was 38 cm in diameter and 10 m high. The nest entrance was the shape of a hen's egg, wider at the top and narrower at the bottom. It measured 58 mm wide and 50 mm (inside) to 76 mm (outside) deep, thus being considerably smaller than the 10 cm diameter reported by Hachisuka and Udagawa (1953: 212). At the end of the 55 mm entrance tunnel was a chamber measuring about 24 cm in diameter and 38 cm in depth, with the greatest diameter opposite the nest entrance (18 cm diameter at bottom).

Hachisuka and Udagawa (loc. cit.) reported a nest found on 30 April containing young about 10 days old. They state that the clutch is "apparently two." They also indicate that nests are used year after year, but Okinawans familiar with the bird told me that nest sites change yearly. The only information that I can add concerning its nesting (see also section on vocalizations) is that food brought to young in the nest includes large grubs (3 cm long or more) and other large arthropods, perhaps including centipedes (large heads seen in bills of adults in brief film made in 1971 by K. Moriguchi).

Other Behavior.—Stretching movements of both the one wing and a leg type (first on one side, then the other), and the double wing type were glimpsed in the field, and seen in Mr. Moriguchi's movie. The only display noted is Wing Flicking, mentioned above (see call notes). Birds moderately alarmed, but not so alarmed as to flee, gave Kup Calls intermittently, and flicked the wings slightly to moderately every few seconds (both while calling and between calls). At close range the Wing Flicking appears to emphasize the white markings on the outer primaries.

TAXONOMIC RELATIONSHIPS

Yamashina (1941) considered *Sapheopipo noguchii* to have no close relatives, but mentioned *Picus*, *Picoides* (*Dendrocopos* or *Dryobates* of Yamashina; for merger of *Dendrocopos* into *Picoides* see Short, 1971) and *Blythipicus* as comparatively closely related to *Sapheopipo*. Unfortunately he did not consider *Blythipicus* further, but he mentioned (1941: 327) resemblance of *Sapheopipo* to *Picoides* in "structure of bill, feet, and wings," "while *Picus* resemble (*sic*) *Sapheopipo* in the colour of the plumage and their habits." Peters (1948) placed *Sapheopipo* between *Picoides* (*sensu stricto*) and *Xiphidiopicus*. Hachisuka and Udagawa (1953: 212) referred to both Peters' placement of *Sapheopipo*, and to Yamashina's (1941) "interesting discussion" relating *Sapheopipo* to *Picus*. Goodwin (1968) suggested that *Sapheopipo* is a derivative of *Picoides*, evolved perhaps from the line that gave rise to the melanic *Picoides leucotos owstoni*, endemic to Amami-Oshima in the northern Ryukyu Islands. I failed (Short, 1969) to detect the traces of an *owstoni*-like pattern in *Sapheopipo noguchii* alluded to by Goodwin, and after recent examination of the British Museum (Natural History) specimens available to Goodwin I still cannot make them out.

Sapheopipo is characterized by the strong feet of a specialized woodpecking picid, and especially by the combination of a strong bill, broad across the nostrils, and bearing a distinct chisel-tip and an unspecialized (broad-vaned feathers, rather soft) tail. I consider that woodpeckers, being an arboreally specialized group, pose great problems of subtile morphological convergence and divergence. Hence, the lack of detailed, especially functional, anatomical study involving many character complexes of *Sapheopipo* and its possible relatives permits only a tentative consideration of the relationships of *Sapheopipo* based upon its external morphology and habits. Nevertheless, the preponderance of evidence at hand inclines me to regard *Sapheopipo* as a specialized, relict offshoot of a picid line that gave rise to modern species of *Picus* and the related *Gecinulus-Blythipicus* line.

The possible affinity of the Okinawa Woodpecker with *Picoides* seems to have little basis except for general bill-foot similarities; on this basis many other, although zoogeographically less satisfactory, relationships could be proposed. *Sapheopipo* in no way resembles *Picoides* in coloration. Its appearance in the field is like that of *Picus canus*; this resemblance is not merely a matter of coloration, but involves size, proportions and attitudes

(*Sapheopipo* "leans" considerably outward from tree trunks). Painted to resemble say *P. leucotos*, it would appear as a behaviorally bizarre woodpecker of that genus. The soft, broad rectrices of *Sapheopipo* are not like those of *Picoides.* No species of the latter genus regularly forages on fallen branches and branchlets, actually moving about on the ground to get at these branches, in the manner of *S. noguchii.* Finally, the vocalizations of the Okinawa Woodpecker are dissimilar to those of *Picoides*; it has no Kix, Peek, or Rattle (Blume, 1968; Short, 1971) call, or other calls found in *Picoides.*

Resemblances of *Sapheopipo* to *Picus* are many, and, indeed, the very strong bill of *Sapheopipo* is the main character separating it from *Picus.* One has but to consider the variation in *Picus canus* from typical green-backed races to the dark-plumaged, red-backed *P. c. dedemi* of Sumatra to see how readily the color pattern of *Sapheopipo* could have been derived from patterns found in *Picus.* The malar patch, crown color and sexual dimorphism in color of the crown, the pale throat, white wing markings, structure of the rectrices and the soft feather texture of *Sapheopipo* are shared with species of *Picus.* Even the pale bill color of *Sapheopipo* has somewhat of a parallel in the pale yellow lower bill of *Picus vittatus*, which contrasts with the dark upper bill, and is visible to the field observer and presumably to the birds (pers. obs.). The attitude of the Okinawa Woodpecker as it perches in trees, and its proportions resemble those of *Picus canus.* Its Long Call resembles similar calls of *Picus canus*, *P. viridis*, and *P. vittatus*, and nestling calls and drumming are not dissimilar to those of these species. *Picus* is a widespread Eurasian genus, with its greatest development in Southeast Asia where 10 species are found.

Blythipicus is a small genus consisting of two species, the smaller, lowland, Sundaland *B. rubiginosus*, and the larger, montane, southern Asian (east to mountains of Fukien, opposite Taiwan) *B. pyrrhotis.* Unlike the related *Picus*, these species have specialized "woodpecking" bills, broad between the nostrils, and their tails also are specialized (rectrices narrow and strong). These species resemble *Sapheopipo* in several features, particularly in their bill structure, the pale bill color, vocalizations, wing-flicking simultaneously with call notes, and in foraging habits. Like *Sapheopipo*, species of *Blythipicus* tear apart rotting wood, mainly (entirely in *rubiginosus*) close to the forest floor, and including rotting logs on the ground. Their call notes are punctuated by wing-flicking, and head movements show off the pale bill, just as in *Sapheopipo.* The plumage of *B. rubiginosus* strikingly resembles that of *Sapheopipo*, with subdued red dorsally, red on the crown (rear only), blackish underparts, and a pale yellow bill, and except for its shorter tail and smaller size, it could be mistaken for *Sapheopipo* in the field.

Gecinulus is a genus related to *Blythipicus* and *Picus*, and it also resembles *Sapheopipo* in several ways. The two species, *grantia* and *viridis*, form a superspecies occupying some lowland areas and hill or montane bamboo brakes in southern Asia, extending eastward to the mountains of Fukien. Like *Sapheopipo*, *Gecinulus* combines an unspecialized tail with a strong bill, which is, however, not as broad between the nostrils, nor as long and chisel-tipped as that of *S. noguchii*. *Gecinulus* shows specializations such as loss of a toe, a rather long tail, and proportionately short bill, all perhaps involved in adaptation to existence in bamboo groves. The two species show a green-red color replacement dorsally, as in *Picus*. Both have a pale bill which may serve a species identification function in the darkness of bamboo clusters. Vocalizations of *G. viridis* heard in Malaya and in Thailand are very like the calls of *Blythipicus* and to an extent like *Sapheopipo*. Its foraging habits, involving woodpecking in bamboo shoots, differ from those of *Blythipicus* and *Sapheopipo*.

I do not consider *Sapheopipo noguchii* congeneric with any one of these genera. *Gecinulus*, although specialized for bamboo-foraging, affords an indication of a possible stage in the evolution of *Blythipicus* and of *Sapheopipo* from *Picus*-like ancestors. The widespread occurrence of *Picus*, and the montane distribution of *Blythipicus pyrrhotis* and *Gecinulus grantia* as far east as Fukien, suggest that an ancestor of *Sapheopipo* derived from *Picus*-like ancestors may have invaded Taiwan and the Ryukyu Islands long ago, become isolated there (through competitive exclusion by evolving *Blythipicus* on the mainland?), and finally become extinct on Taiwan and Ryukyu Islands other than Okinawa. A similar derivation from mainland (montane) ancestors can be argued for the distinct jay *Garrulus lidthi* of Amami-Oshima; the closest extant relative of *lidthi* is the Himalayan *G. lanceolatus* (Yamashina, 1941).

The Ryukyu Islands are oceanic islands situated at the junction of the Eurasian and Pacific continental plates (Chai, 1972). They are the scene of considerable past tectonic activity, and it is difficult to ascertain the past extent of the island land masses during the Pliocene and Pleistocene, when *Sapheopipo* presumably evolved. Taiwan, also a tectonically active area, is, however, on the continental shelf, and likely was connected with adjacent mainland China (Fukien) at several times during Pleistocene glacial periods when sea level was considerably lower than at present. The depth of the Taiwan Strait is barely greater than 50 m. With Taiwan (and Japan) directly connected to continental Eurasia, various Ryukyu Islands interconnected, and the Eurasian land mass much closer to the west of the Ryukyu Islands during glacial maxima, there presumably was greater opportunity for ancestral

Sapheopipo noguchii to invade these islands from the west and southwest at those times than at present.

The behavioral and morphological similarities between *Sapheopipo* and *Picus-Gecinulus-Blythipicus* suggest that these taxa are related, and their zoogeography lends support to this view. I cannot totally discount the possibility of convergence as a factor responsible for these similarities, but I consider this possibility unlikely. Relationship ought to be assumed as a causal factor for manifold similarities, unless proven otherwise. That is, the burden of proof lies with those who would suggest a more complex factor, in this case convergence, as a causal agent for the similarities observed among these picid genera. Pending anatomical and other investigations of *Sapheopipo* and its possible relatives, this genus should be placed after *Gecinulus* and *Blythipicus* in a classification of woodpeckers (placement of *Picus* is problematical in a linear sequence, because of its other relationships, e.g., with *Celeus*, and with *Dinopium-Chrysocolaptes*, Bock and Short, in prep.).

CONSERVATION

The Okinawa Woodpecker, declared a national monument by the Government of the Ryukyu Islands in 1955, is restricted in its distribution to approximately five square miles of undisturbed forest in northern Okinawa. Small populations are known to exist, or to have existed within the past several years on Yonaha Mountain, Nashime Mountain, Mount Ibu, Mount Hedo and Iyu Mountain. Between these "mountain" peaks, the highest of which reaches an elevation of 498 m, undisturbed forest patches exist, presumably containing very small populations and scattered pairs of woodpeckers. Much of the area in which habitat still occurs is in control of the United States Marines and will remain so for the next several years or more. This control, influenced to some degree by an Okinawan movement to protect the woodpecker, probably has been generally beneficial to the woodpecker, since most of the area is used infrequently by the Marines, and the local population has been deterred to some extent from clearing forest lands. Nevertheless, forest fires during the hot summers, limited clearing in the Marine-controlled region, widespread wood-gathering, and wood-cutting have (Fig. 4) seriously affected much of the remaining forest.

Yonaha Mountain has a small area (perhaps 20 ha) of virtually undisturbed forest around its summit, which includes a 7 ha nature preserve. Within this preserve occur the Okinawa Woodpecker, and the endemic Ryukyu Akahige (*Erithacus komodori*), many other forest birds, and some 378 species of plants, including some alpine types (data from unpubl. conservation survey by Dr. George Ruhle of the United States National Park Service, 1965). The entire Yonaha Mountain region is in the Northern

Fig. 4. View looking north from slopes of Yonaha Mountain, 8 February 1972. Note effects of cutting (foreground) and planting of exotic conifers adjacent to the Yonaha Mountain Preserve, and clearing of distant hills, which lie in the U.S. Marine training area.

Training Area of the United States Marines; military activities have not been undertaken in the area, but clearing, and planting of exotic conifers is occurring in the entire region, and a woodcutter working with a power saw was clearing slopes immediately adjacent to the preserve on its northern boundary in 1972. The preserve forms a critical portion of the territory of at least two and probably three pairs of Okinawa Woodpeckers, which forage to some extent in adjacent second-growth, and along forested, narrow but steep slopes extending downward from the preserve. One nest used in 1966 or 1967 was in a dead stub 100 m north of the forest at the edge of the preserve. Another, probably used in 1970 or 1971, was in a small forested ravine above the woodcutter's house, and just northeast of the preserve. On the slope about this nest I made most of my observations of the Okinawa Woodpecker. The ravine and slope up to the preserve are due to be cleared in 1973. I estimate that about five pairs of *S. noguchii* inhabit the forests of Yonaha Mountain, where I saw at least four individuals (three males, one female).

Mr. Hideo Arakaki estimated that 140 ha on Mount Ibu and 50 ha on

Nashime Mountain provide forest habitat in which Okinawa Woodpeckers occur. These sites are under the protection of the Forestry Department of the Ryukyu Government, but they are unfenced, and only occasionally are visited by Forestry Department personnel. Our party found signs (old nesting and roosting cavities, woodpecker work) of Okinawa Woodpeckers and saw one distant individual on the slopes of Mount Ibu. The undisturbed forest there, together with surrounding second growth and forested slopes, may support as many as 10 pairs of Okinawa Woodpeckers. Dr. G. Ruhle observed the Okinawa Woodpecker (number unknown) on Nishime Mountain in September, 1965, and he saw cavities in trees attributed to the activities of these birds. This mountain area may support five or more pairs of *S. noguchii.* Baker (1948) reported two specimens (in U.S. National Museum) of *S. noguchii* collected by military personnel in the Mount Hedo area during 1945, and suitable habitat may remain for a few birds in that region. The Iyu Mountain area is well within the main portion of the Marine training area, and the status of Okinawa Woodpeckers there is unknown. The Kunigami highland area between Mount Ibu and Yonaha Mountain contains much second growth with scattered clearings, old burns, some exotic tree plantations, and much rough terrain bearing forest remnants of small extent. This patchy woodland probably harbors scattered pairs of Okinawa Woodpeckers; a wooded portion of the southeastern part of this area was the nesting site of a pair photographed by Mr. Moriguchi in 1971.

Wood-gatherers and others are at work throughout the area of woodland available to the Okinawa Woodpecker, and not even the nominal preserves are safe from their activities. The greatest danger to the woodpecker, aside from the obvious small extent of remaining undisturbed forests, is the fragmentation of its population into scattered tiny colonies and even isolated pairs. Gestures such as the naming of the species as a national monument, and protecting it from collecting are empty if sufficient habitat is not saved to insure the continued existence of an effective population of Okinawa Woodpeckers. I estimate the population of this species at from 20 possibly to as many as 60 pairs, depending upon the occurrence of pairs scattered about the highlands between the mountain peaks. It is conceivable that fewer than 20 pairs actually exist; it is inconceivable that more than 60 pairs exist, and it is likely that that figure is considerably optimistic. Concerned Okinawans feel that the economic boom engendered by the reversion of Okinawa to Japan (May, 1972) may result in rapid clearing of the remaining forests, enhanced fragmentation and decimation of the woodpecker population, and extinction of the Okinawa Woodpecker within a decade.

A concerted action by the Japanese government, with full support of all international conservation agencies, and indeed of all conservationists, is needed to establish effectively protected, sufficiently large preserves for this woodpecker. In so doing, a considerable portion of Okinawa's original biota, probably including some rare plants and other animals, also will be preserved. These reserves could then serve as a source for reestablishment of the woodpecker in properly managed, surrounding forests. Too often conservation efforts are expended to save small populations representing subspecies or local populations of species otherwise existing elsewhere in numbers, or representing species similar to other, congeneric species elsewhere. I am in favor of preserving as much of organic diversity as possible, but common sense and limited resources demand that some priorities be established. In any scheme of priorities, the distinctive Okinawa Woodpecker, comprising a monotypic genus, ought to be near the top of the list of species requiring immediate attention. It would be a calamity if this species became extinct directly through the activities of man. I hope that this report will contribute to its preservation.

SUMMARY

The endemic, endangered Okinawa Woodpecker (*Sapheopipo noguchii*), comprising a monotypic genus, inhabits scattered patches of original forest in northern Okinawa, Ryukyu Islands. Brief studies in February 1972 established that it forages by excavating for insects in trees, and particularly in rotting branches, and stubs, and in rotten trees and branches lying on the ground. It is found at low levels in trees and undergrowth, much as is *Blythipicus rubiginosus* in Southeast Asia. Various calls are described, as is drumming. Vocalizations show resemblances to those of *Blythipicus* and *Picus.* What is known of this woodpecker's anatomy, and its behavior strongly suggest that *Sapheopipo noguchii* is related to the *Blythipicus-Gecinulus-Picus* line of woodpeckers, and not to *Picoides* (*Dendrocopos*). Although only five to eight individuals actually were observed, information available from my field observations of its habitat, and from Ryukyu Island forestry officials suggests a population of 20 pairs (possibly as many as 60 pairs) distributed patchily over about 1500 ha of the Okinawan highlands. Wood-gathering, woodcutting, forest clearing and replacement by exotic tree plantations, and fires are reducing the natural forests. Because the woodpecker requires undisturbed forest with plenty of rotting trees for foraging, and with standing trees and stubs 25 cm or more in diameter for nesting, the various human activities just mentioned are fragmenting its remaining small population and threatening it with immediate danger of extinction. Loss of this distinctive species and genus of woodpecker can be prevented only by fast action to establish one or, better, several effectively protected, suitably large preserves containing a few pairs of Okinawa Woodpeckers. Proper management of forests in the surrounding regions may permit reestablishment of the species over a large area, such that it no longer would be in danger.

ACKNOWLEDGMENTS

My Asian picid studies were supported by a grant from the National Geographic Society, and financial aid from the American Museum of Natural History. Both of these agencies supplied equipment used in Okinawa. The visit to and studies on Okinawa were supported by a grant from the International Council for Bird Preservation. I am grateful for this aid, and for assistance on Okinawa by various individuals, especially: Mr. Hideo Arakaki, ornithologist and Conservation Officer of the Ryukyu Island Government; Mr. Katsu Moriguchi, newsman; Brigadier General Barrow of the United States Marines; and Mr. Rinsho Onega, Director of the Agriculture and Forestry Department, Government of the Ryukyu Islands. Messrs. Arakaki and Moriguchi accompanied me throughout the field studies, and are largely responsible for my success in finding the Okinawa Woodpecker.

LITERATURE CITED

Baker, R. H. 1948. Report on collections made by United States Naval Research Unit No. 2 in the Pacific war area. Smithsonian Misc. Coll., 107.

Blume, D. 1968. Die Buntspechte. Wittenberg, Germany, Die Neue Brehm-Bucherei, A. Ziemsen Verlag.

Chai, B. H. T. 1972. Structure and tectonic evolution of Taiwan. Amer. J. Sci., 272: 389–422.

Goodwin, D. 1968. Notes on woodpeckers (Picidae). Bull. Brit. Mus. (Nat. Hist.), 17:1–44.

Hachisuka, M., and T. Udagawa. 1953. Contribution to the ornithology of the Ryukyu Islands. Quart. J. Taiwan Mus., 6:141–279.

Peters, J. L. 1948. Check-list of birds of the world. Vol. 6. Cambridge, Harvard Univ. Press.

Short, L. L. 1969. [Review of] Notes on woodpeckers (Picidae). Auk, 86:801.

Short, L. L. 1970. Notes on the habits of some Argentine and Peruvian woodpeckers. Amer. Mus. Novitates no. 2413, pp. 1–37.

Short, L. L. 1971. Systematics and behavior of some North American woodpeckers, Genus *Picoides* (Aves). Bull. Amer. Mus. Nat. Hist., 145:1–118.

Short, L. L. 1972. Systematics and behavior of South American flickers (Aves: *Colaptes*). Bull. Amer. Mus. Nat. Hist., 149:1–110.

Short, L. L. In press. Notes on Okinawan birds and Ryukyu Island zoogeography. Ibis.

Yamashina, Marquis Y. 1941. On the three endemic birds in the Ryukyu Islands. Trans. Biogeogr. Soc. Japan, 3:319–328 (in Japanese, with English résumé).

DEPARTMENT OF ORNITHOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK, NEW YORK 10024, 21 JULY 1972.

BREEDING BEHAVIOR AND LIFE HISTORY OF THE WILSON'S WARBLER[1]

Robert M. Stewart

Bent (1953) summarizes most of the information available on the biology of the Wilson's Warbler (*Wilsonia pusilla*). Dawson (1923), Grinnell and Storer (1924), and Grinnell, Dixon, and Linsdale (1930) described aspects of Wilson's Warbler behavior. Dwight (1902) described plumages and molt cycles, but his descriptions reliably apply only to the eastern race (*W. p. pusilla*). An observation of one nest of *pusilla* not included in Bent was described by Harrison (1951). I observed Wilson's Warbler for two years on a breeding area in Marin County, California.

METHODS AND STUDY AREAS

I spent approximately 500 hours in the field from March to August 1969–1970 observing or looking for Wilson's Warblers. Daily observations were made during the period of spring arrival on individuals that remained to breed. Observations of banded singing males were plotted on the maps of the study areas made from aerial photographs. Lines were drawn connecting the outermost observations for each male and the area on the map was measured resulting in the size and location of the maximum defended territory.

In 1969 the study was limited to Area 1, 4.9 hectares in size, which included Arroyo Hondo Creek and a small tributary. The Arroyo Hondo Creek is a perennial stream cutting into an old marine terrace. The relative density of the cover vegetation based on the point quarter method of vegetation analysis (Cottam, 1956) was: California bay (*Umbellularia californica*) 41 percent; coast live oak (*Quercus agrifolia*) 24 percent; California buckeye (*Aesculus californica*) 19 percent; canyon oak (*Quercus chrysolepis*) 9 percent and five other species 7 percent. The mean height of the cover vegetation was estimated to be 15 m. The predominant understory plants in order of abundance consisted of California blackberry (*Rubus ursinus*), nettle (*Urtica* sp.), sword fern (*Polystichum munitum*), lady fern (*Athyrium felix-femina*), and poison oak (*Rhus diversiloba*).

In 1970 I made observations in a second study area which was 0.8 km northwest of the Arroyo Hondo. Area 2 was 6 hectares in size. The vegetation consisted of willow (*Salix* sp.), coastal scrub species including coyote bush (*Baccharis pilularis*), California sage (*Artemesia californica*), coffeeberry (*Rhamnus californica*), and thimbleberry (*Rubus parviflorus*). The height of the willow cover was approximately 5.5 m. The understory in the willow habitat was similar to the understory in Area 1, despite the different cover vegetation. (Names of plants taken from Munz, 1970.)

ARRIVAL DATES

During the spring of 1970 I determined first arrivals (Table 1). In some species (Dorst, 1962) older males return to the breeding ground before second-year males. My data suggest this for Wilson's Warbler as the males

---

[1] Contribution No. 28 of the Point Reyes Bird Observatory.

TABLE 1
ARRIVAL DATES OF WILSON'S WARBLER IN 1970

Territory	Male	Female
	AREA 1	
1	6 April	?
2	27 March	4 April
3	27 March	15 April
4	29 March	9 April
5	27 March	10 April
6	?	?
7	26 March	?
	AREA 2	
1	20 March	?
2	19 March	5 April
3	5 April	?
4	?	?
5	19 March	?
6	5 April	7 April
7	20 March	12 April
8	20 March	16 April
9	16 March	12 April

arrived in two distinct groups in each study area. In Area 1, five males arrived between 26 and 29 March, and one on 6 April. In Area 2, six males arrived between 16 and 20 March, and three others not earlier than 5 April. The earlier arriving males were returns from previous years in Area 1, as they had all been color-banded during the previous year. Female arrival was marked by the cessation of male advertising song and by observation that the male was being followed by a female. The elapsed time between first arrivals of males and the beginning of pair formation averaged 15 days.

TERRITORY AND TERRITORY DEFENSE

Only slight modifications of territorial boundaries occurred between 1969 and 1970 (Fig. 1). M6 enlarged his 1969 boundary to include the territory of a male that did not return. The other territorial changes were affected by M1 (two years old) who moved 150 m south upon his return on 27 March 1970. Two days later when M3 (at least four years old) returned, he found the younger male in his old territory. A long, intensive boundary dispute (over an hour) ensued, resulting in a division of the older male's 1969 territory.

The mean territory size defended by males in Area 1 was 0.57 hectares

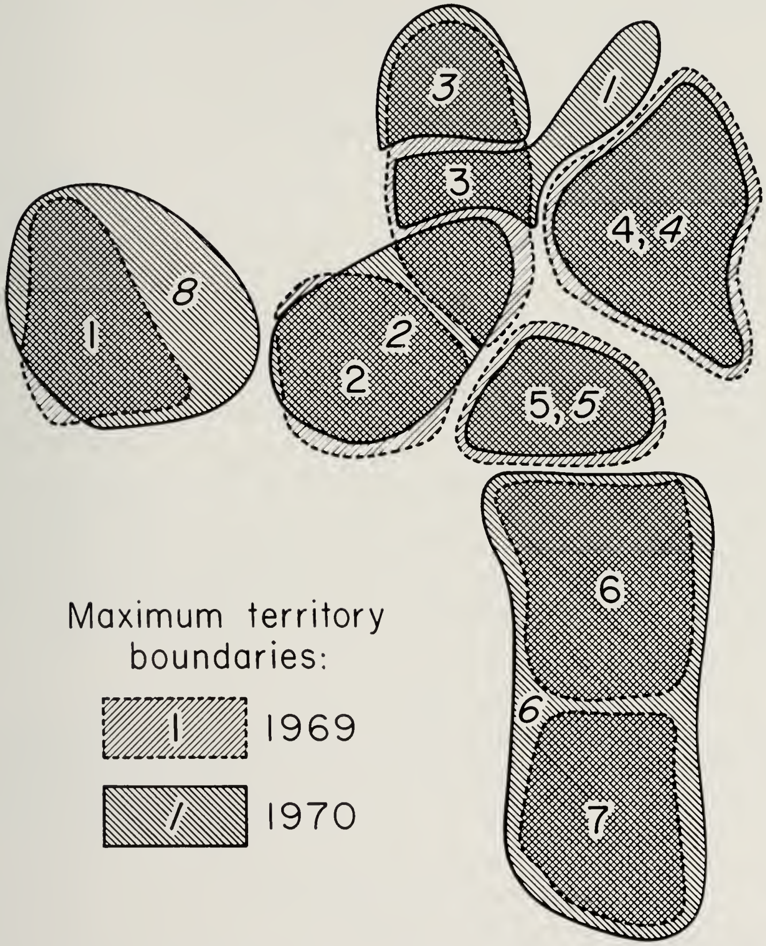


FIG. 1. Territory boundaries in area 1. Straight numerals with dotted boundaries represent territories in 1969. Slanted numerals with solid boundaries represent territories in 1970.

(S.D. = 0.3), ranging from 0.2 to 1.3 hectares. The mean defended territory size in Area 2 was 0.48 hectares (S.D. = 0.2), ranging from 0.3 to 1.0 hectares.

Occasionally, breeding birds were captured or seen away from their normally defended territories, indicating larger home ranges. On five occasions males were seen or captured from 125 to 300 m from their normally defended territory boundaries. In one instance, a *pair* was observed 135 m from their boundary in the extreme edge of the adjacent territory.

Four boundary disputes were observed, which were probably the first such

TABLE 2

MEASUREMENTS OF WILSON'S WARBLER NESTS AT POINT REYES BIRD OBSERVATORY

	Number of nests	Mean ± S.D.	Range
Nest height from ground to top of nest	11	68.0 cm ± 18.0	32.5–82.5
Outside diameter	9	14.5 cm ± 2.4	10.0–17.5
Inside cup diameter	7	5.2 cm ± 0.9	5.0–7.5
Depth of cup	7	3.3 cm ± 0.2	2.5–5.0
Weight of nest	9	27.7 g ± 8.1	10.0–38.0

disputes for the season between neighbors. These lasted from 30 to 60 minutes, occurred 0.5 to 1.5 m off the ground in dense tangles, and occupied a total area of no more than 10–15 m^2. Long chases in a restricted area were interspersed with short encounters where the first bird to arrive flew at or near the second, causing the latter bird to move to another perch. This sometimes continued at a rapid pace. Singing bouts of eight or nine complete songs per minute accompanied two of the disputes, but in the others chipping predominated. No physical contact was ever observed during these disputes.

FORAGING OF ADULTS

Males, being more conspicuous than females, were more easily observed throughout the territory. They fed in both understory and trees, but generally not higher than 1.5 m below the roof of the canopy. In Area 2, where the willow was the dominant cover, males fed no higher than 4 m from the ground. In Area 1, however, males were frequently observed foraging 10–17 m from the ground, suggesting that this species is not necessarily restricted to low vegetation for its foraging habitat.

NESTS

Fourteen nests were found during the study. The dimensions of nests are shown in Table 2. Because the understory of both areas was similar, the composition of the nests was the same. The outside of the nest was composed of leaves, twigs and small branches of blackberry (*Rubus* sp.), nettle (*Urtica* sp.), and oak (*Quercus* spp.). The inside was made of animal hair interwoven with fine stems, moss and deteriorated leaves. By far the major support plant for the nests was blackberry which offered three advantages: horizontal runners for support of nests, overhanging leaves for concealment of the top of the nest, and a dense tangle sometimes so thick that ground predators would find it hard to penetrate. In the two cases studied in detail, nest building was completed in five days. Two to three days later, the first egg was laid and the other eggs were layed one each day thereafter.

CLUTCH SIZE AND INCUBATION

Five nests were found with eggs. Of these, four contained four eggs and one contained three. In one clutch of three eggs, two eggs hatched 11 days and one hatched 12 days after the last egg was laid; and in one clutch of four, all hatched 13 days after the last egg was laid. In both instances incubation did not begin until after the last egg was laid.

DEVELOPMENT OF NESTLINGS

As young Wilson's Warblers develop in the nest, changes take place which are characteristic of their age. Most young appeared to develop at the following rate:

1st day—Young all pink, from 10–15 long downy feathers present;

2nd day—Primaries and secondaries begin to grow and show up as dark areas on the wings. Young gape readily;

3rd day—Prominent dorsal feather tract shows up as a dorsal black stripe;

4th day—Pin feathers on wings are ½ cm long. So much down has grown that young appear all brown with no pink showing;

5th day—Pin feathers on wings one cm long. Eyes begin to open;

6th day—Eyes are open wide, "cheeping" heard for the first time. Pins on wings and head are not erupted, but some dorsal tract feathers are erupted;

7th day—Upper wing coverts are erupted, primaries and secondaries not erupted;

8th day—All feathers are erupted.

ADULT FEEDING OF YOUNG

On the day that young hatched, males appeared in the vicinity of the nest with food in their beaks, but they did not actually feed young until several days later, if at all. Indeed, for one clutch of three, the male was never observed feeding young at the nest. In one clutch of four, I watched the nest at the same time each day (Table 3). Before the fourth day, the male came to the vicinity of the nest with food in its beak, hovered near the entrance, and then flew back to a perch several feet away. After this had occurred several times a minute, he left only to come back several minutes later with the same mass of insects in his beak to repeat the performance. (I was close enough to see the arrangement of green larvae, etc., in his beak.) After the fourth day he regularly fed the young. This behavior cannot be construed as shyness resulting from my presence. Where I discovered nests for the first time and the young were over five days old, this behavior was not

TABLE 3

FEEDING TRIPS TO NEST BY ADULTS WITH FOUR YOUNG
(Between 07:00 and 08:00)

Day after hatching	Female	Male
2nd	5	0
3rd	7	1?
4th	9	4
6th	36	12

shown; that is, the male would routinely make feeding trips to the young despite my first sustained observation of the nest.

One nest with four young was watched for 13 hours on the ninth day after hatching (Fig. 2). The number of feeding visits to the nest by the male averaged 17.2 per hour while the female averaged 40.8 visits per hour, giving an average of 58 visits by parents per hour. If I extrapolate the observations made during 13 hours to include a normal 14-hour day, the male made 241 trips and the female 571, for a total of 812 feeding trips per day. On four previous days, the data from one-hour observations in the morning and afternoon indicated the same level of feeding effort. The rate of feeding was highest between 08:00 and 09:00, but never dropped below 50 trips per hour in the afternoon. This constancy was maintained by the adults relieving each other at the nest. For instance, from 13:00–14:00, when the male reached one of his lowest feeding rates, the female made more trips than she had previously. Later, from 16:00–17:00, when the female made only 29 trips, the male showed his highest feeding rate. The number of fecal sacs removed increased gradually until between 17:00 and 19:00, six sacs were removed per hour. Seventy percent of the sacs were removed by the male.

DEVELOPMENT OF FLEDGLINGS

The young left the nest 8 days after hatching in a brood of three, and 10 days after hatching in a brood of four. Observations of four fledglings from the same nest revealed several plumage changes. Upon leaving the nest, the young were brown except for dull yellow underparts. By 21 days old, the lores and eye ring became bright yellow, while the rest of the plumage remained brown. At 32 days of age bright yellow feathers had grown in on the chin, upper breast and flanks, but the lower breast and belly remained in dull yellow juvenal plumage. The crown was brown with a few black cap feathers beginning to grow in. At this age the young fed on their own for the most part, and in a few days began to leave their parents' territory. As

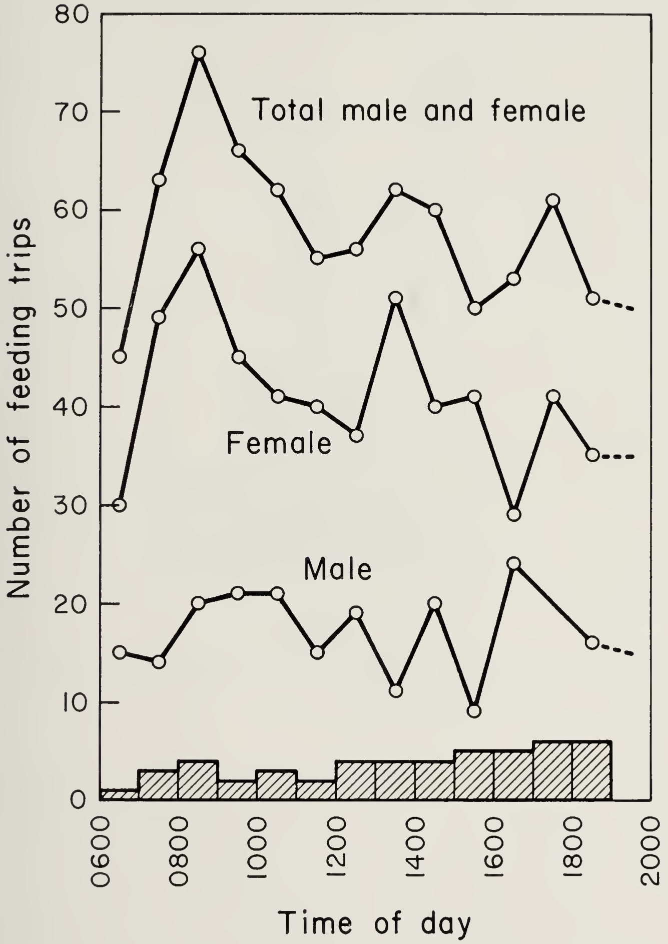


FIG. 2. Number of feeding trips by adults to nest with four, 8-day old young during 13 hours of a 14-hour day. Lined bars at bottom of graph represent the number of fecal sacs removed.

the black cap feathers continued to grow, the sides of the crown remained brown. At 39–40 days of age, these brown juvenal feathers were replaced with yellow.

In the eastern race (*W. p. pusilla*) according to Dwight (1902) young females lack a black cap until the first pre-nuptial molt. Since all 192 young captured in 1969 had black caps, I suggest that this does not apply to individuals breeding in central coastal California. Young Wilson's Warblers remained in quite heavy body molt until early August (Fig. 3).

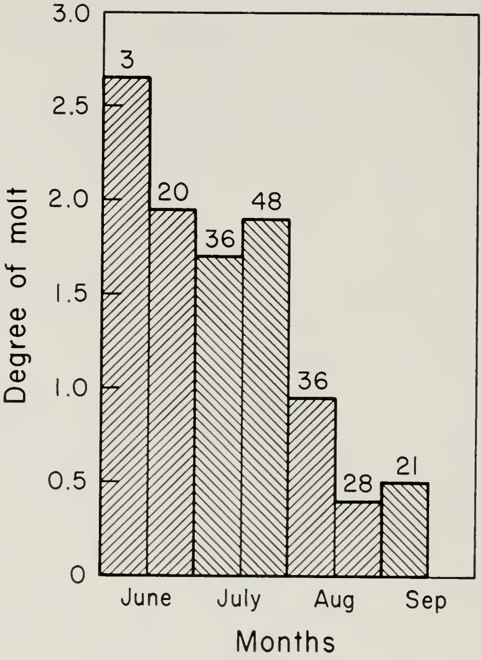


FIG. 3. Body molt of young birds captured in mist nets in 1969. Numbers above bars represent the actual number of individuals.

BREEDING SUCCESS

During 1969 six pairs of adults produced 26 fledglings. In 1970 16 pairs produced 20 fledglings. Only four of 22 pairs were known to attempt a second clutch after successfully raising a first brood, and in only two did young leave the nest during the second attempt. Possible predators observed near the nests were the Scrub Jay (*Aphelocoma coerulescens*), the Steller's Jay (*Cyanocitta stelleri*), and garter snake (*Thamnophis* sp.).

WANDERING OF POST-BREEDING ADULTS

There is good evidence that the peak of adult post-breeding "wandering" occurred in late June. Few second clutches were laid after successful fledging of first broods, and first broods were finished by late June. These facts support data from continuous netting in Area 1 which showed that in both 1969 and 1970 there was a peak increase of unbanded adults between 16 and 30 June (Fig. 4). The unbanded adults in June were probably not part of a surplus breeding population, since it is probable they would have been captured earlier. The sex ratio of these unbanded adults was 1:1. They were

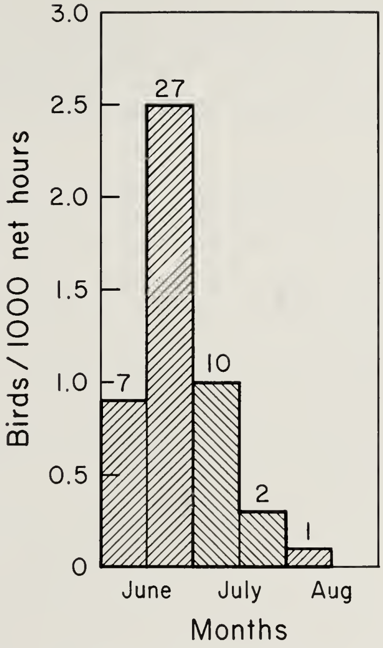


Fig. 4. Unbanded adults captured in mist nets near area 1 in 1969 and 1970. Numbers above bars represent actual number of individuals captured.

all in late stages of breeding condition with a brood patch or cloacal protuberance and had low subcutaneous fat levels. Adult wandering probably occurs after breeding or attempted breeding at a time when territoriality is waning. For whatever functions the territory serves, continued energy expended in defense of a territory after breeding for a migratory passerine species would not benefit the adult. The *unrestricted* search for food in preparation for molt and migration would be appropriate to the bird's survival during the post-breeding period.

SUMMARY

A two-year study of the Wilson's Warbler was made in two different habitats. Older males appeared to return earlier than second-year males and females. With one exception, males returned to essentially the same territories in 1970 they occupied in 1969. The average area of the defended territory was 0.54 hectares. Most of the nests found were supported by blackberry and averaged 68 cm from the ground. Aspects of adult behavior were discussed including territory defense and feeding rates of young by adults. In one 14-hour day, the parents made an estimated 812 feeding trips to the nest, an average of 58 trips per hour. Plumage changes in young from hatching to 40 days of age were described. Field observation and mist net data suggest peak adult post-breeding wandering occurred in late June.

ACKNOWLEDGMENTS

I thank D. G. Ainley, L. R. Mewaldt, C. J. Ralph, and John Smail for making valuable suggestions concerning the manuscript. T. J. Lewis, R. Scheible, C. Scheible and W. Clow helped collect data from birds captured in mist nets. I am indebted to Nick Story for preparing the figures.

LITERATURE CITED

Bent, A. C. 1953. Life histories of North American wood warblers. U.S. Natl. Mus. Bull., 203.

Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology, 37:451–460.

Dawson, W. L. 1923. The birds of California. South Moutlon, San Francisco.

Dorst, J. 1962. The migration of birds. Houghton Mifflin, Boston.

Dwight, J., Jr. 1902. The sequence of plumages and moults of the passerine birds of New York. Ann. New York Acad. Sci., 13:73–360.

Grinnell, J., and T. I. Storer. 1924. Animal life in the Yosemite. Mus. Vert. Zool., Univ. of California, Berkeley.

Grinnell, J., J. J. Dixon, and J. M. Linsdale. 1930. Vertebrate natural history of a section of northern California through the Lassen Peak region. Univ. of California Publ. Zool., 35.

Harrison, H. H. 1951. Notes and observations on the Wilson's Warbler. Wilson Bull., 63:143–148.

Munz, P. A. 1970. A California flora. Univ. of California Press, Berkeley.

POINT REYES BIRD OBSERVATORY, P.O. BOX 321, BOLINAS, CALIFORNIA 94924,
13 APRIL 1972 (ORIGINALLY RECEIVED 16 MARCH 1971).

MOLT PATTERNS AND WEIGHT CHANGES OF THE AMERICAN WOODCOCK

Ray B. Owen, Jr. and William B. Krohn

Few data are available on the timing and extent of molts in the American Woodcock (*Philohela minor*). Pettingill (1936) described the plumages, pterylae, and certain aspects of the molt sequence. Martin (1964) studied flight feather molt and developed a rapid aging technique, while Sheldon (1967) provided molt data for 13 birds. Numerous workers have reported weights of male and female woodcock from various geographical areas at different times of the year (Blankenship, 1957; Glasgow, 1958; Goodrum and Reid, 1952; Lynch, 1952; Liscinsky, 1972; Mendall and Aldous, 1943; Pettingill, 1936; and Tufts, 1940). However, only Greeley (1953) in Wisconsin, Sheldon (1967) in Massachusetts, and Marshall (1970) in Minnesota presented weight data by age and sex classes. Seasonal changes in body weights could indicate periods of stress and might be useful in understanding the timing of such biological events as molt and migration.

A detailed investigation of molt and body weights of woodcock was initiated in 1969. The study was primarily conducted in Maine, although late fall and winter weights of woodcock were obtained in New Jersey, Mississippi, and Louisiana. This paper discusses (1) the sequence, duration, and intensity of molt, (2) seasonal changes in body weights, and (3) the relationships between molt, weight change, fat deposition, and migration.

METHODS

General.—We examined most woodcock in conjunction with various banding programs. In Maine, the birds sampled included those caught on singing-grounds in the spring, on summer fields at night, trapped during the summer in diurnal covers, and shot during the fall hunting season. Woodcock in New Jersey were captured by night-lighting on nocturnal fields during fall migration. In Mississippi and Louisiana, wintering birds were captured by night-lighting. The age and sex of each woodcock handled was determined according to Martin (1964). Adults include all after-hatching-year birds while immatures are hatching-year woodcock. Molt data were collected from June through November, 1969 and 1970. Most of the woodcock were weighed in 1970 and 1971, although a few spring weights date back to 1961.

Molt Study.—Eight hundred and fifty woodcock, captured in the summer or shot during the fall in Maine, were examined. Molt information from 33 areas of the body (Pettingill, 1936; Holmes, 1966) was recorded from 319 birds. The following areas were examined for molt: malar region, frontal region, coronal region,* temporal region, auricular region, occipital region, anterior cervical region,* interscapular region,* dorsal region,* pelvic region, humeral tract, posterior cervical region, axillar region, sternal region,* abdominal region, femoral tract,* crural tract,* primaries,* under greater primary coverts,* under lesser primary coverts, upper greater primary coverts, upper middle primary coverts, secondaries,* under greater secondary coverts,* under middle secondary coverts,* under lesser secondary coverts,* upper greater secondary coverts,* upper middle secondary coverts,* upper lesser secondary coverts,* marginal coverts, rectrices,* under tail coverts, upper tail coverts. The extent of molt, ranging from 0 (no molt) to 3 (heavy molt) was recorded for the 33 areas on 176 birds, while only the presence (+) or absence (–) of molt on these areas was noted for the remaining 143 woodcock. The number of molting primaries, secondaries, and rectrices was counted on all 319 woodcock. Summer banding crews examined selected areas, indicated by asterisks above, on an additional 531 birds. Although these data were not quantitative they were useful in interpreting the August sample, a period when birds were difficult to capture. The termination of flight feather molt was determined by examining 2,629 wings from woodcock shot during 1970 in Maine. The wings were obtained from the Wing Collection Survey of the U.S. Fish and Wildlife Service.

The beginning, ending, and peak of molt did not differ significantly between sexes, nor between years, so the data were combined and expressed only by age and weekly collection periods. We defined the duration of molt for a particular area on the body as the length of time between the first and last occurrence of molt on that area in the total sample of birds examined. Frequency histograms were drawn for each area expressing the percentage of birds molting in each weekly sample and the period of maximum intensity was noted. Figures for particular feathers or areas were combined when they had approximately the same duration and period of highest intensity.

We calculated a molt index for each bird by multiplying the average weight of feathers from each of 33 areas by the degree of molt observed (0–3) on each area and summing all 33 values. In doing this we assumed that the energy needed to renew feathers on each area was proportional to the weight of the feathers from that area (Holmes, 1966). Average feather weights for individual areas were obtained from four woodcock by plucking, oven drying, and weighing feathers to the nearest 0.001 g. This sample was comprised arbitrarily of two males and two females which had completed their molt.

Weight Study.—More than 2,100 woodcock were weighed. Birds were weighed during every month of the year except December, February, and March. Most woodcock were weighed alive, although some October and November weights were of shot birds. Weights were determined with spring scales having a capacity of 300 grams. Spring scales were periodically checked against a more sensitive balance to insure accuracy within two grams. Average weights were calculated by age and sex according to time periods. The chronology of weight change was not significantly different between the summers of 1970 and 1971. We obtained a fat index for 116 birds by recording the degree of deposition, ranging from 0 (no fat) to 3 (very fat) on seven areas and averaging the values. The areas examined were: furcula region, sternal line, pectoral feather tract, an area running from the pectoral tract dorsally behind the humerus to the scapula region, abdominal region, rump, and thigh.

A probability level of 0.05 was required for significance in all statistical tests.

RESULTS

Postnuptial Molt.—The adult postnuptial molt was a complete molt, beginning in June and ending by mid-October. In all cases, the percentage of birds molting particular areas throughout the summer exhibited a normal distribution with very few individuals molting at the extremes. Feather replacement usually started with the loss of the first and second primaries in

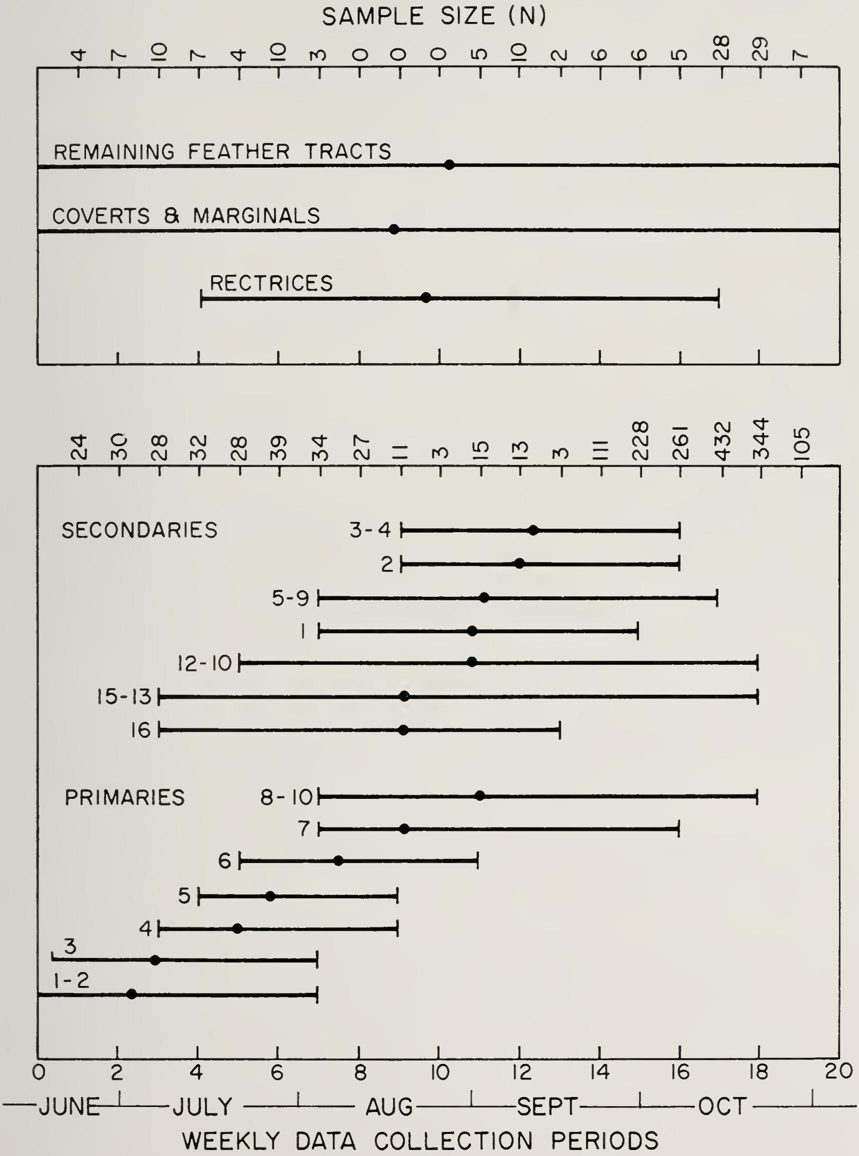


Fig. 1. Chronology of molt of adult Woodcock, 1969–1970. Each dot represents the time of highest intensity of molt.

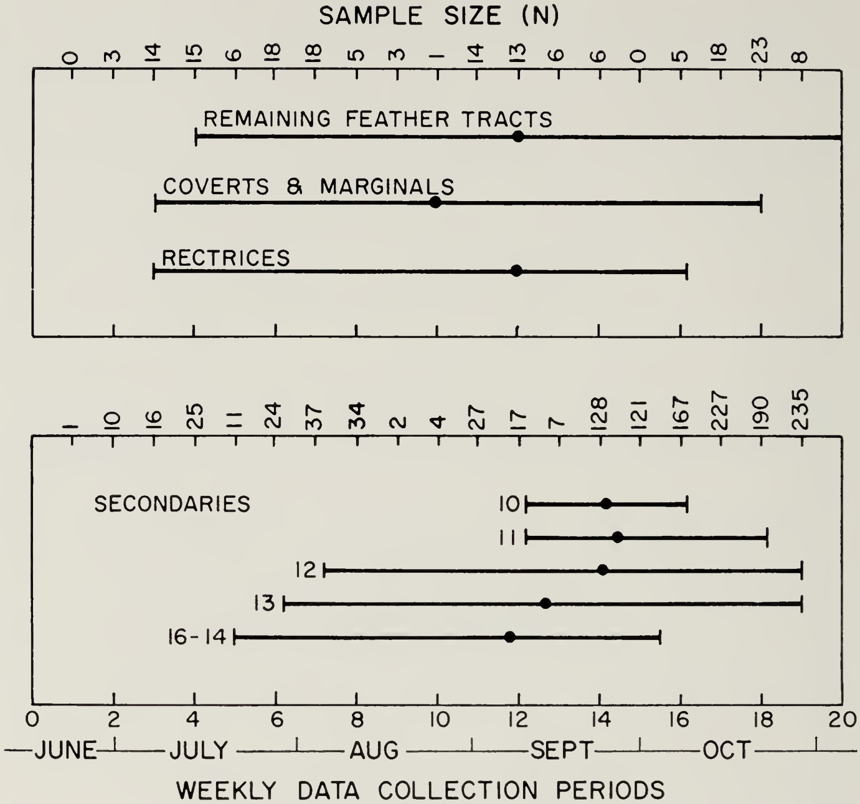


Fig. 2. Chronology of molt of immature Woodcock, 1969–1970. Each dot represents the time of highest intensity of molt.

late June or early July (Fig. 1). Primaries one through eight were dropped sequentially with the emergence and partial growth of one feather before the next was lost. The molt of the first and second primaries tended to overlap while the modified primaries eight through ten were generally dropped simultaneously.

Ability to fly was apparently retained throughout the summer with the majority of the primaries replaced before the secondaries started molting (Fig. 1). The secondary molt exhibited more overlap than did that of the primaries, but like the primaries, the innermost secondaries were molted first. As the molt progressed from the proximal end towards the center of the feather tract, the distal secondaries were also replaced. This resulted in feathers being replaced in sequence from both ends of the feather tract.

TABLE 1

FREQUENCY DISTRIBUTION OF THE LAST SECONDARY REPLACED BY IMMATURE WOODCOCK, 1970

Last Secondary Molted:	1–7	8	9	10	11	12	13	14	15–16
Number of Young Birds:	0	1	6	11	52	87	43	3	0
Percent Distribution:	0	1	3	5	25	42	23	1	0

Welty (1962) noted that a similar pattern of flight feather molt is common in passerine species. Several adult females caught in late August renewed all secondaries simultaneously. Perhaps these birds were late nesters or renesters which caused delayed initiation of molt. Simultaneous loss of feathers could be a physiological mechanism whereby the secondary molt is accelerated. Based on studies of recaptured birds, individual primaries and secondaries required from 14 to 20 days to fully develop. Pettingill (1936) indicated that all retrices were replaced simultaneously. While we found this to be a common pattern, considerable variation between birds did occur.

The capital, ventral, spinal, humeral, femoral, and crural tracts exhibited a prolonged molt extending from late June through October (Fig. 1). The molt period of the coverts and marginals corresponded closely with flight feather replacement. As each primary was molted, the corresponding upper greater primary covert was also replaced. There was a tendency for all secondary coverts in an individual tract to be molted simultaneously, with the under greater secondary coverts being molted last.

Postjuvenal Molt.—Several young birds captured in late June were still undergoing the postnatal molt. The postjuvenal molt generally began in late July and, similar to the adults, ended in mid-October. However, unlike the postnuptial molt, the postjuvenal molt was incomplete. Immature woodcock did not molt primary feathers and replaced only the proximal secondaries (Fig. 2), as reported by Pettingill (1936) and Martin (1964).

Possibly, the number of secondaries molted was related to the time of hatching (Table 1). If woodcock re-nest, then the young from re-nests might renew fewer secondaries when compared to immatures hatched earlier. Renesting was not indicated by the data since the frequency distribution was continuous and not bimodal. The body molt of the young birds was complete as was the replacement of the retrices. As in adults, the duration of molt was longest for the major feather tracts.

Seasonal Weight Changes.—A total of 1,469 woodcock were weighed in Maine between June and November. Sample sizes generally exceeded ten birds weekly for each of the four age-sex classes except during late September

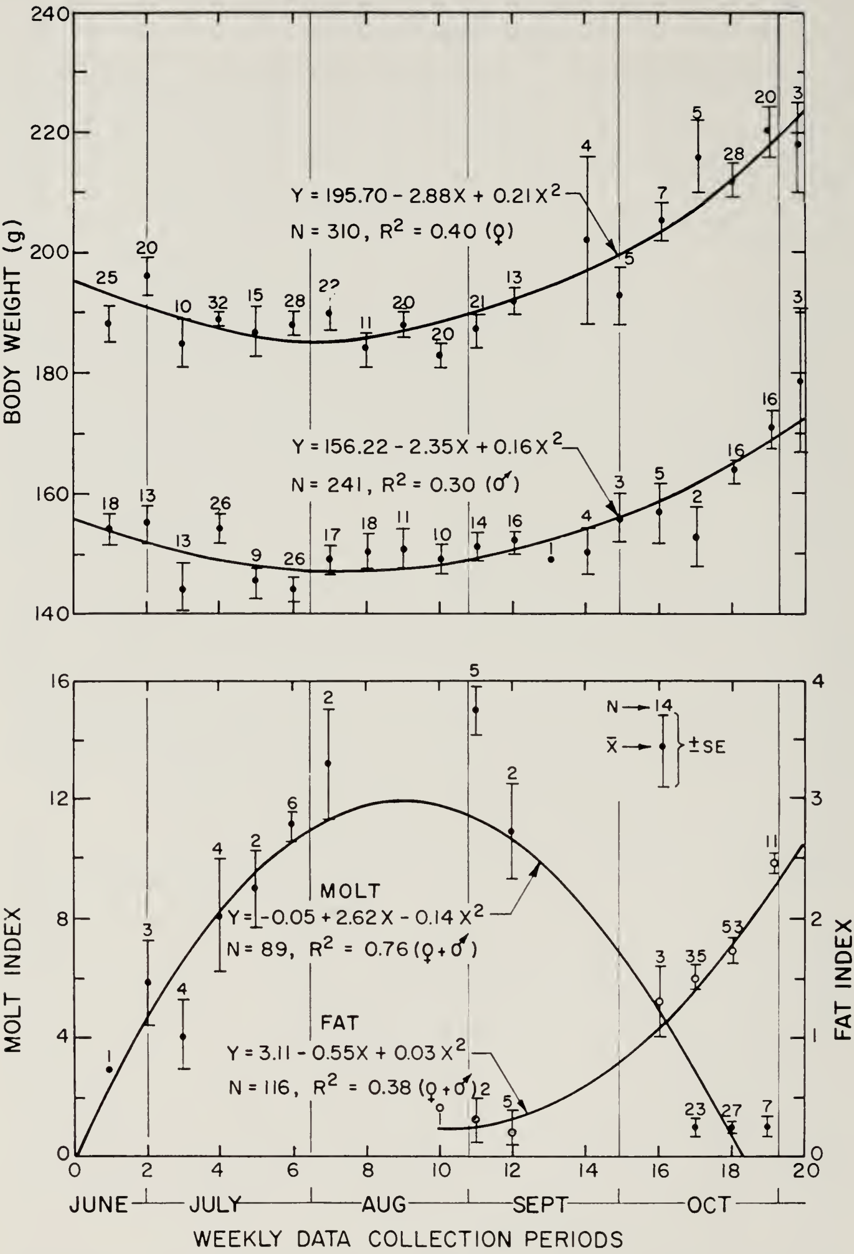


FIG. 3. Relationships between molt, body weight, and fat deposition of adult male and female Woodcock.

TABLE 2

LATE FALL THROUGH SPRING WOODCOCK BODY WEIGHTS BY SEX, LOCATION AND ACTIVITY

			Male		Female	
Date	Location	Activity	x̄ ± S.E.	(N)	x̄ ± S.E.	(N)
15–29 November (1970–1971)	New Jersey	Migrating	166 ± 1	(110)	205 ± 2	(94)
18–28 January (1971)	Mississippi–Louisiana	Wintering	155 ± 1	(111)	192 ± 1	(95)
April (1965–1970)	Maine	Reproducing	135 ± 1	(94)	217 ± 4	(8)
May (1961–1970)	Maine	Reproducing	137 ± 1	(115)	213 ± 5	(9)

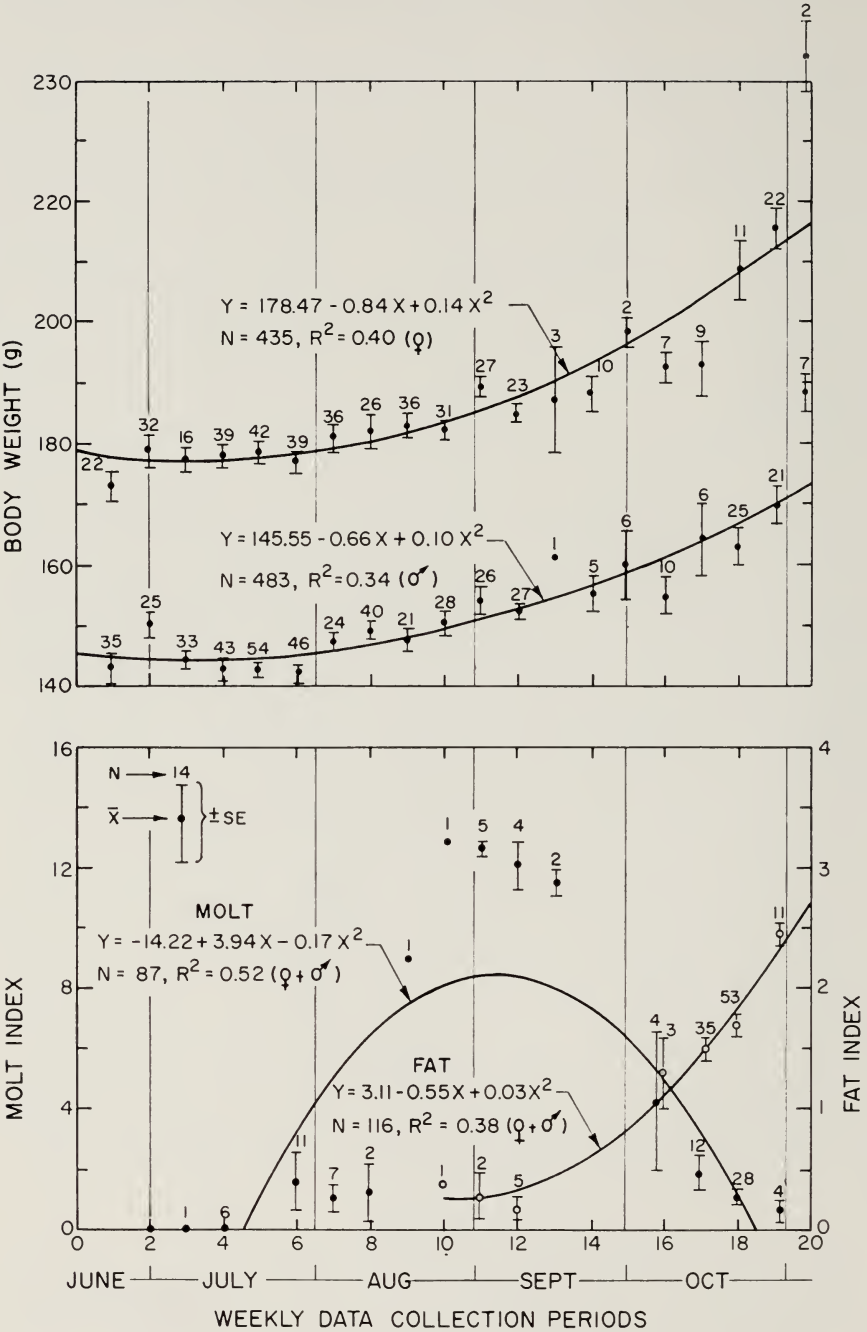
and early October, when preseason banding had ceased and few specimens were submitted by hunters.

Adults lost weight in early summer but by the middle of September were rapidly regaining weight. In contrast, immatures steadily grew heavier during June and July with the rate accelerating in August and September. Immatures of both sexes weighed as much as adults by late August and females of both age classes were significantly heavier than males throughout the entire summer.

Six hundred and thirty-six woodcock were weighed between late November and May (Table 2). Data for age classes were combined because differences were insignificant. Woodcock in Maine reached peak weights in late October and early November (Fig. 3, Fig. 4). Migrating birds captured at Cape May, New Jersey, were about five per cent lighter than the Maine birds (Table 2). Woodcock wintering in Mississippi and Louisiana were approximately six percent lighter than the fall migrants at Cape May. In the spring, early arriving males in Maine were at their lowest point in their annual weight cycle but gradually gained weight during May and June, before decreasing again during the summer molt period. Limited data on the spring weights of females indicated that these birds were lighter than birds during the fall premigratory period (Fig. 3, Fig. 4) but were heavier than fall migrants in New Jersey and wintering birds (Table 2). The relatively high body weights of females in spring were probably due to ovarian development.

DISCUSSION

The interrelationships between molt, fat deposition, and body weight of adult woodcock are shown in Figure 3. Peak molt coincided with a period of weight loss in both sexes and was probably related to the increased energy


BODY WEIGHT (g)
230
220
200
180
160
140
Y = 178.47 - 0.84 X + 0.14 X²
N = 435, R² = 0.40 (♀)
Y = 145.55 - 0.66 X + 0.10 X²
N = 483, R² = 0.34 (♂)
22
32
16
39
42
39
36
26
36
31
27
23
3
10
2
7
9
11
22
2
7
35
25
33
43
54
46
24
40
21
28
26
27
1
5
6
10
6
25
21
MOLT INDEX
16
12
8
4
0
FAT INDEX
4
3
2
1
0
N → 14
X̄ → ±SE
MOLT
Y = -14.22 + 3.94 X - 0.17 X²
N = 87, R² = 0.52 (♀ + ♂)
FAT
Y = 3.11 - 0.55 X + 0.03 X²
N = 116, R² = 0.38 (♀ + ♂)
1
5
4
2
1
11
7
2
1
6
1
2
5
4
3
35
53
11
12
28
4
0
2
4
6
8
10
12
14
16
18
20
JUNE
JULY
AUG
SEPT
OCT
WEEKLY DATA COLLECTION PERIODS

demand of plumage replacement. As the intensity of molt decreased in late September, birds commenced accumulating fat and rapidly gained weight.

Immatures gradually gained weight throughout the summer without a weight loss during the peak of molt (Fig. 4). The postjuvenal molt occurred later, and although not as intensive, ended at approximately the same time as the adult postnuptial molt. Apparently the abbreviated molt of young woodcock is less energy demanding, thus enabling them to gradually gain weight throughout the summer and attain adult size by late summer.

It is generally recognized that birds of the north temperate region store fat immediately prior to migration. In the present study, fat was deposited during the fall by adult and immature woodcock at the same rate. A significant negative correlation ($P < 0.001$) was found between fat deposition and molt index indicating that fall deposition of premigratory fat in woodcock does not start until after the peak molt has passed. Fall weight gain was also directly correlated ($P < 0.001$) with fat deposition in both sexes. Holmes (1966) concluded that during periods of rapid migration of the Red-backed Sandpiper (*Calidris alpina*) molt was suspended, although some body molt did occur during the initial "drifting" phase of migration. Molt, premigratory fattening, and migration are all energy demanding events and are generally sequenced to enable a bird to maintain a positive energy balance (West, 1960). The data presented here on the molt, fat deposition, and weight gain indicate that woodcock in Maine were not physiologically prepared to migrate until mid-October. This finding is in general agreement with Mendall and Aldous (1943), who felt that the migration in Maine did not start until October with the bulk of the migrants passing through the New England region throughout October.

Assuming that weights reflect physical condition, the data presented here indicate that the spring is a time of great stress and possible mortality to male woodcock. Spring is the time of migration, courtship, and reproduction. These strenuous activities, often occurring in sub-freezing temperatures, consume much energy while ice or snow threaten to make food unavailable. F. W. Martin (pers. comm.) found that annual mortality rates of woodcock banded in Louisiana appeared higher for adult males than adult females. Sheldon (1967) has postulated that males, migrating north first, have a shorter life expectancy than females because they are subjected to more severe weather and stress. Weight data suggested that a second but less intense period of stress for adults occurred during the peak of the molt in August. Presumably

---

←

Fig. 4. Relationships between molt, body weight, and fat deposition of immature male and female Woodcock.

weight loss then was not critical because earthworms are generally plentiful during the summer, except perhaps during prolonged droughts.

SUMMARY

A study of molt and changes in body weight of American Woodcock was conducted to better understand the summer and fall behavior of these birds and to indicate periods of physiological stress. The postnuptial molt of adults was a complete molt beginning in late June and ending by the middle of October. In contrast, the postjuvenal molt was a less intensive partial molt beginning in mid-July but also extending to the middle of October. Both male and female adult birds experienced weight loss in August during peak molt. Young birds gradually gained weight throughout the summer. Fat deposition was negatively correlated with molt while fall body weights were positively correlated with fat deposition. The data indicated that the majority of Maine woodcock are not physiologically prepared for migration until mid-October. Weights of adult males during the spring suggested that this is an important period of stress for these birds.

ACKNOWLEDGMENTS

This study was supported by the U.S. Bureau of Sport Fisheries and Wildlife through contract No. 14-16-0008-945A with the Maine Department of Inland Fisheries and Game and the University of Maine. Research was also conducted by personnel of the Bureau's Maine Woodcock Investigation and Moosehorn National Wildlife Refuge. We want to give special thanks to Dan Dunford and John Morgan for their aid in examining birds and to the woodcock banding crews who participated in the study. J. William Peppard assisted with the administration of funds and cooperated with data collection. Wildlife agencies in New Jersey and Mississippi, and personnel of the Louisiana Cooperative Wildlife Research Unit, aided in capturing and weighing woodcock in their respective states. Spring weights came from various reports on file at the Maine Cooperative Wildlife Research Unit. Editorial suggestions were made by Howard L. Mendall, Malcolm W. Coulter and Henry M. Reeves.

LITERATURE CITED

Blankenship, L. H. 1957. Investigations of the American Woodcock in Michigan. Unpubl. Ph.D. Thesis, Michigan State Univ., East Lansing, Michigan.

Glasgow, L. L. 1958. Contributions to the knowledge of the ecology of the American Woodcock, *Philohela minor* (Gmelin), on the wintering range in Louisiana. Unpubl. Ph.D. Thesis, Texas A&M Univ., College Station, Texas.

Goodrum, P. and V. H. Reid. 1952. Wintering Woodcock populations in west-central Louisiana. *In* Aldrich, J. W. Investigations of woodcock, snipe, and rails in 1951. U.S. Fish & Wildl. Serv. Spec. Sci. Rpt.—Wildl. No. 14:10–14.

Greeley, F. 1953. Sex and age studies in fall-shot Woodcock (*Philohela minor*) from southern Wisconsin. J. Wildl. Mgmt., 17:29–32.

Holmes, R. T. 1966. Molt cycle of the Red-backed Sandpiper (*Calidris alpina*) in western North America. Auk, 83:517–533.

Liscinsky, S. A. 1972. The Pennsylvania woodcock management study. Pennsylvania Game Comm., Res. Bull. No. 171.

Lynch, J. 1952. Woodcock in south Louisiana during the freeze of January–February, 1951. *In* Aldrich, J. W. Investigations of woodcock, snipe and rails in 1951. U.S. Fish & Wildl. Serv. Spec. Sci. Rpt.—Wildl. No. 14:3–9.

MARSHALL, W. H. 1970. Woodcock sex and age ratios and weights in Minnesota. The Loon, 42:31–33.
MARTIN, F. W. 1964. Woodcock age and sex determination from wings. J. Wildl. Mgmt., 28:287–293.
MENDALL, H. L. AND C. M. ALDOUS. 1943. The ecology and management of the American Woodcock. Maine Coop. Wildl. Res. Unit, Univ. of Maine, Orono.
PETTINGILL, O. S. 1936. The American Woodcock *Philohela minor* (Gmelin). Mem. Boston Soc. Nat. Hist., 9:169–391.
SHELDON, W. G. 1967. The book of the American Woodcock. Univ. of Massachusetts Press, Amherst.
TUFTS, R. W. 1940. Some studies in bill measurements and body weights of American Woodcock (*Philohela minor*). Canadian Field Naturalist, 54:132–134.
WELTY, J. C. 1962. The life of birds. W. B. Saunders Co., Philadelphia, Pennsylvania.
WEST, G. C. 1960. Seasonal variation in the energy balance of the Tree Sparrow in relation to migration. Auk, 77:306–329.

SCHOOL OF FOREST RESOURCES, UNIVERSITY OF MAINE, ORONO, MAINE 04473, AND MIGRATORY BIRD POPULATIONS STATION, LAUREL, MARYLAND 20810, 22 MAY 1972.

NEW LIFE MEMBER

A recent addition to the list of Life Members of the Wilson Society is Maurice Broun, who needs no introduction to the hosts of ornithologists and birders who have gathered each fall at the Hawk Mountain (Pa.) Sanctuary to study the southbound raptor flight. From 1934 until his retirement in 1966 Mr. Broun was Curator of the Sanctuary. His early year experiences there were reported in the classic book, "Hawks Aloft." Since his retirement Mr. Broun has managed his own private 60-acre wildlife refuge, and busies himself making a bird and plant inventory of that area near New Ringgold, Pennsylvania. He is also a competent botanist and has authored a work on North American ferns. In 1952 Muhlenberg College awarded him an honorary D.Sc. degree for his conservation work. Mr. Broun is a member of the A.O.U., the D.V.O.C., the American Fern Society, and both the Eastern and Northeastern Bird-Banding Associations. He is married with no children.

NOCTURNAL MIGRANTS KILLED AT A CENTRAL FLORIDA TV TOWER; AUTUMNS 1969–1971

Walter Kingsley Taylor and Bruce H. Anderson

Annual bird kills occur at tall structures and airport ceilometers throughout the country. Studies of these nocturnal disasters, often limited to species listings, provide valuable information on relative abundance of each sex and age group of a species, species composition and timing of the migratory flocks, migratory routes, taxonomy, fat composition, and molts and plumages (Tordoff and Mengel, 1956; Brewer and Ellis, 1958; Kemper et al., 1966). Much of this information is lacking for many migrants passing through central Florida since large banding operations and previous tower studies do not exist. Therefore, data are presented on many of these topics in the following study of bird kills at the newly-erected (completed July 1969) antenna and transmitter facility of station WDBO TV.

THE TOWER AND SURROUNDING AREA

The WDBO facility is 0.5 mile east of Lake Pickett near Bithlo, Orange Co., Florida. Heights of the tower are 1,549 feet above mean sea level, 1,484 feet above ground, and 1,465 feet above average terrain. The tower and antenna are said to be the tallest structure in Florida. Eighteen guy wires arranged in triradiate fashion and attached at six levels support the tower; six point to the east, six to the southeast, and six to the northwest. The highest set of wires is attached at the 1,300-foot level. Twenty red lights are on the tower; fifteen that flash and five that shine continuously. Large disasters occurred during times when the transmitter was in operation and when it was shut down for the night.

Near the western side of the tower is a small lake drained by a 20-foot wide canal; both contained water during the kills. About one acre of land virtually devoid of vegetation surrounded the tower during the 1969 disasters. In the autumn of 1970, another TV station (WFTV) erected a transmitter building near that of WDBO and began using the tower and antenna. More recently, a building for FM transmission has been completed and considerable improvements of the grounds, with expansion of the acre plot around the tower, have occurred.

With few exceptions, we looked for birds killed early in the morning; during the large disasters, collections began at night and continued into the morning. The area was carefully searched and all specimens found were recorded or collected. Passerines were aged by plumages and by skull ossification; nonpasserines were aged by plumages. Sex was determined by plumages and by dissection. Over 200 specimens representative of most species were preserved as skins or skeletal materials. Local weather data cited were recorded at the National Weather Station at Herndon Airport in Orlando, located about 14 miles southwest of the tower. In addition, the daily weather maps that appear in the appropriate issues of *Weatherwise* were consulted.

THE MAJOR KILLS

Kills of 100 or more birds occurred the nights of 10–11, 13–14, 29–30

September 1969; 4–5, 17–18 October 1969; 28–29, 29–30 September 1970; 17–18 October 1970: 24–25 September 1971; and 7–8, 10–11, 11–12, 17–18, 19–20 October 1971. On these dates 6,735 (87 percent) of 7,782 individuals killed in August, September, October, November, and December were found dead below the tower or its guy wires. The largest kill was on 28–29 September 1970; 1,592 individuals of 37 species were found. The next day, 859 birds of 31 species were collected. These disasters are believed to be the worst TV tower kills at Orlando (see Robertson, 1971).

WEATHER CONDITIONS

Most of the large kills correlate with arrival of cold fronts and their associated inclement weather conditions. Nevertheless a few birds fell on clear nights. The disasters of 111 individuals on 17–18 October 1971 and of 198 individuals on 19–20 October 1971 were not associated with any large weather system. A similar situation occurred on 19–20 October 1971 at the WCTV tower near Tallahassee (Robertson, 1972). Local weather conditions are believed to have caused these disasters.

The first large kill was the night of 10–11 September 1969; 356 individuals of 24 species were collected. Several live birds were in nearby grassy and wooded areas late the next evening. Many had broken bills, broken wings, blood clots on the skull, and other damaged body parts. A dense fog and overcast were present from 03:10 to 04:55 and clouds were as low as 200 to 400 feet. No rain fell and the winds blew from northeast at 4.6 to 8.0 miles per hour.

The movement and effects of the extensive cold front that caused the largest kill on 28–29 September 1970 were recently studied by Bagg (1971). At least one of us was at the tower throughout that night. Birds began hitting the tower at 23:00 and continued to fall until dawn. It rained hard from 23:40 to 01:50, but most individuals started falling at 02:15. A continuous chorus of chips and calls was heard from the birds flying overhead. Individuals flew in rapid, erratic flights; many hit the two buildings, parked cars, the ground, and the lower part of the tower. Throughout the disaster birds flew erratically around the upper sections of the tower. At day break, living birds were crouched in exposed areas; many had damaged body parts and others were exhausted. Most of the birds were near the base of the tower and in areas toward the north, the east, and the southeast. Few birds, as usual, were below the northwestern guy wires.

NUMBERS OF BIRDS KILLED

Sixteen families and 82 species were represented in the 7,782 individuals collected (Table 1). Numbers of individuals and species found in the autumns

TABLE 1

SEASONAL VARIATION OF MIGRANTS KILLED AT THE WDBO TV TOWER AUTUMNS, 1969–1971

	August		September		October		November		December		
Species	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31	Total
Pied-billed Grebe				1	3						4
Green Heron			13								13
Cattle Egret			1								1
Yellow-crowned Night Heron				1							1
American Bittern				1	1						2
Clapper Rail			1								1
Virginia Rail				1	5	3		1			10
Sora			4	18	5	1					28
Purple Gallinule				2	1						3
Common Gallinule			1	9		1					11
American Coot							1				1
Yellow-billed Cuckoo				23	10	2	1				36
Black-billed Cuckoo					1						1
Yellow-shafted Flicker					1						1
Yellow-bellied Sapsucker						7					7
Eastern Kingbird					1						1
Eastern Wood Pewee				1							1
House Wren				9	56	47		1			113
Long-billed Marsh Wren			4	26	100	48					179
Short-billed Marsh Wren					29	20					49
Mockingbird					1						1
Catbird				21	97	34	1	1			154
Brown Thrasher					1						1
Wood Thrush					1	2					3
Hermit Thrush							1				1
Swainson's Thrush				4	11	2					17
Gray-cheeked Thrush					5	4					9
Veery			7	12	2						21
Ruby-crowned Kinglet				2	6	24	7	3	2		44
White-eyed Vireo			8	52	16	7					83
Yellow-throated Vireo				4	3	1					8
Solitary Vireo							1				1
Red-eyed Vireo	2	1	18	39	31	28					119
Philadelphia Vireo					2						2
Black-and-White Warbler		1	15	61	22	28	1				128
Prothonotary Warbler			1	1							2
Swainson's Warbler			6	28	7	6		1			48
Worm-eating Warbler			10	21	5	2					38
Golden-winged Warbler				1							1
Tennessee Warbler				1	12	1	1				15
Orange-crowned Warbler						1		1	1		3

TABLE 1—*Continued*

Species	August 1–15	August 16–31	September 1–15	September 16–30	October 1–15	October 16–31	November 1–15	November 16–30	December 1–15	December 16–31	Total
Parula Warbler			29	159	72	98	1				359
Yellow Warbler			2	5	3						10
Magnolia Warbler				1	5	6					12
Cape May Warbler			1	78	15	11					105
Black-throated Blue Warbler			20	370	149	312	3	2			856
Myrtle Warbler						5	35	6	11	1	58
Black-throated Green Warbler					2	5					7
Cerulean Warbler		1		3							4
Blackburnian Warbler				5	6	3					14
Yellow-throated Warbler			10	9	12	8					39
Chestnut-sided Warbler				1	3						4
Bay-breasted Warbler					7	7					14
Blackpoll Warbler				4		5					9
Pine Warbler					14	15					29
Prairie Warbler	1	2	22	44	23	10					102
Palm Warbler			2	52	240	219	2	1	1		517
Ovenbird		1	110	364	106	131		2			714
Northern Waterthrush	2	1	26	142	13	5					189
Louisiana Waterthrush	1		2								3
Kentucky Warbler			1		1						2
Yellowthroat	1	1	337	1054	887	424	3	3			2710
Yellow-breasted Chat			1	1	2	1					5
Hooded Warbler			1		1						2
American Redstart	7		46	278	126	119		3			579
Bobolink			10	141	3	1					155
Orchard Oriole		1									1
Baltimore Oriole			2	4							6
Scarlet Tanager						1					1
Summer Tanager				1							1
Rose-breasted Grosbeak					1	2					3
Indigo Bunting				1	2	9					12
Painted Bunting				2	1		1				4
American Goldfinch									1		1
Rufous-sided Towhee						1	1				2
Savannah Sparrow					2	21	6				29
Grasshopper Sparrow					3	4	1	1	1		10
Sharp-tailed Sparrow					1						1
Bachman's Sparrow			1			1					2
Chipping Sparrow								1	1		2
White-crowned Sparrow							1				1
Swamp Sparrow						30	11	3	2		46
Total Species	6	8	31	46	55	48	19	15	9	1	82
Total Individuals	14	9	712	3058	2135	1723	79	30	21	1	7782

of 1969, 1970, and 1971, respectively, were 2,758 (55), 2,793 (53), and 2,231 (67). Yellowthroats, Black-throated Blue Warblers, Ovenbirds, American Redstarts, and Palm Warblers make up 69 percent of the total. Thirty-one (38 percent) of the 82 species were warblers, and of the 7,782 individuals, 85 percent were parulids.

Two banded birds were recovered: a five-year-old Ovenbird that was banded near Ft. Meade, Maryland (Taylor and Anderson, 1971) and a Yellowthroat that was banded near Chatham, Ontario. The Yellowthroat was at least four and one-half years old. One desiccated Florida yellow bat (*Lasiurus intermedius*) was found on 8 October 1971.

SPECIES ACCOUNT

An annotated account of most of the species collected is given below. The number in parentheses after the species name is the total collected in the three autumn periods. Individuals identified to the subspecific level were collected in 1969 and determined by Dr. Richard C. Banks and associates of the National Museum.

Green Heron (*Butorides virescens*)—.(13) All were killed on 11 September. Both immatures and adults were represented; 11 were females. This kill is one of the largest recorded at TV towers on a single autumn night.

Clapper Rail (*Rallus longirostris crepitans*)—.(1) Finding this salt-marsh rail was a surprise. This 11 September specimen, an adult female apparently represents the seventh record of *R. l. crepitans* for Florida and is the southernmost and centralmost autumn record. Previous records are two birds taken by Howell on Amelia Island, 11 January and 6 September 1906 (Sprunt, 1954: 143) and four banding recoveries taken near Amelia Island (Stewart, 1954).

Virginia Rail (*Rallus limicola*)—.(10) All except one were adults.

Sora (*Porzana carolina*)—.(28) Of 27 aged, 14 were immatures. Twenty-five were aged and sexed: 9 adult males, 6 immature males, 4 adult females, and 6 immature females.

Purple Gallinule (*Porphyrula martinica*)—.(3) One immature female and one adult female were collected on 29 September; an immature male was found on 11 October.

Common Gallinule (*Gallinula chloropus*)—.(11) All except two were adults. Both immatures and adults were found together in single kills.

Yellow-billed Cuckoo (*Coccyzus americanus*)—.(36) Both sexes were together in single kills. Of 28 sexed, 20 were males. Most were found directly below the guy wires.

Yellow-bellied Sapsucker (*Sphyrapicus varius*)—.(7) All were found in October. All four age and sex classes were in the sample of 18 October.

House Wren (*Troglodytes aedon*)—.(113) Of 97 sexed and aged, 27 were adult males, 19 were immature males, 24 were adult females, and 27 were immature females. Of 106 aged, 53 were adults. All age and sex classes were together in single kills. The first immature female was collected on 29 September; the first immature male was found on 8 October. Four specimens collected in September and October were *T. a. aedon.*

Long-billed Marsh Wren (*Telmatodytes palustris*)—.(179) Of 153 aged and sexed, 43 were adult males, 12 were immature males, 62 were adult females, and 36 were immature females. Of 165 aged, 112 were adults. Adult males were more common in the first half of October; immature males and females were more common in late September and in the first half of October. All age and sex groups were together in single kills. Three specimens were *T. p. palustris* (14 September) and *T. p. dissaeptus* (13, 18 October).

Short-billed Marsh Wren (*Cistothorus platensis*)—.(49) All hit in October. Adults (24) slightly outnumbered immatures in 45 aged. Forty were aged and sexed: 11 adult males, 4 immature males, 10 adult females, and 15 immature females. All age and sex groups were together in single kills.

Catbird (*Dumetella carolinensis*)—.(154) Of 130 aged and sexed, 44 were adult males, 16 were immature males, 52 were adult females, and 18 were immature females. Adults (100) outnumbered immatures in 141 aged.

Wood Thrush (*Hylocichla mustelina*)—.(3) All were immatures found in 1971; one female on 11 October, and one male and one female on 20 October.

Swainson's Thrush (*Hylocichla ustulata*)—.(17) Of 14 aged, 11 were immatures. One 4 October specimen was *H. u. almae.*

Gray-cheeked Thrush (*Hylocichla minima*)—.(9) Eight were aged and sexed: 4 adult males, 2 immature males, 1 adult female, and 1 immature female. One immature male was *H. m. minima.*

Veery (*Hylocichla fuscescens*)—.(21) Most were found in September while Swainson's and Gray-cheeked Thrushes peaked in October. Of 18 aged, 11 were adults. Fifteen were aged and sexed: 6 adult males, 3 immature males, 4 adult females, and 2 immature females. Immatures and adults were together in single kills. Two 11 September specimens were *H. f. fuscescens.*

Ruby-crowned Kinglet (*Regulus calendula*)—.(44) Over half of the 44 specimens were found in October. Females (31) outnumbered males in 40 specimens sexed. All had completely ossified skulls, but Leberman (1970) has shown that this species is one of few birds that we know that completes the pneumatization process rapidly. This may account for our lacking individuals with unossified skulls.

White-eyed Vireo (*Vireo griseus*)—.(83) Of 58 aged and sexed, 20 were adult males, 5 were immature males, 21 were adult females, and 12 were immature females. Adult White-eyed Vireos outnumbered immatures, the opposite of the situation in the Red-eyed Vireo. The first immature male was not found until 1 October. One bird on 14 September was *V. g. noveboracensis* and a specimen of 18 October was *V. g. griseus.*

Yellow-throated Vireo (*Vireo flavifrons*)—.(8) All were adults (2 males, 6 females).

Red-eyed Vireo (*Vireo olivaceus*)—.(119) Of 76 specimens aged and sexed, 6 were adult males, 37 were immature males, 7 were adult females, and 26 were immature females. Not included in the above were 15 unsexed specimens; 13 immatures, 2 adults. The predominance of immatures probably indicates that most of the adults precede immatures in their migration; the majority of the adults were found in the first part of September. This situation has been noted for this species at other locations (cf. Tordoff and Mengel, 1956; Goodpasture, 1963).

Black-and-White Warbler (*Mniotilta varia*)—.(128) Females outnumbered males. Of 108 aged and sexed, 31 were adult males, 16 were immature males, 29 were adult females, and 32 were immature females. Not included in the above were five unaged females. All sex and age classes were together in single kills.

Swainson's Warbler (*Limnothlypis swainsonii*)—.(48) Weights: 5 adult males, mean 16.7 (14.0–18.0); 4 immature males, mean 18.2 (16.7–19.3); 8 adult females, mean 17.6 (15.6–19.1); 2 immature females, 15.7, 21.3.

The kills of 29 and 30 September 1970 are apparently the largest reported for this species at a TV tower. Twenty-seven were aged and sexed: 6 adult males, 5 immature males, 13 adult females, and 3 immature females. Both immatures and adults were together in single kills.

Worm-eating Warbler (*Helmitheros vermivorus*)—.(38) Twenty-five were aged and sexed: 13 adult males, 2 immature males, 7 adult females, and 3 immature females. Both adults and immatures were together in single kills.

Tennessee Warbler (*Vermivora peregrina*)—.(15) Fourteen were aged and sexed: 4 adult males, 4 immature males, 2 adult females, and 4 immature females. All age and sex classes were in the 12 specimens found on 8 October.

Orange-crowned Warbler (*Vermivora celata*)—.(3) Two adult males (24 October and 17 November) and an unsexed immature (2 December) were found. The October bird was *V. c. celata.*

Parula Warbler (*Parula americana*)—.(359) Of 325 aged, 211 were adults. Totals for 287 specimens aged and sexed follow: 106 adult males, 54 immature males, 75 adult females, and 52 immature females. All age and sex classes were together in single kills.

Yellow Warbler (*Dendroica petechia*)—.(10) Eight were adults: 4 males, 4 females. One immature male and one immature female were found on 29 September. Immatures and adults were together in single kills. Two specimens on 14 September were *D. p. aestiva* and one specimen on 5 October was *D. p. amnicola.*

Magnolia Warbler (*Dendroica magnolia*)—.(12) Both adults and immatures were together in single kills. Eleven were aged and sexed: 1 adult male, 2 immature males, 3 adult females, and 5 immature females.

Cape May Warbler (*Dendroica tigrina*)—.(105) All age and sex classes were together in single kills. Of 90 aged and sexed, 31 were adult males, 16 were immature males, 24 were adult females, and 19 were immature females.

Black-throated Blue Warbler (*Dendroica caerulescens*)—.(856) This was the second most abundant species killed. Of 769 aged and sexed, 222 were adult males, 179 were immature males, 195 were adult females, and 173 were immature females. All age and sex groups were together in single kills. Four specimens taken on 30 September and 29 October were *D. c. caerulescens. Dendroica c. cairnsi* is represented in the samples but not as frequently as the nominate race.

Myrtle Warbler (*Dendroica coronata*)—.(58) Adults (42) outnumbered immatures in 53 specimens aged. Thirty-seven were aged and sexed: 11 adult males, 20 adult females, and 6 immature females. Both age groups were together in single kills.

Black-throated Green Warbler (*Dendroica virens*)—.(7) Three were immature females, three were immature males, and one was an adult male. Both age groups were together in single kills.

Cerulean Warbler (*Dendroica cerulea*)—.(4) All were taken in 1970; one immature male on 30 August, one immature male on 29 September, and one immature female and one adult female on 30 September.

Blackburnian Warbler (*Dendroica fusca*)—.(14) Thirteen were aged and sexed: 1 adult male, 7 immature males, 2 adult females, and 3 immature females. Both age groups were together in single kills.

Yellow-throated Warbler (*Dendroica dominica*)—.(39) Twenty-seven of 30 aged were adults; males slightly outnumbered females.

Chestnut-sided Warbler (*Dendroica pensylvanica*)—.(4) All were immatures; 2 males, 2 females.

Bay-breasted Warbler (*Dendroica castanea*)—.(14) All age and sex classes were together in single kills. Thirteen were aged and sexed: 2 adult males, 1 immature male, 4 adult females, and 6 immature females.

Blackpoll Warbler (*Dendroica striata*)—.(9) Adults outnumbered immatures. Seven were aged and sexed: 2 adult males, 1 immature male, 3 adult females, and 1 immature female. The small number of this species found would offer support for Nisbet's (1970) ideas on the autumn migration route of this species.

Pine Warbler (*Dendroica pinus*)—.(29) Both age groups were together in single kills. Twenty-three were aged and sexed: 5 adult males, 2 immature males, 8 adult females, and 8 immature females. Three specimens collected on 18 October were *D. p. pinus.*

Prairie Warbler (*Dendroica discolor*)—.(102) Of 92 aged, 71 were adults. Eighty-three were aged and sexed: 31 adult males, 6 immature males, 37 adult females, and 9 immature females. All age and sex classes were together in single kills. Two 14 September birds were *D. d. discolor.*

Palm Warbler (*Dendroica palmarum*)—.(517) Of 480 aged, 305 were adults. Of 421 aged and sexed, 115 were adult males, 53 were immature males, 160 were adult females, and 93 were immature females. Both races, *D. p. palmarum* and *D. p. hypochrysea*, were in the samples; the yellow race was the less common.

Ovenbird (*Seiurus aurocapillus*)—.(714) Adults outnumbered immatures and females outnumbered males. A more detailed account of the Ovenbird's autumn migration through central Florida is given by Taylor (1972).

Northern Waterthrush (*Seiurus noveboracensis*)—.(189) Of 129 sexed and aged, 36 were adult males, 15 were immature males, 48 were adult females, and 30 were immature females.

Louisiana Waterthrush (*Seiurus motacilla*)—.(3) One adult male on 14 September 1969, one immature male on 10 September 1970, and one adult female on 14 August 1971 were found.

Yellowthroat (*Geothlypis trichas*)—.(2,710) This was the most abundant species collected. Their autumn migration is prolonged and extensive through central Florida; September and October being months when most of the Yellowthroats move through this area. Of 2,252 aged, 1,463 were adults and 789 were immatures. Of 2,452 sexed, 1,216 were males and 1,236 were females. Data on 2,224 aged and sexed follow: 809 adult males, 323 immature males, 642 adult females, and 450 immature females. All age and sex classes were together in single kills. Six specimens were determined: *G. t. trichas* (11 September and 9 November); *G. t. typhicola* (11 September); *G. t. pelagitis* (11 September and 5 October); and *G. t. brachidactyla* (11 September).

Yellow-breasted Chat (*Icteria virens*)—.(5) One adult male (14 September), one adult female (29 September), one immature female (18 October), and two immature males (8 and 11 October) were collected.

American Redstart (*Setophaga ruticilla*)—.(579) Adults (309) outnumbered immatures (210), and females (282) outnumbered males (219). Of 495 aged and sexed, 127 were adult males, 92 were immature males, 167 were adult females, and 109 were immature females. All age and sex groups were together in single kills.

Bobolink (*Dolichonyx oryzivorous*)—.(155) Adults (111) outnumbered immatures in 134 aged. Of 131 aged and sexed, 52 were adult males, 16 were immature males, 58 were adult females, and 5 were immature females. All age and sex classes were together in single kills.

Baltimore Oriole (*Icterus galbula*)—.(6) All were immatures found in September; three in 1969 and three in 1970. Four were females and two were males.

Rose-breasted Grosbeak (*Pheucticus ludovicianus*)—.(3) All were immatures.

Indigo Bunting (*Passerina cyanea*)—.(12) Eleven were aged and sexed: 3 adult males; 3 immature males; 3 adult females; and 2 immature females. All age and sex classes were together in single kills. The 1970 bunting was collected on 30 September; all others were found in October, especially in the latter half of that month. One adult male collected on 18 October was changing into winter plumage; the adult male taken on 20 October was in full winter plumage.

Painted Bunting (*Passerina ciris*)—.(4) One adult male, one immature male, and two adult females were found.

Rufous-sided Towhee (*Pipilo erythrophthalmus*)—.(2) Both were adult females found in 1969. The specimen on 24 October was *P. e. alleni* and the one on 9 November was *P. e. erythrophthalmus.*

Savannah Sparrow (*Passerculus sandwichensis*)—.(29) Twenty of 28 aged were adults. Of 26 aged and sexed, 10 were adult males, 1 was an immature male, 8 were adult females, and 7 were immature females. Three specimens collected on 18 October and on 9 November were *P. s. labradorius.*

Grasshopper Sparrow (*Ammodramus savannarum*)—.(10) Nine were aged and sexed: 1 adult male, 1 immature male, 3 adult females, and 4 immature females. Four specimens collected in October and November were *A. s. pratensis.*

Sharp-tailed Sparrow (*Ammospiza caudacuta*)—.(1) An immature male found on 5 October was *A. c. nelsoni.*

Bachman's Sparrow (*Aimophila aestivalis*)—.(2) Both were immatures. The specimen on 14 September was the local race, *A. a. aestivalis*; the one on 18 October was *A. a. bachmanii.*

Swamp Sparrow (*Melospiza georgiana*)—.(46) Thirty-nine of 46 specimens were adults: 18 males, 13 females, and 8 unsexed. Five specimens were *M. g. georgiana.*

MOLT OF THE MIGRANTS

Not all birds were examined in detail for molting feathers. Few specimens were molting and such molt as was found was generally limited to a body molt in final stages of completion. Body molt was present in the following: adult female Clapper Rail (11 September); adult male and immature male Yellow-bellied Sapsucker (18 October); immature female Swainson's Thrush (4 October); adult female and adult male White-eyed Vireo (11 and 14 September); adult female Bobolink (14 September); two adult female Rufous-sided Towhees (24 October and 9 November); immature female Bachman's Sparrow (14 September); and an adult male Indigo Bunting (18 October). Molt of the remiges was recorded in an adult female White-eyed Vireo (11 September) and in two immature Bachman's Sparrows (14 September and 18 October). The vireo had the three outermost primaries and the sixth and seventh secondaries in each wing with sheathed bases. Body molt was present, but the tail feathers were not molting. The immature Bachman's Sparrow collected on 14 September had sheathed primaries. The other immature Bachman's Sparrow had the fourth primary in each wing with sheathed bases. Molting rectrices were usually limited to one or two feathers. In-coming rectrices were recorded in six Yellowthroats (both male and female) which were collected on 11 and 14 September. All stages in the development of the black mask of the male Yellowthroat were observed.

SUMMARY

Since the erection of the 1,500-ft TV tower near Bithlo, Orange Co., Florida, studies on the disasters of nocturnal migrants have been conducted. This paper covers the autumn periods of 1969–1971; 7,782 individuals of 82 species are reported. Data on weights, ages, sexes, subspecies, and molts are presented.

ACKNOWLEDGMENTS

Many individuals gave their support, time, and continued interests in this study. We thank the owners of WDBO for allowing us to utilize their facilities. Mr. Ray Campbell, Mr. Joe Lawrence, Mr. Paul Moore, and Mr. Charles Esposito of WDBO were especially helpful. Dr. Herbert Kale, II, and Dr. L. M. Ehrhart kindly read an earlier draft of the manuscript and offered valuable suggestions. Dr. Richard Banks and associates of the National Museum devoted their time to identifying over 60 specimens at the subspecific level. Mrs. Dottie Freeman, Mrs. Karin Taylor, Miss Bette Schardien, and Mr. Bob Pohlad are gratefully acknowledged.

This study was supported in part with funds from a Frank M. Chapman Award and from a NSF Institutional Grant awarded to Florida Technological University.

LITERATURE CITED

Bagg, A. M. 1971. The changing season. Am. Birds, 25:16–23.

Brewer, R. and J. A. Ellis. 1958. An analysis of migrating birds killed at a television tower in east-central Illinois, September 1955–May 1957. Auk, 75:400–414.

Goodpasture, K. A. 1963. Age and sex determinations of tower casualties, Nashville, 1963. Migrant, 34:67–70.

Kemper, C. A., D. G. Raveling, and D. W. Warner. 1966. A comparison of the species composition of two TV tower killed samples from the same night of migration. Wilson Bull., 78:26–30.

Leberman, R. C. 1970. Pattern and timing of skull pneumatization in the Ruby-crowned Kinglet. Bird-Banding, 41:121–124.

Nisbet, I. C. T. 1970. Autumn migration of the Blackpoll Warbler: Evidence for long flight provided by regional survey. Bird-Banding, 41:207–240.

Robertson, W. B., Jr. 1971. Florida region. Am. Birds, 25:44–49.

Robertson, W. B., Jr. 1972. Florida region. Am. Birds, 26:50–54.

Sprunt, A., Jr. 1954. Florida bird life. New York, Coward-McCann Inc. and the National Audubon Society.

Stewart, R. E. 1954. Migratory movements of the Northern Clapper Rail. Bird-Banding, 25:1–5.

Taylor, W. K. and B. H. Anderson. 1971. Recovery of a five-year-old Ovenbird. Bird-Banding, 42:221.

Taylor, W. K. 1972. Analysis of Ovenbirds killed in central Florida. Bird-Banding, 43:15–19.

Tordoff, H. B. and R. M. Mengel. 1956. Studies of birds killed in nocturnal migration. Univ. Kansas Mus. Nat. Hist. Publ., 10:1–44.

DEPARTMENT OF BIOLOGICAL SCIENCES, FLORIDA TECHNOLOGICAL UNIVERSITY, ORLANDO, FLORIDA 32816, 19 JUNE 1972 (ORIGINALLY RECEIVED 20 AUGUST 1971).

BIOENERGETICS OF A COVEY OF BOBWHITES[1]

Ronald M. Case

Purportedly many animals huddle or form roosting groups to conserve energy. This behavior decreases the surface area exposed to the environment and thus lessens dissipation of body heat. Despite frequent reference to it, this phenomenon seldom has been quantified. Kleiber and Winchester (1933) and Brenner (1965) quantified the efficiency of huddling in baby chicks and Starlings (*Sturnus vulgaris*), respectively. In other studies, mainly on small rodents (Retzlaff, 1939; Pearson, 1947, 1960; Sealander, 1952; Prychodko, 1958; Trojan and Wojciechowska, 1968) but also on avian species (Gerstell, 1939; Penney and Bailey, 1970), a metabolic advantage for huddling has been measured or such an advantage has been inferred from growth rates or survival times.

MATERIALS AND METHODS

Energy requirements were determined for Bobwhites (*Colinus virginianus*) under controlled conditions for a 10-hour photoperiod at seven temperature treatments from 5 to 35°C (at 5°C intervals). Equipment limitations prevented experiments at lower temperatures. Determinations were made for eight females, first individually confined and then kept as a single unit (covey). They were fed a balanced mash (prepared by the Department of Grain Science and Industry at Kansas State University): 20.5 percent protein, 2.7 percent fat, and 3.6 percent crude fiber; caloric value of 4.297 ± 0.004 kcal/g (mean ± SE).

The individual cages (48 × 25 × 13 cm) were made of polypropylene and had false wire bottoms and sliding tops (of ½-inch and ¼-inch mesh hardware cloth, respectively). Feed and water were provided ad libitum in glass feeders on the ends of the cages.

As a covey, the eight birds were kept in a wooden-frame cage (61 × 137 × 13 cm) eight times the floor area of an individual cage; the hardware cloth floor and top were of the same size as for the individual cage. The top of the covey cage was hinged in the middle to facilitate cage cleaning and bird removal. A sheet of water resistant, meat wrapping paper under the hardware cloth bottom caught excreta and spilled feed. Feed and water provided ad libitum, each in two dishes (7 cm high and 10 cm in diameter), reduced competition among birds.

A weighed amount of food (monitored for moisture and caloric value) was provided each day. At the end of 3 days, feed (uneaten and spilled) and excrement were collected, separated, and dried at 65°C to a constant weight. Birds, feed, and excrement were weighed to the nearest 0.1 g.

Feed or excrement was prepared for calorimetric analysis by grinding in a Wiley Model micro mill using a 20-mesh screen (0.51 mm openings). Samples were weighed to the nearest 0.1 mg prior to being analyzed in a Parr oxygen-bomb calorimeter. The mean of two determinations (differing by no more than ± 2.5 percent) was used for energy calculations.

---

[1] Contribution No. 1139, Division of Biology, Kansas Agricultural Experiment Station, Kansas State University, Manhattan.

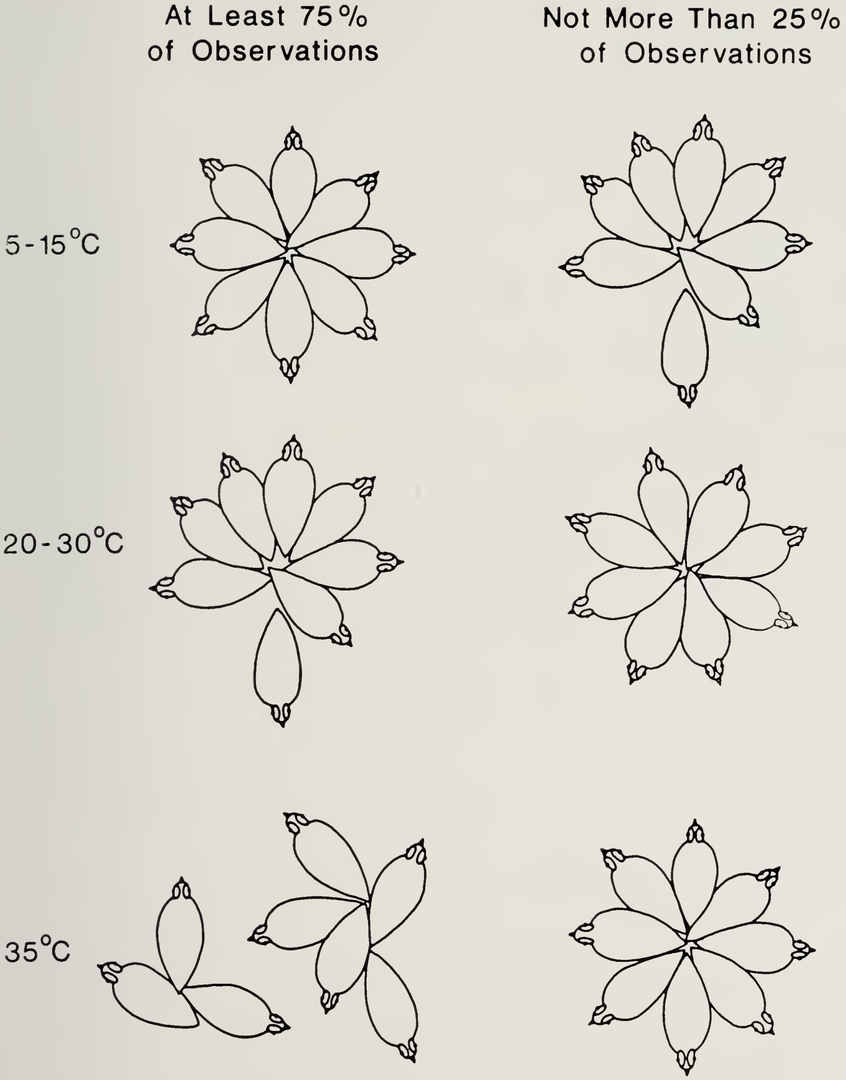
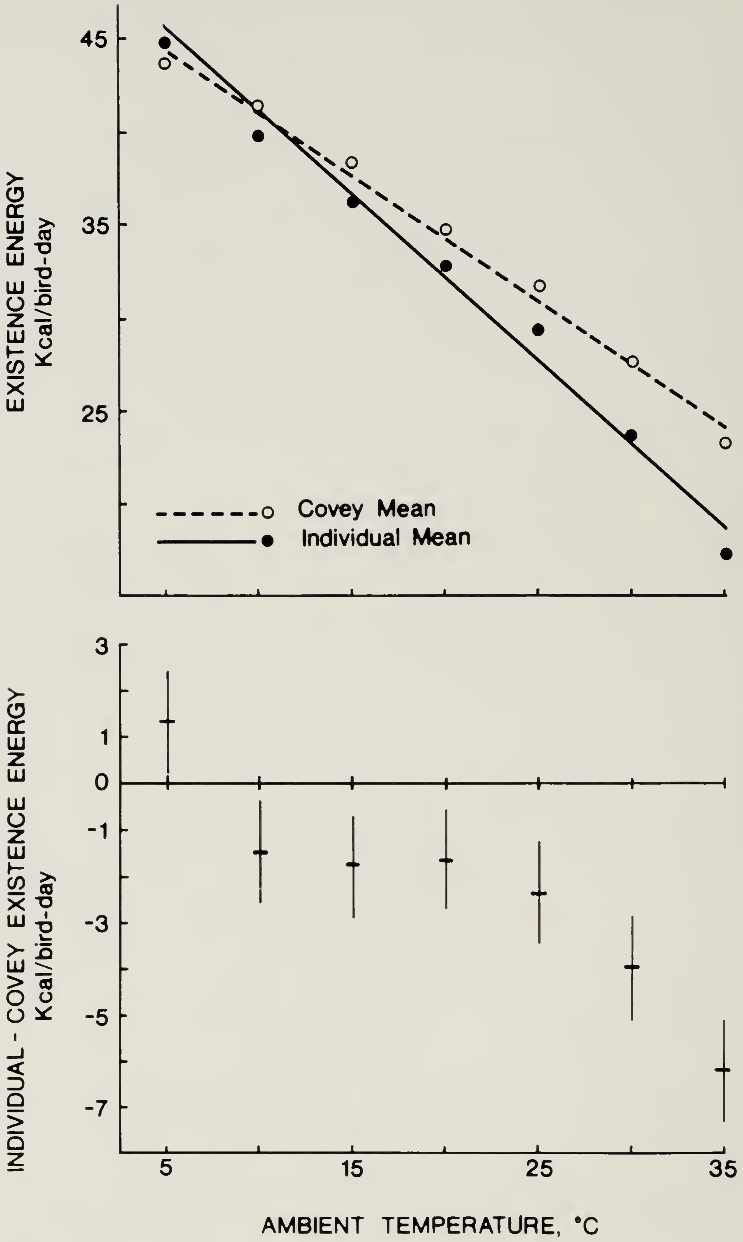


Fig. 1. Types and relative frequencies of roosting formations observed as a function of ambient temperature for eight female quail at a 10-hour photoperiod.

Gross energy intake, excretory energy, and existence energy (see Cox, 1961 for definitions) were determined for each individual and for the covey. Stabilized weight, for existence energy, was defined as no more than ± 1 percent difference in body weight between the beginning and end of the 3-day period. Data for coveys are presented on a per-bird basis, and data on individual birds as means (for regressions) or deviations from


45
35
25
EXISTENCE ENERGY Kcal/bird-day
Covey Mean
Individual Mean
3
1
0
-1
-3
-5
-7
INDIVIDUAL - COVEY EXISTENCE ENERGY Kcal/bird-day
5
15
25
35
AMBIENT TEMPERATURE, °C

covey values (which permitted removing individual bird differences as a source of variation).

RESULTS

Covey Behavior.—The first attempt to form a covey was made with four quail of each sex. The birds existed amicably until the fourth day, at which time males became exceedingly aggressive toward each other. Since Stokes (1967) had found that female Bobwhites show little aggression in the absence of males, an all-female covey was attempted. The first day they were caged the birds formed their characteristic roosting disk and no overt aggressive behavior was observed throughout the experiment. Roosting formations tended to be more compact and compact formations more frequent at lower temperatures (Fig. 1).

Energetics.—Gross energy intake, excretory energy, and existence energy were inversely related to temperature for both covey and individuals. Regressions for each of those variables differed significantly between covey and individually caged birds ($P < 0.01$); no differences in intercepts were detected ($P > 0.10$) (see Fig. 2 for existence energy).

A two-way analysis of variance on differences between individually caged birds and the covey (per-bird basis) resulted in significant ($P < 0.01$) temperature differences for gross energy intake, existence energy, and coefficient of utilization (existence energy/gross energy intake, expressed in percent). In this analysis no temperature difference for excretory energy or body weight was detected. Mean body weights were at a minimum at 35°C, 171.8 and 172.9 g, for covey and individually caged birds, respectively; they were at a maximum at 20°C, averaging 191.1 and 189.7 g, respectively. Figure 2 shows the mean of differences between individuals and the covey for existence energy. Existence energy was greater for birds confined as individuals than for those in coveys at 5°C. At higher temperatures existence energy was greater for birds in coveys and at all temperatures the coefficient of utilization was greater for the covey than for individually caged birds. Coefficients of utilization did not differ significantly with temperature for individually caged birds ($\bar{x} = 76.22$); for birds in coveys they increased as temperatures increased (77.11 at 5°C to 81.45 at 35°C).

←

FIG. 2. Existence energy of covey and individually caged Bobwhites at various temperatures. Upper half: simple regression for covey and individually caged quail. Covey: Y (kcal/bird-day) $= 47.908 - 0.676$ (°C), $r = -0.99$, $P < 0.01$. Individually caged: $Y = 49.498 - 0.872$ (°C), $r = -0.99$, $P < 0.01$. Lower half: mean (± SE) of differences (individual − covey) in existence energy as a function of ambient temperature.

DISCUSSION

The aggressiveness of males was unexpected. In Kansas quail coveys do not start breaking up until late March or April (Robinson, 1957), when photoperiods are lengthening. Genelly (1955) found that most of the fighting in California Quail (*Lophortyx californicus*) took place between March and June. Stoddard (1932) associated aggressiveness in Bobwhites with the time of covey breakup. Possibly fighting occurred during my experiment (which began in February) as a result of the artificial conditions and confined space. Nestler et al. (1945), who interpreted pecking to be a manifestation of cannibalism and fighting in pen-reared Bobwhites, suggested pecking was an outlet for nervousness.

Though pecking about the head and neck was observed in the all-female covey, it was gentle and apparently caused no discomfort to the recipient. Stokes (1967) observed and interpreted such behavior in Bobwhites as preening. Stoddard (1932) and Rosene (1969) believed that quail acting this way were preening or removing lice.

In my experiment the behavior of the roosting birds appeared to substantiate huddling as an adaptive response to conserve energy. Roosting disks generally were more compact at low than at high temperatures, which verified laboratory and field observations of Stoddard (1932), Gerstell (1939), and Rosene (1969). But the quail occasionally formed tight roosting disks at temperatures as high as 30 or 35°C, indicating that temperature was not the only factor controlling this behavior.

Kleiber and Winchester (1933) showed that below the lower critical temperature (LCT), huddling chicks used less energy to maintain homeothermy than did individuals but that at or above the LCT, huddling had no metabolic advantage. My data for coveys seem to agree with that conclusion (Fig. 2). There was a metabolic advantage gained by huddling at 5°C, but at temperatures higher than that birds in coveys used more energy than did individuals. Since there was a leveling off, or plateau effect, of energetic variables (only existence energy is shown) from 10 to 20°C, apparently the LCT for Bobwhites occurred somewhere in that range. Brush (1965) found a LCT of 27.3°C for California Quail (which were summer acclimated) and Johnson (1968) found a LCT of 6.5°C for White-tailed Ptarmigan (*Lagopus leucurus*). A LCT of 10°C seems possible for Bobwhites in light of Kendeigh's (1969*a*) conclusion that the decrease in LCT in non-passerines was not great for various weight differences.

Although the leveling off of energetic variables could be a statistical artifact, a reasonable hypothesis might be that the LCT of Bobwhites in this experiment ranged from a minimum of 10°C to a maximum of 20°C, a range that could be attributed to change in temperature of acclimation and a concomitant change in the feeding level. But I could not test my hypothesis by existence metabolism methods, from which no zone of thermal neutrality is evident (Kendeigh, 1969*b*). (The lack of a zone of thermal neutrality was verified by the high correlation of energetic variables with temperature with very little deviation from linearity.)

It was not clear why birds in coveys used more energy (directly related to temperatures > 20°C) than birds confined as individuals at warm temperatures or why they used feed more efficiently at all temperatures. Possibly birds in coveys had a higher existence metabolism because they ate more. And they ate more because of social facilitation, a common behavior in gallinaceous birds. (As one bird starts to feed, the others also may consume feed even though not hungry [Allee, 1958]). Penney and Bailey (1970) speculated that because of allelomimetic behavior ducks in groups of four consumed more feed than 2-bird groups. However, an increased level of feeding should result in increased weight or decreased use efficiency but my birds in coveys did not gain weight nor did their utilization efficiency decrease. An alternative explanation could be that my birds were more active when in a covey than when individually caged. Increased activity (accounting for increased efficiency in using calories) could have resulted from covey birds having a larger floor area to traverse, increased social interactions, mutual preening, and disturbances by other birds. It remains to be seen whether activity increases as temperatures increase.

How can we resolve the paradoxical situation of evolving and maintaining a social behavior that confers a metabolic disadvantage to covey existence during early fall and late spring? Occasionally cold temperatures (near and below freezing) do occur during those seasons, but why shouldn't covey behavior be manifested only when temperatures are cold? I believe that covey behavior is maintained, even though at a metabolic disadvantage, as a pre-adaptation for cold weather (when such behavior has survival values). Short-term cold spells (even overnight) would result in a metabolic advantage for huddling. The behavior, ultimately concerned with energy conservation (survival value), probably is under the proximate control of the photoperiod. It would be analogous, for example, to nesting and migration in birds.

Alternatively or concomitantly, huddling has a presumed adaptive advantage in regard to predation. Hamilton et al. (1967) proposed that massing Starlings maximized alertness to danger. The same could be true of Bobwhites, as the roosting disk is formed with heads directed outward. Rosene (1969) stated that a few birds in such a formation are always awake; that would further enhance alertness. Also, a covey would be less likely to be found by a predator by chance than would be birds uniformly dispersed throughout a given area. Finally, the disruptive effect of a covey of birds flushing simultaneously could render a predator ineffective in picking out one bird to attack; and that would provide additional protection.

SUMMARY

Existence energy requirements of a covey of eight females were measured and compared with those of the same eight females individually confined.

The roosting formation generally was more compact at cold than at warm temperatures; huddling provided a metabolic advantage at 5°C but became energetically disadvantageous at higher temperatures. Occasionally tight roosting circles were observed at warm temperatures, when the behavior was seemingly metabolically disadvantageous.

Analyses of differences in energy requirements of individuals and covey resulted in a departure from linearity between 10 and 20°C, which presumably represented a shifting LCT (manifested by different temperatures of acclimation and a concomitant lower feeding level).

The adaptive significance of covey behavior when temperatures are warm enough to confer a seemingly metabolic disadvantage may be associated with proximate and ultimate factors. Ultimately the behavior is concerned with energy conservation, but the proximate control (which would be other than temperature) could be photoperiod. Roosting disks may also have an adaptive advantage in regard to predation.

ACKNOWLEDGMENTS

I am grateful especially to R. J. Robel, my major professor, for his advice and assistance. Also I thank the Kansas Forestry, Fish, and Game Commission for providing quail; A. D. Dayton, for his statistical advice; S. D. Fretwell, for his critical evaluation; and my wife Sheri, for her assistance and encouragement.

This report is part of a thesis submitted in partial fulfillment of the requirements for the Ph.D. at Kansas State University. Financial support was provided in part by NSF Grant GB-16010 and P-R Project W-30-R by the Kansas Forestry, Fish, and Game Commission to R. J. Robel.

LITERATURE CITED

Allee, W. C. 1958. The social life of animals. Beacon Press, Beacon Hill, Boston.

Brenner, F. J. 1965. Metabolism and survival time of grouped Starlings at various temperatures. Wilson Bull., 77:388–395.

Brush, A. H. 1965. Energetics, temperature regulation and circulation in resting, active and defeathered California Quail, *Lophortyx californicus.* Comp. Biochem. Physiol., 15:399–421.

Cox, G. W. 1961. The relation of energy requirements of tropical finches to distribution and migration. Ecology, 42:253–266.

Genelly, R. E. 1955. Annual cycle in a population of California Quail. Condor, 57: 263–285.

Gerstell, R. 1939. Certain mechanics of winter quail losses revealed by laboratory experimentation. Trans. N. Amer. Wildl. Conf., 4:462–467.

Hamilton, W. J., III, W. M. Gilbert, F. H. Heppner, and R. J. Planck. 1967. Starling roost dispersal and a hypothetical mechanism regulating rhythmical animal movement to and from dispersal centers. Ecology, 48:825–833.

Johnson, R. E. 1968. Temperature regulation in the White-tailed Ptarmigan, *Lagopus leucurus.* Comp. Biochem. Physiol., 24:1003–1014.

Kendeigh, S. C. 1969*a.* Tolerance of cold and Bergmann's Rule. Auk, 86:13–25.

Kendeigh, S. C. 1969*b.* Energy responses of birds to their thermal environment. Wilson Bull., 81:441–449.

Kleiber, M., and C. Winchester. 1933. Temperature regulation in baby chicks. Proc. Soc. Exp. Biol. Med., 31:158–159.

Nestler, R. B., D. R. Coburn, and H. W. Titus. 1945. Picking among pen-reared Bobwhite Quail. J. Wildl. Mgmt., 9:105–115.

Pearson, O. P. 1947. The rate of metabolism of some small mammals. Ecology, 28: 127–145.

Pearson, O. P. 1960. The oxygen consumption and bioenergetics of harvest mice. Physiol. Zool., 33:152–160.

Penney, J. G., and E. D. Bailey. 1970. Comparison of the energy requirements of fledgling Black Ducks and American Coots. J. Wildl. Mgmt., 34:105–114.

Prychodko, W. 1958. Effect of aggregation of laboratory mice (*Mus musculus*) on food intake at different temperatures. Ecology, 39:500–503.

Retzlaff, E. G. 1939. Studies in mass physiology: growth rate with the white mouse. J. Exp. Zool., 81:343–356.

Robinson, T. S. 1957. The ecology of Bobwhites in south-central Kansas. Univ. Kansas Mus. Nat. Hist. and Biol. Surv. Kansas, Misc. Publ. No. 15.

Rosene, W. 1969. The Bobwhite Quail, its life and management. Rutgers Univ. Press, New Brunswick, New Jersey.

Sealander, J. A., Jr. 1952. The relationship of nest protection and huddling to survival of *Peromyscus* at low temperature. Ecology, 33:63–71.

Stoddard, H. L. 1932. The Bobwhite Quail; its habits, preservation and increase. Charles Scribner's Sons, New York.

Stokes, A. W. 1967. Behavior of the Bobwhite, *Colinus virginianus.* Auk, 84:1–33.

Trojan, P., and B. Wojceichowska. 1968. The influence of darkness on the oxygen consumption of the nesting European common vole *Microtis arvalis* (Pall). Bull. Acad. pol. Sci., Ser. sci. biol., 16:111–112.

DIVISION OF BIOLOGY, KANSAS STATE UNIVERSITY, MANHATTAN, KANSAS 66502, (PRESENT ADDRESS, DEPARTMENT OF POULTRY SCIENCE, UNIVERSITY OF NEBRASKA, LINCOLN, NEBRASKA 68503), 3 JANUARY 1972.

POSSIBLE FUNCTIONS OF HEAD AND BREAST MARKINGS IN CHARADRIINAE

Walter D. Graul

Cott (1966) proposed that many of the markings of shorebirds function as disruptive coloration. Tinbergen (1953) and many other authors suggest that many avian plumage patterns have signal function and reinforce display movements. Ficken and Wilmot (1968) and Ficken, Matthiae, and Horwich (1971) suggested that eye lines in many vertebrates may enhance their vision and enable predaceous species to locate and capture prey more effectively. The latter authors further suggest that the head markings of the Semipalmated Plover (*Charadrius semipalmatus*) probably serve mainly a disruptive coloration function, although they point out that a given pattern may serve several functions. Bock (1958) tentatively speculated that in Charadriinae the breast bands and head markings act as disruptive marks, especially for the nesting bird, and some of the markings also reinforce aggressive and courtship displays.

I have examined the literature concerning the Charadriinae in search of correlations that might provide suggestions on the relative importance of these possible functions in the subfamily as a whole, since many members of this group have complicated head and breast patterns and many have black lore lines. I have given special attention to (1) nest-site characteristics and (2) seasonal, sex, and age differences in coloration. I have also relied upon my 1969–72 observations on the Mountain Plover (*C. montanus*) in eastern Colorado for part of my conclusions.

Jehl (1968) lists 37 species in the subfamily Charadriinae in his system of shorebird taxonomy and I have followed his scheme.

RESULTS AND DISCUSSION

A variety of head and breast markings is found in Charadriinae with 24 basic patterns (Fig. 1) representing the 37 species in this subfamily. All species except the Hooded Dotterel (*C. rubricollis*) have an interrupted, i.e. non-uniform, head pattern (Table 1). Within the genus *Charadrius* there is a high incidence of a black lore line and a black crown patch and within the entire subfamily 21 species have distinct breast bands (Table 1). Breast bands when present usually consist of dark bands on light backgrounds, but in two cases light bands are against a dark background (Fig. 1).

Cott (op. cit.) states that the round shape of the eye is a conspicuous feature that needs to be concealed in many species and that eye lines commonly serve this function. Of the 37 species considered here, 27 have the

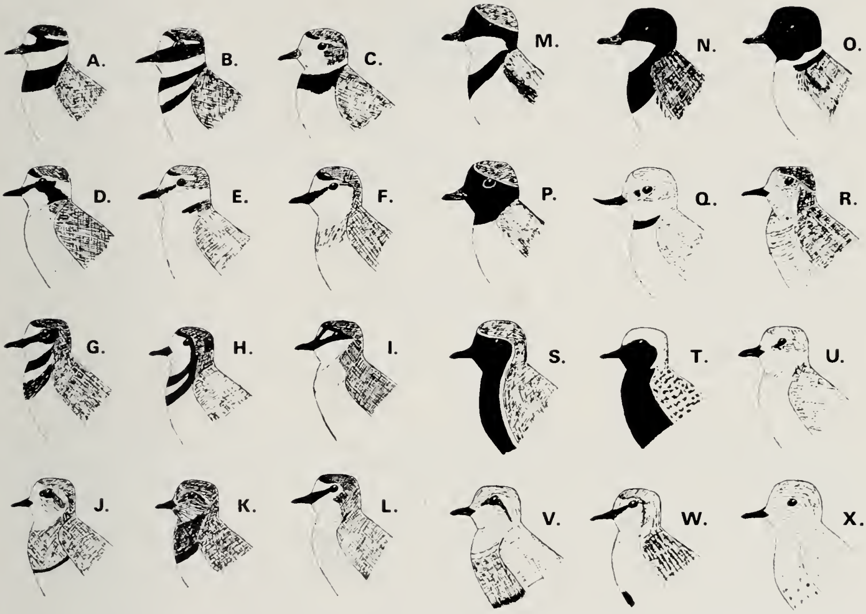


FIG. 1. Breeding adult head and breast patterns in Charadriinae. (A) *Charadrius hiaticula*; similar patterns = *C. collaris, C. dubius, C. placidus, C. semipalmatus, C. thoracicus, C. wilsonia.* (B) *C. vociferus*; similar patterns = *C. tricollaris.* (C) *C. melodus.* (D) *C. pecuarius*; similar pattern = *C. sanctaehelenae.* (E) *C. alexandrinus*; similar pattern = *C. marginatus, C. peronii.* (F) *C. venustus.* (G) *C. bicinctus.* (H) *C. falklandicus.* (I) *C. leschenaultii*; similar pattern = *C. mongolus.* (J) *C. asiaticus*; similar pattern = *C. veredus.* (K) *C. modestus.* (L) *C. montanus.* (M) *C. melanops.* (N) *C. cinctus.* (O) *C. rubricollis.* (P) *C. novaeseelandiae.* (Q) *Anarhynchus frontalis.* (R) *Phegornis mitchelli.* (S) *Pluvialis dominica*; similar pattern = *P. apricaria.* (T) *P. squatarola.* (U) *P. obscura.* (V) *Eudromias morinellus.* (W) *Oreopholus ruficollis.* (X) *Pluvianellus socialis.*

eye outline interrupted by a black line and six additional species have the dark eye against a uniform dark background (Table 1). Either of these two strategies would tend to conceal the eye. The fact that several of these species have colored eye rings does not detract from this function, since the colors cannot be seen at a distance.

In at least 24 of the species the head and breast colors are either absent or subdued in the non-breeding season as compared to the breeding plumage (Appendix I). In addition, immatures in at least 35 species differ from their respective adult breeding plumages (Appendix I). These data support the hypothesis that the patterns are mainly functional for adults during the nesting season.

Table 1

Summary of Breeding Adult Head and Breast Markings in Charadriinae

	Charadrius	Other Charadriinae	Totals
Number Species in Group	28	9	37
Lore-line Present	19	2	21
Black Crown Patch Present	21	0	21
Uniform Dark Face	3	3	6
Breast Band Present	18	3	21
Eye Outline Interrupted by Black Line	24	3	27
Interrupted Head Pattern	27	9	36

Support for the theory that these patterns function as disruptive coloration during nesting comes from the correlation between the presence of breast bands and characteristics of the nest site. Table 2 shows that those species that nest on a discontinuous substrate (Appendix II) tend to have breast bands while those that nest on uniform substrates (Appendix II) tend to lack breast bands. Discontinuous substrates are defined as having many contrasts between light and dark colors (shingle, disturbed areas, stony areas) whereas uniform substrates have no great contrast between light and dark colors (sand expanses, uniform grasslands, holes). A Chi-square Test of Independence shows that the difference is significant ($P < 0.025$). Two species were omitted from Table 2 because of a lack of good nest-site information and six species were omitted because they cannot be placed into one of the two substrate classifications, since they commonly nest near conspicuous dark objects (pebbles, sea drift, shrubs) on an otherwise uniform substrate such as fine sand (Appendix II). This correlation tends to support Huxley's (1958) suggestion that the breast bands in the Killdeer (*C. vociferus*) have a disruptive function.

Indirect evidence supports the hypothesis that some of the head and breast

Table 2

Presence of Breast Bands vs. Nest Site Location*

	Discontinuous Nest Substrate	Uniform Nest Substrate	Subtotals
Breast Band Present	13	4	17
Breast Band Absent	4	8	12
Subtotals	17	12	29

* Compiled from data in Appendix II.

FIG. 2. Horizontal threat display given by the Mountain Plover.

markings in this group also have social signal functions. For instance, in those cases where both sexes incubate (the normal situation in this group) identical head and breast markings would be expected if their sole function is disruptive coloration. In at least 27 cases where both sexes are reported to incubate, however, the male has brighter head and/or breast markings than the female (Appendix I). In the Dotterel (*Eudromias morinellus*) the male usually incubates alone (Pulliainen, 1970) and the female has brighter markings. Since sexual differences do exist it is likely that the differences enhance sexual recognition.

In at least the Killdeer and the Banded Dotterel (*Charadrius bicinctus*) the breast bands appear to reinforce aggressive displays, since in both species the bands are enlarged in threat postures (R. E. Phillips, pers. comm.).

In the Mountain Plover the facial markings seem to serve as reinforcers for threat displays. Males are more aggressive than females and males have brighter facial and breast markings. The most common threat display in this species (the Horizontal Threat—Fig. 2) presents a bold black and white image to the threatened bird. Another aggressive posture in this species (the Upright Threat), whereby two opponents stand close together and face each other with the bodies nearly vertical, also presents the bold facial markings to both participants. Both of these displays, or similar versions, have been described for the following additional species: the Kentish Plover (*C. alexandrinus*) (Rittinghaus, 1961), the Little Ringed Plover (*C. dubius*) (Simmons, 1953*a*), the Ringed Plover (*C. hiaticula*) (Simmons, 1953*b*), the Killdeer (Bunni, 1959), and the European Golden Plover (*Pluvialis apricaria*) (Bannerman, 1961). At least the Horizontal Threat, or a similar version, occurs in the Double-banded Plover (*C. bicinctus*) (R. E. Phillips, pers. comm.), the Black-fronted Dotterel (*C. melanops*) (R. E. Phillips, pers. comm.), the American Golden Plover (*P. dominica*) (Drury, 1961), the New

Zealand Dotterel (*P. obscura*) (R. E. Phillips, pers. comm.), and the Black-bellied Plover (*P. squatarola*) (Drury, op cit.). I suspect that future research will demonstrate that most of the Charadriinae species have aggressive displays in which a frontal view is presented to the opponent. It is perhaps significant that the black crown patch in 21 of the species of *Charadrius* is restricted to the front edge of the crown—the maximum black and white contrast is apparent only in a frontal view.

In the Mountain Plover the social signal function of the facial markings may be more important than the disruptive coloration function. The black lore line and black crown patch are conspicuous during the courtship period, but a molt of the head feathers begins soon after incubation starts and many individuals lack the bold markings before the end of incubation.

Bock (op. cit.) proposes that the Little Ringed Plover, the Ussuri Sand Plover (*C. placidus*), the Wilson's Plover (*C. wilsonia*) and the Killdeer currently represent the basic *Charadrius* stock from which the other species of *Charadrius* have radiated. Maclean's (1972) suggestion that species of Charadrii with reduced clutches have evolved from four egg species does not conflict with Bock's scheme.

Bock's proposal would suggest that the primitive *Charadrius* stock had breast bands, black lore lines and crown patches, since all living members of his basic stock have these features (Fig. 1). Thus, as species evolved in habitats with uniform, light colored substrates, selection would have favored the reduction or complete loss of the breast bands and dark facial marks. This would explain why the Piping Plover (*C. melodus*) has only a faint lore line and sometimes lacks a breast band and why the Kentish Plover, the White-fronted Plover (*C. marginatus*), and the Malay Sand Plover (*C. peronii*) have an incomplete breast band (Fig. 1)—all nest on light colored substrates.

Since the facial markings of many adults are bright only during the breeding season and in many species the immatures lack the markings, I doubt that the lore lines in these species of Charadriinae can serve as sight lines for capturing prey (Ficken and Wilmot, op. cit.; Ficken et al., op. cit.). It is hard to conceive that these species require sight lines for feeding only during the breeding season, especially since other functions appear to exist for the lore lines at this time.

SUMMARY

The 37 species in the subfamily Charadriinae are compared and possible functions of the head and breast patterns are reviewed. It appears that these patterns disrupt the body and eye outlines, which is especially important for the nesting bird. In some species the patterns may enhance sex recognition and may serve as reinforcers for aggressive displays. It is proposed that the primitive *Charadrius* stock had breast bands and nested

on shingle and that as this genus radiated the markings took on social signal functions and were modified by new selective pressures in new habitats. It appears doubtful that the black lore lines have any value as feeding sight lines among the Charadriinae species.

ACKNOWLEDGMENTS

My Mountain Plover observations were supported by an NIH Training Grant (No. 5 T01 GMO1779) from the National Institutes of General Medical Sciences, a Chapman Fund Grant, and a Sigma Xi Grant-in-Aid. I thank R. Ryder for making numerous facilities available to me at Colorado State University and I express my thanks to S. Derrickson and F. McKinney for critically reading the manuscript. I also thank C. A. Fleming, J. A. Goodall, M. Howe, G. L. Maclean, and A. R. McGill for allowing me to use unpublished data. Finally, I thank R. E. Phillips for allowing me to use unpublished data and for reviewing the manuscript.

LITERATURE CITED

Bannerman, D. A. (Ed.). 1961. The birds of the British Isles. Vol. 10, Oliver & Boyd, London.

Bent, A. C. 1927. Life histories of North American shorebirds. Part 2. U.S. Natl. Mus. Bull., 142.

Blaker, D. 1966. Notes on the sandplovers (*Charadrius*) in southern Africa. Ostrich, 37:95–102.

Bock, W. J. 1958. A generic review of the plovers (Charadriinae: Aves). Bull. Mus. Comp. Zool., 118:27–97.

Bunni, M. K. 1959. The Killdeer, *Charadrius v. vociferus* Linnaeus, in the breeding season: ecology, behavior, and the development of homiothermism. Unpubl. Sc.D. Thesis, Univ. of Michigan Ann Arbor.

Cawkell, E. M. and J. E. Hamilton. 1961. The birds of the Falkland Islands. Ibis, 103a:1–27.

Conway, W. G. and J. Bell. 1968. Observation on the behavior of Kittlitz's Sandplovers at the New York Zoological Park. Living Bird, 7:57–70.

Cott, H. B. 1966. Adaptive coloration in animals. Methuen & Co. Ltd., London.

Dement'ev, G. P., N. A. Gladkov, and E. P. Spangenberg. 1969. Birds of the Soviet Union. Israel Prog. Sci. Trans., Jerusalem (U.S. Dept. of Commerce, Springfield, Va.).

Drury, W. H., Jr. 1961. Breeding biology of shorebirds. Auk, 78:176–219.

Ficken, R. W., P. E. Matthiae, and R. Horwich. 1971. Eye marks in vertebrates: aids to vision. Science, 173:936–938.

Ficken, R. W. and L. B. Wilmot. 1968. Do facial eye-stripes function in avian vision? Am. Midl. Nat., 79:522–523.

Hall, K. R. L. 1958. Observations on the nesting sites and nesting behavior of the Kittlitz's Sandplover (*Charadrius pecuarius*). Ostrich, 21:112–125.

Hill, R. 1968. Australian birds. Thomas Nelson Ltd., Melbourne.

Huxley, J. 1958. Why two breast bands on the Killdeer? Auk, 75:98–99.

Jehl, R. J., Jr. 1968. Relationships in the Charadrii (shorebirds): A taxonomic study based on color patterns of the downy young. San Diego Soc. Nat. Hist., Memoir 3.

Johnson, A. W. 1964. Notes on Mitchell's Plover (*Phegornis mitchelli*). Ibis, 106: 249–250.

Johnson, A. W. 1965. The birds of Chile and adjacent regions of Argentina, Bolivia, and Peru. Platt Est. Graficos, Buenos Aires.

Littlejohns, R. T. 1932. Notes on four species of Dotterels. Emu, 31:15–20.

Mackworth-Praed, C. W. and C. H. B. Grant. 1952. Birds of eastern and northern Africa. African Handbook of Birds, Series I, Vol. 1. Longmans, Green and Co., London.

Mackworth-Praed, C. W. and C. H. B. Grant. 1962. Birds of the southern third of Africa. African Handbook of Birds, Series II, Vol. 1. Longmans, Green and Co., London.

Maclean, G. L. 1972. Clutch size and evolution in the Charadrii. Auk, 89:299–324.

Maclean, G. L., and V. C. Moran. 1965. The choice of nest-site in the White-fronted Plover (*Charadrius marginatus* Vieillot.). Ostrich, 36:63–72.

McGill, A. R. 1944. The Red-kneed Dotterel in coastal southeastern Australia. Emu, 43:225–228.

McGregor, R. C. 1909. A manual of Philippine birds. Part 1. Bureau of Print., Manila.

Meyer de Schauensee, R. 1970. A guide to the birds of South America. Livingston Publ. Co., Wynnewood, Pennsylvania.

Oliver, W. R. B. 1930. New Zealand birds. Fine Arts Ltd., Wellington.

Oliver, W. R. B. 1937. The Wrybill Plover. Emu, 37:1–4.

Oliver, W. R. B. 1955. New Zealand birds. A. H. and A. W. Reed, Wellington.

Parmelee, D. F., H. A. Stephens, and R. H. Schmidt. 1967. The birds of southeastern Victoria Island and adjacent small islands. Natl. Mus. Canada, Bull. 222.

Pitman, C. R. S. 1965. The eggs and nesting habits of the St. Helena Sandplover or Wirebird, *Charadrius pecuarius sanctaehelenae* (Harting). Bull. Brit. Ornithol. Club, 85:121–129.

Portenko, L. A. 1963. The ornithology of the Koryak Highlands (U.S.S.R.). Proc. 13th Internatl. Ornithol. Congr., Ithaca, pp. 1140–1146.

Pulliainen, E. 1970. On the breeding biology of the Dotterel (*Charadrius morinellus*). Ornis Fennica, 47:69–73.

Rand, A. L. 1936. The distribution and habits of Madagascar birds. Bull. Amer. Mus. Nat. Hist., 72:143–499.

Rittinghaus, H. 1961. Der Seeregenpfeifer (*Charadrius alexandrinus*). A. Ziemsen Verlag, Wittenberg, Lutherstadt, Die Neue Brehm-Bucherei.

Serventy, D. L. 1943. Hooded Dotterel near Sydney. Emu, 43:72.

Sharpe, R. B. 1896. Catalogue of the Limicolae in the collection of the British Museum. Vol. 24. Longmans and Co., London.

Shewell, E. L. 1951. Notes on the nesting of the White-fronted Sandplover (*Charadrius marginatus*) at Gamtoos River mouth in 1950. Ostrich, 22:117–119.

Simmons, K. E. L. 1953*a*. Some studies on the Little Ringed Plover. Aviculture, 59: 191–207.

Simmons, K. E. L. 1953*b*. Some aspects of the aggressive behavior of three closely related plovers (Charadriidae): Little Ringed, Kentish, and Ringed. Ibis, 95:115–127.

Sutton, G. M. and D. F. Parmelee. 1955. Breeding of the Semipalmated Plover on Baffin Island. Bird-Banding, 26:137–147.

Tinbergen, N. 1953. Social behaviour in animals. John Wiley and Sons, Inc., New York.

Tompkins, I. R. 1944. Wilson's Plover in its summer home. Auk, 62:259–269.

Wetmore, A. 1965. Water, prey, and game birds of North America. Natl. Geogr. Soc., Washington.

Wilcox, L. 1959. A twenty year banding study of the Piping Plover. Auk, 76:129–152.

Winterbottom, J. M. 1963. Comments on the ecology and breeding of Sandplovers (*Charadrius*) in southern Africa. Rev. Zool. Bot. Africaines, 67:11–16.

Witherby, H. F., F. C. R. Jourdain, N. F. Ticehurst, and B. W. Tucker. 1941. The handbook of British birds. Vol. 4. H. F. and G. Witherby Ltd., London.

Appendix I

Seasonal, Sexual, and Age Plumage Difference in Charadriinae

Species	Sexual Plumage Differences in Breeding Season	Breeding Plumage Brighter than Non-breeding	Immature Plumage Different than Adult Breeding Plumage	References*, **
Charadrius hiaticula	Yes	No	Yes	1, 5
C. semipalmatus	Yes	Yes	Yes	30, 31
C. placidus	Yes	Yes	Yes	5
C. dubius	Yes	Yes	Yes	1, 31
C. wilsonia	Yes	Yes	Yes	2, 30
C. vociferus	No	No	Yes	2, 30
C. melodus	Yes	Yes	Yes	2, 30
C. thoracicus	?	?	?	3, 27
C. pecuarius	No	No	Yes	4, 16, 17
C. sanctaehelenae	No	?	Yes	25
C. tricollaris	Yes	?	Yes	16, 29
C. alexandrinus	Yes	Yes	Yes	28, 30
C. marginatus	Yes	Yes	Yes	15, 29
C. peronii	Yes	Yes	Yes	12, 20, 29
C. venustus	Yes	?	Yes	16
C. collaris	Yes	Yes	Yes	9, 23
C. bicinctus	Yes	Yes	Yes	8, 23
C. falklandicus	Yes	Yes	Yes	9, 12, 13, 29
C. mongolus	Yes	Yes	Yes	5, 26
C. leschenaultii	Yes	Yes	Yes	5, 15
C. asiaticus	Yes	Yes	Yes	1, 5
C. veredus	Yes	Yes	Yes	5, 21
C. modestus	No	Yes	Yes	6, 13, 29

APPENDIX I—*Continued*

Species	Sexual Plumage Differences in Breeding Season	Breeding Plumage Brighter than Non-breeding	Immature Plumage Different than Adult Breeding Plumage	References*, **
C. montanus	Yes	Yes	Yes	10
C. melanops	Yes	Yes	Yes	11, 14, 19, 29
C. cinctus	No	No	Yes	18, 19, 29
C. rubricollis	No	No	Yes	14, 19, 29
C. novaseelandiae	Yes	No	Yes	8, 23, 24
Anarhynchus frontalis	Yes	Yes	Yes	22, 23
Phegornis mitchelli	Yes	?	Yes	6, 9, 13, 29
Pluvialis apricaria	Yes	Yes	Yes	1, 31
Pluvialis dominica	Yes	Yes	Yes	2, 7, 30
Pluvialis squatarola	Yes	Yes	Yes	2, 30
Pluvialis obscura	Yes	Yes	Yes	23, 29
Eudromias morinellus	Yes	Yes	Yes	1, 31
Oreopholus ruficollis	No	?	?	6, 9, 13, 17
Pluvianellus socialis	No	?	Yes	6, 9, 12, 13

* Gooders, J. 1969. Birds of the world, Vol. 3 (Parts 6 and 7), IPC Magazines Ltd., London. Contains photographs and drawings of most Charadriinae species and is used here as a general reference.

** References listed in Appendix I as follows:

1. Bannerman (1961)
2. Bent (1929)
3. Bock (1958)
4. Conway and Bell (1968)
5. Dement'ev et al. (1969)
6. Meyer de Schauensee (1970)
7. Drury (1961)
8. Fleming, C. A. (pers. comm.)
9. Goodall, J. A. (pers. comm.)
10. Graul, W. D. (pers. obs.)
11. Hill (1968)
12. Howe, M. (pers. comm.)
13. Johnson (1965)
14. Littlejohns (1932)
15. Mackworth-Praed and Grant (1952)
16. Mackworth-Praed and Grant (1962)
17. Maclean, G. L. (pers. comm.)
18. McGill (1944)
19. McGill, A. R. (pers. comm.)
20. McGregor (1909)
21. Oliver (1930)
22. Oliver (1937)
23. Oliver (1955)
24. Phillips, R. E. (pers. comm.)
25. Pitman (1965)
26. Portenko (1963)
27. Rand (1936)
28. Rittinghaus (1961)
29. Sharpe (1896)
30. Wetmore (1965)
31. Witherby et al. (1941)

APPENDIX II

BREAST BAND PRESENCE, MAIN NEST SITE, AND NEST SITE REFERENCES

Species	Breast Band (× = Present)	Main Nest Site*	Nest Site References**
Charadrius hiaticula	×	Shingle (1)	1, 33
C. semipalmatus	×	Shingle (1)	8, 29
C. placidus	×	Shingle (1)	6
C. dubius	×	Shingle (1)	1, 28, 33
C. wilsonia	×	Sand (frequently near dark objects) (3)	2, 30
C. vociferus	×	Shingle or disturbed areas (1)	4, 8
C. melodus	Usually	Sand (2)	2, 31
C. thoracicus	×	Sub-desert (?)	24
C. pecuarius		Sand (2)	9, 32
C. sanctaehelenae		Grasslands (2)	21
C. tricollaris	×	Shingle, dried mud (1)	3
C. alexandrinus	incom.	Sand, salt flats (2)	12, 25
C. marginatus	incom.	Sand (near objects) or shingle (3)	14, 27
C. peronii	incom.	Sand (near drift) (3)	17
C. venustus	×	Salt pans (2)	3, 13
C. collaris	×	Sand, river beds (?)	7
C. bicinctus	×	Shingle, disturbed areas, sand (1)	19
C. falklandicus	×	Sand, short grass (2)	5, 15
C. mongolus		Stony tundra (1)	6, 22
C. leschenaultii		Stony areas (1)	6
C. asiaticus	×	Arid grasslands (commonly among pieces of clay) (1)	6, 33
C. veredus	×	Stony areas (1)	6
C. modestus	×	Arid grasslands (2)	5
C. montanus		Arid grasslands (2)	8
C. melanops	×	Shingle, dried mud, sand (1)	12, 19
C. cinctus	×	Sand (commonly near shrubs) (3)	16
C. rubricollis	incom.	Sand (near sea drift commonly) (3)	26

APPENDIX II—*Continued*

Species	Breast Band (× = Present)	Main Nest Site*	Nest Site References**
C. novaseelandiae		Holes or crevices (2)	19
Anarhynchus frontalis	×	Shingle (1)	18, 19
Phegornis mitchelli	×	Shingle or rocky sand areas (1)	10, 11
Pluvialis apricaria		Moors (2)	1, 33
Pluvialis dominica		Stony tundra (1)	8, 20
Pluvialis squatarola		Stony tundra (1)	8, 20
Pluvialis obscura		Sand (2)	19
Eudromias morinellus	×	Arid areas (commonly stony) (1)	1, 23
Oreopholus ruficollis		Arid grassland (2)	11
Pluvianellus socialis		Sand (sometimes near rocks) (3)	11

* (1) = Nest site considered discontinuous.
(2) = Uniform nest site substrates.
(3) = Nest sites near conspicuous dark objects on an otherwise uniform substrate.

** References in Appendix II:
1. Bannerman (1961)
2. Bent (1929)
3. Blaker (1966)
4. Bunni (1959)
5. Cawkell and Hamilton (1961)
6. Dement'ev et al. (1969)
7. Meyer de Schauensee (1970)
8. Graul, W. D. (pers. obs.)
9. Hall (1958)
10. Johnson (1964)
11. Johnson (1965)
12. Littlejohns (1932)
13. Mackworth-Praed and Grant (1962)
14. Maclean and Moran (1965)
15. Maclean, G. L. (pers. comm.)
16. McGill (1944)
17. McGregor (1909)
18. Oliver (1937)
19. Oliver (1955)
20. Parmelee et al. (1967)
21. Pitman (1965)
22. Portenko (1963)
23. Pulliainen (1970)
24. Rand (1936)
25. Rittinghaus (1961)
26. Serventy (1943)
27. Shewell (1951)
28. Simmons (1953*a*)
29. Sutton and Parmelee (1955)
30. Tompkins (1944)
31. Wilcox (1959)
32. Winterbottom (1963)
33. Witherby et al. (1941)

JAMES FORD BELL MUSEUM OF NATURAL HISTORY, UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA 55455, 7 SEPTEMBER 1972.

TERRITORIAL AGGRESSION IN WINTERING WARBLERS AT BAHAMA AGAVE BLOSSOMS

John T. Emlen

The massive yellow flower heads of the century plant (*Agave Braceana*) provide rich localized sources of nectar and insects on the northern Bahama Islands during the late winter of each year. Scattered every few hundred feet through parts of the extensive open pine forests, these showy plants, 4 to 7 meters tall, attract large numbers of a wide variety of permanent resident and migrant birds during their brief period of flowering. Bananaquits (*Coereba flaveola*) and Cuban Emerald Hummingbirds (*Chlorostilbon ricordii*) are prominent among the resident species, with smaller numbers of Olive-capped Warblers (*Dendroica pityophila*), native Yellow-throated Warblers (*Dendroica dominica flavescens*) and Red-legged thrushes (*Mimocichla plumbea*) making frequent visits. Among the wintering migrants from North America the Palm Warbler (*Dendroica palmarum*) is most numerous at the blossoms, while Cape May Warblers (*D. tigrina*), Myrtle Warblers (*D. coronata*), Eastern Yellow-throated Warblers (*D. d. dominica*), Prairie Warblers (*D. discolor*), Yellowthroats (*Geothlypis trichas*) and Catbirds (*Dumetella carolinensis*) make frequent appearances.

The scene at each plant is characterized by frenzied chasing through much of each day. Birds alight and are replaced at frequent intervals, and only a few individuals besides the large thrushes and Catbirds and the stubbornly defiant Bananaquits manage to remain for more than 10 to 15 seconds at a time. Although no birds were tagged for individual identification in this study, close watching revealed that a single large plant often served as the continuing focus for aggressive activities of a particular bird for an hour or more and, possibly over several consecutive days.

On the morning of 25 January 1971, I followed all activity on one large agave near Fortune Bay, Grand Bahama Island for 55 consecutive minutes. During this period the plant was persistently dominated by a male Cape May Warbler. In a 25-minute test period the bird spent about 20 percent of the time chasing intruders, about 70 percent sitting on look-out perches within 12 meters of the agave top, and only about 10 percent actually feeding. Conforming to the usual pattern of local wintering warblers the bird did not sing. During these 25 minutes the plant was approached by five Palm Warblers, two Northern Yellowthroats, six Cuban Emeralds, and seven Bananaquits. All intruders of the first three species were quickly and vigorously attacked, some of them when they were still 6 to 8 meters away from the agave. The warblers invariably retreated; a few hummingbirds succeeded in returning and feeding briefly on the back side of a blossom, apparently hidden from view. The Bananaquits, by contrast, persisted. Although smaller than the warbler they flew in directly and fed freely making little or no response to the warbler who approached hesitantly in three instances to perch about a meter away and then fly back to a nearby lookout perch. In no case was the resident warbler seen to feed while the Bananaquits were present. In no case were the Bananaquits seen to attack any visitors to the plant.

On 28 January I watched the activity at five agaves in the same area for uninterrupted periods of 10 to 20 minutes each. Palm Warblers dominated at four of these plants; no single bird dominated in the fighting at the fifth plant, the one held by the Cape May Warbler three days before. At each of the dominated plants all intruding warblers and hummingbirds were vigorously repelled before reaching the blossoms. The behavior was similar to that of the Cape May Warbler, and again, no singing occurred. Repelled species included other Palm Warblers, Cape May Warblers, Yellow-throated Warblers, migrant Yellowthroats, Olive-capped Warblers and Cuban Emeralds. As with the Cape May Warbler on the 25th, Bananaquits were grudgingly tolerated in all cases. Two Catbirds and one Red-legged Thrush which visited were not challenged and remained feeding for several minutes. Activity on the non-dominated agave was difficult to interpret, but irregular chasing by warblers of at least three species, stubborn unconcern by Bananaquits and timid persistence by hummingbirds was observed.

The persistence of the established Cape May Warbler and the four Palm Warblers in repelling birds that approached their plants indicates that more was involved than simple aggressive responses to imposed crowding. In each case a single individual vigorously assumed and retained dominance over conspecifics and a variety of other challengers for appreciable periods of time. Such energy-expensive behavior calls for consideration of the associated circumstances and the potential advantages.

Localized aggression by temporarily established individuals is a familiar phenomenon with various birds at artificial feeding stations in temperate regions where food is locally concentrated in an otherwise impoverished winter environment. Hummingbirds of various species show similar behavior in flower gardens or at seasonally flowering trees where, again, a special food supply is concentrated within a small area (Pitelka, 1942; Armitage, 1955; Stiles and Wolf, 1970). Birds that utilize dispersed food resources such as the insectivorous warblers have rarely been observed in such behavior in their winter quarters, and in the two cases known to me a regional shortage of natural foods was suspected. In one case (Woolfenden, 1962), a Myrtle Warbler established itself for 14 days on an area of green lawn in Gainesville, Florida, during a particularly cold spell, driving off all intruding warblers and kinglets. In the other (Kale, 1967), a migrant Cape May Warbler on Dry Tortugas repeatedly attacked and repelled warblers of several species for three consecutive days whenever they approached a particular agave blossom.

Agave blossoms clearly provide an extremely rich as well as spatially concentrated source of nectar and insects. A corresponding concentration of nectar and insect feeding birds in the Grand Bahama situation is, therefore, not surprising. Intense aggressive activity, on the other hand, would be uneconomical unless the food supply in the surrounding area was so poor as to require a comparable or greater expenditure of energy in search and pursuit of prey. In the present instance the energy cost of aggressive activity appears to have been very high (roughly 90 percent of the bird's time in the one instance where it was evaluated), while the availability of food in the surrounding areas was apparently great as judged by the maintenance of high insectivore densities through the winter and spring and by direct evidence of continuing high arthropod populations and nectar sources before and after the agave blossoming season (unpublished data).

Mild dominance behavior and subtle supplanting of intruders by locally established individuals during the non-breeding season has been observed in a variety of birds (Kluijver, 1951; Kluyver and Tinbergen, 1953; Gibb, 1960; Brown, 1963) and appears to function in the selective survival of established local residents in situations of food scarcity. Vigorous and persistent repulsion of intruders in situations of regional food abundance is quite a different matter, however, and is rarely encountered except in nesting situations.

We have, of course, very little information on the relative food values of nectar *vs* insects, the energy costs of aggressive chasing *vs* foliage gleaning, or the particular conditions applying at the site of the observed episodes on Grand Bahama. I am inclined, however, to interpret the behavior described in this report as extravagant and maladaptive, and to attribute its persistence in the face of natural selection to the graded nature of aggressivity as related to stimulus intensity, and to the unusual and transitory nature of the situation that elicited it. Territorial aggression, beneficial at low intensities, promptly becomes detrimental when it rises in intensity to the point where energy cost exceeds derived value. Special intensity regulating mechanisms could conceivably evolve to alter the stimulus-response curve at the appropriate point, but where the critical situation that produces the detrimental response level occurs only rarely and briefly, the fine adjustment of the genotype needed to effect the adaptation may be impractical.

In conclusion, I propose that the energy-expensive overt aggression displayed by these birds is a transitory and maladaptive over-extension of a normally mild territorial dominance precipitated by the sudden appearance of a concentrated swarm of invaders on their feeding territories.

ACKNOWLEDGMENTS

I am grateful to Drs. Frank Gill and Jack Hailman for reading drafts of this paper and for critical comments.

LITERATURE CITED

Armitage, K. 1955. Territorial behavior in fall migrant Rufous Hummingbirds. Condor, 57:239–240.

Brown, J. L. 1963. Aggressiveness, dominance and social organization in the Steller Jay. Condor, 65:460–484.

Gibb, J. A. 1960. Populations of tits and goldcrests and their food supply in pine plantations. Ibis, 102:163–208.

Kale, H. 1967. Aggressive behavior by a migrating Cape May Warbler. Auk, 84: 120–121.

Kluijver, H. N. 1951. The population ecology of the Great Tit. Ardea, 39:1–142.

Kluyver, H. N. and L. Tinbergen. 1953. Territory and regulation of density in titmice. Arch. Neerl. Zool., 10:265–289.

Pitelka, F. A. 1942. Territoriality and related problems in North American hummingbirds. Condor, 44:189–204.

Stiles, F. G. and L. L. Wolf. 1970. Hummingbird territoriality at a tropical flowering tree. Auk, 87:467–491.

Woolfenden, G. 1962. Aggressive behavior by a wintering Myrtle Warbler. Auk, 79: 713–714.

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN 53706, 15 AUGUST 1972.

GENERAL NOTES

Local distribution of mixed flocks in Puerto Rico.—Moynihan (1962) and Willis (1972) suggest that mixed or interspecific bird flocks primarily protect birds against predation, but Morse (1970) and Cody (1971) suggest that mixed flocks mainly increase foraging efficiency. A recent visit to Puerto Rico shows that mixed flocks there are localized, a situation like that reported by Diamond (1972) for New Guinea but much more accessible. Intensive study of such situations can perhaps help determine whether flocking is due to a single factor or combination of factors.

From 17 to 28 January 1972, I looked in vain for cohesive mixed flocks in several of the major forest types of Puerto Rico. (Mixed flocks of grassquits, swallows, blackbirds, or introduced weaver finches occur in open country, and flocks of shorebirds on shorelines, but these flocks were not studied.) I visited very wet forests on seven days in the Luquillo Mountains: shrubby, mossy "elfin forest" at El Yunque and Pico del Oeste; palm and other forests of moderate height around La Mina; tall forests on the central Rio Mameyes and at the El Verde Experimental Station. Dry, scrubby thorn and cactus woodland much like that in the foothills of Sinaloa, Mexico was scoured for flocks for three days at the Guanica State Forest. Five hours on one day were in patchy and fairly dry woodland of moderate height in a canyon northwest of La Parguera.

On 30 January, 11:00–13:00, I found in two cohesive mixed flocks nearly all the observed small woodland birds (Table 1; bird names from Bond, 1971) at a fourth area: Maricao State Forest, moderately wet and tall (about 15 m) dense woodland on the westernmost ridge of the Central Range. Unfortunately, I was leaving Puerto Rico and could not investigate further, However, Robert MacArthur (pers. comm.) found mixed flocks at Maricao and in the nearby savannahs of the Lajas Valley but not at Guanica when he censused the three areas in March–April, 1964. He found that flocks made his censusing difficult, but did not investigate further. The localized flocking is thus not a new or accidental phenomenon, but regular.

The Luquillo Forest did produce a few cases of loose association of Black-throated Blue Warblers with pairs of Bananaquits, and one instance where several other species flocked to a flowering bush. The Rechers (1966) found Cape May Warblers associating with Black-throated Blue Warblers and Puerto Rican Tanagers, occasionally joined by Pearly-eyed Thrashers, Bananaquits, and Stripe-headed Tanagers in December censuses. I saw no Cape May Warblers in Puerto Rico in January. Possibly these birds were at fruits or flowers that do not persist into January.

At Guanica, Adelaide's Warblers twice had Puerto Rican Vireos loosely associated with them. In both cases I found other birds about, but the birds seemed to be concentrating in areas of thick foliage during the hot hours of the day rather than associating with each other. Once a Parula Warbler followed two Puerto Rican Bullfinches. Otherwise, the birds wandered singly or in pairs; the family groups sometimes noted in Puerto Rican Tanagers and Elfin Woods Warblers at Luquillo were absent in Guanica.

The first Maricao flock circled slowly from 11:00 to 11:25 through woodland along bulldozed trails at picnic tables north of the new Forest Service Recreation Area. Only the Mango strayed from the group. At 12:45, however, only part of the flock was near the road just south. The second flock moved slowly 11:45 to 12:25 in continuous woodland along a trail north of there some 300 m. In both flocks, the noisy Puerto Rican Tanagers seemed the central species, even though they supplanted several smaller birds. Close to them were immature or female migrant warblers; the only adult male seen was a Black-throated Blue 75 m north of the second flock and not with it. Pairs of the re-

TABLE 1
BIRDS IN AND OUTSIDE OF FLOCKS IN PUERTO RICO

Species	Maricao Flock 1	Maricao Flock 2	Maricao Outside	Luquillo[a]	Guanica[b]	La Parguera[c]
Green Mango	1	–	1	–	–	–
Puerto Rican Tody	1+	1	–	61	10	6
Puerto Rican Vireo	1+	1+	–	–	17	5
Black-and-White Warbler	1	1	–	6	3	–
Black-throated Blue Warbler	1	1	1	18	–	–
Elfin Woods Warbler	2	2	–	4	–	–
Parula Warbler	2	1	–	7	7	5
American Redstart	1	1	–	11	4	1
Bananaquit	1	–	–	320	26	10
Puerto Rican Tanager	2+	3+	–	50	–	–
Stripe-headed Tanager	2	–	2	17	3	–
Puerto Rican Bullfinch	2+	1+	–	21	21	3

[a] 13 other forest species seen. [b] 14 others. [c] 12 others.

cently described Elfin Woods Warblers, previously recorded only from elfin woodland in the Luquillo Forest, followed closely, as did Puerto Rican Vireos. Other native species wandered more widely around the flocks, especially the loosely associated Bananaquit and Stripe-headed Tanagers.

The most likely reason for flocking at Maricao is that it is the only forest in which Sharp-shinned Hawks are regular (Leopold, 1963; Biaggi, 1970). The Keplers (1970) report Sharp-shins locally in the Luquillo Forest, however; possibly some flocks observed by the Rechers were in such areas. I saw no Sharp-shins, but Sparrow Hawks are common at La Parguera and Guanica while Red-tailed Hawks fly over all four areas surveyed. Probably these last two hawks seldom chase birds. Diamond (1972) thought there were forest-dwelling accipiters in regions with no mixed flocks in New Guinea. However, the lack of bird flocks on Hawaii seems a result of the absence of effective predators (Willis, in press). Perhaps the flocking at Maricao will prove to be a way of using an otherwise unsafe habitat in the presence of a bird predator. However, Maricao is on serpentine soil and probably has low productivity. It could thus be that bird territories are larger there than in other areas, which would facilitate flocking. Certainly there is a relatively low number of Bananaquits there compared to other forests in Puerto Rico.

I gratefully acknowledge the support of the Ford Foundation to the "Tropical Ecology" course of Robert MacArthur and John Terborgh.

LITERATURE CITED

BIAGGI, V. 1970. Las aves de Puerto Rico, Editorial Universitaria, Universidad de Puerto Rico.

Bond, J. 1971. Birds of the West Indies. Second Edition. Houghton Mifflin, Boston.

Cody, M. 1971. Finch flocks in the Mojave Desert. Theor. Population Biol., 2:142–158.

Diamond, J. 1972. The avifauna of the eastern highlands of New Guinea. Publ. Nuttall Ornithol. Club, 12.

Kepler, C. B. and A. K. Kepler. 1970. Preliminary comparison of bird species diversity in Luquillo and Guanica forests. E-183 to E-191, in H. T. Odum (Ed.), A Tropical Rain Forest. AEC, Oak Ridge, Tennessee.

Leopold, N. F. 1963. Checklist of birds of Puerto Rico and the Virgin Islands. Agr. Exp. Sta. Univ. Puerto Rico, Bulletin 168.

Morse, D. H. 1970. Ecological aspects of some mixed-species foraging flocks of birds. Ecol. Monogr., 40:119–168.

Moynihan, M. 1962. The organization and probable evolution of some mixed species flocks of neotropical birds. Smithsonian Misc. Coll., 143:1–140.

Recher, H. F. and J. T. Recher. 1966. A contribution to the knowledge of the avifauna of the Sierra de Luquillo, Puerto Rico. Caribbean Jour. Sci., 6:151–162.

Willis, E. O. 1972. The behavior of Spotted Antbirds. Am. Ornithol. Union. Ornithol. Monogr., 10.

Willis, E. O. In press. Are there bird flocks on Hawaii? Calif. Birds, 3.

Edwin O. Willis, *Department of Biology, Princeton University, Princeton, N.J. 08540, 22 February 1972.*

The wing molt of the Florida Duck.—There does not appear to be any documentation of the Florida Duck (*Anas fulvigula fulvigula*) undergoing a wing molt, rendering it flightless, in the wild. Beckwith and Hosford (Am. Midl. Nat. 57:461–473, 1957) reported circumstantial evidence that the Florida Duck undergoes such a molt in the wild. They reported that three one-year-old captive Florida Ducks underwent a molt and became flightless during the month of July 1954.

Between 1 August and 1 September 1967 nightlighting operations were conducted on the Merritt Island National Wildlife Refuge, Titusville, Florida. These operations were designed primarily to capture broods of Florida Ducks utilizing a modification of the method described by Cummings and Hewitt (J. Wildl. Mgmt. 28:120–126, 1964).

These nightlighting operations yielded a total of 13 flightless adult Florida Ducks, six males and seven females, in varying stages of a wing molt that had rendered them flightless. The primary wing feathers are lost first (Fig. 1), followed by secondaries and tertials. The tertial feathers are not entirely molted until after the new primary and secondary feathers begin to appear. The molting succession of axillars and coverts was not determined. A wild Florida Duck retained after capture was found to remain flightless for approximately 4 weeks. All flightless females were found alone. In one instance, four flightless adults were encountered, two of which were captured, and proved to be males.

All molting Florida Ducks were found in impoundments of 515 to 555 acres in size. Water salinities in these two areas varied from 7,910.4 to 14,184.0 ppm. Vegetation utilized for escape by molting Florida Ducks consisted of saltgrass (*Distichlis spicata*) and mangrove (*Rhizophore mangle* and *Avicannia nitida*). At no time were molting birds found very far from such cover.

I thank the following employees of the Bureau of Sport Fisheries and Wildlife for

FIG. 1. Adult female Florida Duck in early stage of wing molt; primaries and secondaries lost, greater primary coverts, tertials and underwing coverts essentially intact. Merritt Island National Wildlife Refuge, Florida (1967).

their assistance during the study: W. O. Steiglitz, C. T. Wilson, J. Carroll, D. Kosin and S. Wineland. Appreciation is also expressed to Dr. R. E. Martin, Tennessee Technological University.—TERRY W. JOHNSON, *Georgia Game and Fish Commission, Route 3, Ridgewood Apartment 9, Forsyth, Georgia 31029, 25 April 1972.*

Turkey Vulture harassed in flight by Mallard pair.—While observing a Turkey Vulture (*Cathartes aura*) circling over a swampy area in Guilford, Connecticut on 6 April 1972, I noticed a pair of Mallards (*Anas platyrhynchos*) climbing upwards and circling it in wide spirals. Flying about a foot or so apart, and with the drake in the lead, the ducks made a pass at the vulture's wing whereupon the vulture rolled to one side. The ducks then circled above the vulture which sailed downward. The ducks resumed the attack, this time diving at its tail and making the vulture flap again to gain height. After climbing above the now rising vulture the ducks again dived close to its wing making the vulture roll sideways. The vulture was by now gaining altitude rapidly and the ducks made an attack from below. As they approached they separated, the female making a pass at the tail and the male at the wing, the vulture suddenly swerving to avoid them as it continued to rise. The ducks then sailed back to the marsh, where I presume they had arisen. The vulture continued to rise and drifted away.—NOBLE S. PROCTOR, *Biology Department, Southern Connecticut State College, 501 Crescent Street, New Haven, Connecticut 06515, 14 April 1972.*

Harlan's Hawk from Utah: first record for the Great Basin.—The Harlan's Hawk (*Buteo harlani*) is known to breed chiefly in Alaska and Northern British Columbia and winter chiefly in the Great Plains region south to Louisiana (A.O.U. Check-list 1957: 106). On 4 November 1967 Everett C. Peck collected a single Harlan's Hawk at a farm located 6 miles west of Delta, 4600 feet elevation, Millard County, Utah (lat 39° 21′ N, long 112° 41′ W). The area is typical open farm community interspersed with occasional windrows of several species of deciduous trees: principally boxelder (*Acer negundo*), cottonwood (*Populus fremontii*), siberian elm (*Ulmus pumila*), and white poplar (*Populus alba*). The bird was shot from a large white poplar in one of the windrows.

The specimen, now in the University of Utah collection (No. 20931), was a bird in little-worn juvenal plumage with an ossified skull. The sex of the bird could not be positively determined, but it was thought to be a female. Its identification as a Harlan's Hawk was corroborated by Dr. Richard Banks of the U.S. National Museum.

This specimen constitutes the first record for the Harlan's Hawk in Utah, as well as the Great Basin as a whole; and although the status of the Harlan's Hawk is at present equivocal (Mayr and Short, Publ. Nuttall Ornithol. Club, 9:38, 1970), the specimen presents data on the vagrancy of a morphologically distinct form.—GARY L. WORTHEN, *Museum of Natural History, University of Kansas, Lawrence, Kansas 66044, 1 May 1972.*

Status and habits of *Megapodius pritchardii*.—The Malau (*Megapodius pritchardii*) lives only on the small, isolated island of Niuafo'ou in the Tongan archipelago. Due to its isolation and the volcanic nature of the island there has been some concern as to the future of this species. My wife and I were on Niuafo'ou from November 1967 through August 1969 and were able to spend some time observing these birds. Friedlander (Ornithol. Monatsber., 7:37–40, 1899) and Kellers (Smithsonian Inst. Publ., 3111:71–74, 1931) reported briefly on observations on *Megapodius pritchardii*, but the species remains poorly known.

The Malau appears to be in no immediate danger of extinction. There is a limited amount of natural predation from Barn Owls (*Tyto alba*) and feral cats but the most significant predator is *Homo sapiens*. There is a law in Tonga which prohibits the taking of Malaus or their eggs or chicks but this law is generally disregarded in the frontier area of Niuafo'ou. The birds are not being decimated by this human predation because of the difficulty in reaching the majority of their nesting sites. Since Malaus are only taken in the vicinity of nests they generally lead a relatively unmolested life. I suppose that there would be a definite increase in pressure if the human population were to increase significantly above its present limit of 800 or so. Prior to the 1946 evacuation there was a human population of roughly 1500 and the Malau was said to be more numerous at that time than it is at present.

Niuafo'ou is roughly circular in outline with a land area of 13.5 square miles. At least 3.5 square miles are unsuitable habitat for the birds due to extensive lava flows. The Malaus seem to be concentrated around the inner slopes of the caldera and the central lake. There also are a few breeding areas on the southwest seashore. The birds seem to prefer the steep, wooded slopes to the more level areas of the island.

Malaus lay their eggs only in certain specific areas. Six of these areas are regularly visited by egg collectors and there are several other areas which are known but are seldom visited due to the extreme difficulties involved. These sites are quite different. Some are near the lake shore on cinder slopes with little vegetation, others are on the caldera rim in dense forest, and some are between these extremes. The common factors are loose soil composed mainly of volcanic ash and proximity to a volcanic heat vent.

FIG. 1. A man digging for Malau eggs. Each depression in the foreground is a nest site which may have entrances to several tunnels.

We observed Malau eggs throughout the year and saw newly hatched chicks in January, June, July, August, September, and December. The residents report an increase in the numbers of eggs in the burrows during April and May. This observation coincides with our observations. It is also corroborated in the sightings of the chicks since the incubation period is probably in the neighborhood of three months.

The birds lay their eggs in burrows six to eight inches in diameter and three to five feet long. The burrows are carefully filled in after each excavation. The burrow extends more or less diagonally downward into the earth and there may be several burrows in any given nest site (Fig. 1). The people report up to twelve eggs in a burrow during the peak nesting season. This accumulation is over an approximate two-week period and almost certainly is not the work of a single female. I have seen two and three birds digging at one time within a few feet of each other in one nest site. It is believed that only female birds visit the burrows and then only to lay eggs. Twelve birds taken in the vicinity of nests while we were there all had either laid an egg or did subsequent to their capture.

Each egg laying trip probably requires a full day for the female. The work begins in the early morning before sunrise and may last until almost noon. She begins by digging a shallow depression in the floor of the nest site and as she gets into firmer sand that doesn't collapse and slide she begins digging a tunnel. She digs first with one foot for several strokes and then takes a few with the other. From outside a tunnel I have watched soil flying out in five to eight bursts followed by a pause of 10 to 20 seconds before the next series of bursts. Ejected soil may land more than three feet from the tunnel entrance.

FIG. 2. A successful egg collector. This being the off season one egg is not unusual.

Eggs are light brown in color occasionally having scattered white flecks. The eggs tend to lighten with age but this is not a reliable indicator of age since there is a great variation in color at the time of laying. The eggs average about three inches in length with diameters of about one and a half inches. They are equally rounded at both ends rather like a rugby ball (Fig. 2). Temperatures recorded in the vicinity of incubating eggs ranged from 29° C to 31° C and remained stable despite fluctuating ambient temperatures. I hatched two eggs in a crude incubator after determining that the embryos were well advanced. One hatched after 11 days and the other after 26 days. Temperatures varied from 28° C to 34° C during this period. Several of the local people have told of having Malau eggs hatch in their cupboards and in their homes. I regard these stories as true since the average air temperature is only slightly lower than the optimum incubating temperature. I observed one chick that had emerged from a hole in which the eggshell fragments were only six inches from the surface. Apparently a landslide which had occurred about three weeks previously had left the egg in the exposed position and allowed it to suffer rather extreme day-night temperature variations. From these observations it can be assumed that the more mature embryos can withstand substantial temperature changes which would kill most species.

I noted an egg tooth on one newly hatched Malau which was given to me but failed to see any on the two birds which hatched in my incubator. Three of the newly hatched birds I observed had shriveled external yolk sacs which persisted for up to three weeks before falling off. Young Malaus have a distinct natal and juvenal plumage before attaining the definitive adult aspect. Although the young can fly at hatching, they are slow to develop feeding habits. After the third day they begin occasionally to scratch the ground but do not look at the area they have been scratching. It is not until the fourth or fifth day that they really look for food. Their initial pecking efforts are inaccurate. They do not appear to judge distances accurately nor do they readily consume such food as is picked up. By six days after hatching they recognize and peck normally at ants and small insects and worms. During the first few days the birds rested for long periods; their balance was imperfect and they wobbled when standing. Movement during this period tended to be in bursts rather than continuous. The young I kept for periods up to two weeks never did become tame although adults I had usually were fairly quiet after one week.

Malaus are difficult to observe in the field due to their secretive behavior and dull brown color, but I was able to watch a few adults in addition to those that I kept in captivity. Wild birds spend much of their time searching for food by scratching with their feet in the leaves and forest litter. Birds were not easily approached in the wild but if approached from downslope they tended to be less wary. When frightened they usually ran off rather than flying unless the intruder was very close or above them. A flushed bird commonly landed in a nearby tree and looked back at the source of disturbance. If no further danger was apparent after some minutes the bird would then return to the ground near its original location and carry on its activity. I rarely saw birds in flapping flight unless they had been frightened. They tend to move by walking, occasionally using their wings as an aid in climbing steep slopes. Going downslope they will sometimes glide without flapping.

Captive birds ate grated coconut supplemented daily with worms, ants, roaches, centipedes, and similar foods. The Malaus would not eat a species of yellow wasp common to the island. The captives on this artificial diet lost the bright yellow color of their legs. Captives vigorously defended their food from chickens on the outside of the cage. Twice in July 1969 I saw Malaus of unknown sex (presumed to be male) fighting. These scenes occurred on the big island in the lake where the population is quite dense. The fighting was characterized by wing beating, kicking, pecking, and shoving. In one case the combatants separated only after they had fallen into the lake. On emerging they went in opposite directions each emitting a call I had not previously associated with the Malau although I had heard it rather frequently. Malaus scratch their heads directly under the wing and after feeding commonly bill-wipe on sticks.

I would estimate that the present population is above two thousand adults and is close to the carrying capacity of the island.

Acknowledgment.—I thank G. A. Clark, Jr., for suggestions on the manuscript.—
Donald G. Weir, *2428 - 5th Street, Monroe, Wisconsin 53566, 13 September 1971.*

Black-bellied Plover incubation and hatching.—The Black-bellied Plover (*Squatarola squatarola*) has been little studied on its nesting ground in the Arctic. There has been some confusion about its usual incubation period, and so far as I am aware no one previously has watched the bird from a blind for any considerable time during incubation and hatching. Therefore, I am summarizing observations made in 1970 and 1971 mainly on two nests located in the interior of Bathurst Island, N.W.T., Canada.

The climate of Bathurst is high Arctic, and its shores remain in the grip of sea ice all summer. The terrain is rolling and mostly below 200 m in elevation. The pebble-strewn earth of the hilltops and slopes are nearly bare of vegetation, but the wettest of the lowlands often form sedge-moss flats that are almost completely covered with vegetation and look in the distance like a mowed meadow. The biological research camp of the National Museum of Canada where I worked overlooks an extensive meadow of this kind. The plover nests I watched were here, about 14 km inland from the sea at lat 75° 44′ N, long 98° 25′ W.

All five of the Black-bellied Plover nests I examined were situated on ground that was nearly bare and at least slightly raised above the more richly vegetated flats nearby, where the adults did most of their feeding and where they took the young after hatching. In each instance the nest depression was shallow and floored with only a few wisps of lichens and leaves.

In 1970 I spent 23 hours observing a nest near the middle of the incubation period. The time was distributed over 5 days, 9–13 July, mostly in the afternoon hours. These young hatched 25–26 July.

Although other observers have noted males at the nest more often than females, I found this female on the eggs almost 60 percent of the time when I was watching. Each member of the pair had attentive periods as long as 3 hours, but each such period was broken briefly by alarms. Both adults sat closely except when frightened. The incubating bird always returned within 10 minutes after the disturbing factor went away. Arctic foxes (*Alopex lagopus*) passed within sight several times daily, particularly in 1971 when foxes were unusually abundant, and all three species of jaegers (*Stercorarius pomarinus, S. parasiticus,* and *S. longicaudus*) nested within 1 km and coursed frequently in the vicinity.

The male and female exchanged places on the nest quickly. In a typical interchange, the male approached on wing from a distance giving both loud single notes and the characteristic *pee-oo-wee* call of the species. The female flew directly from the nest to a point several hundred meters away and began feeding there. The male alighted 20 m from the nest and ran rapidly to the eggs. The nest was unattended less than a minute.

I watched another nest one and a half hours during incubation on 15 July and five and a half hours continuously during hatching in the afternoon of 18 July 1971. This set of four eggs was complete when found at 17:40, 22 June. One of these eggs was pipped at 00:45, 18 July, and the voice of the chick could be heard within. This first hatchling freed itself from the shell more than 12 hours later at about 13:15. The second chick hatched about 15:30; the third, about 22:00; and the fourth, between 00:15 and 04:45, 19 July. The time between the hatching of the first and last egg of the set was about 12 hours, and all of the young were out of the nest fifteen and a half hours after the hatching of the first. My frequent examinations of the nest may have accelerated their departure. When I visited the nest in the early morning after a four and a half hour absence, the youngest of the brood was covered by an adult on bare ground 10 m from the nest and the other three were more than 50 m away in the concealment of grass. Both parents ran about in agitation.

The incubation period of the fourth egg was at least 26 days, 6½ hours. In addition I had two other nests with incubation periods in excess of 25 days. From this information and other evidence to be given here, I have concluded the usual incubation period for the Black-bellied Plover is 26–27 days.

Parmelee et al. found it was "at least 27 days" (Birds of southeastern Victoria Island and adjacent small islands, Natl. Mus. Canada Bull., 222:220, 1967). Drury reported for two nests "at least 26 days" and "at least 27 days" but, noting shorter periods in earlier accounts, expressed concern that incubation might have been lengthened by his regular visits to the nests (Auk, 78:188, 1961). Brandt gave 23 days without details (Alaska bird trails, Bird Res. Found., Cleveland, p. 373, 1943), and Höhn reported 24 days in an inconclusive instance where only one egg hatched (Auk, 74:207, 1957). Two of the most comprehensive books available on shorebirds follow Brandt in giving 23 days, A. C. Bent

Fig. 1. Black-bellied Plover female carrying eggshell from nest after hatching.

(Life histories of North American shore birds, Pt. 2, U.S. Natl. Mus. Bull. 146, p. 159, 1929) and R. S. Palmer (Shorebirds of North America by Stout, G. D., P. Matthiessen, R. V. Clem, R. S. Palmer, Viking Press, New York, p. 163, 1967).

I am inclined to minimize the significance of human disturbance in these examples. My observations revealed that incubating Black-bellied Plovers are often frightened from the nest whether human beings visit them or not. The birds I watched left the nest many times a day when alarmed by the approach of jaegers and were sometimes off the nest many minutes when arctic foxes were near or caribou and muskoxen grazed nearby. They left the nest to chase Red Phalaropes (*Phalaropus fulicarius*) and White-rumped Sandpipers (*Erolia fuscicollis*) walking close at hand. Unlike some tundra nesters that sit tightly, the Black-bellied Plover often leaves when danger is 200 m or more away. In a species so skittish, frequent absence from the eggs with some cooling is probably normal.

The incubation period of the closely related Greater Golden Plover (*Pluvialis apricaria*) is 27–28 days (Witherby, H. F., Handbook of British birds, Vol. 4:366, 1940), and for the American Golden Plover (*Pluvialis dominica*) is about 26 days, 4 hours according to Parmelee et al. (op. cit.:85).

At the time of hatching, whichever adult was in attendance flew away with pieces of eggshell within minutes after a young bird broke free (Fig. 1). While the other young were hatching, the earlier hatchlings ventured as much as 20 cm out of the nest. The young alternated sleep and vigorous activity within and outside the edges of the nest. Both parents sometimes twittered softly when approaching or covering the chicks.

I saw elaborate distraction displays from both male and female when I was near the nest during incubation and hatching. The birds moved on rapid feet, breast touching the ground, wings spread and drooping until the primaries brushed the earth, tail usually low but sometimes high and always showing much white, body trembling.

I would like to thank Stewart D. MacDonald and the Canadian National Museum for the opportunity to study on Bathurst Island, and David F. Parmelee and David J. T. Hussell for reading an earlier draft of this note.—Harold F. Mayfield, *Waterville, Ohio 43566, 22 May 1972.*

Ten years of Barn Owl prey data from a Colorado nest site.—Few reports on the food habits of Barn Owls (*Tyto alba*) are available from the Rocky Mountain region. Consequently, the ten years of prey data from a single site presented here should be of interest.

Barn Owls have used an abandoned gravel pit 3 miles southwest of Fort Collins, Larimer Co., Colorado, for nesting and roosting over a period of at least 17 years. Land surrounding the pit is largely short-grass prairie interspersed with some farmland, both dry and irrigated. Shrub covered hogbacks bordering the Front Range of the Rocky Mountains are located one-half mile west of the pit.

Table 1
Ten Years of Barn Owl Prey from Northcentral Colorado

Prey	Per cent of prey numbers by year										
	1953*	1961	1962	1963	1964	1966	1967	1968	1969	1970	Total
Mammals											
Sorex spp.	–	–	1.7	1.0	–	–	–	–	–	–	12
Cryptotis parva	–	–	–	–	–	–	–	0.3	–	–	2
Sylvilagus spp.	1.1	–	0.2	–	0.3	–	–	0.8	2.2	1.9	31
Dipodomys ordii	0.2	–	0.2	0.5	–	–	0.4	–	–	–	5
Perognathus spp.	6.4	3.5	0.5	2.0	1.7	0.8	3.1	1.2	4.8	1.6	116
Reithrodontomys spp.	10.6	4.3	2.4	1.1	0.3	4.3	–	3.7	1.8	3.2	176
Peromyscus spp.	26.1	17.6	16.7	23.2	27.3	14.5	6.2	24.0	21.6	20.6	825
Neotoma spp.	0.1	–	0.2	–	–	–	–	–	–	–	2
Microtus pennsylvanicus	15.4	21.3	20.6	29.1	22.1	9.2	49.8	23.5	17.2	16.1	800
Microtus ochrogaster	28.4	52.5	47.9	36.1	35.7	51.6	40.1	43.3	48.4	54.2	1,565
Ondatra zibethicus	–	–	0.2	–	–	–	–	–	–	–	1
Rattus norvegicus	0.2	–	–	–	–	–	–	–	–	–	2
Mus musculus	3.5	–	3.1	4.0	–	7.7	0.4	2.3	1.5	1.1	94
Unidentified mammals	4.8	–	5.3	1.0	10.9	9.4	–	–	–	–	126
Birds											
Unidentified birds	3.2	0.7	1.0	2.0	1.7	2.5	–	0.9	2.8	1.3	69
Total numbers	1,018	141	582	203	293	116	227	600	273	373	3,826

* From Reed, ibid.

Food habits were first studied from this pit in 1953 (Reed, J. Mammal., 38:135–136, 1957). Students in mammalogy classes at Colorado State University studied foods of Barn Owls using the pit from 1961 to 1964 and in 1966 (unpublished), and I collected and analyzed pellets from 1967 to 1970. During the last four years of the study, Barn Owls were present from March to November but most activity occurred from May to August. No information on times of occupancy is available prior to 1967.

Mammals in the genera *Peromyscus*, *Microtus* and *Reithrodontomys* formed the principal portion of the diet. Non-mammalian prey consisted entirely of birds. Complete prey lists are found in Table 1.

This study was completed while I was an NSF Trainee at Colorado State University.—Carl D. Marti, *Department of Zoology, Weber State College, Ogden, Utah 84403, 27 June 1972.*

First record of the Ovenbird in Trinidad, West Indies.—During routine bird-bleeding and banding operations in conjunction with arbovirus studies in Trinidad, a male Ovenbird (*Seiurus aurocapillus*) was caught in a mist net on 19 January 1971, in a secondary tropical forest at Waller Field, Trinidad, West Indies. Meyer de Schauensee (The species of birds of South America and their distribution, 1966) states that the Ovenbird winters from the southern United States southward through Mexico and Central America to Colombia, and northern Venezuela, and to the Greater and Lesser Antilles. This bird has not been recorded, heretofore, from Trinidad, but two individuals were recorded by J. J. Dinsmore on neighboring Little Tobago Island in November 1966 and March 1967, the first being banded and released (J. J. Dinsmore, unpubl. M.S. thesis, Univ. Wisconsin, 1967). The skin (TRVL 15585) is in the reference collection of the Trinidad Regional Virus Laboratory.—Elisha S. Tikasingh, *Trinidad Regional Virus Laboratory, P.O. Box 164, Port-of-Spain, Trinidad, West Indies, and* Richard ffrench, *St. Peter's School, Texaco Trinidad Inc., Point-a-Pierre, Trinidad, West Indies, 15 May 1972.*

Blackbird nest placement and nesting success.—In a 1971 paper (Francis, Wilson Bull., 83:178–185, 1971) that reviewed eight studies of the nesting success of Red-winged Blackbirds (*Agelaius phoeniceus*) in relation to various environmental factors, I concluded that nest placement with respect to height above ground or water was not significantly related to nesting success. The heterogeneity of the samples on which this finding was based suggested that further study of nest placement, in which as many variables as possible are eliminated, would clarify our understanding of factors affecting the choice of nest location and the relation of placement to nest success.

During May and June 1970, when I was investigating Redwing reproductive phenology in an upland nesting habitat (old-field community) in Erie County, Ohio, 47 nests were found, and examined regularly as long as eggs or nestlings were in the nest. Both the height of the nest above ground and the height of the vegetation were measured to the nearest centimeter. Goldenrod (*Solidago nemoralis*) was the substrate for 31 nests, daisy fleabane (*Erigeron strigosus*) for nine; the remaining seven were located in mustard, clover, thistles, and grasses.

Nests in goldenrod were analyzed for height with respect to vegetation height. Since the plants were growing throughout the period, a regression of plant height on date was computed. Nest completion dates were then estimated by back-dating from the observed laying and hatching dates, and the plant height on the date of nest completion was calculated for each nest. Three nests which failed to hatch were eliminated in the process, leaving a sample of 28 nests in goldenrod, of which 12 successfully fledged young. Comparison of nest height with plant height showed that nests were farther above the ground in taller plants. The distances of the nests below the top of the vegetation were then compared, and found to be essentially the same, averaging 22.6 cm (95 percent confidence limits 20.1 to 25.1 cm). A similar situation occurred in the daisy fleabane, where the nine nests averaged 34 cm below the top of the plants (95 percent confidence limits 30.1 to 37.3 cm). Selection of nest location apparently was independent of the height above ground, but was related to the distance below the top of the vegetative canopy in both plant species.

Although placement of nests was not determined by height above the ground, nest success may be affected by placement. The successful nests were compared with unsuccessful nests (most losses were attributed to predation of eggs and nestlings) with respect to plant height at the time of nest completion, nest height, distance of the nest below the top of the vegetation, date of nest completion, and vegetation type (goldenrod, daisy fleabane, and all others combined). In no case was a significant difference found between successful and unsuccessful nests. The findings substantiate the conclusion cited above.—William J. Francis, *U.S. Bureau of Sport Fisheries and Wildlife, Division of Wildlife Research, Patuxent Wildlife Research Center, P.O. Box 2097, Sandusky, Ohio 44870, 30 May 1972.*

House Finch nests abandoned after snow.—Schroeder's note (Wilson Bull., 84: 98–99, 1972) on the abandonment of nests containing eggs by Vesper Sparrows (*Pooecetes gramineus*) after an unseasonable snow storm in Wyoming prompts me to report a similar incident involving House Finches (*Carpodacus mexicanus*) that I observed at Fort Logan (ca. 10 miles west of Denver), Colorado in 1946. Six nests built in small ornamental evergreens located around the fort's parade ground and living quarters were observed periodically during late April and early May. During the night of 11–12 May several inches of snow with freezing rain fell. The next morning when I examined the nests (three with eggs, three with young, 1–4 days old), the eggs were cold and the young in two nests were dead. Five nestlings in another nest were still alive although cold and feeble. All of the nests appeared abandoned because no alarmed adults called nearby—in contrast to each of my earlier visits. The live nestlings were taken home and successfully hand-reared. Within a day or so after the storm the snow was gone and the finches began renesting in nearby trees.—Herbert W. Kale II, *Entomological Research Center, P.O. Box 520, Vero Beach, Florida 32960, 21 June 1972.*

ORNITHOLOGICAL NEWS

At each annual meeting of the Wilson Society the President appoints a Committee to draw up a set of resolutions to be adopted by the membership. In far too many instances the only resolution emerging is one thanking the local committee for its hospitality. When this happens a great opportunity is lost since a series of formally adopted resolutions in the name of the Society is the only way that the Society can make its collective opinion known to the public or to the people responsible for making final decisions in matters of interest. There must be a great many matters of conservation, both of birds and wildlife, and of natural environment in which a formal statement of position by the Wilson Society might be influential. Any member who knows of such matters, or who would like the Society to take a stand on some matter of conservation interest is urged to communicate the particulars of the case to our Secretary, James Tate. He will forward the proposals to the Resolutions Committee for possible action at the Chapel Hill meeting. Such material should be in Dr. Tate's hands no later than early May.

At this writing plans for the Annual meeting are well advanced, and all signs point to another fine gathering. A feature of the program will be a symposium on "Progress in Rare and Endangered Species Programs."

We have received word of the death on 2 January 1973 of Walter P. Nickell, formerly naturalist at the Cranbrook Institute of Science, and a member of the Wilson Society since 1943.

The Bird Banding Laboratory is re-editing, bringing up to date, and expanding Merrill Wood's "A Bird-banders Guide to Determination of Age and Sex of Selected Species." This will be volume II of the recently revised "North American Bird Banding Manual," but the component parts will come out as they are done. The first group to be worked up will be the Fringillids.

Anyone with more recent information, emendations to, or criticisms of the material as published by Wood should send this information to Erma J. Fisk (Mrs. Bradley), 17101 SW 284th Street, Homestead, Florida 33030.

Texas Heron Banding Project—In the spring of 1972 a total of 338 herons of eight species were color-banded, and marked with colored plastic wing tags along the Texas coast and near the Welder Wildlife Foundation. A more extensive project is planned for 1973. Persons seeing such marked birds are urged to report all sightings, with such detail as species, color of tag, location, date, time of day, and behavior to: Gene Blacklock or Douglas Mock, Welder Wildlife Foundation, P.O. Box 1400, Sinton, Texas 78387.

Pacific Seabird Group. The Pacific Seabird Group has been formed by the participants in a seabird symposium held at the December 1972 meeting of the Western Society of Naturalists. The aims of the group are to promote and coordinate needed research on marine birds of the Pacific Basin, to make systematic studies of pollution effects upon birds and to promote a greater awareness of this marine resource. Anyone interested in further information should contact the group's acting secretary, George Divoky, c/o U.S. Fish and Wildlife Service, 1412 Airport Way, Fairbanks, Alaska 99701.

CONSERVATION SECTION

CONSERVATION STATUS OF BIRDS OF CENTRAL PACIFIC ISLANDS[1,2]

WARREN B. KING

In the course of investigations conducted by the Pacific Ocean Biological Survey Program (POBSP) of the Smithsonian Institution, field workers paid visits to a large number of islands in the central Pacific Ocean, many of which are or were important because of the abundance of their bird resources. Visits to many central Pacific islands by biologists have been infrequent, and reports on the conservation status of the biota are difficult to glean from the meagre published information currently available. Berger (1972) has reported on the status of birds from the main Hawaiian Islands, so these will not be discussed here.

Figure 1 depicts the islands or island groups discussed in this report. Most of this report is based on surveys conducted between 1963 and 1968; in a few instances the information is current to 1972.

The report will stress man's influence on the islands, even though in some instances it would be difficult to show direct causal relationships between man's activities and deterioration of the bird fauna. In other instances it is all too blatant. I will also indicate where avian predators or potential predators have been introduced, as far as is known. Finally, I will point out where populations of birds are of more than passing significance in terms of the central Pacific breeding avifauna as a whole. There are few landbirds in this area but the seabird populations are vast and varied. This report will stress the status of the latter.

In general, among seabirds, the shearwaters, petrels, and storm petrels are the most sensitive to disturbance and predation. Ground-nesting tropicbirds, terns, boobies, and frigatebirds are somewhat less sensitive, while the tree-nesting boobies, frigatebirds, and noddies are least sensitive. A rapid assessment of the relative health of an island as a seabird habitat may be made by comparing the species representation in these three groups with the species one might predict would occur on an island taking into account climate, vegetation, and terrain. King (1967) lists the seabirds known to occur in the island groups covered in this report.

NORTHWESTERN HAWAIIAN CHAIN

Theodore Roosevelt proclaimed the Northwestern or Leeward Hawaiian Chain a wildlife refuge in 1909, since which time it has enjoyed relative stability and protection. Seven islands comprise the Hawaiian Islands National Wildlife Refuge. The refuge is administered from Oahu with actual visits to the refuge once or twice a year, dependent upon the cooperation of the U.S. Coast Guard. The administrator has no boat to patrol the islands over which he has jurisdiction.

Nihoa (0.25 square miles).—Nihoa has two endemic landbirds, the Nihoa Finch (*Psit-*

---

[1] As indicated in the June 1972 issue of The *Bulletin* (84:222) the Conservation Committee of the Wilson Ornithological Society decided to concentrate for this year on bird conservation problems in the Pacific Islands. This report is the second contribution from the committee on this subject.—GUSTAV A. SWANSON, *Chairman.*

[2] Paper No. 88, Pacific Ocean Biological Survey Program.

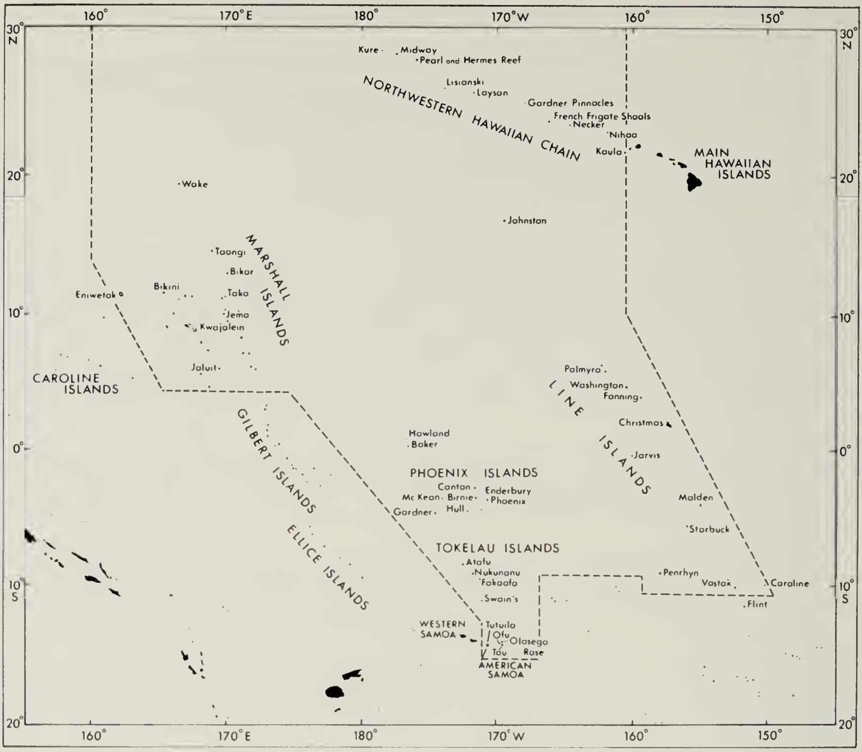


FIG. 1. Islands of the central Pacific Ocean. Islands within dashed perimeter are included in this report.

tirostra cantans ultima) and the Millerbird (*Acrocephalus familiaris kingi*), both listed as endangered by the U.S. Department of Interior (1966). The population estimate for 1971 of the former is in the low thousands, and of the latter in the low hundreds (J. Sincock, pers. comm.). Both populations are thought to be stable, and the habitat may be saturated.

In addition Nihoa has representative populations of all the seabird species that are found throughout the Northwestern Chain. Of special significance are its population of Bulwer's Petrel (*Bulweria bulwerii*), estimated at up to 250,000, the largest known population of this species in Hawaii, and perhaps in the world; Great Frigatebirds (*Fregata minor*) estimated at 10,000; up to 25.000 Wedge-tailed Shearwaters (*Puffinus pacificus*), and up to 100,000 Sooty Terns (*Sterna fuscata*) (Clapp, Kridler, and Fleet, in prep.). There are no introduced predators on Nihoa.

Although unauthorized visits to this island are kept to a minimum because landing is difficult, personnel from a U.S. Navy vessel recently placed a sign near the top of the island announcing their visit.

Necker (0.07 square miles).—Necker Island is smaller than Nihoa, has no landbirds, and supports smaller numbers of the same seabirds that breed on Nihoa. Fifty thousand

Sooty Terns breed on Necker (Clapp and Kridler, in prep.). It is equally difficult of access, and is less frequently visited than Nihoa.

French Frigate Shoals (0.17 square miles).—French Frigate Shoals is a group of 13 islands, the largest of which, Tern Island, is the site of a U.S. Coast Guard LORAN A Station. Tern Island, now half of the land area of French Frigate Shoals, is mostly man-made, having been enlarged from 11 acres to 56.8 acres in 1942 for a U.S. Navy Air Facility; it now accommodates the station, a runway, and a 129-foot antenna (almost no bird mortality has been caused by this tower). Nineteen Coast Guard personnel inhabit Tern Island. The Coast Guard facility was formerly on East Island, but that island is now abandoned and seabirds breed there again in large numbers. A written agreement drawn up in 1965 between the Coast Guard and the U.S. Bureau of Sport Fisheries and Wildlife forbids use of any but Tern Island by the Coast Guard. Between 1952, when the Station moved from East to Tern Island, and 1965, there was apparently no formal agreement about the use of the refuge by the Coast Guard. Coast Guard personnel have been permitted to keep dogs (three are presently on the island), and at one time or another, but not presently, cats and pigs were present as well. The dogs are restricted to Tern Island, where they occasionally harass green sea turtles (*Chelonia mydas*) and Hawaiian monk seals (*Monachus schauinslandi*). French Frigate Shoals is the most important breeding site for green sea turtles in the Hawaiian Islands. Seabirds continue to breed there in undiminished numbers; a breeding population of 120,000 Sooty Terns is present. No rats occur there in spite of military activity.

The Refuge Manager, Eugene Kridler, introduced 27 Nihoa Finches to French Frigate Shoals in March 1967. They have nested in crevices in piles of concrete blocks near the buildings on Tern Island. The population had declined to three by 1968, but was back to nine by 1971 (Amerson, 1971).

Gardner Pinnacles (0.01 square miles).—Gardner Pinnacles is nearly impossible to land on from the sea. In 1961 or 1962 the U.S. military made an unauthorized landing on Gardner Pinnacles as part of their HIRAN project, one purpose of which was to determine the exact location of several of the Northwestern Hawaiian islands for navigational purposes. Among other activities the landing party blew the top off the island with explosives to create a flat area for future helicopter landings. Part of the work of the Refuge Manager in his 1969 inspection of Gardner Pinnacles was to clear some of the refuse left behind by the military.

Because of its small size Gardner Pinnacles has small populations of the representative sea birds, including the northernmost breeding population of the Blue-gray Noddy (*Procelsterna cerulea*) (Clapp, in press).

Laysan (1.56 square miles).—Laysan has had a colorful history which includes guano mining, feather poaching, seal killing, and egg collecting on a massive scale. It had five endemic land or water birds, two of which, the Laysan Teal (*Anas laysanensis*) and the Laysan Finch (*Psittirostra c. cantans*), survived defoliation of the island by introduced European rabbits (*Oryctolagus cuniculus*) and exist now in relatively stable numbers. The story of the extinction of the other three landbirds from Laysan is too well known to need repeating here (see, for example, Laycock, 1970). The teal fluctuates in abundance, having dropped recently to the very low hundreds in September 1971 (J. Sincock, pers. comm.). With a population of about 10,000 birds (Ely and Clapp, in press) the Laysan Finch has apparently saturated its habitat. Laysan has the largest known population of several species of seabirds: 300,000 Laysan Albatrosses (*Diomedea immutabilis*), 40,000 Black-footed Albatrosses (*Diomedea nigripes*), 200,000 Wedge-tailed Shearwaters, and 2,000 to 3,000 Sooty Storm Petrels (*Oceanodroma markhami*), the last nesting along the edge of the central lagoon in an area where storms must cause frequent flooding of burrows. Other notable populations include several hundred thousand Bonin Petrels (*Pterodroma hypoleuca*), a Sooty Tern colony of approximately 2,000,000 birds, several thousand Red-tailed Tropicbirds (*Phaethon rubricauda*) and 1,000 Blue-faced Boobies (*Sula dactylatra*) (Ely and Clapp, in prep.).

There have been numerous authorized and unauthorized visits to Laysan. Among the latter was a U.S. Military visit in early 1963 as part of the HIRAN project. Burrgrass (*Cenchrus echinatus*) became established as a result of this visit, expanding outward concentrically from the abandoned military campsite on successive visits by POBSP or refuge personnel. The Refuge Manager has been successful in controlling this species. A second inadvertent introduction, hairy horseweed (*Conyza bonariensis*), became established in the late 1960's and promises to be more difficult to eradicate.

In 1970 a Japanese fishing vessel was shipwrecked on the reefs surrounding Laysan. The crew members lived briefly on Laysan before being rescued. The vessel was known to contain rats of uncertain species, but they may not have reached the island. The U.S. military was granted a special use permit to lay large canvas tarpaulins on Laysan and Lisianski as high resolution targets for satellite reconnaissance. The Refuge Manager collected 18 pounds of seeds of 20 species of alien plants from these tarpaulins. A letter from the Secretary of the Interior was required to convince the U.S. military that the tarpaulins should be removed.

Lisianski (0.07 square miles).—Lisianski Island has large populations of seabirds, including the largest known population of Bonin Petrel, estimated roughly at one million birds. Other notable populations include 8,000 Laysan and 3,000–4,000 Black-footed Albatrosses, a Sooty Tern colony of approximately 1,000,000 birds, and large colonies of Great Frigatebirds, Red-footed Boobies (*Sula sula*), and Red-tailed Tropicbirds. Historically there was a large population of Bulwer's Petrels, but these evidently were extirpated, or nearly so, by rabbits (Clapp and Wirtz, in prep.). Alexander Wetmore exterminated the rabbits on Laysan and Lisianski in 1923.

Pearl and Hermes Reef (0.14 square miles).—Pearl and Hermes Reef, comprised of nine islets, is presently uninhabited. A pearl-oyster gathering industry thrived between 1928 and 1930 on this atoll. The pearl fishermen built four houses which survived until World War II. Rabbits were introduced in the early 1920's but were extirpated within three years. Pearl and Hermes Reef has large populations of Bulwer's Petrels and Sooty Storm Petrels in addition to smaller populations of most of the other seabirds relative to populations on other Northwestern Hawaiian islands (Amerson, Clapp, and Wirtz, in prep.).

In 1967 the Refuge Manager transplanted 12 Laysan Teal and about 100 Laysan Finches to Southeast Island (34 acres), the largest of the atoll. The former did not survive. The latter have bred successfully and have increased to several hundred at last census in 1971 (J. Sincock, pers. comm.) and may well have saturated their habitat on Southeast Island.

In 1961 or 1962 there was an amphibious landing on Southeast Island. An 18-foot observation tower, 50 oil drums and a dismantled house were left behind. The amphibious vehicle left tracks across the island which persisted for several years. The tread of the vehicle probably carried seeds of the mustard *Brassica* to the island. A major portion of each visit by the Refuge Manager is now spent treating the fast-spreading *Brassica* with herbicides and pulling up new plants.

Midway (3.1 square miles).—Midway is not in the Hawaiian Islands National Wildlife Refuge. It has been a U.S. Naval Station since 1903. It has two major islets, Sand Island, the site of the Naval Air Station, on which 2,000 military personnel reside, and

Eastern Island, which has runways as well, but has in the recent past been used as a large communications base. Midway has had continuous human occupancy since 1903 and is the most altered of the Northwestern Hawaiian Chain. Fairly large numbers of seabirds continue to nest on Midway in spite of the efforts of the U.S. Navy to remove them from some parts of the island. Both albatrosses, which were killed in vast quantities by Japanese plume hunters, increased markedly from U.S. Navy protection, but have declined somewhat in recent years.

Sand Island is officially a bird sanctuary; a $50 fine accompanies the killing of an albatross, or "gooney," as they are known there. The official posture of the U.S. Navy toward the birds of the island is one of benevolence, yet there is constant conflict between birds, primarily the two species of albatross, and the military's interests in maintaining safe air transport. Cessation of the Early Warning Barrier flights caused air traffic at Midway to decrease sharply in the past few years, and aircraft strikes of birds, once a problem of major dimensions (Robbins, 1966), has declined accordingly. However, the price for decreased air strikes has been the paving over in 1964 of all land 750 feet from the centerline of each of the three runways on Sand Island, necessitating the destruction by asphyxiation of 18,000 incubating albatrosses, 13 percent of Midway's and about 5 percent of the world's population. Recently all active nests on Sand Island's golf course have been destroyed to keep the area open for recreation. Here we have an example of the ethical paradox by which government sanctioned mass killing is permissible, while the same activity conducted on a small scale by individuals is heavily penalized.

Sand Island still maintains large breeding populations of both albatrosses and Red-tailed Tropicbirds. Black Noddies (*Anous tenuirostris*) and White Terns (*Gygis alba*) breed in good numbers in introduced *Casuarina* trees between the barracks. Introduced populations of Canaries (*Serinus canaria*) and Rock Doves (*Columba livia*) have been maintained for many years. Laysan Rails (*Porzanula palmeri*) survived on Midway until 1944. An attempt to reintroduce them to Laysan by Alexander Wetmore in 1923 failed because the vegetation had not yet recovered.

Eastern Island has Midway's remaining populations of frigatebirds and boobies, and a substantial colony of 350,000 Sooty Terns. The Sooty Tern colony relocated on Eastern Island after official harassment programs on Sand Island in 1957 and 1958 chased them off. Unofficial policy, confided several times to POBSP personnel engaged in field work on Eastern Island, was the encouragement of the destruction of Sooty Tern eggs, young and adults. Navy personnel participated in "chick-stamps," and admitted to clubbing adult Sooty Terns from the air with sticks on several occasions. Dogs were brought from Sand Island to Eastern for the express purpose of running them through the incubating albatrosses.

Fisher (1966 and 1970) gives accounts of the destruction of hundreds of albatrosses on Eastern Island from striking guy wires of the antennas of the communications system there. In 1967 the antennas were demolished by explosives and pushed by bulldozers to the sea's edge through the thousands of Sooty Terns then incubating eggs in the antenna fields.

The black rat (*Rattus rattus*) is present on both islands of Midway and probably preys on seabirds and their eggs. Cats are forbidden on Midway.

Kure (0.33 square miles).—Kure is under the jurisdiction of the State of Hawaii. It is a wildlife sanctuary. It has a 4,000-foot runway of packed, crushed coral, and a U.S. Coast Guard LORAN C Station was constructed there in 1960. A complement of 24 Coast Guard personnel is normally present. The LORAN C antenna is a 625-foot tower, guyed by steel cables that fall just short of spanning the island's width. A 70-foot radar reflector tower is also present. The Coast Guard personnel have not seriously disturbed the breeding sea birds of Kure. Dogs have been kept as pets intermittently, and a pig, scheduled as the prime attraction at a feast, also became a pet, but these have not caused undue damage.

A colony of 25,000 Sooty Terns which became established in 1963 originated, in part at least, from displaced individuals from the harassed Midway population. The populations of Blue-faced Boobies and Hawaiian monk seals have declined historically, the former due to disturbance associated with construction of the antenna, the latter due to repeated disturbance by man and at certain times by dogs.

A squirrel monkey (*Saimiri* sp.) lived free on the island from 1961 to 1967, but rarely disturbed birds.

The Polynesian rat (*Rattus exulans*) population on Kure fluctuates widely from season to season (20–77 rats per acre). Kepler (1967) reports this rat preys on Laysan Albatrosses, Bonin Petrels, Sooty Terns, and Brown Noddies (*Anous stolidus*) on Kure. Bonin Petrels lay up to 500 eggs annually on Kure, but no egg hatched during the five years POBSP personnel were present (Woodward, in press).

Kaula Rock (0.21 square miles).—No account of the Northwestern Hawaiian Chain should omit Kaula Rock. Most accounts do. While it is south of and closer to Niihau, the westernmost Main Hawaiian island, its avifauna is typical of the Northwestern Chain. The only avifaunal survey of the island was in 1932 (Caum, 1936), and it revealed that Kaula is inhabited by Bonin Petrels, Brown Noddies, Sooty Terns, Blue-gray Noddies, Gray-backed Terns (*Sterna lunata*), White Terns, possibly Black-footed Albatrosses, Bulwer's Petrels, Wedge-tailed Shearwaters, Red-tailed Tropicbirds, three booby species and Great Frigatebirds (*Fregata minor*).

Kaula is under the administrative jurisdiction of the U.S. Department of Navy and has been used as a bombing target by the Navy since 1952. In 1932 a lighthouse was constructed on the summit of Kaula. The construction crew reported the presence of a rat of unknown species on the island.

JOHNSTON ATOLL

Although Calvin Coolidge decreed Johnston Atoll (0.98 square miles) a bird sanctuary in 1926, it was turned over to the U.S. Navy and then to the U.S. Air Force because of its strategic location. Atmospheric nuclear tests were conducted here in the early 1960's.

The appearance of Johnston Atoll has been changed drastically by the demands of U.S. military activities. The largest island, Johnston Island, is 570 acres, 75 percent man-made. Two islets, 24 and 17 acres respectively, are also man-made, while the fourth, Sand Island, supports a U.S. Coast Guard LORAN C Station with a 625-foot antenna, separated from the Coast Guard billets by a long causeway. The antenna guy wires anchor in the ocean around the periphery of this 16-acre island. In spite of human inhabitants and the hazard of the guy wires to bird flight, Sand Island has a large seabird colony, all but three species having been chased from Johnston. Eleven species breed on Sand. The Sooty Tern colony there numbers 300,000 birds.

Johnston Island has up to 1,000 human inhabitants, mostly U.S. Air Force personnel. About 60 percent of the island is covered by man-made objects, including an aircraft runway. Black rats, a few cats, and a few dogs are also on the island.

By contrast, Sand Island has a complement of 19 Coast Guard personnel and two to five Air Force personnel. It has no rats, and the pet cats and dogs are normally confined to the end of the causeway away from the seabirds (Kirkpatrick, 1966*a*). The attitude of the personnel on Sand Island toward seabirds is largely dependent upon the attitude of their commanding officer. There have been cases of jeeps driven on joy rides through the Sooty Tern colony during incubation. The antenna guy wires kill approximately two dozen Sooty Terns per day at the start of the breeding season when the birds swirl in vast numbers above the island (Shelton, in prep.; A. B. Amerson, Jr., pers. comm.).

LINE ISLANDS

Palmyra (0.82 square miles).—Palmyra is administered by the U.S. Department of Interior. It is presently uninhabited and privately owned. There are dozens of abandoned buildings in various states of repair there. As of 1966 it had no dogs or cats, but black rats were fairly common. It has the largest Red-footed Booby colony in the central Pacific, 25,000 birds, and a Sooty Tern colony of 750,000. Black rats have been observed in the Sooty Tern colony preying on eggs. In 1967 a weather project of the National Center for Atmospheric Research (NCAR) utilized Palmyra. At certain times several airplanes per day were landing on the runway. The runway was scraped to prepare for this activity. The Sooty Tern colony was located in large part on the runway at that time, and wholesale death and nest abandonment occurred. Dead Sooty Terns were to be found in the piles of dirt scraped from the runway. No new population figures are available subsequent to the NCAR Weather Project's use of Palmyra (POBSP, unpubl. reports; R. B. Clapp, pers. comm.).

Washington (ca. 2 square miles).—Washington is administered by the United Kingdom. It has a population of 78 Gilbertese whose income is derived from copra harvest. Cats, dogs, and pigs are kept by the Gilbertese, and feral cats are abundant. Rats, species not determined, are present, but rare. Seabirds are eaten by the Gilbertese. Seabird populations are low, and are restricted to tree-dwelling species. The large fresh-water lagoon is visited by up to 200 ducks annually and was the home of the Washington Island Gadwall (*Anas strepera couesi*), extinct since ca. 1874. The Christmas Island Warbler (*Acrocephalus aequinoctialis*) reaches maximum population here, ca. 2,000, but there are indications that the population may fluctuate considerably. The introduced lorikeet *Vini kuhli* is also present, numbering about 800 (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

Fanning (13 square miles).—Fanning is administered by the United Kingdom. It has a population of 337 Gilbertese who derive their livelihood from copra harvest. The Gilbertese eat seabirds, populations of which are now insignificant. Dogs, cats, and pigs are present under domestication. Black rats are common.

The Christmas Island Warbler once occurred here but appears to be extirpated. The introduced lorikeet maintains a population of ca. 200 birds (POBSP unpubl. reports).

Christmas (124 square miles).—Christmas is administered by the United Kingdom. It supports a population of 400 Gilbertese who work the island's extensive coconut plantations for copra. Nuclear tests were conducted here in 1956 and 1958 by the British and in 1962 by the U.S. In 1960 the administrator made it illegal to catch seabirds, but many are still taken for food. Most seabird species nest on islets within the island's several lagoons. Three of these islets are recognized as important bird sanctuaries, and visits are restricted.

Both Polynesian and black rats are present, along with large numbers of feral cats. In addition hermit crabs (*Coenobita perlitus*) are reported to prey on ground nesting birds here as well. Great Frigatebirds prey heavily on Sooty Tern chicks on Christmas. This practice is not widespread on other central Pacific islands. Large populations of several species of sea birds are present on Christmas. The island supports the largest population of Sooty Terns in the Pacific, estimated at 25,000,000 birds. The Gilbertese collect as many as 250,000 Sooty Tern eggs for food annually. In one Sooty Tern colony where 500,000 eggs were laid in 1968, one half were gathered by Gilbertese, and most of the remaining hatched, to be eaten by Great Frigatebirds, rats and cats. Only perhaps 25 nestlings, fledged from this colony.

The Lesser Frigatebird (*Fregata ariel*) population on Christmas has declined as a direct result of cat predation, and may be eliminated entirely in the next few years.

The Christmas Island Warbler has a population of about 400 birds, while the lorikeet, introduced repeatedly from Washington Island, was represented by 2 individuals in 1968 (Schreiber and Ashmole, 1970).

Jarvis (1.60 square miles).—Jarvis is administered by the U.S. Department of Interior. It is uninhabited, but an attempt at colonization was made from 1938 to 1940. It was further occupied in 1966 by scientists connected with the International Geophysical Year (IGY). The IGY scientists' house, a few sheds, trash, an old lighthouse, and a tramway are the only signs of human habitation remaining. The settlers brought cats with them, and these now feed on seabirds. Rats formerly occurred on Jarvis but were probably extirpated by cats. POBSP personnel killed over 200 cats in 1964 and 1965, and in later visits in 1967 and 1968 eight or nine were seen in a day or two. Jarvis has a large Sooty Tern colony numbering 1,900,000, and large populations of both frigatebirds and the three boobies, e.g., 9,000 Blue-faced Boobies. Elimination of the remaining cats would make Jarvis among the most important seabird islands of the Central Pacific. There is presently no special protection afforded the birds of this island (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

Malden (7.78 square miles).—Malden is claimed jointly by the United Kingdom and the United States. It is uninhabited, but extensive guano mining took place. The remains of an Atomic Energy Commission camp, set up in 1962 in connection with a nuclear test here, are still apparent.

POBSP killed a herd of five pigs in 1964, and one last pig died in 1967 or 1968. Five cats were seen in 1967, indicative of a very small population. The pigs were evidently responsible for the moderate numbers of most species of seabirds. The size of the guano deposits suggest that this island was at one time a very significant seabird island. No petrels were found on the island, an indication of predation pressure, although islets in the central lagoon, where they might be expected to occur still, were not visited (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

Starbuck (ca. 8 square miles).—Starbuck is uninhabited. It is claimed jointly by the U.K. and the U.S. A few stone buildings remain from the days of guano mining.

Cats and Polynesian rats are present on Starbuck, the former in large numbers. Cats prey heavily on the large Sooty Tern colony (estimated at 2,500,000 birds); about 1,000 adult birds per night were killed by cats during POBSP visits. POBSP personnel killed 120 cats here in 1964 but in 1967 the cat population was still about 150. In 1968 "scattered wings and bodies, and piles of bodies were frequently noted" around the edges of the Sooty Tern colony. Petrels were evidently present once, but no longer (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

Caroline (1.45 square miles).—Caroline is claimed jointly by the U.K. and the U.S. It was used as a coconut plantation until 1943, when it was abandoned after a prolonged drought. Polynesian rats are uncommon and may be restricted to one islet in the atoll. Seabirds attain significant numbers; for example, 10,000 Great Frigatebirds, 5,000 Red-footed Boobies, 500,000 Sooty Terns (Clapp and Sibley, 1971*a*).

Vostok (0.10 square miles).—Vostok is claimed jointly by the U.K. and the U.S. It is uninhabited. Polynesian rats are abundant. Most of this small island is covered by a *Pisonia* forest. Moderate populations of the representative sea birds, primarly those adapted to nesting in trees, occur (Clapp and Sibley, 1971*b*). Vostok is a relatively unaltered, but simple island ecosystem.

NORTHERN COOK ISLANDS

Penrhyn (6.2 square miles).—Penrhyn is administered by New Zealand but it is claimed both by New Zealand and the United States. Its human population in 1966 was 694. It has extensive coconut plantations, and copra harvesting is the main source of income of the inhabitants. Domestic cats, pigs, and chickens are common, as are rats, species not determined. Most of the few seabirds that inhabit Penrhyn occur on the islet farthest from the village. These are almost exclusively the tree-nesting species, numbers of which are of no great significance (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

TOKELAU ISLANDS

The Tokelau Islands are claimed by New Zealand and the United States, and administered by New Zealand.

There are three islands as follows:

Island	Land area	Human Population in 1966	Cat Population in 1965	Pig Population in 1965
Fakaofo	1.02 sq. mi.	733	40	227
Nukunonu	2.08 sq. mi.	551	30	300
Atafu	0.78 sq. mi.	616	"many"	300

All three islands are devoted to coconut palm culture. All have populations of Polynesian rats and, at times, dogs (Kirkpatrick, 1966*b*). The inhabitants take seabirds for food without restriction; for example, up to 1,000 Brown and Black Noddies are taken by the residents of Fakaofo annually. Palea Islet of Fakaofo has breeding populations of several seabirds, including Sooty Terns, and is undoubtedly the most valuable islet in the group from this point of view. Two landbirds occur, the migratory Long-tailed Cuckoo (*Eudynamis taitensis*), and the Pacific Pigeon (*Ducula pacifica*). The latter is said to have declined from overhunting (Thompson and Hackman, 1968; Wodzicki and Laird, 1970).

AMERICAN SAMOA

American Samoa is an unincorporated territory of the United States, administered by the U.S. Department of Interior. It is composed of six islands as follows:

Island	Land area	Human population in 1970
Tutuila	54 sq. mi.	24,973
Tau	15	540
Ofu	2	412
Olosega	1.5	380
Rose	0.3	0
Swain's	1.25	74

The black rat is found on Tutuila, and may be present on some of the others as well. Polynesian rats have been observed on all islands of this group. There are no legally recognized nature sanctuaries in American Samoa.

The following are the major recent changes in the avifauna of American Samoa. The Sooty Rail (*Porzana t. tabuensis*) from Tau has not been seen in recent years, but the wetland from which it was collected is no longer used for cultivation of taro, and is suspected to be better habitat for the species than in the past. The Mao or Giant Honeyeater (*Gymnomyza samoensis*) has been extirpated from Tutuila, although it still can be found occasionally in Western Samoa. Samoans hunt doves and pigeons avidly, and populations of the Pacific Pigeon are now low. The introduced Red-vented Bulbul (*Pycnonotus cafer*) is now abundant on Tutuila (Clapp and Sibley, 1966; R. S. Crossin, pers. comm.).

The dense interiors of Tutuila and Tau are visited by Samoans only rarely on hunting forays after wild pigs. A recently discovered colony of three and possibly four procellariid species in the mountains of Tau, attests to the relatively unaltered nature of the interior of this island (R. Crossin, pers. comm.).

Rose Island has substantial seabird populations including a Sooty Tern colony (Swerdloff and Needham, unpubl. MS). It is uninhabited, has as a predator only the Polynesian rat, and should be given legal status as a sanctuary. Swain's Island, on the other hand, has been inhabited for many years, has Polynesian rats, cats, dogs and pigs (Kirkpatrick, 1966*b*) and few birds (Clapp, 1968), and would be of little value as a sanctuary.

PHOENIX ISLANDS

Canton (3.5 square miles).—Canton is administered jointly by the U.K. and the U.S. It was inhabited by 500 people up to 1966, when the island was evacuated, and the military base was closed. It was reinhabited by about 200 U.S. Air Force personnel and civilian contractors of the firm Holmes and Narver in 1969, and is now an essential part of a new U.S. missile testing system. About 40 percent of the land area of the island is covered by man-made structures. The Air Force has placed installations on Enderbury and Hull Islands as well, and they have leased Birnie, Gardner, and Sydney from the U.K. but have not yet utilized them. The Air Force, conscious of its "ecological image," requested a consultant from the U.S. Bureau of Sport Fisheries and Wildlife, who advised them on ways of minimizing disturbance of the substantial seabird colonies of these islands, and who laid out guidelines for conduct vis-a-vis natural resources for those stationed on the islands.

Canton has feral cats, dogs, and Polynesian rats, in spite of which three and possibly four procellariids are breeding in small numbers. Red-footed Boobies and Great Frigatebirds formerly nested in the thousands, but are now extirpated because of clearing of the shrubs on which they bred (Clapp, in prep.).

Enderbury (1.95 square miles).—Enderbury is administered jointly by the U.K. and the U.S. The only visible signs of human habitation were a frame house in hopeless repair and a lighthouse until 1970 when Holmes and Narver constructed a 200-foot antenna at one end of the island near a colony of 10,000 Gray-backed Terns, two 40-foot sighting towers at the other end, and a road across the island from their air-conditioned trailer near the antenna to the two towers. Two or three employees are now on the island most of the time. Supplies are brought in by helicopter from Canton. The seabird colonies have not been disturbed unduly by this activity. A few feral cats still are present, descendants of pets brought during an attempt at colonization from 1938 to 1940. Hermit crabs, in large numbers, have been seen to cause mortality in the large Sooty Tern colony (800,000 birds) and in the frigatebird colonies.

Enderbury is the most important green sea turtle breeding island in the south central Pacific (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

Phoenix (0.16 square miles).—This island is claimed both by the U.K. and the U.S. It has been uninhabited since guano mining days, and the coral rock walls of the miners' houses still stand, providing nesting sites for White Terns and Black Noddies. Phoenix has large populations of all representative seabirds that do not require trees for nest sites. It has five breeding procellariiform species, the largest known Blue-gray Noddy population (10,000 birds) and a Lesser Frigatebird population of up to 45,000 birds.

Phoenix has European rabbits, estimates of which vary from 100 to 1,000. This population is evidently kept in check by periodic harvesting, along with some seabirds, by the crews of copra boats that service the Line Islands (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

McKean (0.13 square miles).—McKean is claimed by the U.K. and the U.S. Rock walls remain from guano mining days; otherwise there are no signs of man's activities. It has no introduced predators. The largest known populations of White-throated Storm Petrels (*Nesofregatta albigularis*) (1,000) and Lesser Frigatebird (85,000) occur here. Populations of the other representative seabirds are large also (POBSP unpubl. reports, R. B. Clapp, pers. comm.).

Birnie (0.10 square miles).—Birnie is claimed by the U.K. and the U.S. It has never been inhabited and is one of the few dry central Pacific islands not to have been mined for guano. Polynesian rats, presumably introduced from an early shipwreck on reefs around the island, are abundant at times. Although populations of seabirds are not high, owing to the small land area, the island has great value because it is nearly in an undisturbed state (POBSP, unpubl. reports; R. B. Clapp, pers. comm.).

Sydney (2.07 square miles).—Sydney is claimed jointly by the U.K. and U.S. It was inhabited by Gilbertese for copra harvest until 1961, when it was evacuated because of prolonged drought. Both Polynesian and black rats occur, and cats and dogs were left behind during evacuation. POBSP personnel killed several cats between 1964 and 1968 but there may still be enough cats to continue reproduction. One dog seen in 1968 may be the last on the island. Seabird abundance is low. In 1968 POBSP observers saw a pre-breeding swirl of roughly 4,000 Sooty Terns above the island. This species was not recorded previously, and may attempt to breed now that the larger predators have been removed or reduced (Clapp and Woodward, in prep. *a*).

Hull (2.21 square miles).—Hull is claimed jointly by the U.K. and the U.S. The 590 Gilbertese who inhabited Hull were evacuated in 1963. They left behind dogs and cats, of which a few individuals of each are still present, but their reproductive status is unknown. In 1967 the Sooty Tern population was estimated at 3,000,000 birds. Other species, mostly the tree-nesting ones, are not abundant. In 1970 the U.S. Air Force had a 200-foot antenna built on Hull as part of their new missile testing system in the Phoenix Islands. The Sooty Terns are presently not nesting near the antenna. Periodic maintenance visits are made to the antenna by helicopter from Canton (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

Gardner (1.41 square miles).—Gardner is claimed jointly by the U.K. and the U.S. In 1963 the 210 Gilbertese inhabiting Gardner were evacuated because of drought. They left behind cats, dogs, and chickens. Polynesian rats are present. Only low numbers of the tree-nesting seabirds occur here (Clapp and Woodward, in prep. *b*).

HOWLAND

Howland (0.64 square miles) is administered by the U.S. Department of Interior. It was colonized between 1935 and 1942, and an airstrip and a lighthouse were built, intended for use by Amelia Earhart. Howland was used extensively during World War II by U.S. troops.

The airstrip is now obscured by vegetation. The lighthouse and a few low stone walls remain to tell of human occupancy. Cats, introduced by the colonists, eliminated the once abundant Polynesian rats and then were extirpated in 1964 by POBSP personnel. Cats reappeared in 1966 after a visit to the island by the U.S. Military, and are evidently still present.

Howland has a large Blue-faced Booby population (3,000 birds) and a Sooty Tern population of up to 200,000 birds. Wedge-tailed Shearwaters nest in small numbers in spite of the cats. This island would quickly become among the most significant seabird colonies in the central Pacific if the cats were removed and the island were given protection from disturbance (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

BAKER

Baker (0.53 square miles) is administered by the U.S. Department of Interior. It is uninhabited but was heavily utilized by U.S. troops during World War II. The island was nearly scraped clean of vegetation at that time. Signs of former activities are still evident. The ruins of buildings, trenches, oil drums, metal airstrip matting and a lighthouse still remain. The small lagoon has an islet, on which nest a few Brown Noddies, the only breeding species in 1963. In 1964 the last of a small cat population was removed by POBSP personnel. Within months three species of seabirds previously absent were breeding on Baker, having emigrated from Howland. In 1966 after a visit by the U.S. military at least two cats reappeared on the island, and they are presumably still present (POBSP unpubl. reports; R. B. Clapp, pers. comm.).

Baker has excellent potential as a seabird colony, but it is kept nearly devoid of birds by the presence of at least two cats.

MARSHALL ISLANDS

The Marshall Islands (70.09 square miles) are U.S. Trust Territory administered by the Department of Interior. Land area of the 34 islands ranges from 0.07 square miles (Jemo) to 6.15 square miles (Mili). Eight of the ilsands are uninhabited. Two of the uninhabited islands, Taongi and Bikar, are too dry to sustain the harvest of coconuts. These are both important seaboard islands. The remainder of the uninhabited and several of the inhabited islands have cats, dogs, pigs, chickens, Polynesian rats and some have black rats as well. Almost all uninhabited islands are devoted to coconut culture. The Marshallese utilize seabirds and their eggs for food. They recognize the importance of affording protection to seabirds to preserve their populations as a renewable resource. They have traditionally considered Taongi, Bikar, Jemo, and islets of Taka and Jaluit as bird sanctuaries, on which the taking of birds and eggs for food is restricted but not prohibited. Taongi and Bikar have at least three species breeding which do not breed on any other island in the Marshalls, and two more that breed only on one other island. Taongi, Bikar, and Jaluit have 11 or more breeding seabird species.

The U.S. Government has conducted nuclear tests on Eniwetok and Bikini. In the long run seabird populations of these islands seem not to have been affected by the explosions. The relative isolation of some islets around the circumference of these large atolls permits the continuance of seabird populations; for example Eniwetok has breeding Sooty Terns and Red-tailed Tropicbirds in spite of a large human population and the presence of cats and two species of rats on some islets (Amerson, 1969).

WAKE

Wake Island (2.5 square miles) is a U.S. Territory administered by the Federal Aviation Agency. It was occupied by the Japanese during World War II. There are presently about 1,400 U.S. civilian and military personnel on Wake. The island has a long jet strip, radio transmitter and receiver towers, Pacific Missile Range facilities, and a U.S. Coast Guard LORAN Station. The three islets of this atoll are connected by bridges. Feral cats, black and Polynesian rats occur on all three islets. An endemic rail (*Rallus wakensis*) became extinct during World War II. There are eight breeding seabird species; seven more bred in the recent past but have been extirpated. Sooty Terns are the most abundant (1,750,000 birds). Rats prey heavily on the Sooty Terns. Following Typhoon Sarah on 15 September 1967 rat populations exploded. "All fresh eggs disappeared within 24 hours and on two occasions I actually saw rats dragging eggs away while the adult bird stood 'helplessly' watching. We watched several rats chewing on young birds." (R. Schreiber, POBSP unpubl. field notes). By September 1968, after an active rat control project, rats were neither seen nor trapped by POBSP personnel (POBSP unpubl. reports).

CONCLUSIONS AND RECOMMENDATIONS

Most of the islands covered by this survey have been materially altered by man. Isolation is no longer a sufficient deterrent to alteration; in some instances, e.g. military operations, it appears to be a desirable asset. Seabird faunas have experienced wholesale depletion, but have demonstrated remarkable resiliency. Future utilization of these islands is bound to take place, for which reason it is essential to identify and protect those islands with relatively intact avifaunas, and to insist that users pick up after themselves when they have finished with an island, so that its value as a bird habitat is undiminished or improved. The status of fish, invertebrates or plants on some islands is unknown. Special care should be taken to prevent the extirpation of species from islands before they are investigated. Nonscientific visits to such islands should be stringently controlled.

The following islands are considered to be of outstanding value in terms of the diversity or abundance of their avifauna, or because they are in a relatively unaltered or recovered state: Nihoa, Laysan, Lisianski (and the other islands of the Hawaiian Islands National Wildlife Refuge), Christmas, Jarvis, Vostok, Rose, Phoenix, McKean, Birnie, Taongi, and Bikar.

The following are potentially important as bird habitats, but are kept from attaining that importance by one or more factors capable of correction: Kaula, Malden, Starbuck, Enderbury, Howland, and Baker.

To materially improve the bird habitats of the central Pacific, it is recommended:

1. That the U.S. Navy discontinue bombing of Kaula, and surrender jurisdiction of it to the Department of Interior for inclusion in the Hawaiian Islands National Wildlife Refuge.
2. That the U.S. Coast Guard LORAN A Station on French Frigate Shoals be abandoned as soon as other navigational systems render LORAN A obsolete or redundant.
3. That the U.S. Department of Interior remove introduced populations of Nihoa and Laysan Finches from French Frigate Shoals and Pearl and Hermes Reef respectively

since neither of these populations is in "last resort" status on its native island, and their egg-eating habits may exert undesirable effects on the indigenous birds of the islands to which they were brought.

4. That Eastern Island, Midway, be made a strict bird sanctuary by the U.S. Navy, or, preferably, that it be turned over for inclusion in the Hawaiian Islands National Wildlife Refuge.
5. That the U.S. Department of Interior declare Jarvis, Howland, and Baker as National Natural Monuments, and that the Department of Interior seek the cooperation of the Department of Defense in removing the cats placed on Howland and Baker by the latter.
6. That a joint U.S.-British expedition visit islands in the Line and Phoenix Group to remove cats, and, where pertinent, dogs from presently uninhabited islands where they occur. These include Jarvis, Malden, Starbuck, Hull, Gardner, Sydney, and Enderbury. The last four could best be visited through the cooperation of the Air Force, which is currently leasing them. Associated with this recommendation, and of greater importance, is the removal of rabbits from Phoenix Island.
7. That the U.S. Department of Interior take an active hand in the preservation of Taongi and Bikar as bird sanctuaries by legal recognition and by regulation of the taking of birds and eggs by Marshallese commensurate with the principle of sustained yield.

ACKNOWLEDGMENTS

I would like to acknowledge the contributions made to this paper by all former members of the POBSP, and particularly A. B. Amerson, Jr., R. B. Clapp, and R. S. Crossin for their cooperation in supplying information. In addition to these latter, P. S. Humphrey and M. A. Howe commented on this manuscript. Anne K. Poulson kindly prepared the figure.

LITERATURE CITED

Amerson, A. B., Jr. 1969. Ornithology of the Marshall and Gilbert Islands. Atoll Research Bulletin, No. 127.

Amerson, A. B., Jr. 1971. The natural history of French Frigate Shoals, Northwestern Hawaiian Islands. Atoll Research Bulletin, No. 150.

Amerson, A. B., Jr., R. B. Clapp, and W. O. Wirtz, II. In prep. The natural history of Pearl and Hermes Reef, Northwestern Hawaiian Islands. Atoll Research Bulletin.

Berger, A. J. 1972. Hawaiian birds 1972. Wilson Bull., 84:212–222.

Caum, E. L. 1936. Notes on the flora and fauna of Lehua and Kaula Islands. B. P. Bishop Mus. Occas. Papers, 11 (21).

Clapp, R. B. 1968. The birds of Swain's Island, south-central Pacific. Notornis, 15: 198–206.

Clapp, R. B. In press. The natural history of Gardner Pinnacles, Northwestern Hawaiian Islands. Atoll Research Bulletin, No. 163.

Clapp, R. B. In prep. Present status of the birds of Canton Island, Phoenix Islands.

Clapp, R. B. and E. Kridler. In prep. The natural history of Necker Island, Northwestern Hawaiian Islands. Atoll Research Bulletin.

Clapp, R. B., E. Kridler, and R. R. Fleet. In prep. The natural history of Nihoa Island, Northwestern Hawaiian Islands. Atoll Research Bulletin.

Clapp, R. B. and F. C. Sibley. 1966. Notes on the birds of Tutuila, American Samoa. Notornis, 13:157–164.

Clapp, R. B. and F. C. Sibley. 1971*a*. Notes on the vascular flora and terrestrial vertebrates of Caroline Atoll, Southern Line Islands. Atoll Research Bull., No. 145.

Clapp, R. B. and F. C. Sibley. 1971*b*. The vascular flora and terrestrial vertebrates of Vostok Island, south-central Pacific. Atoll Research Bull., No. 144.

Clapp, R. B. and W. O. Wirtz, II. In prep. The natural history of Lisianski Island, Northwestern Hawaiian Islands. Atoll Research Bulletin.

Clapp, R. B. and P. W. Woodward. In prep. *a*. The vascular flora and terrestrial vertebrates of Sydney Island, Phoenix Islands.

Clapp, R. B. and P. W. Woodward. In prep. *b*. The vascular flora and terrestrial vertebrates of Gardner Island, Phoenix Islands.

Ely, C. A. and R. B. Clapp. In prep. The natural history of Laysan Island, Northwestern Hawaiian Islands. Atoll Research Bulletin.

Fisher, H. I. 1966. Midway's deadly antennas. Audubon, 68:220–223.

Fisher, H. I. 1970. The death of Midway's antennas. Audubon, 72:62–63.

Kepler, C. B. 1967. Polynesian rat predation on nesting Laysan Albatrosses and other Pacific seabirds. Auk, 84:426–430.

King, W. B. 1967. Preliminary Smithsonian identification manual: Seabirds of the tropical Pacific Ocean. Washington, D.C., Smithsonian Institution.

Kirkpatrick, R. D. 1966*a*. Mammals of Johnston Atoll. J. Mammal., 47:728–729.

Kirkpatrick, R. D. 1966*b*. Mammals of the Tokelau Islands. J. Mammal., 47:701–704.

Laycock, G. 1970. Haunted sands of Laysan. Audubon, 72:42–49.

Robbins, C. S. 1966. Birds and aircraft on Midway Islands. U.S. Bureau Sport Fish. and Wildl., Spec. Sci. Rept.—Wildlife, No. 85.

Schreiber, R. W. and N. P. Ashmole. 1970. Sea-bird breeding seasons on Christmas Island, Pacific Ocean. Ibis, 112:363–394.

Shelton, P. C. In prep. The natural history of Johnston Atoll, central Pacific Ocean. Atoll Research Bulletin.

Thompson, M. C. and C. D. Hackman. 1968. Birds of the Tokelau Islands. Notornis, 15:109–117.

U.S. Department of Interior. 1966. Rare and endangered Wildlife of the United States. U.S. Bureau of Sport Fisheries and Wildlife, Resource Publication 34.

Wodzicki, K. and M. Laird. 1970. Birds and bird lore in the Tokelau Islands. Notornis, 17:247–276.

Woodward, P. In press. The natural history of Kure Island, Northwestern Hawaiian Chain. Atoll Research Bulletin, No. 164.

THE INTERNATIONAL COUNCIL FOR BIRD PRESERVATION, SMITHSONIAN INSTITUTION, WASHINGTON, D.C. 20560, 13 OCTOBER 1972.

ORNITHOLOGICAL LITERATURE

Breeding Biology of the Blue-faced Booby *Sula dactylatra personata* on Green Island, Kure Atoll. By Cameron B. Kepler. Publ. Nuttall Ornithol. Club 8, 1969: 6 × 9 in., 97 pp. $5.00. Obtainable from the Nuttall Ornithological Club, Museum of Comparative Zoology, Harvard University, Cambridge, Mass. 02138.

Detailed investigation of the biology of the boobies started comparatively recently with studies on the three, widespread, pantropical species—by D. F. Dorward on the Masked, Blue-faced, or White Booby (*Sula dactylatra*) and also on the Brown Booby (*S. leucogaster*) at Ascension Island over 18 months in 1957–59, and by J. Verner on the Red-footed Booby (*S. sula*) in British Honduras for some three months in 1958. This work was followed by the reviewer's own study of the Brown Booby at Ascension for two years in 1962–64, with further visits in 1966 and 1971–72, and by J. B. Nelson's extensive survey of all six species of booby—the Masked, Red-footed, Blue-footed (*S. nebouxii*) and Peruvian (*S. variegata*), mainly in the Galapagos Islands for about a year in 1964, and the Red-footed, Brown, and Abbott's (*S. abbotti*) on Christmas Island, Indian Ocean, for some six months in 1967.

More or less at the same time as Nelson was studying the Masked Booby in the Galapagos, Cameron B. Kepler was similarly engaged on Green Island. Although Kepler himself was in the field for only about four months, he was able to draw on data assembled by personnel of the Pacific Ocean Biological Survey (Smithsonian Institution), so that collectively two breeding seasons were covered, with Kepler also studying the birds' ethology in detail. It is regrettable that such a system of investigation has not been maintained at Kure, though it could well be established elsewhere, with a resident team collecting routine data in the long term and visitors undertaking more detailed projects over shorter periods. It is becoming increasingly obvious that the breeding biology of the boobies, indeed of tropical seabirds generally, requires long-term observation because, for example, their breeding cycles are protracted, and laying dates and productivity can vary greatly from year to year. Further, there is now clear indication of variation between allopatric populations of the same species, especially the three pantropical boobies. Thus, at different stations, there may be intraspecific differences not only, for example, in the duration of pair-bonds, of colony occupation, and of nestling and juvenile dependence, but also in certain aspects of the behavior functioning in social communication. More and more, therefore, is there need for long-term and repeat studies at various seabird stations. It is becoming clear that one is ill-advised to generalize too widely from the findings on one population or one breeding period.

Kepler's book deliberately avoids this danger and is particularly welcome as a most useful addition to our knowledge of the Masked Booby and sulid biology in general. Of the six chapters, the two concluding ones, which occupy about one-third of the space, deal with the behavior of the Masked Booby at Kure—spacing-out behavior in Chapter 5 and heterosexual behavior in Chapter 6. Although these observations were made independently of those of Nelson in the Galapagos, for convenience the terms used and the order of presentation follow those of Nelson's paper on the same species, published earlier in *Ibis* (1967). It is not proposed to summarize Kepler's interesting and careful observations here, but it should be noted that he detected small differences in the Sky-pointing display of the male on Kure as compared, for example, with the form of that behavior in the Galapagos.

Chapter 1 describes the environment at and around Kure. During the previous decade, the atoll itself was considerably altered by man, whose artifacts continue to cause mortality among the seabirds. There are some fourteen breeding species of the latter, the most numerous being the 7,000 Laysan Albatross (*Diomedea immutabilis*). Among the Pelecaniformes, 2,200 Red-tailed Tropicbirds (*Phaethon rubricauda*) and 1,600 Great Frigatebirds (*Fregata minor*) predominate, while the three pantropical boobies, all at the northern edge of their range, are among the least numerous of all seabirds on Kure, with 160 Masked Boobies, 90 Brown, and 550 Red-footed.

Chapter 2 discusses taxonomy, distribution, and morphology. Like an increasing number of workers, Kepler prefers to treat the boobies in a separate genus (*Sula*) from the larger gannets (*Morus*), a practice which has much to recommend it. The Masked Booby finds its northernmost breeding station at Kure (latitude 28° 25′ N), where the birds belong to the race *personata.* The sexes are similar except in size (females significantly larger), color of the bill (brighter in males), and in voice.

The Green Island colony of Masked Boobies is described in Chapter 3. It is virtually confined to the central plain and not to the periphery of the island, as in most central Pacific colonies of the species. The population averaged 140 birds in 1963–66 and was evidently declining slightly each year. Seventy-five percent of the birds breed in one discrete sub-colony, the rest in another, with no communal gathering areas or "clubs," as reported at some other colonies of the species. Kepler plotted the diurnal fluctuation in numbers and assessed the time spent feeding at sea. Most absences that terminated during the daily 12-hour observation period were short, averaging 4.9 hours for males and 5.9 hours for females, a significant difference. Absences lasting 36 hours or longer were not adequately covered, however, and many of the shorter absences—those of less than two hours—may not have been concerned with feeding at all; as another reviewer has remarked, no mention is made of out-flights for bathing. The chapter provides such information about the territories defended by pairs of birds and bachelor males, and concludes with a discussion of the "functions" of territory in the Masked Booby. Kepler suggests that the wide spacing out of breeding pairs (1) increases the efficiency of nesting (by reducing adverse pair-interactions) and (2) limits population size and hence competition for food in waters that are poor in food supply. Comparison is made with the colony of Masked Boobies on Boatswainbird Islet, Ascension, where territories were ten times smaller and nesting success nearly six times lower. In the reviewer's opinion, however, the value of such interpretation is limited. At both Kure and Ascension, nesting density is a function of available space and numbers; because of predation by feral cats, virtually all the Ascension Masked Boobies now nest on Boatswainbird Islet, where they are overcrowded. It is the Ascension birds, not the Kure ones, that frequently face food difficulties when breeding; if territory size were really adaptive in trimming population size to suit the availability of food, one would expect denser nesting on Kure than on Ascension.

Chapter 4 is concerned with breeding biology. Following a brief outline of reproductive seasons in other populations of *S. dactylatra*, those at Kure in 1964–65 are described in detail. As elsewhere, the species is an annual breeder, laying mainly in the period January–May, but the 1965 season was later than that of 1964 due, apparently, to climatic factors, including a severe gale, which affected foraging behavior in 1965. The author then digresses to review briefly some of the literature dealing with the effect of the food supply on breeding phenomena in birds. Copious information is given on many aspects of nesting, and lastly in this chapter, the development of the chick is described in detail.

Kepler's paper poses many interesting questions for future consideration. For instance, the Masked Boobies at Kure seem to have a favorable food supply, at least when breeding, and do not have to range far out to sea for days at a time in search of their prey, unlike most other populations of the species. Yet numbers are small and decreasing, in spite of a high fledging success. Most puzzling of all, the juveniles, once fledged, return only briefly—unlike those in the Galapagos, where Nelson recorded the "period of post-fledging feeding" as over 60 days. Does this mean that Kure juveniles come much quicker to independence, or was there, for example, an extremely high mortality soon after fledging during the period of study? Much the same question can be raised at Ascension, where Dorward recorded return-periods of only up to four weeks during 1957–59, not only for the Masked Booby but also for the Brown. Later observations by the reviewer in 1962–64, however, established a mean return-period after fledging for juvenile Brown Boobies of no less than 25 weeks.—K. E. L. SIMMONS.

A FIELD GUIDE TO THE BIRDS OF MEXICO AND CENTRAL AMERICA. By L. Irby Davis. Univ. of Texas Press. 1972: 5 × 8¾ in., 282 pp., 48 col. pls. by F. P. Bennett, Jr., $10.00 hardbound, $6.50 softbound *and* A FIELD GUIDE TO THE BIRDS OF MEXICO by Ernest P. Edwards, published by Ernest P. Edwards, Sweetbriar, Virginia, 1972: 5¾ × 9 in., 300 pp., 3 maps, 24 col. pls. (Murrell Butler 14½; Ernest P. Edwards 7½; John P. O'Neill 1, and Douglas Pratt 1), $8.50 softbound.

The purpose of a field guide is to aid those unfamiliar with an avifauna in correctly identifying to species birds seen in the field. That many field guides also serve as exceedingly useful quick references for research workers may be considered a secondary function. The introduction of a field guide should define and describe the region covered and, if the region is politically or ecologically complex, present a thumbnail discussion and map to assist readers in locating geographic names or habitats used in range descriptions; terminology should be explained. The text of a good guide should follow a set format sufficiently to permit comparisons back and forth between species. It should be concise yet explicit; accurate yet brief. Taxonomic innovations should be avoided and changes in popular names should be minor. The illustrations should present diagnostic characters in as simple and as large a format as economically feasible, ideally with major age or sex (or geographic) variations included when possible. Using these criteria, the two nearly simultaneously appearing field guides covered by this review represent nearly the extremes in quality. The Davis book is a farce except for the useful colored plates by F. B. Bennett, Jr., while the Edwards guide is good (excepting some exceedingly poor colored plates)! Both authors elected to illustrate only forms not illustrated in available guide books to North American birds.

Although Davis's guide covers nine countries, and range descriptions mention most of the 31 states of Mexico, a map is not presented nor are habitats defined, although occasionally used in range descriptions. Because of Davis's interest in sound recording, 70 percent of the brief introduction is devoted to an exceedingly complex (and confusing but perhaps unavoidably so) discussion of song analysis and description. However, a bird watcher would need to include a stopwatch and a pitch harmonica (or set of tuning forks) in his field gear to decipher the voice descriptions which are presented for only some birds. Often only one song is presented, although many species have more than one type. The voice of many birds is not mentioned at all, *nor* are field characters given for many either in text or in the captions of the plates. The range is presented for all forms, but some ranges are less than accurate; for example; the Song Sparrow is more widespread in winter only in Sonora. The range given for *Rallus elegans tenuirostris* has not incorporated information from literature 11 years old; the Pinnated Bittern has not been collected in Belize, Guatemala, Honduras, or Panama, yet it is said to occur E. Mexico to Argentina. The Swamp Sparrow winters to central Mexico, etc.

But these criticisms pale to insignificance compared to the appalling English and scientific terminology. "The taxonomy adopted is intended to be useful to those having little knowledge of the technical classification presently in vogue among museum systematists. A name is provided for each distinct population [known to Davis] in order to make taxonomy useful rather than confusing to the student."

This stated, Davis apparently felt he had license to ride roughshod over more than two centuries of ornithological work. I am sure few of the "museum ornithologists," living or dead, who are said to have advised him will appreciate being associated, even by inference, with the nomenclature used. To decipher the names, both Latin and English, and to correlate them with recognized species, and with names used in other standard guides and texts, one would need the 11 volumes of Ridgway and perhaps the 15 volumes of Hellmayr too! The "species" recognized are at times ludicrous—as for example, the Long-crested Cardinal, obviously no more than a race of the Common Cardinal. Yet forms equally as distinct, with which Davis is apparently unfamiliar, were not given distinct names. If he had been consistent, he should have included six species of Song Sparrows in Mexico, each easily recognized in the field!

It is obvious that the University of Texas Press did not have the manuscript read by an ornithologist before accepting it for publication. If some devoted soul—or someone mad enough—would make available new captions to the 48 plates, the other 282 pages could be discarded, saving weight in the field and shelf space in the library. The plates, when provided with new captions, will be useful in the field and in the museum, for they do provide stylized but adequate illustrations of all non-1957-A.O.U. Check-list species found in Central America, and of many subspecies as well.

By comparison Edwards' guide is nearly exemplary. The introduction is brief but good, defining and describing the regions and the author's format, terminology, and abbreviations. Maps are presented of the states of Mexico and the countries of Central America, and of the regions and subregions of Mexico used in the ranges. Species accounts include the usual information: common name in English *and* Spanish, Latin name without subspecies, illustration reference, migratory status and distribution in altitude and geographically. Then briefly the general status, comparative field marks, often ecological niche and call notes are described, and finally the description is briefly repeated in Spanish. If a species exhibits major geographic variation, this is usually mentioned. Sounds good, and it is. Still, criticisms can be made.

1. The binding of my copy has not lasted through the review preparation and I have a set of loose colored plates. This is a nuisance, to say the least, for a field guide.
2. Although the subtitle reads "including all birds occurring from the northern border of Mexico to the southern border of Nicaragua," the inclusion of species south of Mexico seems to have been an afterthought. These are listed with only one to four-line capsule accounts and without illustrations. I hope a second edition will find these expanded to full accounts with illustrations.
3. The colored plates range from poor (and poorly reproduced—especially plate 17) to excellent. Some, such as plate 9 with the trogons, kingfishers, and motmots or, for that matter, plates 13 or 20–22, will stand favorable comparison to those of any field guide in print. Unfortunately, for unknown reasons some plates were printed on colored stock and the bird colors are consequently distorted, particularly plates 21 and 22 printed on blue paper!
4. Edwards, as in his "Finding Guides," uses a few of his own common names, but usually provides the alternative names. Likewise, a few subspecies are listed as full

species, although relationships are usually mentioned. Unfortunately, the yellow-eyed Baird's Junco is said to be often "lumped with [the dark-eyed] Oregon Junco," whereas it is related to the yellow-eyed *Junco phaeonotus.*

5. And finally, in a later edition better editing will prevent some inconsistencies between English and Spanish descriptions. For example, the bill of the Common Merganser is said to be red (male) or dull orange (female) in English but is said to be yellow in Spanish.

For those visiting Mexico the Edwards guide will prove adequate, especially if supplemented by the plates by Bennett; for those visiting the rest of Central America, Edwards supplemented by the Bennett plates with annotations, together with H. C. Land's "Birds of Guatemala" and F. B. Smithe's "The Birds of Tikal," provide the only currently available aids.—ROBERT W. DICKERMAN.

TIBET AND ITS BIRDS. By Charles Vaurie, H. F. and G. Witherby Ltd., London, 1972: 7 × 10 in., xv + 407 pp., 3 col. pls. by Arthur Singer, 24 photos, maps. £10.50.

This book is a labor of love by the author, who has become fascinated by one of the remotest areas of the world during his years of work on the bird faunas of northern Europe and Asia. Dr. Vaurie, who has worked at the American Museum of Natural History for many years, became interested in Eurasian birds under the tutelage of Dr. Ernst Mayr, then Curator of birds in New York, and much of his early work was concerned with sorting out and classifying the large collections of Dr. Walter Koelz, the plant explorer. Dr. Koelz had deposited his bird collections in New York while he travelled incessantly in Asia from Iran to Afghanistan, Ladak and India as well as the sub-Himalayas of Nepal. It is not, therefore, a narrative of field work, for Dr. Vaurie has never visited Tibet, but rather what might be called, in an old-fashioned sense, a "cabinet" work.

As such the book has great value. The description of the geography of Tibet is detailed and highly comprehensive, the best of its kind I have encountered. The account of the voyages of the travellers who have penetrated the country is equally comprehensive, although confined only to those who have collected specimens of birds, thus excluding some of the travellers who have made important meteorological or kindred observations such as William Rockhill. Some of the mountaineers and botanists such as Smythe have similarly been neglected, although the late Frank Kingdon-Ward has come in for a good deal of attention. But to treat all the authors who have speculated about the origins of Tibetan eco-geography, or its fauna and flora would require still more encyclopedic labors, and the present author has created a history and a description of Tibet which will stand doubtless for many years.

For those who might be interested in a synoptic list or a hand-book of Tibetan birds, giving information on habits or ecology, this book will not provide a compendium. Much of the current work on migration of birds across central Asia is still unpublished, in records either in India or the USSR. The question of *how* the enormous volume of birds migrate across the desert areas at high altitude, and then cross the mountain barrier of the Himalayas is still unrefined. As one who has witnessed the passage of huge numbers of birds, along with other recent workers such as Sálim Ali and Gerd Diesselhorst, I can agree with Vaurie that Colonel Meinertzhagen was mistaken in referring to any resident or partially migratory species of the area as "weak" or a "refugee." However, I believe the recent geology of the higher Himalayas and the adjacent Tibetan plateau is still poorly understood. I suspect that glaciation was far from complete, and that endemism in birds, mammals, and other animals as well as plants, has had ample opportunity to flourish during the recent geological past despite the recurrence of pluvial and glacial conditions. Much remains to be done to correlate biogeographical evidence with paleohistorical evidence in order to understand the present distribution of a fauna such as the avifauna.

The maps are drawn with Vaurie's usual attention to detail. The photographs are interesting, especially the inclusion of portraits of some of the early explorers. The plates by Arthur Singer strike me as extraneous, being only three in number, therefore only a very partial representation of the fauna, and very cold and somewhat harsh in tone. Perhaps they are a come-on by the publisher.

Much remains to be discovered about Tibet as well as its avifauna. There are still bird species to be recorded from there, notably another tragopan most likely. At least this volume sets out to detail the birds that have been found by every bird collector, an extraordinary feat in itself. It points out the obstinacy of communication, the failure of too many collectors from Hume to Schäfer to Koelz to record what in fact they did do, where they went and where they actually collected. Alas for the lost opportunities, and oh for the power of total recall. Stuart Baker used to say, "it's all here," tapping his forehead. But what was all there, and where did it go? Will anyone ever collect birds again in Tibet, and publish their observations? One wonders. Meanwhile we have Dr. Vaurie's fascinating compendium, an essay as it were, in aquisition, in man's frailty, and in our fragmentary knowledge of the world of birds.—S. Dillon Ripley.

THE BIRDS OF KOREA. By M. E. J. Gore and Won Pyong-Oh. Royal Asiatic Society, Korea Branch in conjunction with Taewon Publishing Co., Seoul, Korea and Charles E. Tuttle Co., Rutland, Vermont and Tokyo, Japan, 1971: 6¾ × 9¾ in., 450 pp., end-paper maps, photos, 40 col. pls. $15.00, Won 4800.

During the past ten years a number of books on Asian birds have appeared, to fill the gaps where amateur and professional bird people previously had little to use. Beautiful bird books in Japanese are available, and there is Yamashina's inadequate book, in English, on a few Japanese birds. Other works include Severinghaus, Kang, and Alexander's little book on a sample of the birds of Taiwan in English and Chinese, designed to stimulate interest in birds among Chinese students, Boonsong's very valuable "Bird Guide of Thailand" with color plates showing most of the birds of southeast Asia, and Wildash's "Birds of South Vietnam." King and Dickinson's volume on birds of continental southeast Asia is soon to appear, Boonsong's work is being revised, Smythies' "Birds of Borneo" has been reprinted, duPont's "Philippine Birds" has recently been published, and Medway and Wells are working on a volume on Malaysian birds.

Now we have this very complete volume on the birds of Korea, covering 366 species. Excerpts from the brochure advertising this book accurately describe it and its authors as follows: "The first guide to the birds of the Republic of Korea with 240 species illustrated in full color. Every species of bird which occurs or has occurred in Korea is described with notes under the following headings: Identification—an easy-to-follow description with the field characteristics to enable anyone to identify the bird; Habitat—the type of habitat where the species is most likely to be encountered; Status—an assessment of its present status in Korea with detailed records of uncommon or rare species. The world range is included and recognized subspecies are listed. There are also chapters on: Topography and climate; Bird habitats in Korea, with an indication of the species commonly encountered in each zone; Migration through Korea; The problem of conservation. . . . Michael E. J. Gore is a British diplomat who has studied birds in Europe, Africa and Southeast Asia. Since 1967 he has been Consul in Seoul. A member of the British Ornithologists Union, he has previously published papers on birds of Cyprus and Borneo. . . . Won Pyong-Oh is Director of the Institute of Ornithology, Kyung Hee University, Seoul and is a recognized authority on the birds of Korea. A professor of zoology, he has published many papers on the subject and on conservation of wildlife in Korea. He is a Secretary of the International Council for Bird Preservation and a member of the Survival Service Commission of the International Union for the Conservation of Nature and Natural Resources."

The real charm and value of this book lie in its bilingual nature. Koreans are a proud and individualistic people, so this volume in both Korean and English should please them. Because of the dual languages, the book is too bulky to be used as a field guide, but it is very good to have at home when you want to check on what has been seen in the field. The plates are adequate but some of the reds are too red, the blacks too pale, etc. The text concerning each species is good although I feel that most laymen are not interested in subspecies, and that this space might better have been given to more discussion of ecology or habitats. Dr. Won is a taxonomist—as I am not—so he insisted that these data be included. The subspecies could have been listed as an appendix checklist.

The introductory chapters are very useful, especially the one on the history of Korean ornithology, which gathers together bits of information that would be difficult for the reader to find elsewhere. A list of additional birds known from North Korea is given, there is a list of references, and the book is indexed both in Korean and English.

When I visited with Dr. Won in 1969, he and Mr. Gore were deeply engrossed in the preparation of this volume. They were having their problems of communication, agreement, and objectives. The end result is a fine compromise and a valuable addition to the English ornithological literature of Asia. It will be useful to anyone living in Japan, Korea, China, or Hong Kong.—H. ELLIOTT MCCLURE.

BIRDS OF NEW GUINEA. 160 colour-plates from the lithographs of John Gould. Text by Abram Rutgers. St. Martin's Press, New York, 1971: 7½ × 10 in., viii + 321 pp., 160 col. pls. $15.00.

Reproduction in color of the bulk of the John Gould lithographs of the birds of New Guinea in a single short volume priced within the reach of the average layman and ornithologist is an occasion of some moment. New Guinea with some 670 recorded species and at least 550 land and fresh-water forms, has one of the richest bird faunas in the world; it is the heartland of cassowaries, paradise kingfishers, the great crowned pigeons, loriine parrots and birds-of-paradise and bower birds. Collectively, the Gould paintings, including those added under the direction of Bowdler Sharpe, remain the finest and most comprehensive available on the region's bird fauna, even though only about a quarter of its species are represented. Some 160 of these appear in the book under review. As is well known, the attitudes of the figures are often distorted, the postures of a number of birds-of-paradise being particularly unreal; there is at times a less-than-virile Audubonesque quality about them. An intriguingly consistent feature is the Australian background to many of the paintings: *Monarcha vidua* and *Todopsis cyanocephala* are depicted among Australian *Grevillea*, and *Micropsitta geelvinkiana* on *Leptospermum*; and the mouse-like animals in the background of *Pitta 'rubrinucha'* from Buru are the Australian marsupial *Sminthopsis crassicaudata*. Many arboreal rain forest species such as *Pitohui kirhocephalus* and *Diphyllodes magnifica* are perched on rocks in open habitat. But these quirks aside, the paintings are noteworthy for their historical significance and accuracy of color, of which little has been lost in the present reproductions.

The accompanying text by Abram Rutgers and the choice of species are rather less successful. To claim as does the book by its title that it is about New Guinean birds is misleading. Of the species shown, no less than 38 (almost 25%) are not found in New Guinea or its off-shore islands, and another sixteen are of races occurring outside the region. Five endemic Australian species, e.g. *Aphelocephala pectoralis* and *Chlamydera maculata,* could well have been left out to preserve integrity, especially as they might have been replaced by Gould figures of such exquisite New Guinean species as *Halcyon nigrocyanea.* Current systematic arrangement but lack of an index makes individual species difficult to find.

Rutger's text is poorly contrived. Its scientific nomenclature, vernacular names, and textual information are drawn in the main from A. L. Rand and E. T. Gilliard's fine handbook, "A Handbook of New Guinea Birds." Not only have these been combined in an amateurish and at times confusing way, but a baffling number of misapprehensions and exaggerations have crept in as well. In a leafing-through of the pages, I noted over fifty serious errors. These cannot be itemized here, but some of the more obvious are as follows. In distribution, *Casuarius casuarius* is said to be confined to the New Guinea area, whereas it occurs also in northeastern Australia; it is inferred that *Chalcopsitta scintillata* occurs all over New Guinea whereas it is actually confined to the southern lowlands; conversely, details given under *Astrapia nigra* imply that all five allopatric species of the genus are sympatric in the Arfak Mountains; lowland *Pitta sordida* is said to live in mountain forests; and two species of the essentially montane genus *Peneothello* are claimed to occur in the lowlands. Concerning habits, the observation that *Epimachus fastosus* (correctly, *fastuosus*) feeds on amphibians which it wedges in tree crannies before tearing them to pieces is fantasy; the species is largely a fruit-eater. And *Sericulus chrysocephalus,* mentioned under *S. aureus,* builds a primitive avenue, not a domed bower.

Nomenclatural inconsistencies and taxonomic inaccuracies are all too frequent. The scientific name heading for each species changes from binomial to trinomial in a bewildering and, in a book of this kind, pointless way. There are also several anomalous departures from Rand and Gilliard nomenclature, notably in the use of the now obsolete *Kakatoë* in lieu of *Cacatua.* The taxonomic accounts of the genus *Meliphaga* given under *M. flaviventer* and of *Timeliopsis griseigula* are nonsense: in *Meliphaga,* infra-specific groups in *M. flaviventer* have been confused with species groupings in the genus; in *Timeliopsis griseigula,* the race *fulviventris* appears to have been confused with Rand and Gilliard's account of the distinct montane species, *T. fulvigula.* Ornithologists familiar with Australo-Papuan flycatchers will be surprised to note that the Solomon Islands *Monarcha vidua* has been referred to the genus *Piezorhynchus,* which is said to be characterized by a white collar and rump. *Piezorhynchus* in fact was based on *P. alecto,* a plain-backed species now known to be an aberrant member of the genus *Myiagra.*

The text has some praiseworthy features. Most forms figured have been identified according to current taxonomic concepts and with names presently in use. (One exception is the plate of *Mino anais,* which apparently represents the race *orientalis,* not *robertsoni* as stated.) There are also useful comments on the advent of various species live in Europe and of their performance and behavior as caged birds. Offsetting this are the frequent plumage descriptions of figured species, all of which are superfluous because of the colored illustrations.

If the text can be overlooked, the book is beautifully produced. Reproduction of the lithographs is faithful, the printing clear and well laid out, the quality of the paper excellent, and the binding sound. Orthographic errors are few and not serious. In summary, the book is a rich and lovely collection of the Gould lithographs of New Guinean birds. In practice, it is useful when consulted along with a reliable text such as Rand and Gilliard's Handbook. This in turn highlights a remaining great gap in the ornithological literature of New Guinea—a completely illustrated manual of the birds of the region wedded to a full, sound, and balanced text.—RICHARD SCHODDE.

NATURAL RESOURCE CONSERVATION—AN ECOLOGICAL APPROACH. By Oliver S. Owen. Macmillan, New York, 1971: 6½ × 9½ in., xii + 593 pp., photos and diagrams. $9.95.

Putting together a text for natural resource education is indeed a troublesome task. In these times a rather diversified set of scientific, economic, and social factors are expected to be considered. It is especially difficult when an author of the old school tries to jump on the environmental bandwagon by putting an "ecological" framework around the "natural resources conservation" of his youth. The job *has* been done effectively, but not by this author.

I gave the text to Klint Wigren, one of the best foresters in a heavily forested state. As a "natural resource conservation" man looking for some insight into the "new ecology" he was totally confused by an author who treated the two concepts as separate entities for which he, the author, could find only a *rough* fit at best. If Klint was confused, I doubt that a student using this text would fare much better, and certainly would not be left with any grasp of the ecological basis for conservation measures.

The cover flap of this book suggests that it is "informal—but very carefully integrated." I take issue with somebody's idea of integration. In fact, it appears to me that loosely organized chapters and lack of appropriate continuity throughout the book are major faults of the work.

There are other faults. The writing contains long, wordy sentences. The heavy, heavy documentation serves no purpose for the intended audience of beginning students, but adds to the disjointed flavor of the book. Most of the many photographs are either superfluous or confusing adjuncts to the text. Many of the charts are crowded and difficult to read. The author apparently tries to be contemporary in his use of the metric system in some illustrations, but then compares such data with other information expressed in the English system.

The book misses its mark by a long way. Students of natural resources conservation or ecology or "an ecological approach to natural resources conservation" can find other, more useful texts.—RICHARD B. FARRAR, JR.

This issue of *The Wilson Bulletin* was published on 8 March 1973.

SUGGESTIONS TO AUTHORS

See Wilson Bulletin, 84:513, 1972 for more detailed "Suggestions to Authors." Manuscripts intended for publication in *The Wilson Bulletin* should be neatly typewritten, double-spaced, with at least one inch margins, and on one side only of good quality white paper. Tables should be typed on separate sheets, and should be designed to fit the normal page width, i.e., narrow and deep rather than wide and shallow. Before preparing these, carefully consider whether the material is best presented in tabular form. Follow the AOU Check-list (Fifth Edition, 1957) insofar as scientific names of United States and Canadian birds are concerned unless a satisfactory explanation is offered for doing otherwise. Use species names (binomials) unless specimens have actually been handled and subsequently identified. Summaries of major papers should be brief but quotable. Where fewer than five papers are cited, the citations may be included in the text. All citations in "General Notes" should be included in the text. Follow carefully the style used in this issue in listing the literature cited; otherwise, follow the "CBE Style Manual" (1972, AIBS). Photographs for illustrations should be sharp, have good contrast, and be on gloss paper. Submit prints unmounted and attach to each a brief but adequate legend. Do not write heavily on the backs of photographs. Diagrams and line drawings should be in black ink and their lettering large enough to permit reduction. Extensive alterations in copy after the type has been set must be charged to the author.

NOTICE OF CHANGE OF ADDRESS

If your address changes, notify the Society immediately. Send your complete new address to the Treasurer, William A. Klamm, 2140 Lewis Drive, Lakewood, Ohio 44107. He will notify the printer.

The permanent mailing address of the Wilson Ornithological Society is: c/o The MUSEUM of Zoology, The University of Michigan, Ann Arbor, Michigan 48104. Persons having business with any of the officers may address them at their various addresses given on the back of the front cover, and all matters pertaining to the Bulletin should be sent directly to the Editor.

PAST PRESIDENTS OF THE WILSON ORNITHOLOGICAL SOCIETY

J. B. Richards, 1888–1889
Lynds Jones, 1890–1893
Willard N. Clute, 1894
R. M. Strong, 1894–1901
Lynds Jones, 1902–1908
F. L. Burns, 1909–1911
W. E. Saunders, 1912–1913
T. C. Stephens, 1914–1916
W. F. Henninger, 1917
Myron H. Swenk, 1918–1919
R. M. Strong, 1920–1921
Thos. L. Hankinson, 1922–1923
Albert F. Ganier, 1924–1926
Lynds Jones, 1927–1929
J. W. Stack, 1930–1931
J. M. Shaver, 1932–1934
Josselyn Van Tyne, 1935–1937
Margaret Morse Nice, 1938–1939
Lawrence E. Hicks, 1940–1941
George Miksch Sutton, 1942–1943
S. Charles Kendeigh, 1943–1945
George Miksch Sutton, 1946–1947
Olin Sewall Pettingill, Jr., 1948–1950
Maurice Brooks, 1950–1952
W. J. Breckenridge, 1952–1954
Burt L. Monroe, Sr., 1954–1956
John T. Emlen, Jr., 1956–1958
Lawrence H. Walkinshaw, 1958–1960
Harold F. Mayfield, 1960–1962
Phillips B. Street, 1962–1964
Roger Tory Peterson, 1964–1966
Aaron M. Bagg, 1966–1968
H. Lewis Batts, Jr., 1968–1969
William W. H. Gunn, 1969–1971

PAST SECRETARIES OF THE WILSON ORNITHOLOGICAL SOCIETY

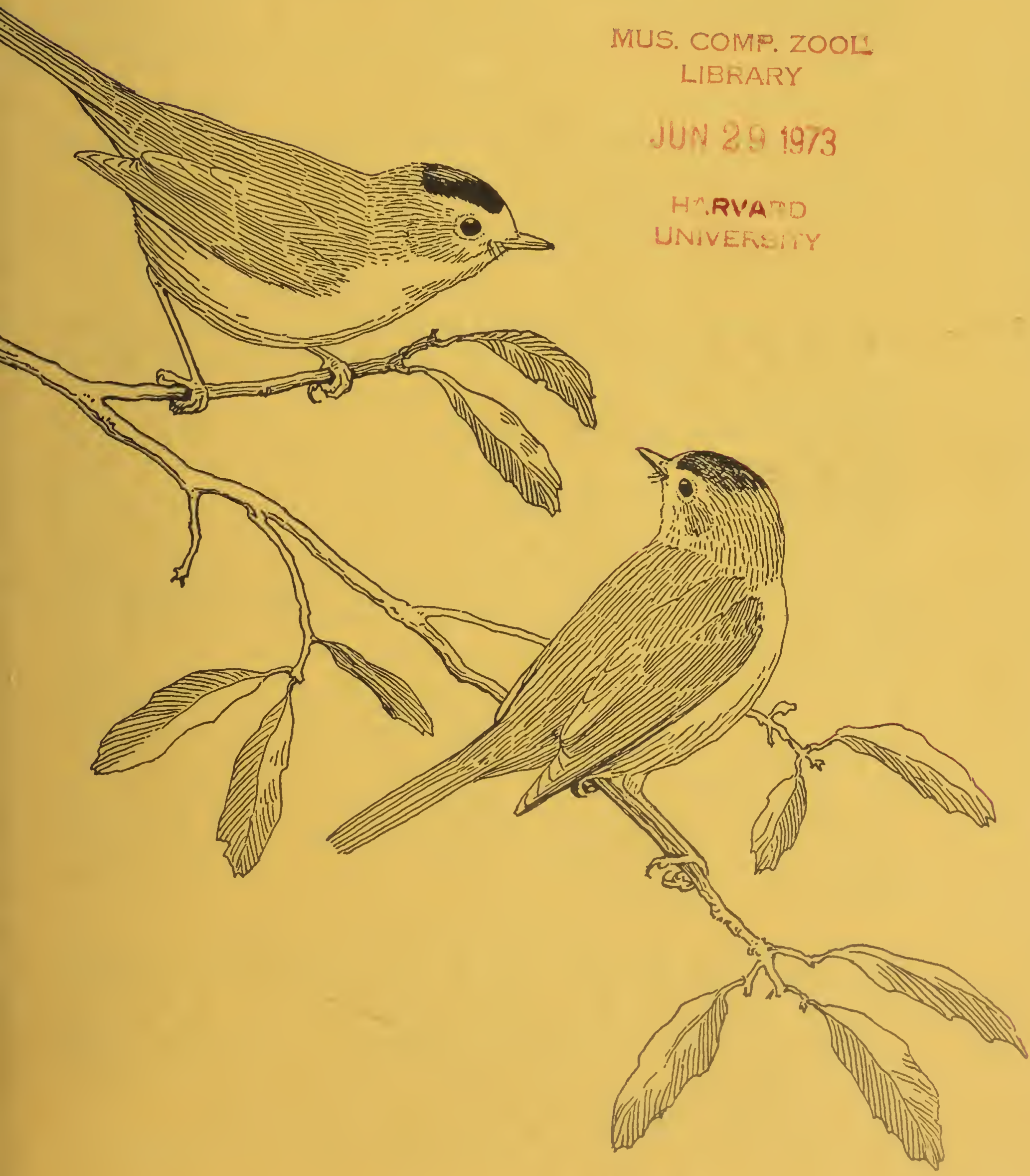
Lynds Jones, 1888–89
J. Warren Jacobs, 1890–91, 1893
Willard N. Clute, 1892
William B. Caulk, 1894
J. E. Dickinson, 1895–97
W. L. Dawson, 1898–1901
John W. Daniel, Jr., 1902–05
Frank L. Burns, 1906
Benj. T. Gault, 1907–11
C. W. G. Eifrig, 1912–13
Orpheus M. Schantz, 1914
Thos. L. Hankinson, 1915–16
G. A. Abbott, 1917
Albert F. Ganier, 1918–22
Gordon Wilson, 1923–25
Howard K. Gloyd, 1926–28
Jesse M. Shaver, 1929–31
Lawrence E. Hicks, 1932–36
Olin Sewall Pettingill, Jr., 1937–41
Maurice Brooks, 1942–46
James B. Young, 1947–48
Harold F. Mayfield, 1948–51
Phillips B. Street, 1952–55
Fred T. Hall, 1956–57
Aaron M. Bagg, 1958–61
Pershing B. Hofslund, 1962–66
Jeff Swinebroad, 1967–70

w

The Wilson Bulletin

PUBLISHED BY THE WILSON ORNITHOLOGICAL SOCIETY
WEST VIRGINIA U. • MORGANTOWN, W. VA.

VOL. 85, NO. 2 JUNE 1973 PAGES 113–256



THE WILSON ORNITHOLOGICAL SOCIETY

FOUNDED DECEMBER 3, 1888

Named after ALEXANDER WILSON, the first American Ornithologist.

President—Pershing B. Hofslund, Dept. of Biology, University of Minnesota Duluth, Duluth, Minnesota 55812.

First Vice-President—Kenneth C. Parkes, Carnegie Museum, Pittsburgh, Pennsylvania 15213.

Second Vice-President—Andrew J. Berger, Dept. of Zoology, University of Hawaii, Honolulu, Hawaii 96822.

Secretary—James Tate, Jr., Laboratory of Ornithology, Cornell University, Ithaca, New York 14850.

Treasurer—William A. Klamm, 2140 Lewis Drive, Lakewood, Ohio 44107.

Elected Council Members—Elden W. Martin (term expires 1973); Robert D. Burns (term expires 1974); Harvey I. Fisher (term expires 1975).

Membership dues per calendar year are: Active, $8.00; Sustaining, $15.00; Life memberships, $200 (payable in four installments).
THE WILSON BULLETIN is sent to all members not in arrears for dues.

THE JOSSELYN VAN TYNE MEMORIAL LIBRARY

The Josselyn Van Tyne Memorial Library of the Wilson Ornithological Society, housed in the University of Michigan Museum of Zoology, was established in concurrence with the University of Michigan in 1930. Until 1947 the Library was maintained entirely by gifts and bequests of books, reprints, and ornithological magazines from members and friends of the Society. Now two members have generously established a fund for the purchase of new books; members and friends are invited to maintain the fund by regular contribution, thus making available to all Society members the more important new books on ornithology and related subjects. The fund will be administered by the Library Committee, which will be happy to receive suggestions on the choice of new books to be added to the Library. William A. Lunk, University Museums, University of Michigan, is Chairman of the Committee. The Library currently receives 104 periodicals as gifts and in exchange for *The Wilson Bulletin.* With the usual exception of rare books, any item in the Library may be borrowed by members of the Society and will be sent prepaid (by the University of Michigan) to any address in the United States, its possessions, or Canada. Return postage is paid by the borrower. Inquiries and requests by borrowers, as well as gifts of books, pamphlets, reprints, and magazines, should be addressed to "The Josselyn Van Tyne Memorial Library, University of Michigan Museum of Zoology, Ann Arbor, Michigan." Contributions to the New Book Fund should be sent to the Treasurer (small sums in stamps are acceptable). A complete index of the Library's holdings was printed in the September 1952 issue of *The Wilson Bulletin* and newly acquired books are listed periodically.

THE WILSON BULLETIN

The official organ of the Wilson Ornithological Society, published quarterly, in March, June, September, and December, at Morgantown, West Virginia. The subscription price, both in the United States and elsewhere, is $10.00 per year. Single copies, $2.50. Subscriptions, changes of address and claims for undelivered copies should be sent to the Treasurer. Most back issues of the *Bulletin* are available (at $2.50 each) and may be ordered from the Treasurer. Special prices will be quoted for quantity orders.

All articles and communications for publications, books and publications for reviews should be addressed to the Editor. Exchanges should be addressed to The Josselyn Van Tyne Memorial Library, Museum of Zoology, Ann Arbor, Michigan.

Second class postage at Lawrence, Kansas, U.S.A. 66044

PRINTED IN U.S.A. Allen Press, Inc., Lawrence, Kansas 66044

THE WILSON BULLETIN

A QUARTERLY MAGAZINE OF ORNITHOLOGY

Published by The Wilson Ornithological Society

VOL. 85, NO. 2 JUNE 1973 PAGES 113–256

CONTENTS

GENERAL NOTES

A Stilt Sandpiper chick wanders near the nest while the male parent awaits the hatching of the remaining eggs. Churchill, Manitoba, 30 June 1965. Photo by S. Marie Kuhnen.

BREEDING BIOLOGY AND SYSTEMATIC RELATIONSHIPS OF THE STILT SANDPIPER

JOSEPH R. JEHL, JR.

THE subfamily Calidridinae (family Scolopacidae) includes 24 species of small to medium-sized sandpipers, nearly all of which are entirely restricted as breeding birds to arctic or subarctic areas. Eighteen species are included in the genus *Calidris*, the remaining six each being assigned to a monotypic genus (Jehl, 1968*c*). Many species of *Calidris* are quite similar morphologically, perhaps reflecting a fairly recent radiation in tundra areas. Within the entire subfamily, however, there is wide diversity in bill morphology, sexual size dimorphism, and breeding biology. To date, studies of morphology and plumage characters have not resulted in any real understanding of calidridine evolution, and other approaches are necessary. Studies of the evolution of social systems by Pitelka, Holmes, and others seem to offer a significant approach to the problem, but their value is dependent upon detailed data on the biology of individual species.

In recent years there has been renewed interest in the biology of calidridine sandpipers, in part because of their important position in arctic ecosystems, and fairly complete accounts are now available for a few species (e.g., *Calidris melanotos*, Pitelka, 1959; *C. fuscicollis*, Parmelee et al., 1968; *C. alba*, Parmelee, 1970). The outstanding studies on Dunlin (*C. alpina*) by Holmes (1966*a, b, c*, 1970, 1971*a*) in Alaska and by Soikkeli (1967, 1970*a, b*) in Finland are the most complete treatments of the ecology and breeding adaptations in any sandpiper.

This paper deals with the Stilt Sandpiper (*Micropalama himantopus*), a little-studied species which has generally been considered a somewhat aberrant member of the calidridine complex. Most of the literature on the breeding biology of this species is anecdotal, incomplete, or even erroneous (e.g. Farley, 1936), but important contributions have been made by Sutton (1961), Parmelee et al. (1967) and Jehl (1970).

METHODS

Field work was conducted near Churchill, Manitoba, mainly in the summers of 1965, 1966, and 1967; a few additional observations were made in 1964. I was present in the Churchill region between 28 May–2 August 1964, 29 May–22 July 1965, 2 June–26 July 1966, and 9 June–13 July 1967. In 1964 and 1965 I arrived before the earliest migrants and departed after the adults had migrated southward.

The bulk of my observations were conducted within two miles of Fort

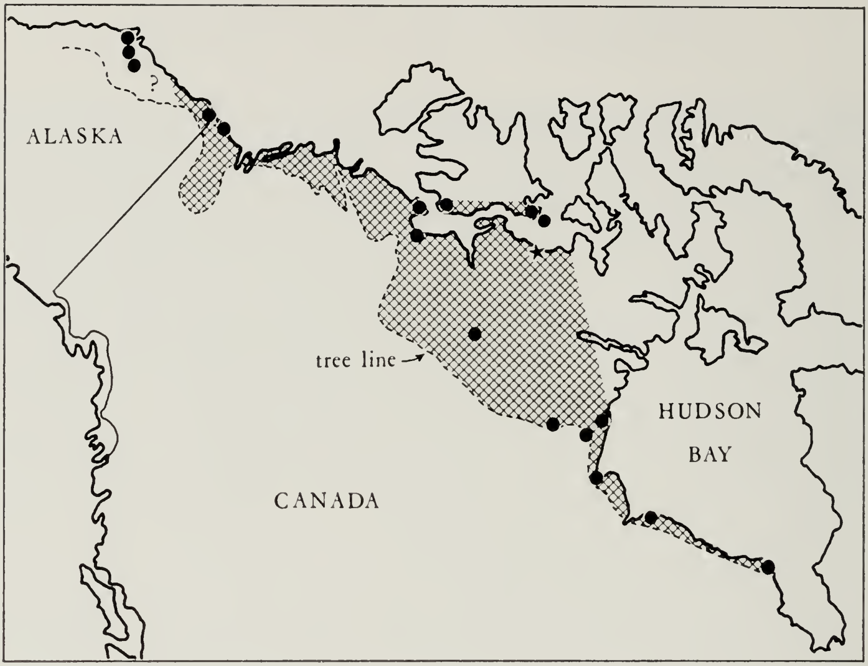


FIG. 1. The approximate breeding range of the Stilt Sandpiper (cross hatched). Solid circles within the cross hatched region indicate areas from which breeding specimens were examined. The three circles in western Alaska indicate areas from which presumed breeding specimens were examined. The star indicates a breeding locality mentioned in the literature.

Churchill. Other observations, particularly searches for banded birds, were made in suitable habitat throughout the region and up to eight miles east of Fort Churchill.

Birds were trapped at the nest using a simple hardware cloth trap. Most birds accepted the trap within 30 minutes, and efforts to trap warier birds were discontinued after a few attempts. Trapping had no adverse effect on reproductive success, except that several eggs were cracked as adults sought to escape. The birds were then banded, measured (see Jehl, 1970), and dyed on the rump with a Magic Marker for individual identification. The color markings were retained for about three weeks before fading into obscurity. Central rectrices were removed from most birds for molt studies. In 1964 and 1965 a few birds were mist-netted at feeding ponds, but this procedure proved to be extremely inefficient.

There is little sexual plumage dimorphism in this species. On the average, the ventral barring of males is blacker and lacks the brownish cast of that found in females, but there is so much overlap that sexing by this character alone is unreliable. As in many other calidridine sandpipers, females average larger than males (Jehl, 1970: Table 1). I determined sex from behavioral characters associated with courtship or territorial defense, and from the knowledge that males almost invariably incubate by day, females by night (see below). Measurements were used to confirm the sexing of some birds, and several birds were shot for positive identification. All statements regarding the roles of the sexes in this paper are based on birds of known identity.

Banding studies showed that birds tended to mate with their mates of the previous year, and that the breeding behavior of experienced pairs differed from that of inexperienced pairs. To differentiate, I refer to *old pairs*, i.e., pairs known from banding to have been formed in a previous season, and *new pairs*, i.e., pairs not known to have formed before (see also Jehl, 1970: 312).

Specimens were collected throughout this study for data on molt and breeding condition. In addition, for studies of geographic variation, I examined 427 specimens borrowed from the American Museum of Natural History, United States National Museum, Carnegie Museum, Museum of Comparative Zoology, Chicago Natural History Museum, Cornell University, Museum of Vertebrate Zoology, Royal Ontario Museum of Zoology, National Museum of Canada, the University of Michigan Museum of Zoology, and from George M. Sutton and David F. Parmelee.

DISTRIBUTION

As a breeding bird the Stilt Sandpiper is restricted to the North American tundra, where it occurs chiefly in the Subarctic and Low Arctic zones (Johansen, 1963). The nesting range extends westward from Cape Henrietta Maria, Ontario, to Alaska, though the precise western limits are unknown (Fig. 1). Bailey (1948) knew of only one Alaskan nesting record. However, Brooks (1915) suspected nesting near Demarcation Point, and I have examined 10 other Alaskan specimens collected on dates when one would expect nesting activity; one of these was collected only 65 miles south of Barrow. The occurrence of spring migrants at Anaktuvuk Pass (Irving, 1960), in north-central Alaska, seems too regular to be fortuitous, and it may be that the species is expanding westward.

According to the A.O.U. Check-list (1957), the Stilt Sandpiper winters "in South America (range imperfectly known) from Bolivia, central western Brasil (Mato Grosso), and Paraguay south to Uruguay, and central eastern Argentina (Province of Buenos Aires)." However, its winter range is cer-

FIG. 2. Typical breeding habitat of Stilt Sandpipers at Churchill, Manitoba, consisting of well-drained sedge marshes with scattered tundra ponds.

tainly more extensive and probably far more northerly. In recent years small numbers have wintered as far north as the Salton Sea, California (McCaskie, 1970) and concentrations have been found near San Blas, Mexico (Alden, 1969) and in northern Venezuela (McNeil, 1970). There are also a few recent records for southern Peru (Hughes, 1970) and northernmost Chile (A. W. Johnson, pers. comm.). Previously published records for southern Chile by Peña and Barros (Johnson, 1965) are based on misidentified Wilson's Phalaropes (*Phalaropus tricolor*; Jehl, unpubl.).

HABITAT

At Victoria Island, Stilt Sandpipers occupy a variety of habitats, from "wet tundra areas upgrown to fairly high willows" to "higher, much drier slopes with moderate vegetative cover, avoiding the truly barren ridge tops" (Parmelee et al., 1967). At Churchill their habitat preference is much less broad. There they occur mainly in well-drained sedge (*Scirpus caespitosus*) meadows that are interrupted by old beach ridges, eskers, or other elevated areas which provide dry nesting sites early in the spring (Fig. 2). Some nesting areas also contain small ponds varying in depth from a few inches to several feet. In late spring the tundra may be flooded when the earliest migrants appear, with patches of snow remaining in sheltered areas. Run-off is extremely rapid, however, and by mid-July the shallow ponds are dry.

Dominant plants on elevated areas are dwarf birch (*Betula glandulosa*) and heaths (*Rhododendron lapponicum, Andromeda glaucophylla, Arctostaphylos* sp., *Vaccinium uliginosum, V. vitis-idaea*). Other conspicuous plants include *Dryas integrifolia, Empetrum nigrum, Salix reticulata,* and *Cladonia* spp. Passerines occurring in this habitat are Savannah Sparrow (*Passerculus sandwichensis*), Smith's Longspur (*Calcarius pictus*) and Lapland Longspur (*C. lapponicus*). Common nesting shorebirds are Hudsonian Godwit (*Limosa haemastica*), Hudsonian Curlew (*Numenius phaeopus*), Dunlin, Least Sandpiper (*C. minutilla*), and Golden Plover (*Pluvialis dominica*).

ARRIVAL

Stilt Sandpipers begin arriving at Churchill in late May (earliest, 21 May: Mowat and Lawrie, 1955). The earliest migrants occur singly and within a day or so flocks of up to ten birds appear, flying low and fast northward over the tundra. The peak of migration occurs in the first days of June and by 6 June, even in late seasons, the bulk of local breeders have arrived. Migrants, which continue to pass through the region until mid-June, concentrate in marshes along the Churchill River or on the shore of Hudson Bay and avoid tundra areas.

Observations backed by selected collecting indicate that males tend to arrive a day or two in advance of females. This conclusion is supported by the high percentage of males collected throughout the breeding range in early June, and by the high but progressively declining proportion of males collected from migrating flocks in the northern prairie states and provinces from May through the first week of June (Jehl, unpubl.).

Soikkeli (1967) found that experienced Dunlin arrived somewhat earlier than birds nesting for the first time. Limited data indicate the same is true of Stilt Sandpipers, as territories of experienced birds are the first to be occupied. Experienced birds immediately return to their territories of the previous year. In late springs the sexes may appear on the territories almost synchronously and without studies of marked individuals one could justifiably conclude that pairing had been accomplished during migration. Knowledge of the entire breeding cycle of the Stilt Sandpiper renders this hypothesis untenable, and in fact, virtually impossible (Jehl, 1968*a*:519).

The suggestion of enroute pairing has been advanced for other arctic sandpipers (e.g., *C. alpina*: Holmes, 1966*a*) and seems logical in view of the severe constraints on the reproductive cycle imposed by the short arctic summer. However, Soikkeli (1967) found no evidence for pairing during

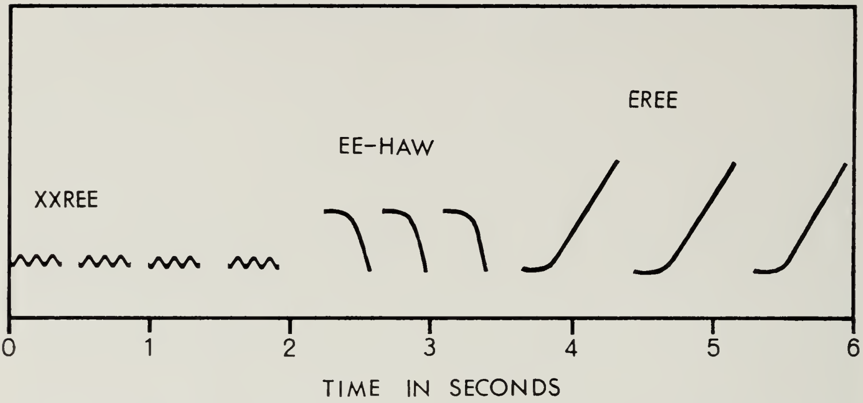


FIG. 3. Schematic representation of the flight song of the Stilt Sandpiper.

migration in Dunlin and argued strongly against that possibility. Recent studies have demonstrated strong site and mate fidelity in several species (*C. alpina*, Soikkeli, 1967; *C. mauri*, Holmes, 1971*b*; *C. minutilla*, Jehl, unpubl.). As knowledge of marked populations increases it becomes evident that most if not all cases of enroute pairing in sandpipers reflect only the strong homing ability and site fidelity of experienced breeders.

VOCALIZATIONS

Stilt Sandpiper vocalizations are no less complex, variable, and difficult to transcribe than those of other calidridine sandpipers. The most frequent calls and the contexts in which they are given are summarized below.

Eree.—A drawn-out ascending call given by flying males marking a territory. The call is delivered at a rate of one per second and may be given incessantly, save for pauses for breath, for periods of up to eight minutes. This is the "whine note" of Holmes and Pitelka (1964). It is also given by females.

Song.—The song is usually given in flight after a series of *eree* notes. It may be roughly transcribed as *xxree-xxree-xxree-xxree-ee-haw, ee-haw, ee-haw* (Fig. 3). After completing this portion of the song, the bird may revert to a series of *eree* calls, or, if about to land, will add on one or two *eree* notes before descending. The *xxree* note (I have sometimes transcribed it as *creek* or *craw*) is harsh and guttural, and as many as 14 may be run together. The *ee-haw* note has been likened to the braying of a donkey. When given from the ground the song is used in an aggressive context and is often accompanied by a typical calidridine Wing-up threat display. Females also sing, though less melodiously than males.

Errit (or *currick*, or *quo-ick*).—An insistent, slightly ascending guttural note that is used in several contexts. It is given by males that have landed after completing a territorial flight and apparently announces that the territory is occupied. A similar note was heard from a male that was attempting to attract a female to a nest scrape. The note may also indicate annoyance and is occasionally given by birds that have been flushed from the nest and are hesitant to return. Several *errit* notes may be run together as a threat; such a series introduces the threat song on the Peterson Field Guide record (Allen and Kellogg, 1962). A similar run-on call, slightly descending in pitch and reminiscent of a mechanical toy running down, was often heard from birds announcing their presence from a small hillock. This note is very similar to the alarm call of the Dunlin.

Trrrrr.—A rapid, gurgling, descending trill. I heard it on only a few occasions, for example, from a male threatening other Stilt Sandpipers at a feeding pond and from a male defending chicks, where it was accompanied by a Wing-up display. It appears to function as a low intensity threat and is similar to the trilling threat call of the Dunlin.

Oo-it.—A sharp alarm call given by birds with chicks. This note is rarely heard before late June and is an almost certain sign that the eggs have pipped or hatched.

Toi.—Apparently a contact note between members of a pair; rarely heard except in the interval after the pair has occupied the territory and before the start of incubation.

Kyow (sometimes *kyow-it*).—A strong threat note given, for example, to intruders at the nest or when chicks are disturbed (when it is alternated with *oo-it* calls).

Weet.—A soft contact note given by birds incubating pipped eggs or brooding small chicks.

TERRITORIALITY, COURTSHIP, PAIR FORMATION

Males begin to establish territories through aerial displays immediately upon arrival. The territorial flights follow no apparent pattern. A male may hover over an area for several seconds, make a wide circle over favorable nesting areas, or fly completely out of sight. Typically flights are prolonged, lasting as much as eight minutes. The male flies slowly at elevations of 20 to 60 m—his wings describing a narrow arc of only a few degrees above and below the horizontal, legs outstretched, and tail spread—giving the *eree* call almost incessantly. Occasionally, he glides with wings set at an angle of 30° above the horizontal and sings; this is a low intensity display, usually given when no other birds are in the vicinity. He may then fly off erratically, only to resume the display a few hundred meters away. Prior to landing, the male sings once more, then raises his wings almost vertically and plummets earthward. Landing on a conspicuous spot, he holds both wings vertically for a moment before folding them. He surveys the territory, occasionally calling *errit*, which announces that the territory is occupied. Other birds passing over the territory are chased vigorously, but because of the distances over which the displays are performed, the rapidity of the chases, and the slight sexual plumage dimorphism, it is not always possible to distinguish chases from courtship displays.

Aerial displays largely suffice to establish and maintain territories and it seems that mainly air space is defended. Early in the period, intruders landing on the territory may be chased off. It is not unusual, however, for three or four males to land together on one's territory after a prolonged chase but without exhibiting any aggressive behavior.

Air space is strongly defended through the egg-laying period, but soon thereafter the duration and intensity of displays declines. By about a week after the clutch is completed males no longer give the Wing-up display on landing and they ignore other Stilt Sandpipers performing territorial flights over their area. Other species are generally ignored. Yet, in one area where Dunlin and Stilt Sandpipers nested in proximity aerial interactions were common. These included bouts of flight singing and occasional chases that continued through the first week of the nesting season. Although the flight songs and postures of these similarly-sized species differ, their general patterns of territorial display are similar (see Holmes, 1966*a*:9–10), and the interactions appear to constitute interspecific territoriality (cf. Murray, 1971).

Territory size can be determined only indirectly because of the virtual absence of ground displays and because aerial displays extend over such vast areas. In most suitable areas nests were 300–400 m apart and territory size approximated 15 to 20 acres. However, in a 50-acre study plot where five pairs nested in two successive years, only 60 percent of the area was suitable and nests of three pairs were aligned approximately 100 yards apart in one corner of the plot; territory size there approximated 3 to 5 acres. Even closer-spacing was achieved by two late-nesting pairs which squeezed into prime areas 48 and 53 m from other nests by delaying nesting for 7 to 10 days, until territorial behavior in the original occupants had waned.

The function of territoriality and nesting dispersal is often difficult to ascertain, both "protection from predators and feeding habits" being important (Lack, 1968:140). For territorial shorebirds, however, Lack (1969: 143) concluded that territoriality is not related to food supply inasmuch as "the territories claimed do not usually include any of the feeding grounds, and the young are often taken from the breeding territory soon after they hatch." This conclusion applies to the Stilt Sandpiper, for neither adults nor young obtain any appreciable fraction of their food from the nesting territory. In this species, territoriality spaces the population by setting a limit on the number of pairs that can begin nesting synchronously; as a result nests are less accessible to predators. However, the general applicability of Lack's conclusion requires further verification, as shown by Holmes' (1970) study of territory size in Dunlin.

Courtship.—Courtship begins as soon as females appear in the nesting areas and involves prolonged and spectacular aerial displays which extend over an extremely wide area. Males fly after females singing song after song. They attempt to fly slightly ahead of the female, then raise their wings almost vertically and sing frantically as they fall, tilting from side to side. After dropping earthward for 40 m or more, they resume the chase and repeat the entire performance. Often these displays involve several courting males, which are joined by territorial males defending their air space. Females apparently do not sing during these displays, but I have heard them utter a nasal *yaw, yaw*, as well as a churring note.

Mate and territorial fidelity.—Mate and territorial fidelity are high. Of 29 pairs studied between 1964 and 1966, 25 were known to be alive at the end of the breeding season, and 11 reunited the following year, annual re-mating rates varying from 42 to 50 percent. Of the 11 pairs, seven which had hatched young returned to their previous nest scrape; the remaining four pairs moved their nests 12, 18, 21, and 76 m. Two of the four pairs had failed to nest successfully, and one other pair had nested in an unusual location.

Not one member of the 14 pairs that did not reunite was found mated in that year, although a few were found defending territories; one male that occupied the same territory for three years was found defending a new area 900 m distant in the fourth year, when his mate did not return. Some unmated birds returned to their original territory after missing one breeding season. For example, two birds (one male, one female) banded in 1965 failed to nest in 1966 but in 1967 nested with new partners 150 and 300 m from their previous nests. Another male, whose nest was not located was found defending chicks ¼ mile from this 1965 nest.

Coulson (1966) found that if Black-legged Kittiwakes (*Rissa tridactyla*) failed to nest successfully the pair was not re-formed in the next year. In Stilt Sandpipers failure to reunite probably results from the death of the mate in most cases; 12 of 14 pairs which did not reunite had raised young, whereas two of 11 that reunited had not. It may also be caused by the delayed arrival of one partner (Soikkeli, 1967), but this did not seem to occur in the present study.

Pair formation.—The basis for mate selection in birds has not received adequate experimental study. Verner and Engelsen (1970) hypothesized that the size or quality of the male's territory might be important in attracting females in Long-billed Marsh Wrens (*Telmatodytes palustris*), but their results were inconclusive.

In Stilt Sandpipers initial pairing is on the basis of size (Jehl, 1970), small males and/or large females being among the first to pair and hatch young. Presumably the birds evaluate each others' size through ground displays, since that could not be done precisely during the complicated aerial courtship. Ground displays associated with pair formation are described in other calidridines (e.g., *C. ferruginea*, Holmes and Pitelka, 1964) but I did not observe any in this species.

In old pairs, pair formation and mate retention seem to be largely a consequence of territorial fidelity. Females return to the territory, where they encounter their mate of the previous season and begin nesting at once. Although I was unable to obtain quantitative data, it was obvious that territorial and courtship behavior was reduced in their territories. In fact, the presence of one old pair was not even suspected until an egg appeared in the old nest. Nethersole-Thompson (1951:103) found that in the Greenshank (*Tringa nebularia*) new pairs were "always noisier . . . than are birds that have maintained or re-formed old associations." Morris and Erickson (1971) showed that pre-mating courtship behavior in Ring Doves (*Streptopelia risoria*) was not necessary for the reinstatement of a pair bond, even after members of the pair had been separated for seven months.

The pre-nesting behavior of old pairs constitutes a series of adaptations that permit rapid nesting. Pre-laying formalities are accomplished largely at the time of first pairing. Territorial fidelity insures that experienced birds need lose no time in seeking a nesting area, and by foregoing prolonged courtship displays or even choice of a nest site, old pairs can begin nesting as soon as environmental conditions permit. Early nesting is advantageous because the tundra dries rapidly, and chicks of late-nesting pairs may find it difficult to obtain food. The persistence of this mating system despite its major disadvantage—celibacy for a year if the mate fails to return—is evidence of strong selection for early nesting imposed by the short arctic summer.

NESTING

Stilt Sandpipers nest in relatively open areas of dry tundra, usually atop small sedge hummocks or on low, well-drained gravel ridges that cross the sedge meadows. The location of the nest bears no necessary relation either to the location of standing water (contra. Farley, 1936:16) or to nests of other shorebirds. I have found nests within 10 m of Hudsonian Curlew, 5 m of Least Sandpiper, 4 m of Hudsonian Godwit and 25 m of Dunlin nests. Of more than 40 nests examined, only three were in atypical situations; one was atop a bulldozed pile of peat next to a road, and two were in very wet marshes. These were among the latest nests to produce young and were presumably made by inexperienced birds unable to secure territories elsewhere.

The nest, a scrape 95–120 mm wide and 25–35 mm deep, is made by the bird rotating its breast against the soft terrain; no lining is added. Often the scrapes are enlargements of pre-existing depressions, and one covered the entrance to a clogged lemming burrow. Most nests are fully exposed, although perhaps 15 percent were adjacent to a dwarf rhododendron or birch.

The male takes the lead in scrape-making whereas the female determines which scrape will be used for the nest. In one territory I watched the male make a scrape atop a sedge hummock. The female approached, giving a low chattering call, crouched briefly in the scrape, then walked away. Rejected, the male raised one wing and sang. He then flew to another hummock and began to toss plant material over his shoulder, calling *errit, errit*; the female gave no response. He continued to another hummock, where he continued calling and tossing debris, again without response. Both birds then resumed feeding. A nest was made in this area, but the original scrape was not used.

It is not uncommon to find five or more fresh scrapes in territories of new pairs. Old pairs tend to re-use their nest of the previous year, and many make no new scrapes. The old nest may or may not be cleared of debris, but even uncleaned nests are probably visited prior to their re-use, because my dog scented an old scrape in 1966 that contained an egg the next day.

Copulation.—In four summers I observed only one attempt at copulation. It occurred on the shore of a small pond at least 400 m from any nest site. A pair landed together, whereupon the female immediately crouched and gave a low gurgling call lasting 15 seconds. The male then attempted to mount, but lost his balance; the pair immediately flew off together.

Laying; eggs.—The normal clutch is four. At five nests found before the clutch was completed, the interval between successive eggs averaged 36 hours, with extremes of 26 and approximately 48 hours.

Eggs range in ground color from light green to olive green and are heavily dotted with dark brown. They are similar to Dunlin eggs but the ground color averages darker and dark markings are more extensive. Measurements of 121 eggs are: length, 34.6–39.9 (36.5) mm, SD ± 0.82, C.V. 2.26; width, 24.5–26.8 (25.5), SD ± 0.33, C.V. 1.37. I found no differences in egg size of four females whose clutches were measured in two consecutive years.

Role of sexes in incubation.—Continuous incubation begins after the final egg is laid. At several nests females brooded at night, and perhaps sporadically during the day, after the third and occasionally second egg was laid. Once the clutch is completed, both sexes share incubation duties. As Parmelee et al. (1968:17) indicate, the role of the sexes in incubation is almost inflexible; the male incubates without relief during the "day" and the female at "night." At most nests I studied change-over occurred about 05:00 and 19:00; 95 of 110 observations (87 percent) of incubating males were made between 05:00 and 19:00; 44 of 57 observations (77 percent) of females between 19:00 and 05:00. Most of the exceptions reflect minor differences in change-over times at specific nests; at one nest, for example, the female did not relieve the male until 21:00. However, six females were trapped at midday early in incubation. In at least three of these cases the male had been incubating, but would not enter the trap, and the female came to the nest in response to his alarm calls.

Change-over behavior is simple. Usually the returning bird lands 10–25 feet from the nest without giving any prior announcement. The incubating bird may fly to the intruder, give a Wing-up display and sing, challenging the returning bird to "prove" its identity. More frequently, the incubating bird flies off immediately to a feeding area far removed from the territory.

In the Dunlin (Holmes, 1966*a*:11; Soikkeli, 1967:166) and in certain other calidridines, the male's share of incubation reportedly increases as hatching approaches, particularly in late-nesting pairs. I found no such pattern in Stilt Sandpipers, not even after the eggs had pipped.

A fairly rigid "male by day, female by night" incubation pattern characterizes several other shorebirds nesting at Churchill (58°50′N), including Least Sandpiper and Dunlin (Jehl, unpubl.). A similar pattern is found in Dunlin in Finland (61°30′N: Soikkeli, 1967) though at Point Barrow, Alaska (71°20′N) only the general pattern persists (Holmes, pers. comm.). As the Alaskan population enjoys continuous daylight during the nesting season, whereas Finnish and Churchill populations do not, one might speculate that timing breaks down in the absence of a dark period. This is unlikely, however, since Stilt Sandpipers on Jenny Lind Island (68°N), also on a continuous light regime, maintain the same pattern as Churchill birds (Parmelee et al., 1968).

Gonad development, renesting.—Males are capable of breeding as soon as they arrive. Although their testes have not attained maximum size, free spermatozoa are present in the lumina of some tubules (stage 5b of Selander and Hauser, 1965). Testicular volume increases to an average of 110 mm^3 (maximum 226 mm^3) by early June, decreases sharply in mid-June, and drops to 3 to 4 mm^3 by the time males depart (Fig. 4). Ovarian development is not completed on arrival. The largest ova of newly-arrived females approxi-

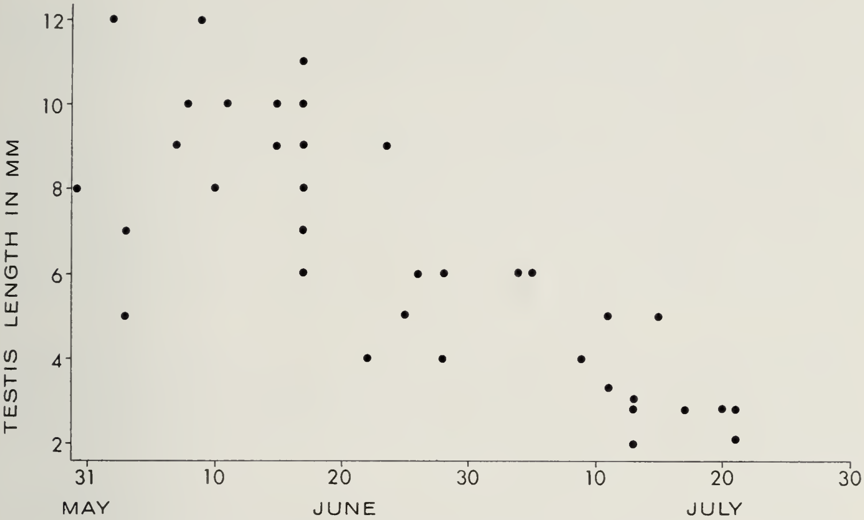


Fig. 4. Seasonal variation in testes size in Stilt Sandpipers.

mate 4 to 5 mm in diameter, enlarging to 9 mm within three to five days. A week after laying they average 4 mm and by the time of hatching 1 mm.

Because of the rapid gonadal regression, Stilt Sandpipers are probably incapable of producing a replacement clutch if their eggs are lost more than a week or so after laying. In this study I found no direct evidence for re-nesting, the only hint of that event being the late nesting of one old pair in 1966 nearly two weeks after other experienced breeders had nested. In 1938, after a severe snowstorm, Farley (1939) reported that many sandpipers re-nested, but the chronology of events suggests that the small clutches he reported were the remainder of the first clutches, the first eggs having been deserted.

Behavior during incubation.—The pair remains on or near the territory until several days after the clutch is completed, leaving only occasionally to feed. Early in the incubation period the male continues to defend air space over the territory, but through most of the period the birds remain so quiet that their presence may be unsuspected.

They generally ignore other birds on the territory, although I have seen males walk off the nest to threaten godwits and curlews that were returning to their nests only a few feet away. On several occasions I placed mounted Stilt Sandpipers and Short-billed Dowitchers in conspicuous locations on the territory and as close as one foot from the nest. The birds paid little attention, except to stare at the mounts for a moment before resuming incubating. Avian predators, such as jaegers, hawks, and ravens, also evoke scant reaction, but their movements are watched carefully. Nevertheless, Stilt Sandpipers quickly leave the nest to investigate alarm cries of curlews and godwits directed at these same predators.

Rarely can a Stilt Sandpiper be surprised at the nest. When a human approaches within 75 to 100 m the incubating bird flies off inconspicuously only a foot or so above the vegetation for 50 m or more before climbing rapidly to a height of 30 to 50 m. Often the first clue to the presence of a nest is a bird flight singing overhead. The bird may then fly away for up to 15 minutes, before alighting 60 m away and cautiously sneaking back to the nest.

Birds flushed at the nest flutter off a few feet, then challenge the intruder with a Wing-up display or threat song; common displacement activities include vigorous preening of the neck and scapulars and tossing bits of debris over the shoulder.

Distraction displays are far less common than in those species (e.g., *C. minutilla*) which sit tightly and flush almost from underfoot. However, the display is similar to that of other calidridines in that the head is lowered, the wings are held slightly away from the body but are not spread, the back is hunched with back feathers ruffled, and the tail is drooped and fanned prominently. Williamson (1950:29) stated that this behavior, the "rodent-run display," "clearly owes its biological success to its semblance of a small mammal running away." In support of this hypothesis (p. 31), he likened the dark central upper tail feathers of some calidridine sandpipers, which may be obvious in the display, to the "lemming's dark-colored dorsal stripe." This interpretation has been widely followed (e.g., Armstrong, 1964) and the term "rodent-run" is now deeply ingrained in the literature (e.g., Brown, 1962). Nevertheless, I believe that the interpretation is anything but clear and that the name of the display is misleading and inappropriate. I find it inconceivable that any predator could mistake this behavior as that of a mammal. The calidridine species I have studied do not shuffle off furtively but make themselves conspicuous, occasionally giving plaintive calls. Duffy and Creasey (1950:28) noted that *C. maritima* "spared no pains to make its presence known." Further, the display is well developed in such species as *Micropalama himantopus*, *Calidris fuscicollis* (Drury, 1961) and *Calidris canutus* (Hobson, 1972), which lack dark central rectrices or upper-tail coverts. The simplest interpretation is that the birds are imitating weak and flightless sandpipers—and they do this very well.

Birds startled at the nest at the end of the incubation period also perform an "injury-flight" distraction display (Brown, 1962) but such behavior is rare. In this display they flop away conspicuously, beating their wings along the ground and calling occasionally. One bird, alternating weak flights and short runs, led me more than 150 feet before it flew away.

Incubation period.—The incubation period ranges from about 19½ to 21 days. At four nests at which the eggs were marked, incubation periods from laying to hatching of the final eggs were: 19 days, 20 hours ± 6 hours; 19 days, 17 hours ± 10 hours; 19 days, 22 hours ± 10 hours; 20 days, 15 hours ± 2 hours. Two other clutches were incubated at least 20 days and one 21 days; a five-egg clutch in which one egg failed to hatch required 21 days, 6 hours.

HATCHING, DISPERSAL, DEPARTURE

Eggs begin to pip three or four days before they hatch. At this time there is brief resurgence of flight singing as the adults become increasingly restless. They fly toward intruders calling *kyow* and *oo-it* and giving Wing-up threat displays on landing, the latter call being an unmistakable indication that hatching is well along.

Usually the clutch hatches within a span of 10 to 14 hours. As in other ground-nesting species there is strong selection for synchronous hatching; at two nests I found well-pipped eggs (one contained a strongly peeping chick) that had been deserted because they were slow to hatch. Egg shells are carried off by the adults, though not usually until the chick has dried, which requires several hours; in a few nests shells of the final egg were not removed. Either parent may be present at hatching and at 10 of 15 nests both were in attendance after the first egg had hatched.

The chicks are similar to those of other calidridine sandpipers (Jehl, 1968*c*), especially *C. melanotos*, from which they can be distinguished by their dilated bill tip. The eyes are dark brown, legs grayish with a faint green tinge; the back of the tarsus and the base of the toes are yellowish. The egg teeth (Jehl, 1968*b*) are lost within a few hours of hatching.

Hatching Synchrony.—At 41 nests in 1965–1967 hatching dates ranged from 28 June to 14 July, with 80 percent of the clutches hatching between 28 June and 5 July. In general, old pairs nested earlier and with greater synchrony than pairs nesting for the first time (Fig. 5). In the Dunlin, Soikkeli (1967:165) found that all birds exhibiting "mate-faithfulness started laying within 5 days of the beginning of laying by the population." In the Stilt Sandpiper, 70 percent of old pairs hatched young within the first five days of the hatching period as compared to 60 percent of new pairs; the figures are 75 and 50 percent if the data for 1965, which include many pairs of unknown age, are excluded.

Hatching synchrony reflects tundra conditions that prevailed when the birds arrived. In 1966, the tundra was dry and conditions were suitable

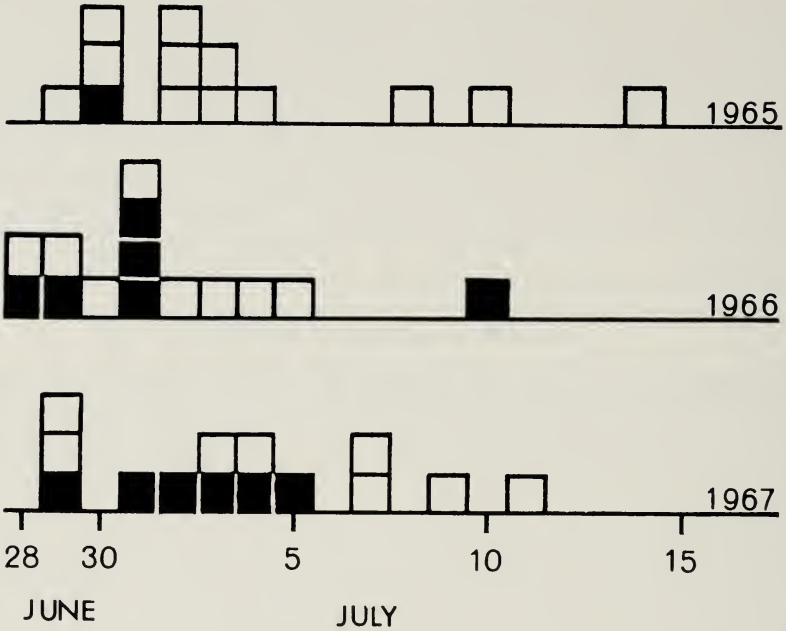


Fig. 5. Hatching synchrony of old pairs (solid squares) and new pairs (open squares) of Stilt Sandpipers, 1965–1967.

for nesting when the birds appeared. With the exception of one old pair, whose eggs hatched nine days after those of other old pairs and five days later than those of new pairs, the hatching period extended over only eight days. In the late springs of 1965 and 1967, standing water persisted in many nesting areas through early June and the hatching periods for the population extended over 16 and 14 days, respectively. I suspect that in extremely wet years, such as 1967, the emergence of insects is delayed. Consequently, some females are unable to find sufficient food for egg production and the laying period is extended. Indirect evidence of food shortage in 1967 was provided by studies of Least Sandpipers. On 10 June I found four nests each containing one egg. Three of these were deserted and at the fourth nest the second egg was not added until three days later. As the normal interval between eggs in that species is 24 hours, I infer that Least Sandpipers at least were unable to find sufficient food to produce eggs.

Dispersal.—While newly-hatched chicks are drying, the older chicks begin to wander a few feet from the nest. This causes the incubating parent obvious anxiety and hastens the eventual departure of the brood. Usually the brood departs as soon as the last chick has dried, although broods hatched in the evening remain in the nest until the next morning and those hatched in inclement weather remain for 24 hours or more.

Departure is simple. At one nest, I watched the male arise, walk a few feet from the nest, crouch, and begin peeping softly. One by one the chicks ran to him, and within ten minutes they were being brooded 20 feet away. The female was present but made no attempt to call or brood the chicks. The entire family then disappeared into the marsh. Ten minutes later the male returned, investigated the empty nest, and flew off.

Adults are very solicitous of small chicks and leave them to direct Wing-up threat displays at approaching humans. Such challenges are invariably given from the ground and, unlike those of many other Churchill sandpipers, never from tops of small trees. Even when surprised with the brood, threat displays rather than injury feigning are the rule.

One male whose mate and nest had been destroyed a day earlier approached in response to the alarm calls of a pair of Dunlin whose chicks I was banding. He directed threat displays at me, then lowered his breast feathers, made scraping movements, and gave brooding calls. After I captured the male Dunlin, the Stilt brooded the chicks, including one I was holding in my hand.

After leaving the nest the chicks are led from the drying inland marshes to the wetter areas near the coast. The rate of movement varies with local conditions but I have found chicks two miles from the nest within two weeks of hatching. Although chicks swim well, they avoid deep water areas and occur mainly at the edges of marshes or along dry ridges, where they feed on surface-dwelling invertebrates. I have never seen small chicks attempt to probe for food, nor have I observed adults make any attempt to feed young or to direct their attention to food.

From the time they leave the nest chicks are almost always hidden from the parent's sight by vegetation and communication within the family group is almost entirely vocal. Both parents attend the brood for several days, in some cases one week, but the females soon disappear. Males remain with the chicks for about two weeks before deserting them. At that time the chicks are fully independent, although they do not develop flight capabilities until they are 17–18 days old. It is extremely unusual to encounter both parents with chicks more than one week old. In late July 1965 I found two adults defending what appeared to be a single brood of well-grown chicks: when collected, however, both proved to be males.

Prior to attaining flight the young are extremely inconspicuous. After that event they emerge from the marshes and feed openly near drying tundra ponds and soon begin to congregate in small flocks.

TABLE 1

DIFFERENTIAL MIGRATION OF ADULTS IN FALL AS INDICATED BY SPECIMENS TAKEN ON THE NESTING GROUNDS

Date	Churchill, Manitoba ♂	Churchill, Manitoba ♀	All nesting grounds (including Churchill) ♂	All nesting grounds (including Churchill) ♀
1– 5 July	4	3	7	7
6–10 July	3	3	7	5
11–15 July	8	1	9	1
16–20 July	2	1	5	1
21–25 July	4	0	8	0

Departure.—In the first days of July, small groups of migrants from farther north can be seen flying eastward along the Hudson Bay coast and transient flocks begin to appear on coastal ponds. At the same time local birds resume flocking in inland marshes. Flocking actually begins in mid-June, when small groups of males relieved from incubation congregate at feeding ponds in the early evening. Flocks gradually increase so that by late June groups of up to 15 birds may be encountered. With the start of the hatching period the flocks disappear but form again in early July, when females desert the brood. These do not persist for long and by 10 to 12 July most adult females have departed, the latest date being 17 July. Males leave the chicks by mid-July, some apparently departing the nesting grounds without joining flocks. After 18 July in most years it is extremely rare to find an adult in the inland marshes. In 1964, a late season, males departed by 21 July, and despite an intensive search over the next ten days I saw only one additional adult. In 1966 virtually all local adults left prior to 16 July, and between 16 and 22 July I found only two adults caring for late broods.

The early departure of adult females is confirmed by a small series of specimens collected at Churchill and elsewhere on the breeding grounds over the past three decades (Table 1) and by specimens from the northern United States (Jehl, unpubl.). According to McNeil (1970), both sexes are present among flocks arriving in Venezuela in early August.

Juveniles are less than a month old when they begin to disappear from the nesting grounds. The peak of migration occurs in the first week of August. Young birds from farther north pass through the Churchill area through 15 August, and stragglers occur until the end of the month.

TABLE 2

CLUTCH SIZE AND HATCHING SUCCESS OF STILT SANDPIPERS AT CHURCHILL, MANITOBA 1964–1967

	Clutch size					Hatching success by year (eggs hatch/ eggs laid).	
Year	2	3	4	5	x̄		
1964	–	–	2	–	4.0	8/8	(100%)
1965	2	–	11	–	3.69	41/48	(85.5)
1966	–	2	12	–	3.86	43/54	(79.6)
1967	–	2	10	2	4.0	46/56	(82.3)
Total	2	4	35	2	3.86	138/166	(83.2)
Hatching success by clutch size	4/4 (100%)	10/12 (83.4%)	117/140 (83.6%)	7/10 (70%)			

PRODUCTIVITY AND MORTALITY

Data on clutch size and hatching success are given in Table 2. There were no important annual differences in hatching success, and success was high regardless of clutch size. At neither of the five-egg clutches were all the eggs hatched successfully, which suggests that adults were unable to incubate the larger clutch effectively (cf. Maclean, 1972).

In this study inclement weather had no effect on nesting success; birds incubated through light snowfalls and up to five days of continuous rain. Heavy snowfalls, however, may lead to desertion of the nest (Farley, 1939).

The following causes of hatching failure were noted at 43 nests followed to completion; the first figures refer to number of eggs, the second, in parentheses, to number of nests involved: predation—9(3); scientific collecting—8(2), unknown—3(2); infertile—2(2); disappeared—2(2); egg cracked (due to trapping?)—2(2); desertion of pipped egg that failed to hatch on time 2(2).

Of the avian predators, Parasitic Jaegers (*Stercorarius parasiticus*) posed the greatest threat to sandpiper nests, and several eggs were known to be destroyed by these birds. Short-tailed weasels (*Mustela erminea*) and red foxes (*Vulpes fulva*) are the only important mammalian predators in the Churchill region. One incubating female was thought to have been killed by a weasel.

In three instances the death of one member of a pair led to nesting failure. One female was killed by a predator while incubating and two other females were collected by me off the territory. At each nest the eggs were pipped but the male alone was unable to hatch them successfully, and the chicks died of exposure when he left the nest to feed. The long and almost unbroken incubation periods in this species may be advantageous in minimizing change-over and other activity near the nest, and therefore in preventing predators from locating the nest. However, this rigid system also seems to preclude adaptive adjustment by one member of the pair if its mate is killed or is unable to perform its role.

Losses of young.—Data on posthatching mortality are few because chicks are extremely difficult to find after they leave the nest. Mortality appears to be relatively high among very young chicks, and I doubt that fledging success far exceeds 50 percent. Broods of four are rarely encountered more than a few days after hatching, and after two weeks most broods consist of two, rarely three, young. As noted above, small chicks usually feed out of the parents' sight and return only for brooding. Many become lost in the high vegetation and fail to rejoin the family. This appears to be the most important cause of chick mortality. Some are "adopted," as evidenced by the not uncommon occurrence of broods with chicks of widely differing ages.

I have no direct evidence of chick loss to predators. Once I observed a pair of adults in pursuit of a Parasitic Jaeger, but it was impossible to determine whether the jaeger had made a kill.

Adverse weather conditions such as prolonged rainy periods at hatching time (see Jehl and Hussell, 1966) could lead to chick loss. The large yolk-sac enables newly hatched chicks to fast for about two days if necessary. Slightly older chicks that must leave the shelter of the adult to feed would be presumably more susceptible to inclement weather.

Food shortage is probably not a significant cause of chick mortality in most years for chicks hatching in late June or early July. Soon thereafter, the inland marshes dry out, the number of emerging insects diminishes, and chicks hatched later may find food in short supply if they are unable to reach wet areas near the coast.

I have few data on post-fledging survival. Only one of 81 chicks banded in 1964–1966 was recovered, and it was defending chicks 300 m from its banding site. I occasionally encountered banded birds whose nest could not be located; those collected invariably proved to have been banded as adults. Dunlin may breed in their first summer (Holmes, 1966*a*), although in Finland most do not breed until their second year (Soikkeli, 1967). The extremely low recovery rate in Stilt Sandpipers as compared to Dunlin (Soikkeli, 1967:188) indicates that Stilt Sandpipers probably do not breed in their first year. Further, the rarity of unmated birds on the nesting ground suggests that most first-year birds summer farther south.

Adult mortality.—Because site tenacity is strong in some sandpipers, one can estimate the annual mortality rate of adults by assuming that birds not found in subsequent years have died (see Soikkeli, 1967).

Forty-one Stilt Sandpipers trapped at the nest between 1964 and 1966 were known to be alive at the end of the nesting season; 19 were recaptured one year later, 9 two years later, and one three years later. Calculated annual mortality rates ranged from 36 to 52 percent, with a mean of 47 percent, but these are much too high for several reasons: 1) Several birds not observed one year after banding returned two years later. 2) Banded birds whose nests could not be found were seen each year; these were certainly banded locally. 3) The potential for band loss is high, and although loss within one year is unlikely, loss within two years is probable (Jehl, 1969). 4) A few birds were collected in each year of this study. As shown above, a bird whose mate does not return probably does not nest in that year and soon leaves the territory. Consequently the chance of observing that bird is far less than of finding a nesting pair. All these factors tend to inflate the apparent mortality rate. Soikkeli (1967:179) found a mean adult mortality rate of 27 ± 3 percent for Dunlin in Finland; a similar rate for Stilt Sandpipers seems reasonable.

FEEDING

Stilt Sandpipers do not feed on the territory except in early spring when territorial boundaries are being established. At that time the nesting grounds may be partially covered with meltwater, so the birds forage mainly on dry ridgetops, around clumps of sedges, or at the edges of tiny depressions filled with melting snow. For most of the summer they feed in small groups in the vicinity of tundra ponds. Initially they tend to feed in marshes at the pond margins, where they peck at the ground surface for small insects. By mid-June pond life increases and the depth of the ponds decreases so that the birds are able to forage in their characteristic fashion—wading belly deep, bill and face, sometimes the entire head, immersed below the water surface. The birds walk slowly and seem to gather most if not all of their food by deliberate thrusts at organisms detected visually (see Burton, 1972). Later in summer as the ponds become shallower many birds feed on the newly-emergent mudflats along the shore, often probing the soft muck in typical calidridine fashion. The location of the feeding ponds bears no obvious relationship to the nest site. I have often seen birds a mile or two from their territories and one female was collected five miles from her nest.

Stomach contents of 39 adult birds were retained for examination. This sample, collected over four years, was too small for detailed study, and contents of many stomachs were digested beyond all but the broadest identification, e.g., adult winged insects. Nevertheless, it was evident that Stilt Sandpipers feed on a relatively small spectrum of food, and that they feed opportunistically, because the stomach contents of the majority of birds contained largely or entirely the remains of one prey item.

The observed feeding patterns are in accord with what might be predicted from the foraging patterns outlined above. Early in spring (29 May to 10 June) the variety of available food is limited and birds seemed to feed to a large extent on adult beetles judged by fragmentary exoskeletal remains; of nine birds collected in this period, five had also fed extensively on small seeds. The variety of food taken increased between 11 June and 30 June, largely as a result of the shift to pond habitats and the emergence of some insects. Yet, no single prey item was found in more than three of the 10 stomachs examined. The major food resources at this period, included 1) larval dystiscid beetles and small snails, and 2) seeds and adult dipterans and other flying insects; insect larvae of several families were found in a few birds but their volume was miniscule. Between 1 and 10 July adult beetles and water bugs and larval dytiscids seemed to comprise the bulk of the diet, being present in four of the eight stomachs examined; seeds were found in three birds, but none contained snails. From 11 to 26 July adult beetles, snails, seeds, and larval dytiscids, in decreasing order of abundance, were the commonest prey items of 12 birds; but, as in samples taken earlier in the summer, no single item predominated and other larval insects were virtually absent.

Data on nine birds from 6 days to three weeks in age are too few for analysis. It appears that for about 10 days chicks feed entirely on surface-dwelling forms including adult winged insects; larval dytiscids were not found in birds less than an estimated 12 days old but were common in three of five older chicks; two of four flying juveniles, about three weeks old, had fed extensively on larval chironomids.

Holmes (1966*c*) found that Dunlin at Barrow fed largely on insects, particularly on dipteran larvae, Tipulidae in June and August, Chironomidae in midsummer. Further, Holmes and Pitelka (1968) demonstrated wide overlap in foods taken by four sympatric calidridine sandpipers at Barrow. I found tipulid larvae in only one Stilt Sandpiper stomach, where they constituted the entire contents, and chironomid larvae in only six; and, with the exception of dytiscids, larval insects constituted only a small fraction of the Stilt Sandpiper's diet. This suggests, as one would predict on morphological and behavioral evidence, that the Stilt Sandpiper is able to avoid food overlap with other calidridines by exploiting pond habitats. The possibility of interaction with other species utilizing pond habitats at Churchill (Short-billed Dowitcher, Hudsonian Godwit, Northern Phalarope) remains to be determined.

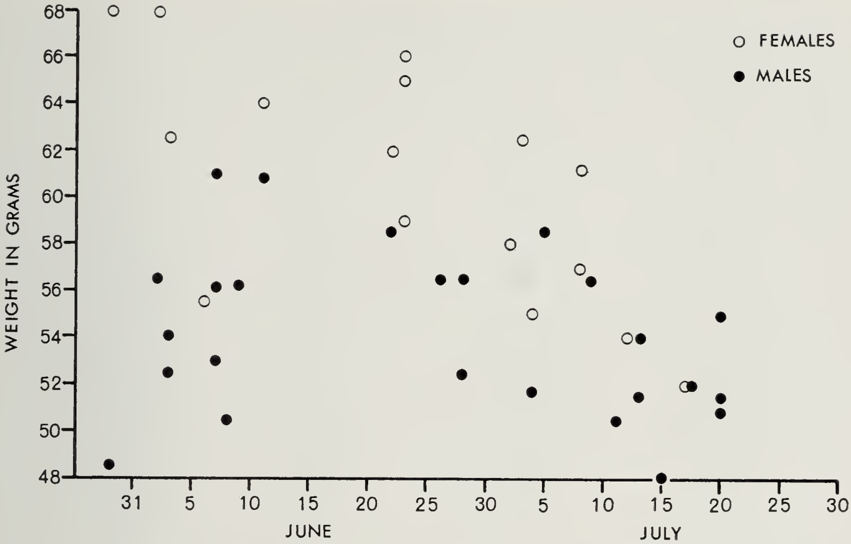


Fig. 6. Seasonal weight changes in Stilt Sandpipers.

WEIGHTS

Weights of nine chicks, all less than 24 hours old, averaged 8.1 g (range 7.3–9.9). Two barely flying chicks, estimated age 17 days, weighed 43 and 48 g.

The mean weight of 24 males collected at Churchill was 53.8 g (range 48.0–60.8), that of 15 females 60.9 g (range 52.0–68.0). Seasonal variation in weights of adults are plotted in Figure 6. Birds collected soon after arrival in late May and early June possess little or no subcutaneous fat deposits. Females are heaviest immediately upon arrival and show a gradual weight loss through the summer. Males seem to be lightest while they are establishing territories and defending chicks. As neither sex shows any evidence of weight increase prior to migration it may be inferred that the first migratory flights are short, perhaps extending no farther than to the northern United States. Migrants in southern Canada and the northern United States average heavier: two adult males from Michigan each weighed 60 g; Woodford (1958) removed 19.2 g of fat from a 75 g male collected in Ontario in early August; two adult females from Michigan and New Jersey weighed 60 and 67.5 g, respectively; seven juveniles from Michigan and Minnesota averaged 61.0 g (range 47.4–78.6). According to McNeil (1970) the heaviest birds have sufficient fat reserves for non-stop flights from southern Canada to northern South America.

MOLT

The first prebasic molt of Stilt Sandpipers, like that of the Dunlin (Holmes, 1966*b*) is largely confined to the body tracts. It begins in August, before the young leave the nesting grounds, and seems to be largely completed by mid-September in most individuals. However, McNeil (1970) reported that young birds arriving in Venezuela in November were just finishing molt. Succeeding, prebasic molts are more extensive, and involve the entire plumage. Molt begins on the neck and chest and spreads anteriorly and posteriorly. Adults may begin molting as early as 2 July, while still incubating, but most birds do not start until about 10 July. Extensive molt is evident in all body tracts by mid-July, but the flight feathers are not replaced until after adults leave the nesting grounds. Four adults collected in southern California on 2 September 1963 had replaced all but the outermost primary and molt of the retrices was well advanced. McNeil (1970) suggested that molt may be suspended during migration as adults arriving in Venezuela in early August showed no active molt. Molt was resumed upon arrival and was largely completed by the end of September.

The prealternate molt begins in January and ceases by late March or April (McNeil, 1970: Fig. 23). The extent of this molt is variable and may change from year to year in the same individual. All birds replace the body plumage and about 90 percent molt the tertials; one bird that molted tertials in 1966 did not in 1967. The remiges are not molted; approximately 60 percent of the birds also retain all wing coverts, the remainder molt only one or two of the proximal median and lesser secondary coverts. One bird molted the entire series of median secondary coverts, four proximal, and a few lesser secondary coverts. The limited data indicate no relationship between the extent of molt and age.

The prealternate molt of the rectrices is also variable, the most common patterns being the loss of the central pair (or two pairs) of rectrices, and loss of all but the central pair; a few birds replace the entire tail, some only one or two feathers, and a few apparently do not show molt. As with the wing coverts, the extent of tail molt varies from year to year and only three of eight birds trapped in two consecutive years showed identical molt patterns.

Stilt Sandpiper rectrices are usually gray-brown distally, fading to whitish at the base. The coloration of rectrices renewed in the prebasic molt is fairly uniform, but the color patterns of those renewed in the prealternate molt is variable (Fig. 7). To determine the significance of this variation, I scored the variant patterns in four categories ranging from plain and unmarked ("1") to strongly barred ("4"). In addition, I plucked and retained the central rectrices of many birds for future comparison. In 11 of 15 birds

Fig. 7. Variations in rectrix pattern of adult Stilt Sandpipers. From left to right, the feathers illustrate categories "1" through "4" (see text for explanation).

caught in two or more years, the pattern of central rectrices was unchanged or changed no more than one category; female 66-F, for example, ranked "1" in 1965, "2" in 1966, and "2–3" in 1967. Two birds changed from "4" to "1" and two from "1" to "4"; for example, male 65-F ranked "1" in 1965 and 1966 but "4" in 1967; male 65-M, "4" in 1965, "1" in 1966, and "2" in 1967. The annual variations, therefore, are usually slight, may occur in either direction, and do not indicate either age or sex.

SYSTEMATICS

Geographic variation.—In this study I examined 427 specimens of Stilt Sandpipers of which 231 (115 adults, 48 juveniles, 70 downy young) were collected on the breeding grounds (Fig. 1). The sample was geographically biased, with 71 of the adult specimens coming from the vicinity of Churchill, Manitoba. Nevertheless, I found no evidence of geographic variation in either size or coloration.

Relationships.—It is well established that the Stilt Sandpiper is a member of the Calidridinae (Lowe, 1915; Peters, 1934; Jehl, 1968*c*), and one suspects that if *Micropalama* bred in Europe, Witherby et al. (1940:227) would have included it in their expanded genus *Calidris.* They defined that genus to include a number of small to medium-sized sandpipers with variable bill morphology but in which the bill averaged longer than the tarsus. This definition would seem to exclude the long-legged *Micropalama*; yet, its bill/tarsus proportions are surprisingly similar to those of more typical species. For example, bill length exceeded tarsus length on 10 of 71 Stilt Sandpipers trapped and measured at Churchill, as well as in only 12 of 80 Least Sandpipers. Thus, the generic distinctness of *Micropalama* on morphological grounds is tenuous at best, and behavioral evidence indicates no significant differences between *Micropalama* and some unquestioned members of *Calidris.* In view of the broad genera that are currently recognized by most shorebird taxonomists there are no compelling reasons for considering *Micropalama* as distinct. The important question, however, is not whether this monotypic genus should be retained, but, rather, to which of the calidridine sandpipers is the Stilt Sandpiper most closely related.

There are no reasons for inferring a close relationship between the Stilt Sandpiper and the small calidridines or "peep," or to other monotypic calidridines (*Philomachus pugnax, Tryngites subruficollis, Limicola falcinellus, Aphriza virgata, Eurynorhynchus pygmeus*). On the other hand, aspects of morphology, territoriality, breeding behavior, and vocalizations suggest its affinity to such species as the Knot (*C. canutus*), Dunlin, and Curlew Sandpiper (*C. ferruginea*).

Of the species for which adequate comparative data are available, the Stilt Sandpiper seems to be most closely allied to the Curlew Sandpiper. The general morphological resemblance in body size and proportions between the two species is striking (cf. Holmes and Pitelka, 1964: Fig. 2, and Parmelee et al., 1967: Plate 5) ; both species have relatively long, decurved bills: and females average slightly larger than males. The juvenal and winter plumages of the two species are similar and the distinctive breeding plumages also share certain similarities: in both the abdomen is patterned and males are more highly colored than females. Transversely barred underparts characterize the Stilt's breeding plumage, but male Curlew Sandpipers are also similarly barred with black on the chest. Rump and tail patterns of these species are virtually identical, and the peculiar barred rectrices described above are also found in approximately 30 percent of adult Curlew Sandpipers. (I found similarly-patterned feathers in nine of 181 adult Dunlins, but in no other calidridine).

Both Curlew and Stilt Sandpipers have unusually varied and complex vocalizations. Holmes and Pitelka (1964) described those of the Curlew Sandpiper in detail and noted (p. 368) that the "basic resemblances in

Fig. 8. The approximate breeding ranges of the Stilt Sandpiper (black) and the Curlew Sandpiper (cross hatched). Data, in part, from Holmes and Pitelka, 1964, and Portenko, 1959.

phrasing and other features are striking" between the two species. They commented particularly on the similarity in flight songs (cf. Holmes and Pitelka, 1964, Fig. 4 with Fig. 3 herein), and noted that both species followed the flight song with a series of "whine notes."

Behavior.—General patterns of aerial courtship in the two also seem similar, except that the display flight of the male Stilt Sandpiper is given with wings upraised, of the Curlew Sandpiper with wings held horizontally. In both territorial displays are particularly wide-ranging; in the Curlew they are performed at low elevations, in the Stilt fairly high. Both use the whine note in territorial defense, the Curlew Sandpiper mainly from the ground, the Stilt Sandpiper from the air. Both have a ground announcement display to indicate that the territory is occupied; in the Curlew Sandpiper the whine note is used in this display, in the Stilt Sandpiper the *errit* call.

Holmes and Pitelka (1964) stated that the whine note was "absent in the other eight species of *Calidris*" they had studied, and they also noted the absence of ground announcement displays in those species. Parmelee et al. (1967) commented on the similar territorial and courtship behavior of Knots and Stilt Sandpipers. Descriptions of the Knot's territorial call (Parmelee and MacDonald, 1960; Hobson, 1972) are reminiscent of the Stilt's whine-note, which suggests that the Knot is more closely allied to this species than is currently acknowledged.

Ground displays of the Curlew Sandpiper are apparently much more conspicuous and complex than those of the Stilt Sandpiper, but the most pronounced difference is the role of the sexes in nesting. In the Stilt Sandpiper the pair bond persists through the nesting season, both sexes incubate, and the male remains longest with the brood; in the Curlew Sandpiper the pair bond is transitory and only the female incubates (Holmes and Pitelka, 1964; Portenko, 1959) and cares for the young. The ecological advantage of a short pair bond in high arctic sandpipers has been argued by Pitelka (1959; see also Holmes and Pitelka, 1968). Its taxonomic implications, if any, remain to be determined.

Biogeography.—The occurrence of many closely related shorebird taxa on opposite sides of the Bering Straits is evidence of the importance of this barrier in shorebird evolution. The occurrence in Alaska of an ice-free region, the Bering Sea-Yukon refugium, in the Pleistocene also provided opportunity for the isolation and subsequent divergence of some populations (e.g., Rand, 1948; Pitelka, 1950; Cade, 1955; Fay and Cade, 1959), one result being the evolution of a distinctive Alaskan shorebird assemblage.

In Table 3 I have outlined the general distributions of some shorebirds occupying the Bering Straits region and their close allies. This table does not include all possible species pairs in that area (see Larson, 1957) and some of the relationships suggested are admittedly unconfirmed; for example, *Calidris ptilocnemis* may be more closely related to *C. alpina* than to *C. maritima*; Pitelka (1959) questioned whether *C. melanotos* was particularly close to *C. acuminata*; and Holmes (pers. comm.) has suggested that *C. mauri* is more closely allied to *C. fuscicollis* than to *C. pusilla.* Despite these uncertainties, the isolating influence of the straits and the refugium is unquestionable. The allopatric distribution of the Curlew Sandpiper and Stilt Sandpiper (Fig. 8), in addition to their morphological and behavioral similarities, suggests that these species also have diverged from a common ancestor in this region.

In a speculative attempt to reconstruct evolution in the Charadrii, Larson (1957) outlined climatic and geographic conditions during the Tertiary and

TABLE 3

BIOGEOGRAPHIC RELATIONSHIPS OF CLOSELY RELATED SHOREBIRD TAXA IN THE BERING STRAITS REGION

North America	Bering Sea-Yukon refugium	Asia	Reference[1]
Charadrius semipalmatus	———	*C. hiaticula*	h
Pluvialis d. dominica	———	*P. d. fulva*	h
Limosa haemastica	———	*L. limosa*	d
———	*Limosa lapponica baueri*	*L. l. menzbieri*	e
Numenius p. phaeopus	*N. tahitiensis*	*N. p. variegatus*	d
Numenius borealis	———	*N. minutus*	d
Tringa solitaria	———	*T. ocrophus*	d
Heteroscelus incanus	———	*H. brevipes*	d
Actitis macularia	———	*A. hypoleucos*	d
Arenaria interpres	*A. melanocephala*	*A. interpres*	d
Limnodromus griseus	*L. scolopaceus*	*L. semipalmatus*	g
———	*Aphriza virgata*	*Calidris tenuirostris*	b
Calidris pusilla	*C. mauri*	*Eurynorhynchus pygmeus*	a
Calidris minutilla	———	*C. subminuta*	c
Calidris melanotos	———	*C. acuminata*	f
Calidris maritima	*C. ptilocnemis*	———	c
Micropalama himantopus	———	*C. ferruginea*	i
Tryngites subruficollis	———	*Philomachus pugnax*	c

[1] Reference: a, Burton, 1971. b, Jehl, 1968*d*. c, Larson, 1957. d, Mayr and Short, 1970. e, Portenko, 1936. f, Portenko, 1968. g, Rand, 1950. h, Vaurie, 1964. i, this paper.

Pleistocene that led to the isolation and subsequent divergence of previously widespread populations. These included major oceanic barriers and shifting glacial refugia during the Pleistocene. According to Larson, members of the evolving species pairs tended to occupy climatic regions similar to those utilized by the ancestral populations. One of his conclusions (1957:59) was that during interglacial periods the Eurasian component of a stenothermal cold species pair was probably destroyed more often than was its North American counterpart, which accounted for the existence of so many monotypic North American genera (*Aphriza, Micropalama, Tryngites*). However, it appears that for *Micropalama* and *Aphriza* (Jehl, 1968*d*) close relatives are alive and well on the Asian side of the Bering Straits, and the European member of the species pair with *Tryngites* is certainly *Philomachus*, as Larson (p. 50) admits. Thus, the suggested differential extinction of Eurasian representatives of presumed species pairs seems doubtful. In fact, only one monotypic genus of the Calidridinae, *Limicola,* has no obvious close allies (Burton, 1971), and it is absent from North America, not Eurasia.

ACKNOWLEDGMENTS

Field work on this study was supported by the Frank M. Chapman Memorial Fund of the American Museum of Natural History, The University of Michigan Horace H. Rackham Graduate Student Research Fund, A National Science Foundation Summer Fellowship for Teaching Fellows, a National Science Foundation Assistantship in Systematic and Evolutionary Biology administered by The University of Michigan Museum of Zoology (GB-3366), and the San Diego Society of Natural History.

I am indebted to Richard T. Holmes and David F. Parmelee for their comments on the manuscript.

SUMMARY

A banded population of Stilt Sandpipers was studied at Churchill, Manitoba, in the summers of 1964–1967. The species arrives in late May or the first days of June, with males tending to arrive a day or two in advance of females. Mate and territorial fidelity is high. Experienced breeders return to their nesting territories in well-drained sedge meadows, where they encounter their mate of the previous year. Nesting begins almost at once; often the old nest scrape is re-used. There is no evidence that birds form pair bonds during migration. The apparent en route pairing that has been alleged in several species of arctic sandpipers can be attributed to the strong homing ability and site fidelity of experienced breeders.

The complex vocalization of the Stilt Sandpiper, and the contexts in which they are used, are outlined. Territories are established and maintained through aerial displays. Territorial defense wanes about a week after the clutch is completed, at which time late-nesting pairs may be able to nest in close proximity to established pairs. Nesting behavior is described in detail. The role of the sexes in incubation is rigid, with males incubating by "day" (05:00–19:00), females by "night." Males are capable of breeding immediately upon arrival, but females do not attain breeding condition until several days later. Gonadal regression occurs about a week after the clutch is completed and after that time re-nesting seems impossible. The incubation period averages about 20 days. In most years the peak of hatching occurs in the first days of July, old pairs hatching young, on the average, a few days earlier than pairs nesting for the first time. The chicks are led from the drying sedge meadows to wet areas near the coast. Females remain with the brood for about a week, males for two weeks, before migrating. Most chicks leave the Churchill area by mid-August. In this study predation was the major cause of nesting failure. Separation from the adults and adverse weather are probably the major sources of chick mortality.

Stilt Sandpipers do not feed to any appreciable extent on the territory, but forage in small tundra ponds up to five miles from their nests. Analysis of stomach contents suggests that by exploiting pond habitats the species is able to avoid food overlap with most other sandpipers.

Body molt of adults begins in July, after the chicks have hatched, but flight feathers are not molted until after the birds migrate from the nesting areas. Variations in the molt pattern do not seem to be associated with age or sex.

No geographic variation was detected in this species. There are no strong reasons for maintaining *Micropalama* as a monotypic genus distinct from *Calidris.* Evidence from behavior, morphology, vocalizations, and biogeography indicates that the Curlew Sandpiper (*C. ferruginea*) is the closest relative of the Stilt Sandpiper.

LITERATURE CITED

Alden, P. 1969. Finding the birds in western Mexico. Univ. Arizona Press, Tucson.

Allen, A. A., and P. P. Kellogg. 1962. A field guide to western birds' songs. 33⅓ rpm record. Houghton Mifflin Co., Boston.

American Ornithologists' Union. 1957. Check-list of North American birds. Fifth Ed., Lord Baltimore Press, Baltimore.

Armstrong, E. A. 1964. Distraction display, p. 205. *In* A. L. Thompson, Ed., A new dictionary of birds. London (Nelson) and New York (McGraw-Hill).

Bailey, A. M. 1948. Birds of arctic Alaska. Popular Ser., No. 8, Colorado Mus. Nat. Hist.

Brooks, W. S. 1915. Notes on birds from east Siberia and arctic Alaska. Bull. Mus. Comp. Zool., 59:379.

Brown, R. G. B. 1962. The aggressive and distraction behaviour of the Western Sandpiper *Ereunetes mauri.* Ibis, 104:1–12.

Burton, P. J. K. 1971. Comparative anatomy of head and neck in the Spoonbilled Sandpiper, *Eurynorhynchus pygmeus* and its allies. J. Zool., London, 163:145–163.

Burton, P. J. K. 1972. The feeding techniques of Stilt Sandpipers and Dowitchers. San Diego Soc. Nat. Hist., Trans. 17:63–68.

Cade, T. J. 1955. Variation of the Common Rough-legged Hawk in North America. Condor, 57:313–346.

Coulson, J. C. 1966. The influence of the pair-bond and age on the breeding biology of the Kittiwake gull *Rissa tridactyla.* J. Anim. Ecol., 35:269–279.

Drury, W. H., Jr. 1961. The breeding biology of shorebirds on Bylot Island, Northwest Territories, Canada. Auk, 78:176–219.

Duffy, E., and N. Creasey. 1950. The "rodent-run" distraction-behaviour of certain waders. Part 1.—Field observations of the Purple Sandpiper. Ibis, 92:27–28.

Farley, F. 1936. The Stilt Sandpiper on its nesting grounds. Oologist, 53:14–17.

Farley, F. L. 1939. Further notes on the bird-life of Churchill, Manitoba. Canadian Field-Naturalist, 52:56–58.

Fay, F. H., and T. J. Cade. 1959. An ecological analysis of the avifauna of St. Lawrence Island Alaska. Univ. California Publ. Zool., 63:73–150.

Hobson, W. 1972. The breeding biology of the Knot. Proc. Western Found. Vert. Zool., 2(1):5–25.

Holmes, R. T. 1966*a*. Breeding ecology and annual cycle adaptations of the Red-backed Sandpiper (*Calidris alpina*) in northern Alaska. Condor, 68:3–46.

Holmes, R. T. 1966*b*. Molt cycle of the Red-backed Sandpiper (*Calidris alpina*) in western North America. Auk, 83:517–533.

Holmes, R. T. 1966*c*. Feeding ecology of the Red-backed Sandpiper (*Calidris alpina*) in arctic Alaska. Ecology, 47:32–45.

Holmes, R. T. 1970. Differences in population density, territoriality, and food supply of Dunlin on arctic and subarctic tundra. Symp. Brit. Ecol. Soc., 10:303–319.

Holmes, R. T. 1971*a*. Latitudinal differences in the breeding and molt schedule of Alaskan Red-backed Sandpipers (*Calidris alpina*). Condor, 73:93–99.

Holmes, R. T. 1971*b*. Density, habitat, and the mating system of the Western Sandpiper (*Calidris mauri*). Oecologia (Berl.), 7:191–208.

Holmes, R. T., and F. A. Pitelka. 1964. Breeding behavior and taxonomic relationships of the Curlew Sandpiper. Auk, 81:362–279.

Holmes, R. T., and F. A. Pitelka. 1968. Food overlap among coexisting sandpipers on northern Alaskan tundra. Syst. Zool., 17:305–318.

Hughes, R. A. 1970. Notes on the birds of the Mollendo District, southwest Peru. Ibis, 112:229-241.

Irving, L. 1960. Birds of Anaktuvak Pass, Kobuk, and Old Crow. U. S. Natl. Mus. Bull. 217.

Jehl, J. R., Jr. 1968*a*. The shorebirds of North America. Book review. Auk, 85: 515–520.

Jehl, J. R., Jr. 1968*b*. The egg teeth of some charadriiform birds. Wilson Bull., 80: 328–330.

Jehl, J. R., Jr. 1968*c*. Relationships in the Charadrii (shorebirds): A taxonomic study based on color patterns of the downy young. San Diego Soc. Nat. Hist., Memoir 3.

Jehl, J. R., Jr. 1968*d*. The systematic position of the Surfbird, *Aphriza virgata*. Condor, 70:206–210.

Jehl, J. R., Jr. 1969. Band wear in Stilt Sandpiper—a warning. Bird-Banding, 40:47.

Jehl, J. R., Jr. 1970. Sexual selection for size differences in two species of sandpipers. Evolution, 24:311–319.

Jehl, J. R., Jr., and D. J. T. Hussell. 1966. Effects of weather on reproductive success of birds at Churchill, Manitoba. Arctic, 19:185–191.

Johansen, H. 1963. Zoogeographical aspects of the birds of the subarctic. Proc. XIII Internatl. Ornithol. Congr.,:1117–1123.

Johnson, A. W. 1965. The birds of Chile and adjacent regions of Argentina. Vol. 1 Buenos Aires, Platt Establecimientos Graficos S.A.

Lack, D. 1968. Ecological adaptations for breeding in birds. Methuen and Co., Ltd., London.

Larson, S. 1957. The suborder Charadrii in arctic and boreal areas during the Tertiary and Pleistocene. Acta Vertebratica, 1:1–84.

Lowe, P. R. 1915. Studies on the Charadriiformes.—I. On the systematic position of the Ruff (*Machetes pugnax*) and the Semipalmated Sandpiper (*Ereunetes pusillus*), together with a review of some osteological characters which differentiate the Eroliinae (Dunlin group) from the Tringinae (Redshank group). Ibis, 1915:609–616.

Maclean, G. 1972. Clutch size and evolution in the Charadrii. Auk, 89:299–324.

McCaskie, G. 1970. Shorebird and waterbird use of the Salton Sea. Calif. Fish and Game, 56:87–95.

McNeil, R. 1970. Hivernage et estivage d'oiseaux aquatiques Nord-Américains dans le nord-est du Vénézuela (mue, accumulation de graisse, capacité de vol et routes de migration). L'oiseau et la Rev. Franc. d'Ornith., 40:185–302.

Morris, R. L., and C. J. Erickson. 1971. Pair bond maintenance in the Ring Dove (*Streptopelia risoria*). Anim. Behav., 19:398–406.

Mowat, F. M., and A. H. Lawrie. 1955. Bird observations from southern Keewatin and the interior of northern Manitoba. Canadian Field-Naturalist, 69:93–116.

Murray, B. G., Jr. 1971. The ecological consequences of interspecific territoriality in birds. Ecology, 52:414–423.

Nethersole-Thompson, D. 1951. The Greenshank. Collins, London.

Parmelee, D. F. 1970. Breeding behavior of the Sanderling in the Canadian High Arctic. Living Bird, 9:97–146.

Parmelee, D. F., and S. D. MacDonald. 1960. The birds of west-central Ellesmere Island and adjacent areas. Natl. Mus. Canada Bull. 169.

Parmelee, D. F., H. A. Stephens, and R. H. Schmidt. 1967. The birds of southeastern Victoria Island and adjacent small islands. Natl. Mus. Canada Bull. 222.

Parmelee, D. F., D. W. Greiner, and W. D. Graul. 1968. Summer schedule and breeding biology of the White-rumped Sandpiper in the central Canadian Arctic. Wilson Bull., 80:5–29.

Peters, J. A. 1934. Check-list of birds of the world. Vol. 2. Harvard University Press, Cambridge.

Pitelka, F. A. 1950. Geographic variation and the species problem in the shore-bird genus Limnodromus. Univ. California Publ. Zool., 50:1–108.

Pitelka, F. A. 1959. Numbers, breeding schedule, and territoriality in Pectoral Sandpipers of northern Alaska. Condor, 61:233–264.

Portenko, L. 1936. The Bar-tailed Godwit and its races. Auk, 53:194–197.

Portenko, L. A. 1959. Studien an einigen seltenen Limicolen aus dem nördlichen und östlichen Sibirien II. Der Sichelstrandlaufer—*Erolia ferruginea.* J. Ornithol., 98: 454–466.

Portenko, L. A. 1968. Studien an einigen seltenen Limicolen aus dem nördlichen und östlichen Sibirien III. Der Graubruststrandläufer—*Heteropygia melanotos* (Vieill.). J. Ornithol., 109:96–115.

Rand, A. L. 1948. Glaciation, an isolating factor in speciation. Evolution, 2:314–321.

Rand, A. L. 1950. Critical notes on *Limnodromus semipalmatus.* Condor, 52:228–231.

Selander, R. K., and R. J. Hauser. 1965. Gonadal and behavioral cycles in the Great-tailed Grackle. Condor, 67:157–182.

Soikkeli, N. 1967. Breeding cycle and population dynamics in the Dunlin (Calidris alpina). Ann. Zool. Fenn., 4:158–198.

Soikkeli, M. 1970*a*. Dispersal of Dunlin *Calidris alpina* in relation to sites of births. Ornis Fennica, 47:1–9.

Soikkeli, M. 1970*b*. Mortality and reproductive rates in a Finnish population of Dunlin *Calidris alpina.* Ornis Fennica, 47:149–158.

Sutton, G. M. 1961. Stilt Sandpiper, p. 340–346. *In* D. A. Bannerman, The birds of the British Isles. Vol. 9, Oliver and Boyd, London.

Vaurie, C. 1964. Systematic notes on Palearctic birds. No. 53. Charadriidae: The genera *Charadrius* and *Pluvialis.* Amer. Mus. Novitates No. 2177.

Verner, J., and G. H. Engelsen. 1970. Territories, multiple nest building, and polygyny in the Long-billed Marsh Wren. Auk, 87:557–567.

Williamson, K. 1950. The "rodent-run" distraction-behaviour of certain waders. Part 2.—Interpretation of "rodent-run" display. Ibis, 92:28–33.

Witherby, H. F., F. C. R. Jourdain, N. F. Ticehurst, and B. W. Tucker. 1940. The Handbook of British birds. Vol. 4. London, H. F. & G. Witherby Ltd.

Woodford, J. 1958. Fat deposition on a migrant Stilt Sandpiper. Auk, 75:215.

NATURAL HISTORY MUSEUM, P. O. BOX 1390, SAN DIEGO, CALIFORNIA, 92112
28 JULY 1972.

RACIAL COMPOSITION OF MIGRANT POPULATIONS OF SANDHILL CRANES IN THE NORTHERN PLAINS STATES

Douglas H. Johnson and Robert E. Stewart

During recent years, there has been increasing pressure to expand hunting seasons on Sandhill Cranes (*Grus canadensis*) in the northern plains states. Hunters desire to take advantage of the opportunity presented by the sizable flocks of this large bird in this area. Prior to passage of the Migratory Bird Treaty Act in 1918, the Sandhill Crane was hunted and considered to have high sporting and eating qualities. In addition, complaints have been received from farmers regarding grain crop depredations by cranes. It has been suggested (Boeker et al., 1961:16) that flocks of cranes would be more widely dispersed by hunting pressure, thus alleviating local damage to crops.

The fact that three apparent subspecies of the Sandhill Crane occur in the northern plains of the United States during migration (Walkinshaw, 1965) complicates the situation since one of these, the Greater Sandhill Crane (*Grus canadensis tabida*) was until late 1971 officially designated as rare by the U.S. Bureau of Sport Fisheries and Wildlife (Anon., 1968). The other subspecies occurring in this area are the Lesser Sandhill Crane (*Grus c. canadensis*) and the Canadian Sandhill Crane (*Grus c. rowani*). We are using these subspecific designations on a tentative basis only. The validity of the *rowani* subspecies has been questioned (e.g. Stephen, 1967), and more detailed work on the breeding grounds in the future may demonstrate the existence of gradient populations of Sandhill Cranes that occur between areas occupied by typical members of the three currently recognized subspecies. These populations may be expected to differ in migrational and wintering patterns as well as in morphological characteristics. Such clines have been demonstrated for the Canada Goose (*Branta canadensis*) (Aldrich, 1946; Hanson, 1965:13). but evidence accumulated from cranes on their breeding grounds is insufficient to establish a similar pattern in this species.

Until adequate breeding-ground studies have been conducted, it is useful for the purposes of this paper to assume the existence of three populations which may be distinguished on the basis of the average size of the cranes which comprise each population. For reasons of convenience, at least, these populations can be referred to as *canadensis*, *rowani*, and *tabida.*

Current information concerning the breeding ranges of the three northern subspecies was derived from reports by Walkinshaw (1949, 1965), supplemented with data furnished by John W. Aldrich (pers. comm.). The Lesser Sandhill Crane, the most northern of the subspecies, breeds on the Arctic tundra of northwestern Canada, Alaska, and northeastern Siberia. Breeding populations of the Canadian Sandhill Crane favor the boreal forest and aspen parklands of west-central Canada. The breeding range of the eastern population of the Greater Sandhill Crane formerly extended throughout the glaciated prairie region in south-central Canada and north-central United States, and also included disjunct outliers of prairie or prairie-forest ecotonal communities within the Lake Forest (hardwood-pine) region to the east. At present, this population appears to be restricted to isolated groups of breeding birds in Michigan, Wisconsin, and northern Minnesota, and to groups of birds that are probably breeding in southwestern Ontario and southeastern Manitoba. Another segment of the breeding population of the Greater Sandhill Crane occurs west of the continental divide in southern British Columbia and in several western states, and therefore is not considered in this discussion.

Numerous migrating Sandhill Cranes (often many thousands) occur regularly in a few local staging areas. In North Dakota these concentrations are normally found from late August to early November on glacial outwash plains in the vicinity of wetland complexes composed of large shallow lakes that are brackish, subsaline, or saline. These include semipermanent lakes, permanent lakes, and alkali lakes (wetland habitat types IV-D, IV-E, V-E, and VI—Stewart and Kantrud, 1971). Fen pockets or man-made dugouts that occur along the margins of these lakes are utilized as roosting sites. Scattered flocks of cranes range out for several miles from these roosting sites to forage on croplands (Madsen, 1967). Similar habitat complexes are occupied in Montana but only for brief periods from late September through early November. In northwestern Minnesota roosting concentrations occur for a brief period during the latter half of September (Robert E. Farmes, pers. comm.) on large fens or alkaline bogs within the prairie-forest ecotone.

The primary purpose of this study was to determine the racial composition of Sandhill Crane populations that occur in northwestern Minnesota, North Dakota, and eastern Montana during the fall migration period. These investigations were initiated in 1970 and continued in 1971. Particular attention was given to the geographical distribution and seasonal occurrence of these populations as related to racial composition. Incidental information concerning the morphological distinctiveness of the three northern populations of Sandhill Cranes was also obtained.

METHODS

During the fall migration periods in 1970 and 1971, 180 Sandhill Cranes (153 adult and 27 immature) were collected in five major concentration areas (Fig. 1) of the northern plains states. These collections involved 11 series of specimens that were taken during early and/or late portions of the fall migration period. Attempts were made to collect the adult specimens in a random manner, whereas concurrent collections of immature

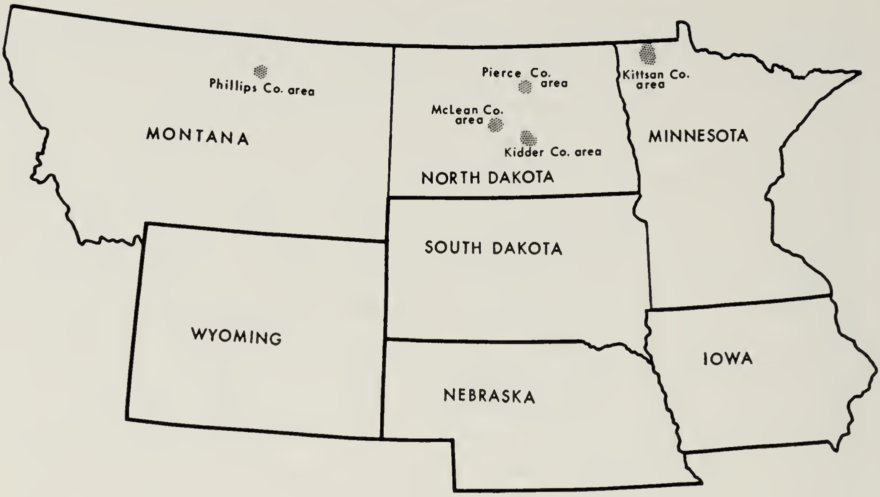


Fig. 1. Collection sites of migrant Sandhill Cranes.

birds were largely incidental. The age and sex composition of birds comprising each series of specimens and the dates of collection are indicated in Table 1.

All of the collected specimens were weighed in the field, and detailed laboratory examinations were made at the Northern Prairie Wildlife Research Center. These examinations involved sex and age determinations and the following linear measurements: wing chord, tarsus length, exposed culmen, culmen post nares (culmen from posterior edge of nostril), middle toe (without claw), and tail length.

A wing, a leg, and the head of each specimen collected in 1970, together with information on sex and age, were sent to Dr. John W. Aldrich, Division of Wildlife Research, U.S. Bureau of Sport Fisheries and Wildlife, Washington, D.C. He made independent measurements and, using those of wing chord, tarsus length, and culmen post nares, determined subspecies from them. This afforded a valuable opportunity for comparison and confirmation of our results.

MEASUREMENTS OF BREEDING SPECIMENS

The identification of the subspecies represented by an individual specimen collected during the migration period is preferably determined by comparing it with adequate series of breeding specimens that are typical of each of the relevant subspecies. Unfortunately, only minimal requirements are satisfied in this respect by the limited series of breeding Sandhill Crane specimens that are available. Walkinshaw (pers. comm.) has compiled a useful list of measurements together with data on collection dates and locations. Of these specimens and those described by Lumsden (1971), we selected individuals collected between late April and mid-July to form a sample of breeding ground specimens of known subspecies. In our analysis

TABLE 1
COLLECTIONS OF MIGRANT SANDHILL CRANES

	Adults		Immatures	
	Male	Female	Male	Female
Kittson Co., Minnesota				
22–24 September 1970	14	6	3	4
Pierce Co., North Dakota				
14 September 1971	7	5	0	1
27–28 October 1971	4	4	0	0
Kidder Co., North Dakota				
8–15 September 1970	11	14	2	1
26 October–1 November 1970	14	7	2	4
3–4 September 1971	9	6	0	0
McLean Co., North Dakota				
28 October–3 November 1970	18	9	2	2
7 September 1971	3	2	0	1
27–28 September 1971	6	2	1	0
Phillips Co., Montana				
4 October 1970	2	2	1	1
3 October 1971	5	3	1	1
Total	93	60	12	15

of the birds, we employed all available complete measurements of wing chord, tarsus length, and exposed culmen taken from adults of known sex. These measurements are summarized in Table 2.

In order to appraise the separability of the intermediate population, *rowani*, a series of statistical tests can be formulated, following Rao (1962, 1965: 490–493). Omit the presumed *rowani* specimens and assume for the moment that only two populations, *canadensis* and *tabida*, are separable. Let $\mu = (\mu_1, \mu_2, \mu_3)$ represent the vector of means of wing chord, tarsus length, and exposed culmen. Then μ_c is the mean vector for *canadensis*, and μ_t is the mean vector for *tabida.* Assume both populations have a common variance-covariance matrix, and let S be an estimate of it, based on n degrees of freedom. Then let $X = (X_1, X_2, X_3)$ be an observation of wing chord, tarsus length, and exposed culmen of any crane to be examined. The first test is whether or not X could reasonably have come from either a *canadensis* or *tabida* population or from a population intermediate to them. The form of this test is

$$F_0 = (n-1)\{(X-\mu_t)'S^{-1}(X-\mu_t) - [(\mu_c-\mu_t)'S^{-1}(X-\mu_t)]^2/(\mu_c-\mu_t)'S^{-1}(\mu_c-\mu_t)\}/2n$$

which is distributed as an F ratio with 2 and $(n-1)$ degrees of freedom. If

TABLE 2

MEASUREMENTS OF ADULT SANDHILL CRANES COLLECTED DURING THE BREEDING SEASON[1]

	Grus c. canadensis		*Grus c. rowani*		*Grus c. tabida*	
	Male	Female	Male	Female	Male	Female
Sample Size	36	17	10	3	11	7
Wing Chord						
Mean	469.1	445.5	503.9	472.7	541.5	538.9
Standard deviation	22.8	21.8	16.7	20.1	25.3	28.5
Extremes	418–505	420–490	480–524	456–495	502–575	503–575
Tarsus Length						
Mean	187.4	177.6	228.8	210.7	240.0	229.4
Standard deviation	12.7	11.3	7.6	5.5	9.9	5.4
Extremes	160–210	156–198	216–239	205–216	226–253	223–237
Exposed culmen						
Mean	91.4	89.7	119.4	103.0	135.2	129.3
Standard deviation	7.0	5.7	6.4	10.5	7.5	11.9
Extremes	69–102	80–101.6	109–127	93–114	122–144	113–147

[1] Linear measurements in millimeters; data from Walkinshaw (pers. comm.) and Lumsden (1971).

F_0 is not significant, it is then valid to further test the likelihood that X represents a *canadensis* member. This is tested by comparing

$$F_1 = (n-2)[(\mu_c - \mu_t)'S^{-1}(X - \mu_c)]^2/[(\mu_c - \mu_t)'S^{-1}(\mu_c - \mu_t) \times (n + 2nF_0/(n-1))]$$

to an F variate with 1 and $(n-2)$ degrees of freedom. An analogous value F_2 with μ_t replacing μ_c can be calculated to test that X belongs to the *tabida* population.

This sequence of statistical tests was applied to each of the 10 male and three female breeding specimens presumed to be *rowani*. The outcome for males is shown in Table 3; similar results were obtained for females. For no specimen was F_0 significant, even at the $P = 0.10$ level. This suggests that if the measurements are not from *canadensis* or *tabida*, they are from a population intermediate between them. This result is not intrinsically useful, but it validates further testing using F_1 and F_2. The calculated values of F_1 ranged from 11.51 to 32.63, and were all significant at the $P = 0.05$ level. It is thus highly unlikely that any of these specimens represents the *canadensis* population.

The results of testing for affinity to *tabida* were also significant, if not as conclusive. The F_2 values of eight male specimens were significant at the $P = 0.05$ level while the remaining two were nearly so. It follows then that those particular breeding specimens taken within the range of *rowani* are

Table 3

F Values for Testing Separability of Male Breeding Specimens Presumed to be *Grus canadensis rowani*

Specimen number	F_0	F_1	F_2
1	.37	20.43	8.91
2	.47	17.96	10.56
3	1.42	24.10	5.88
4	.90	30.15	3.71
5	1.33	11.51	15.65
6	.01	32.63	3.43
7	.22	25.28	6.26
8	.11	19.63	9.72
9	.60	14.22	13.65
10	1.70	26.10	4.76
Critical Values of F			
$P = 0.05$	3.21	4.06	4.06
$P = 0.10$	2.43	2.83	2.83

distinct from both *canadensis* and from *tabida*, although they appear somewhat closer to the latter population, at least in terms of wing chord, tarsus length, and exposed culmen measurements.

This sequence of tests provides stronger conclusions than would be obtained by merely comparing means of the populations. Finding a significant difference among means would indicate that *on the average* the presumed *rowani* group differs from the known populations. The tests above allow us to conclude that *each* of the questioned specimens differs from those taken in the ranges of typical *canadensis* and *tabida.* Such findings do not refute the possibility of a cline in morphological measurements, because the sampling (collection) of breeding specimens was not done uniformly throughout the breeding ranges and any groups intermediate between *tabida* and *rowani* or between *rowani* and *canadensis* may not be represented.

MEASUREMENTS OF ADULT MIGRANT SPECIMENS

For the purpose of making racial determinations of migrant Sandhill Cranes, certain linear measurements were found to be particularly useful. These include wing chord, tarsus length, and exposed culmen. To identify an individual migrant specimen, we compared its measurements to those taken from the series of breeding specimens that were representative of each of the three subspecies. The migrant specimen in question was assigned to a subspecies on the basis of similarity to measurements of the breeding specimens.

TABLE 4
MEASUREMENTS OF ADULT MIGRANT SANDHILL CRANES[1]

	Grus c. canadensis		*Grus c. rowani*		*Grus c. tabida*	
	Male	Female	Male	Female	Male	Female
Sample size	31	17	51	33	11	10
Wing Chord						
Mean	467.0	445.7	503.0	475.5	518.9	487.3
Standard deviation	15.5	12.0	12.9	14.3	9.4	13.8
Extremes	419–502	421–464	469–530	434–505	504–531	472–524
Tarsus Length						
Mean	187.5	179.2	230.6[2]	217.0	236.5	228.3
Standard deviation	14.4	10.8	9.5	7.6	8.3	6.3
Extremes	151–203	165–197	211–249	203–232	227–253	219–235
Exposed Culmen						
Mean	97.3[2]	92.0	119.7	114.1	131.8	120.4
Standard deviation	3.9	5.2	5.9	3.9	5.0	2.9
Extremes	91.6–105.9	83.2–99.7	99.6–130.6	107–122.5	124.4–141.1	114.9–125.3
Culmen post nares						
Mean	76.5	72.4	92.1	86.7	100.7[2]	93.5
Standard deviation	3.1	4.0	4.8	3.3	4.5	2.5
Extremes	70.3–84.0	63.7–78	74–102	82.8–94	95–107	90–98
Middle Toe						
Mean	75.4	73.4	86.4	83.3	87.2	84.5
Standard deviation	3.2	4.8	3.2	3.7	2.5	2.6
Extremes	69.3–82.2	61.5–78.8	80.6–93.5	77.2–92.7	83.3–91.0	79.4–88.5
Tail Length						
Mean	168.0	159.6	190.2	179.8	196.9	184.1
Standard deviation	6.5	6.7	7.4	6.0	4.5	6.2
Extremes	157–180	150–177	175–209	166–192	190–203	173–192
Weight						
Mean	3945.6	3459.9	4794.8[3]	4110.2[3]	4885.6	4453.7[2]
Standard deviation	299.6	250.1	385.3	251.9	370.8	427.1
Extremes	3235–4671	2866–3829	3890–5613	3676–4895	3870–5432	3645–5052

[1] Linear measurements in millimeters; weight in grams.
[2] Sample size one less than indicated.
[3] Sample size two less than indicated.

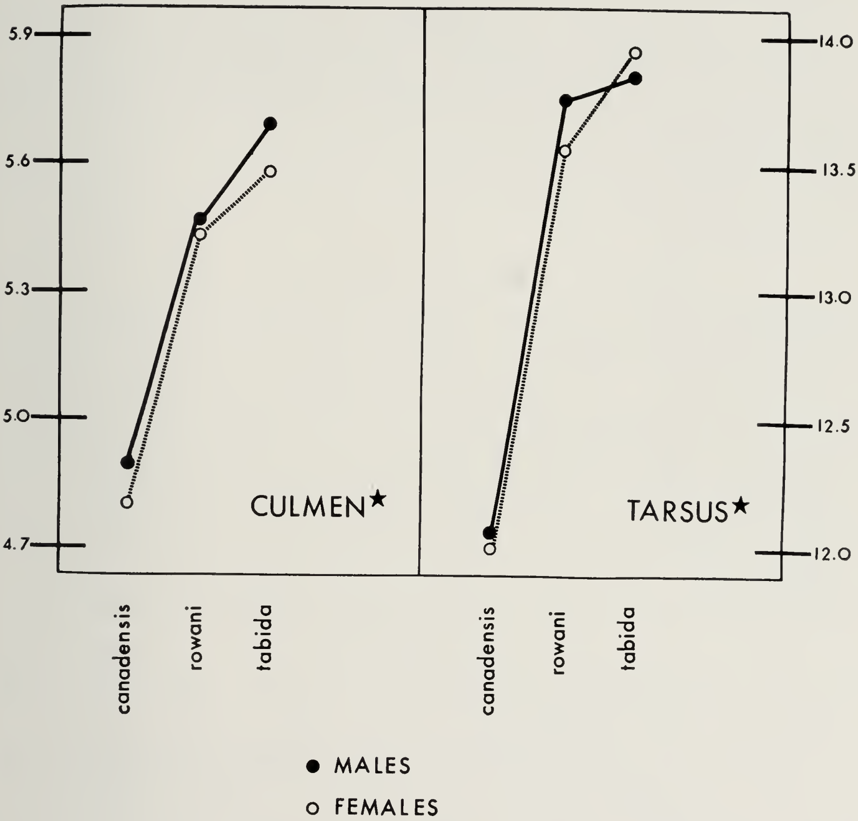


FIG. 2. Proportions of culmen post nares and tarsus measurements relative to overall body size.

Table 4 summarizes the measurements of adult migrant cranes in accordance with our racial determinations. Included are the mean, standard deviation, and extremes for wing chord, tarsus length, exposed culmen, culmen post nares, middle toe (without claw), tail length, and weight for males and females of each subspecies.

It is clear that the subspecies of *Grus canadensis* differ in body measurements; *tabida* is the largest, *canadensis* the smallest, and *rowani* intermediate. The possibility remains that the three subspecies also differ in their relative body proportions. This question was considered by investigating the ratio of linear dimensions, e.g. tarsus length, to a measure of general body size. Amadon (1943) presents a case for using the cube root of weight as a mea-

Table 5

Geographic and Seasonal Composition of Adult Migrant Sandhill Cranes

	Grus c. canadensis	*Grus c. rowani*	*Grus c. tabida*
Kittson Co., Minnesota			
22–24 September 1970	0	7	13
Pierce Co., North Dakota			
14 September 1971	0	11	1
27–28 October 1971	0	8	0
Kidder Co., North Dakota			
8–15 September 1970	0	24	1
26 October–1 November 1970	2	16	3
3–4 September 1971	0	12	3
McLean Co., North Dakota			
28 October–3 November 1970	26	1	0
7 September 1971	0	5	0
27–28 September 1971	8	0	0
Phillips Co., Montana			
4 October 1970	4	0	0
3 October 1971	8	0	0

sure of overall body size. (The value of the cube root is interpreted as being comparable to a linear dimension.)

Although weights were not available for breeding specimens (nor, indeed, was any measure of general body size), all cranes collected for the present study were weighed. So by assuming that our classification of subspecies is correct, we may proceed by examining each specimen for the quantities:

$$\text{culmen}^* = \text{culmen post nares}/(\text{weight})^{1/3}$$

and

$$\text{tarsus}^* = \text{tarsus length}/(\text{weight})^{1/3}$$

Culmen* and tarsus* represent measurements relative to body size. Averages of these quantities can then be compared among subspecies. Of the remaining measurements, we considered only the corresponding function of wing chord, which did not prove useful.

The averages of culmen* and tarsus* for male and for female specimens of each race are graphed in Figure 2. One t-test was employed to test the difference between *canadensis* and *rowani*, and another for the difference between *rowani* and *tabida*. All differences were significant ($P = 0.05$) except for the difference in tarsus* between male *rowani* and *tabida*.

It would be preferable if measurements from breeding Sandhill Cranes of known origin could be used for this analysis; however, until such data become available, we may tentatively conclude that the subspecies differ not only in overall body size, but also in relative proportions. It should be noted that the *rowani* means lie closer to *tabida* than to *canadensis*, a situation analogous to one encountered earlier when testing the separability of individuals of the intermediate race. Also, the differences between *rowani* and *tabida* are more acute in culmen measurements than in tarsus length, a feature noted by Aldrich (pers. comm.).

RACIAL COMPOSITION OF MIGRANT POPULATIONS

The samples of adult migrant specimens (Table 5) exhibit considerable geographical variation in racial composition. The data from these samples indicate that three fairly distinct migrant populations are represented: a population in northwestern Minnesota that is dominated by the Greater Sandhill Crane; a population in Pierce and Kidder Counties, North Dakota, that is dominated by the intermediate Canadian Sandhill Crane; and a population in McLean County, North Dakota, and Phillips County, Montana, that is dominated by the Lesser Sandhill Crane. It is noteworthy that gross differences in racial composition exist between the migrant populations of Kidder County and those in McLean County despite a distance of less than 70 miles separating the two sites. The similarity in racial composition between the migrant populations of Kidder County and those of Pierce County, which lies about 70 miles north, suggests that these cranes may have originated from the same geographical breeding grounds. Variations in racial composition of specimens from the North Dakota collections are illustrated in Figure 3.

The Greater Sandhill Crane was found to comprise 65 percent of the late September sample from northwestern Minnesota. This relatively high proportion is of special interest since the total numbers of cranes that congregate in this area probably exceed 3000 birds. In addition, this subspecies comprised small proportions (5 to 11 percent) of the total sample specimens from the concentration areas in Kidder and Pierce Counties, North Dakota, which generally support peak fall populations of 10,000 or more birds. Apparently the present eastern population of the Greater Sandhill Crane is much larger than has been generally realized.

The Canadian Sandhill Crane comprised about 95 percent of all the sample specimens collected from Pierce County and about 85 percent of the sample specimens from Kidder County. This subspecies also is an important component of the northwestern Minnesota population since it comprised 35 percent of the sample from there.

In McLean County, North Dakota, a small population of about 250 Sandhill Cranes was present in early September 1971. The five adults collected from

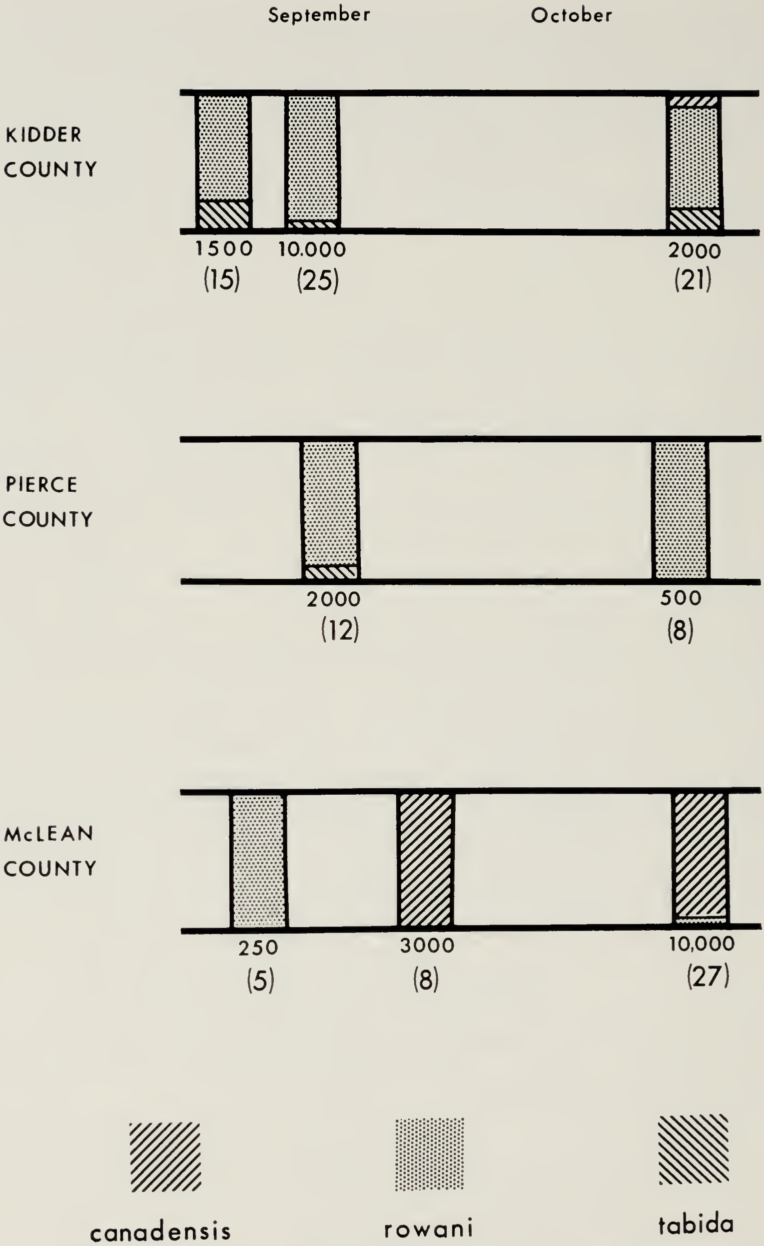


FIG. 3. Racial composition of migrant Sandhill Cranes from North Dakota, indicating seasonal variation in samples from various locations. Also shown are estimates of the population present during the collection period, and, in parentheses, the sizes of the samples.

TABLE 6

MEASUREMENTS OF IMMATURE MIGRANT SANDHILL CRANES[1]

	McLean Co., N. D. Phillips Co., Mont.		Kidder & Pierce Cos., N. D.		Kittson Co., Minn.	
	Male	Female	Male	Female	Male	Female
Sample Size	5	5	4	6	3	4
Wing Chord						
Mean	455.4	447.0	493.5	463.8	505.3	469.0
Standard deviation	9.0	16.2	9.5	9.7	8.1	26.7
Extremes	446–465	424–469	481–503	447–474	496–510	441–499
Tarsus Length						
Mean	196.8	189.2	229.5	202.5	240.7	224.5
Standard deviation	13.1	15.7	10.7	15.6	8.1	8.7
Extremes	178–212	175–215	215–240	180–226	232–248	216–232
Exposed Culmen						
Mean	85.7	85.0	109.4	98.1	115.3	103.2
Standard deviation	8.4	6.8	8.9	7.0	5.1	9.3
Extremes	73.7–95.9	77.2–95.4	96.5–116.3	86.8–105.4	111.7–121.1	89.7–109.4
Culmen post nares						
Mean	66.6	67.2	84.8	76.9	90	81.9
Standard deviation	6.2	5.0	7.5	7.3	2	8.2
Extremes	57–73	60.8–72	74–90	67.2–83	88–92	70–87.5
Middle Toe						
Mean	75.7	73.0	84.4	81.0	86.6	83.0
Standard deviation	5.6	4.1	4.4	2.9	2.8	2.3
Extremes	66.1–80.0	70.5–80.2	79.2–90.0	75.6–83.7	84.9–89.8	80.8–86.2
Tail Length						
Mean	157.0	156.0	178.2	162.0	184	170.8
Standard deviation	5.9	4.1	9.3	7.2	1	8.9
Extremes	152–167	150–161	166–188	153–171	183–185	160–179
Weight						
Mean	3475.8[2]	3157.4	4389	3715.2[3]	4310.7	3794.0
Standard deviation	428.7	287.7	738.0	505.5	295.1	535.5
Extremes	3027–4024	2880–3512	3415–5082	3270–4360	4058–4635	3022–4258

[1] Linear measurements in millimeters; weight in grams.
[2] Sample size one less than indicated.
[3] Sample size two less than indicatel.

this group were identified as the intermediate subspecies, *rowani.* Later in the season, from late September to early November, many thousands of Sandhill Cranes congregate in this area. Series of specimens that totaled 35 adults were collected from these late aggregations in 1970 and 1971. Since only one of these (3 percent) was identified as *rowani,* we hypothesize that the small numbers of this subspecies which arrive early in this staging area are subsequently greatly outnumbered when the large flocks of *canadensis* arrive.

The arrival of flocks of Lesser Sandhill Cranes on the migration staging areas is noticeably later than the arrival of the Greater and Canadian Sandhill Cranes. Ordinarily the population build-up begins in late September as compared to late August for the other two subspecies. During the period of peak numbers, the Lesser Sandhill Crane comprised about 97 percent of the sample specimens from McLean County, North Dakota, and 100 percent of the sample specimens from Phillips County, Montana. In Kidder County this subspecies represented a very small proportion (3 percent of the sample) of the population.

Buller (1967) summarized information on the racial composition of Sandhill Crane specimens that had been collected in a non-random fashion in McLean County and in the Kidder County area during the fall migration periods of previous years. A sample of five specimens collected 23–24 September 1964, in McLean County included 4 *canadensis* and 1 *rowani.* Another collection of five made one month later in the same location had an identical racial composition. The Kidder County sample of 33 specimens taken 22 September–2 November 1965, contained 29 *rowani* and four *canadensis.* Data from small samples (13 taken 27 October–3 November 1959; 12 taken 9–12 September 1960; seven taken 16–19 October 1963; four taken 8–12 September 1964; four taken 19–23 October 1964) in the Kidder County area showed that *canadensis* predominated in some of the collections made after mid-October. Additional measurements from a series of nine specimens of adult Sandhill Cranes from southeastern Wyoming (Goshen County) are also of interest since this location lies approximately 475 miles south-southeast of the staging area in Phillips County, Montana. These birds were collected by the Wyoming Game and Fish Department during 28–30 October 1971. As might be expected, all of these specimens proved to be Lesser Sandhill Cranes.

MEASUREMENT OF IMMATURE MIGRANT SPECIMENS

The collections of immature Sandhill Cranes, although largely incidental, provided some insight into the comparative size of these cranes as related to area of collection. Reliable racial determinations cannot be made for immatures because series of measurements of immature cranes of known subspecies are lacking. For this reason we grouped immatures by geographic locations within which the racial composition of adults was similar. Table 6 gives the mean, standard deviation, and extremes of measurements for males and females from (1) Kittson County, Minnesota; (2) Kidder and Pierce Counties, North Dakota; and (3) McLean County, North Dakota and Phillips County, Montana. In general, the mean linear measurements and weights indicate that immature birds from Kittson County, Minnesota, were comparatively large; those from McLean County, North Dakota, and Phillips County, Montana, were comparatively small; whereas birds from Pierce and Kidder Counties, North Dakota, were intermediate.

NEED FOR FURTHER RESEARCH

Before appropriate management procedures can be developed for migrant populations of Sandhill Cranes, additional research concerning other important aspects of their breeding biology and distribution must be undertaken. A careful delineation of the breeding range of each of the respective subspecies should be of high priority. Information thus obtained would help to clarify the separability of the various populations. The numerical status and population dynamics of each identifiable group also need to be determined, particularly if hunting becomes an appreciable mortality factor. More detailed information concerning migration patterns and locations of wintering grounds (such as obtained by Williams and Phillips, 1972) is also required.

SUMMARY

A statistical analysis employing measurements of breeding specimens representing the three migrant subspecies of Sandhill Crane (*Grus canadensis canadensis*, *Grus c. rowani*, and *Grus c. tabida*) provided supportive evidence that the intermediate population, *rowani*, is separable on the basis of wing chord, tarsus length, and exposed culmen.

A series of 180 migrant Sandhill Cranes was collected in Minnesota, North Dakota and Montana during the fall migration periods in 1970 and 1971, and racial determinations were made according to similarity with breeding specimens of known origin. On the basis of this classification, it was demonstrated that the subspecies differ in relative proportions to body size of tarsus length and culmen post nares as well as differing in overall body size. The racial composition of migrating cranes collected in different areas varied; *tabida* was predominant in Kittson County, Minnesota; *rowani* in Kidder and Pierce Counties, North Dakota; and *canadensis* in McLean County, North Dakota and Phillips County, Montana. Measurements of immature cranes were found to vary in the same general way as those of adults.

ACKNOWLEDGMENTS

These investigations could not have been undertaken without the cooperation of the North Dakota Game and Fish Department, Minnesota Department of Natural Resources, and the Montana Fish and Game Department. During the collection of specimens of

Sandhill Cranes in Minnesota and North Dakota, assistance in the field was furnished by several biologists, particularly by Jerome H. Stoudt in Minnesota and North Dakota, and by Harold A. Kantrud in North Dakota. Montana specimens were collected by Dale Witt. The examination of specimens in the laboratory was conducted with the help of Harold A. Kantrud, Dr. Charles W. Dane, and Dr. Robert E. Stewart, Jr. Dr. L. H. Walkinshaw generously provided his extensive set of measurements of Sandhill Cranes. We are especially indebted to Dr. John W. Aldrich for his help in providing data and advice concerning the determination of subspecies. In addition, George Wrakestraw made available measurements of Sandhill Cranes collected in Wyoming by the Wyoming Game and Fish Department.

LITERATURE CITED

Aldrich, J. W. 1946. Speciation in the white-cheeked geese. Wilson Bull., 58:94–103.

Amadon, D. 1943. Bird weights as an aid in taxonomy. Wilson Bull., 55:164–177.

Anonymous. 1958. Rare and endangered fish and wildlife of the United States. U.S. Bureau of Sport Fisheries and Wildlife. Resource Publ. 34. Washington, D.C.

Boeker, E. L., J. W. Aldrich, and W. S. Huey. 1961. Study of experimental Sandhill Crane hunting season in New Mexico during January 1961. U.S. Bureau of Sport Fisheries and Wildlife. Special Scientific Report—Wildlife No. 63. Washington, D.C.

Buller, R. J. 1967. Sandhill Crane study in the central flyway. U.S. Bureau of Sport Fisheries and Wildlife. Special Scientific Report—Wildlife No. 113. Washington, D.C.

Hanson, H. C. 1965. The Giant Canada Goose. Southern Illinois Univ. Press. Carbondale.

Lumsden, H. G. 1971. The status of the Sandhill Crane in northern Ontario. Canadian Field-Naturalist, 85:285–293.

Madsen, C. R. 1967. Food and habitat selection by fall migrant Sandhill Cranes in Kidder County, North Dakota. Unpubl. M. S. thesis. Michigan State Univ., East Lansing.

Rao, C. R. 1962. Use of discriminant and allied functions in multivariate analysis. Sankhya, A24:149–154.

Rao, C. R. 1965. Linear statistical inference and its applications. John Wiley & Sons, Inc. New York.

Stephen, W. J. D. 1967. Bionomics of the Sandhill Crane. Canadian Wildlife Service Report Series—No. 2. Ottawa.

Stewart, R. E., and H. A. Kantrud. 1971. Classification of natural ponds and lakes in the glaciated prairie region. U.S. Bureau of Sport Fisheries and Wildlife. Resource Publication 92. Washington, D.C.

Walkinshaw, L. H. 1949. The Sandhill Cranes. Cranbrook Institute of Science Bulletin No. 29. Bloomfield Hills, Michigan.

Walkinshaw, L. H. 1965. A new Sandhill Crane from central Canada. Canadian Field-Naturalist, 79:181–184.

Williams, L. E., Jr., and R. W. Phillips. 1972. North Florida Sandhill Crane populations. Auk, 89:541–548.

U.S. BUREAU OF SPORT FISHERIES AND WILDLIFE, NORTHERN PRAIRIE WILDLIFE RESEARCH CENTER, JAMESTOWN, NORTH DAKOTA, 58401, 24 JULY 1972.

THE BEHAVIOR AND ECOLOGY OF HERMIT HUMMINGBIRDS IN THE KANAKU MOUNTAINS, GUYANA.

Barbara K. Snow

For nearly three months, 17 January to 5 April 1970, my husband and I camped at the foot of the Kanaku Mountains in southern Guyana. Our camp was situated just inside the forest beside Karusu Creek, a tributary of Moco Moco Creek, at approximately 80 m above sea level. The period of our visit was the end of the main dry season which in this part of Guyana lasts approximately from September or October to April or May.

Although we were both mainly occupied with other observations we hoped to accumulate as much information as possible on the hermit hummingbirds of the area, particularly their feeding niches, nesting and social organization. Previously, while living in Trinidad, we had studied various aspects of the behavior and biology of the three hermit hummingbirds resident there: the breeding season (D. W. Snow and B. K. Snow, 1964), the behavior at singing assemblies of the Little Hermit (*Phaethornis longuemareus*) (D. W. Snow, 1968), the feeding niches (B. K. Snow and D. W. Snow, 1972), the social organization of the Hairy Hermit (*Glaucis hirsuta*) (B. K. Snow, 1973) and its breeding biology (D. W. Snow and B. K. Snow, 1973), and the behavior and breeding of the Guy's Hermit (*Phaethornis guy*) (B. K. Snow, in press).

A total of six hermit hummingbirds were seen in the Karusu Creek study area. Two species, *Phaethornis augusti* and *Phaethornis longuemareus*, were extremely scarce. *P. augusti* was seen feeding once, and what was presumably the same individual was trapped shortly afterwards. In other areas this species is mainly a mountain bird of fairly high levels (600–1500 m) (Meyer de Schauensee, 1948, Phelps and Phelps, 1958, Snyder, 1966), so our record was probably a straggler from higher levels in the Kanakus. *P. longuemareus* was trapped twice but not otherwise seen. In Guyana and Surinam this species is mainly a bird of coastal areas (Snyder, 1966, Haverschmidt, 1968), so the individuals trapped were possibly also vagrants. The four other hermits present, the Hairy Hermit, the Pale-tailed Barbthroat (*Threnetes leucurus*), the Long-tailed Hermit (*Phaethornis superciliosus*), and the Reddish Hermit (*Phaethornis ruber*), were all breeding residents and seen on most days.

Throughout our stay we both made records of all hermit hummingbirds seen feeding and noted the abundance of the different flowers at which they fed. We also hunted for nests and approximately once a week trapped with mist-nets. Leks or singing assemblies of the Reddish and Long-tailed Hermits were found and also the solitary singing perch of a Pale-tailed Barbthroat.

TABLE 1

WEIGHT, BILL LENGTH, AND NUMBER OF FIELD RECORDS OF HERMIT HUMMINGBIRDS RESIDENT IN STUDY AREA

Species	Weight (gm)	Bill length (mm)	Field records: Number trapped	Field records: Nests	Field records: Feeding records
Glaucis hirsuta	6.8 (6.0–8.1)	31	5	3	15
Threnetes leucurus	6.9	27	1	3	8
Phaethornis superciliosus	5.8 (5.2–6.8)	38	16	4	67
Phaethornis ruber	2.7 (2.3–3.1)	23	(2)*	–	29

Weights (range and mean) are of birds trapped during this study; bill-lengths are means of museum specimens.

* Very small hermits such as *P. ruber* more often bounce out or fly through nets than become entangled in them.

All were visited and watched at fairly regular intervals.

The relative abundance of the four resident species is indicated by the number trapped and the number of feeding records obtained (Table 1). The number of nests found is not a good index of abundance, as the much higher and more exposed nests of the Barbthroat and the Hairy Hermit are undoubtedly easier to find than the lower nests of the Long-tailed and Reddish Hermits.

There have been several publications on the singing assemblies of the Long-tailed Hermit in Guyana. Nicholson (1931) proved by collecting that the large and constant groups of calling birds were in fact assemblies of males. Davis (1934, 1958) published additional information on the calling behavior of the males and the size and abundance of singing assemblies. He also gave an account of the singing assemblies of the Reddish Hermit and described some of the male's displays. His accounts are compared in detail with my observations in the following sections.

The data on feeding niches are presented in relation to more extensive evidence on the feeding niches of the hummingbirds of Trinidad (B. K. Snow and D. W. Snow, 1972). The Trinidad observations showed that the larger hummingbirds feed predominantly on large flowers which are usually red and have a long corolla, and are apparently adapted for pollination by hummingbirds, while the small hummingbirds visit a greater variety of small unspecialized flowers, their shorter beaks apparently excluding them from some of the large flowers.

BREEDING SEASON

In Trinidad the breeding season of hummingbirds largely coincides with the main dry season although a substantial number of hermits, particularly

Glaucis hirsuta, breed in the first two to three months of the wet season (Snow and Snow, 1964). In Costa Rica the cup-nesting hummingbirds breed almost entirely in the dry season (Skutch, 1950) and the hermits breed in both the dry and wet seasons (Skutch, 1964, 1972), some species i.e. *Threnetes ruckeri* and *Glaucis aenea* exclusively in the latter season. In northern Guyana (Davis, 1934, 1958) the breeding season of hummingbirds largely coincides with the main dry season (August to November) which is shorter here than in the Kanakus. Consistent with this, our observations indicated that January to the beginning of April was the end of the hermit breeding season in the Kanakus. A total of ten occupied hermit nests were found. The calculated months of laying for these nests were: Hairy Hermit, two in February, one in March; Barbthroat, one each in January, February and March; Long-tailed Hermit, two in January and two in February. In early March a Reddish Hermit was seen feeding a juvenile recently out of the nest which gives an approximate laying date in January. Towards the end of March there was a decrease in attendance at the two leks of the Long-tailed and Reddish Hermits and at the solitary singing post of the Barbthroat, which indicates, as do the nesting data, that the breeding season was coming to an end.

A total of 23 hermits were trapped and examined for wing moult. Of these only three Long-tailed Hermits were moulting, one in January and two in March.

PALE-TAILED BARBTHROAT (*THRENETES LEUCURUS*)

The Barbthroat found in Guyana, the eastern of the two widespread species of *Threnetes*, has not been studied previously in the field. Those watched in the Kanakus had a considerably brighter throat pattern than specimens from the coastal and lowland areas further north in Guyana, as represented in the British Museum collection; there are no specimens from the Kanakus for comparison. The adult Barbthroats in the Kanakus have a white moustachial streak and a partial white superciliary stripe, a black chin and a blackish area below the conspicuous orange throat band; the four outermost tail feathers appeared to be entirely white except for small dark spots near the tip.

Observations on the western species, *Threnetes ruckeri*, in Costa Rica (Skutch, 1964) showed that first one and in subsequent years two then three males called in the same patch of forest, but not close together, over 15 years. My observations in Guyana suggested that *T. leucurus* has a similar kind of behavior. One adult male Barbthroat was discovered singing on 3 February in mature forest about half a mile from Karusu Creek. The canopy was unbroken in the area, so the undergrowth was thin. The bird sang within an area approximately 9 × 2 m where he had three commonly used perches, slender horizontal twigs 60 to 80 cm above the ground.

Throughout February and March weekly watches of at least an hour, covering both the morning and afternoon, were made at this singing territory. Up until the last week of March the adult was present at all watches. The average attendance was 73 percent of afternoon and 62 percent of morning watches. This difference was due to the persistent visits of a young male in the mornings, for the adult was frequently absent chasing this bird. During the last week of March the young male took over the singing territory.

Young males.—In plumage the young male differed from the adult male in having a much larger area of the outer tail feathers dark instead of white, and in having a more extensive area of white behind and below the eye. That these were immature characteristics was confirmed at a nest of the species where one of the young after leaving the nest stayed in the vicinity for a week and allowed close examination. Besides the above characteristics this juvenile had a warm buff instead of orange throat band.

Song.—The adult male's song was a brief rather high-pitched phrase repeated many times. This phrase, sounding something like *zit-zit-zeri*, lasted approximately 1½ seconds and was repeated anything from once or twice a minute up to a maximum of 33 phrases a minute. The singing rate was generally higher in the morning, around 15 phrases per minute, compared to the afternoon when it dropped to one or two per minute. If any species of hummingbird came into the vicinity the male immediately increased his singing rate to a maximum. The song of the young male was a hesitant quieter version of the adult song. About two miles further up Karusu Creek another adult male Barbthroat was discovered singing in a flat area of forest near the river. Its song phrase, which sounded like *zer-zee-zer-zeri*, was noticeably different from that of the first adult, except for the terminal *zeri*. The song of *Threnetes ruckeri* in Costa Rica is apparently very different. Skutch (1964) describes it as a sweet warbler-like song, each phrase lasting four or five seconds and always spaced by intervals of silence longer than the song.

Like all other hermits that I have so far encountered, the Pale-tailed Barbthroat has a flight call, a single *seep* or *weep*, which is uttered by male or female when flying about in the forest.

Display.—While singing the male wags his tail up and down. At the approach of any other hummingbird there is an increase of tail movement and it is also spread so that the white outer tail feathers are displayed.

Throughout the period of observations on the adult male an immature male was frequently in the vicinity of the singing territory, usually coming and singing in it when the adult was absent. During the final period of observation when the immature had taken over the singing territory, he was visited by a juvenile Barbthroat with a pale buff instead of orange throat band.

Fig. 1. a. A hovering male Pale-tailed Barbthroat displaying the throat pattern. b. The posture of a male Reddish Hermit singing at the lek.

All display and social interactions observed appeared to be between these birds and no known female visited the singing territory although the juvenile could have been a female.

When another Barbthroat visits a singing male, the latter hovers off his perch with tail fanned, draws his head sharply backwards and at the same time throws his breast forward, so displaying the striking throat pattern (Fig. 1 a). This is accompanied by a very quiet version of the normal song phrase. Meantime the visitor hovers in front of the owning male who always maintains a position below the visitor. Usually the visitor then flies away, chased by the owning male still with tail spread and uttering the muted song. The encounter between the juvenile-plumaged bird and the young male culminated in a brief mounting. The juvenile flew into the singing territory and perched there silently for a minute with its tail wagging up and down. It then flew over to the young male who was singing and briefly hovered down on to his back; the young male hovered up and his place on the perch was taken by the juvenile. The young male then hovered with tail fanned facing the juvenile and displaying the throat pattern, meantime uttering the muted song. He then hovered, still singing, round and onto the juvenile's back, hovering there briefly before the juvenile flew off followed by the young male. This sequence, or something closely akin to it, is probably the pre-copulatory display.

Twice the adult male was seen to behave as though mating with a leaf, each time with the same dead leaf caught over a twig. Before each leaf-mating he hovered with tail fanned, uttering the muted song over the dead leaf, and briefly hovered down onto it. These leaf-matings occurred once in the middle and once after a period of normal advertising song. Male Guy's Hermits also quite frequently behave as though mating with leaves. These leaf-matings occur within a male's singing territory and the same leaf is used repeatedly. The behavior that immediately precedes leaf-mating is similar to the premating display.

In the four *Phaethornis* species so far studied, *P. guy*, *P. superciliosus*, *P. ruber*, and *P. longuemareus*, all of which have colorful gapes and congregate at singing assemblies, the males all display their gapes, by opening their beaks wide, to other individuals who visit them at their singing perches. The Barbthroat, with a pale drab-colored gape, does not display it; instead the beak is kept closed and the throat pattern is displayed. It is the only species of hermit with a colorful and contrasting throat pattern, which seems to be functionally analogous to the colored gape of the other species, so some behavior that displays it is to be expected. The Hairy Hermit (*Glaucis hirsuta*) which is almost certainly closely related to the Barbthroats, does not display its gape either.

LONG-TAILED HERMIT (*PHAETHORNIS SUPERCILIOSUS*)

The singing assembly or lek of the Long-tailed Hermits was a large one stretching along one bank of Karusu Creek for at least a 100 m. It was in primary forest mostly on a steep slope coming down to the river. It was two miles up the valley from our camp where two nests were found and many of the feeding records were obtained, yet it appeared to serve this area as the local Amerindian who lived with us in camp did not know of another singing assembly in the valley.

The males called at perches about 9 to 10 m apart and most were in view of their neighbors. They called from slender twigs with an uncluttered horizontal section of about 45 cm, a feature that is possibly of importance during the visiting behavior described below.

Calling and attendance at the singing assembly was high from mid-January to mid-March but dropped sharply towards the end of March. The call was a rapidly repeated *chip chip chip* or *chit chit chit* etc. This suggests a different note from the *jang jang* etc as interpreted by Nicholson (1931) at the singing assemblies in northern Guyana. Each *chip* lasts about one-fourth to one-third of a second and between 92 and 102 were uttered per minute. It was noted that a bird often adjusted his calls with his closest neighbor so that the calls alternated and did not overlap. Another sweeter and quieter call *who-ee who-ee* etc was heard at the singing assembly. This is undoubtedly the *who-dee* described by Nicholson (1931). The *who-ee* was always uttered in flight, either during chases or when the male was flying for any other reason within the precincts of the singing assembly but not outside it. Another flight call, *switch*, is uttered by both males and females when flying through any other part of the forest but the singing assembly.

While at their singing perches the males call very persistently, continuing to call during such activities as stretching, preening, head scratching, and wiping the beak. A watch on one male from 09:00 to 10:00 in February showed that it was present and singing for 73 percent of the hour with five absences averaging three minutes each. During a watch at the same time on 17 March a nearby male was present only 41 percent of the hour and the male watched previously was present only 30 percent of half an hour.

Display.—A number of males were seen to visit each other at their lek perches. Once a bird that had not been singing at a neighboring perch, so might have been a female, was seen to visit. In all cases, the visitor flew up and landed on the same twig about 5 cm from a calling male. As the visitor approached, the calling male spread his tail and rapidly fanned it up and down, then as the visitor landed the owning male opened his beak and displayed his orange-red gape. The visitor then touched the inside of the displayed gape either with its tongue or the tip of its beak. Once the visitor also displayed its gape. Visits ended by the visitor flying away, the owner usually staying but sometimes following.

REDDISH HERMIT (*PHAETHORNIS RUBER*)

The singing assembly of the Reddish Hermit was in dry scrubby forest, probably secondary, about half a mile from Karusu Creek. Five visits were made to this assembly between 13 February and the end of March. There were four adult males and one probable young male present on the first three visits, three adults and a young male on the fourth visit, and only the young male on the final visit on 26 March. The general level of singing decreased during the period and displays at the assembly were only seen on the first three visits.

The assembly covered an area of approximately 30 m by 45 m. Individual calling territories were approximately 15 by 15 m. The assembly was in an area of dense low undergrowth and usually individuals were audible but not visible to their neighbors. Individual birds appeared to occupy the same territories at each visit; in the case of the young bird with a slightly different song this could be verified.

The song, interpreted as *zee zee zee zeezeze*, consists of three notes coming down in scale, each lasting about half a second, followed by a fourth shorter note which is joined to a jumble of still shorter notes also coming down in scale. The whole phrase lasts 2½ to 2¾ seconds and a usual rate of calling was eight or nine phrases in 30 seconds. The phrase of the bird believed to be a young male lasted 4½ seconds. It was believed to be a young male because of its slower call and its occupation of the singing assembly after the adult males had deserted it, as both are characteristics of young male *Phaethornis guy* (B. K. Snow, in press). When two neighbors audible to each other are singing at the same time they often sing their phrases alternately so that they do not overlap. The Reddish Hermit's song at this assembly appears to be very similar to its song near Bartica in northern Guyana, described by Nicholson (1931) as *see-see-see-seezeree.* However it is different from the song of a captive bird from Brazil which is described by Mobbs (1971) as *sweep, sweep, sweep, swee-e-ep, see-e-e-e-p, swee-e-e-e-e-p.*

The very characteristic posture adopted for singing is shown in Figure 1 b. While singing the bird looks intently upwards, turning his head slightly from side to side. A male does not have a favorite or usual perch for singing but uses a number of perches within his territory, and he frequently flies, usually still singing, from one perch to another. When a male first returns to his singing perch the white thigh feathers are not visible but as he starts singing he displays them conspicuously. When a male on his singing perch scratched his head with his foot, he retracted the white thigh feathers on the scratching leg so they were no longer visible but when the foot was restored to the perch he extended them again.

No perched display was seen and Mobbs (1971) has not seen his captive birds do a perched display. Davis's description (1934) of a perched display is extremely like the stretching movement of hermit hummingbirds. This movement, which consists of arching both wings over the back while the head is thrust out and the tail fanned and depressed, often culminates in a general shaking or vibrating of all the feathers. I have seen similar stretching movements done by four species of *Phaethornis* where the males sing at leks, *P. guy, P. superciliosus, P. ruber*, and *P. longuemareus*, and in all it is diagnostic of imminent flight. The Barbthroat stretches in the same way before flying off from his solitary singing post. Twice male Reddish Hermits did another stretching movement before leaving. They pointed their beaks upwards and distended outwards the flexible rami of the lower mandible while the rest of the beak remained closed. Skutch (1964) has described a similar yawning movement in *Threnetes ruckeri.*

Aerial displays.—The Reddish Hermit's aerial displays are extremely elaborate. A detailed description of aerial displays culminating in a false mating performed by a captive male from Brazil has been given by Mobbs (1971). Davis (1958) has also described aerial displays which took place in front of a female but nowhere near any known singing assembly. From this he concluded that aerial courtship displays were always performed only to females at some place remote from a singing assembly. My observations, described below, show this not to be so. Two variations of an aerial display were seen; each was seen twice and occurred at or near a singing perch. One was accompanied by a musical warbling, a soft just audible *weep weep* etc, each call well spaced from the next. This was a much sweeter call than the song, strongly reminiscent of the alarm call of the Willow Warbler or Chiffchaff (*Phylloscopus* spp.).

The display was performed by a visiting bird, apparently a neighboring male, in front of the owning male on his perch. The visitor hovered with his tail spread and cocked over his back and his yellow gape displayed upwards, 8–10 cm above and in front of the owning male. In displaying the gape the rami of the lower mandible were spread wide apart so they were about four times further apart than when the beak is closed. While it hovered the bird's rear swayed from side to side by about an inch while the head remained stationary. The sweet *weep* appeared to be uttered by the perched bird in time with the swaying of the hovering bird.

This display is close to performance (a) described by Mobbs except that his male made a twittering noise that accompanied the movement. Davis describes a similar display by a male in front of a probable female; he also thought the perched bird was uttering the subdued warbling that accompanied the performance, so possibly the call can be made by either bird.

In the other aerial display, which was silent, both birds involved hovered facing each other between 25 to 150 mm apart. The lower bird displayed its gape and had its tail raised and fanned, so was fundamentally in the same position as the airborne bird described above; the upper bird intermittently protruded its white tongue. One incident took place after three birds had been chasing each other and the participants were not identified. The other incident occurred between a male that had been watched for the previous 40 minutes in his singing territory, where the incident took place, and another bird probably a neighbor.

Both Mobbs and Davis describe the protrusion of the tongue during aerial displays. The Long-tailed Hermit also protrudes its tongue during the visiting display. In the Guy's Hermit (B. K. Snow, in press) the males visit each other at their singing perches and perform the same display sequence as at the visit of a female which may culminate in mating, and probably some or all

TABLE 2

FLOWER CHARACTERISTICS AND FEEDING RECORDS OF THREE HERMIT HUMMINGBIRDS

	Color	Corolla		Timed feeds (seconds)	*Glaucis hirsuta*	*Phaethornis superciliosus*	*Phaethornis ruber*
		lgth	wdth				
Acanthaceae							
Trichanthera gigantea	pink	15	3	½–1	1	13	15
Red vine	red	60	3		1	2	
Passifloraceae							
Passiflora longiracemosa	red	44	11	5–12	4	29	
Verbenaceae							
Petraea macrostachya	purple					1	2
Musaceae							
Heliconia bihai	red	40	5	4–5		2	
Heliconia sp.	blue	39	5	3–6	1	1	
Zingiberaceae							
Costus spiralis	red	35	5	1–1½	6	15	2
Unidentified						1	6
Insect searching records					2	3	3
Total nectar feeding records					13	64	26
Number of plant species					5	9	9

of these displays of the Reddish Hermit are performed to females prior to mating. Mobbs' captive bird frequently followed aerial display by a stylized mating movement on the perch.

It was found in the Guy's Hermit that during the period when young males begin to attend the singing assemblies and call there they also occasionally call and display elsewhere. This period coincides with the end of the breeding season. The aerial display of the Reddish Hermit away from the singing assemblies described by Davis occurred in September and October, which from the nests he records is also the end of the breeding season in that part of Guyana; so it may have been the display of young birds.

AVAILABLE FLOWERS AND THEIR NECTAR POTENTIAL

The nectar potential of a flower was assessed by measuring the length of its corolla tube and its width near the base and also by timing the length of a hummingbird's feed at it, from insertion to withdrawal of the beak. This information was obtained for most of the flowers where there were three or more feeding records (Table 2).

The most abundant riverside plant in the forest was *Costus spiralis*. It was flowering throughout our stay. An idea of its abundance is indicated by a count on 17 March of 114 plants with flowering heads along approximately a mile of Karusu creek immediately downstream from the Long-tailed Hermit's singing grounds. This plant was also very abundant along the gullies that ran into the main stream. A timed feed of a Hairy Hermit at Costus was 1–1½ seconds.

Where the river received ample sunshine, usually due to felling, the shrub *Trichanthera gigantea* was abundant. It was flowering when we arrived in January but most flowers were over by mid-March. Individual flowers opened in the afternoon around 3 o'clock and were over and dropped soon after 8 o'clock the following morning. The flower has two nectaries (3 mm across) at the base of two groups of stamens. Evidence of timed feeds, ½–1 second for the Reddish and Long-tailed Hermits, suggests that only a small amount of nectar is available. This is probably the reason for the lack of feeding records for the two larger hermits.

Passiflora longiracemosa is a liana that climbs to canopy level but produces its flowers at ground level. It was found flowering soon after we arrived and it continued to flower until the end of March. It was common in luxuriant primary forest and was also found in some dryer forest fringing the savannah which may have been secondary. It was apparently a rich source of nectar; the average of 12 timed feeds of the Long-tailed Hermit was 7 seconds. Birds were re-visiting the same flower at approximately half-hour intervals.

An unidentified *Heliconia* species which had hanging purplish blue flowers did not grow on the banks of the river but set back from it 10 meters or more; it also grew along the gullies that opened into the river. It was not particularly abundant. It started to flower at the beginning of February and continued to do so until we left. The timed feeds at this flower of the three big hermits were 3, 4, and 6 seconds. A few clumps of *Heliconia bihai* were found, mostly up side gullies. This plant is very abundant in Trinidad, where our records showed it to be the most important nectar source for the two large resident hermits, *G. hirsuta* and *P. guy*. Timed feeds at this plant from both Guyana and Trinidad averaged 5 seconds.

A red-flowered vine (Acanthaceae) bloomed from the first week of February until the end of March and was quite common in the forest. The long corolla tube had a 15 mm curvature and the flower looked as if it was adapted to pollination by long-billed hermits, but not many were seen feeding at it.

The flowers described above were fairly certainly the major source of nectar for hermits in the study area during February and March. Both of us spent all the hours of daylight in the forest or its edges and normally interrupted other observation to note the activity of any hermit hummingbird that came into view. As all the hermits make a flight call when flying about feeding they are not readily overlooked.

FEEDING NICHES

Table 2 gives the number of feeding records obtained at the different flowers. Only eight feeding records were obtained for the Barbthroat so they have not been included. Two of the eight were nectar-feeding records, one at the unidentified Heliconia, and one at *Costus spiralis.* Once the Barbthroat was seen sucking sap at a recently broken branch and the remainder of the records were of insect searching. The preponderance of insect searching records is interesting in view of the Barbthroat's relative scarcity. In a study of the feeding niches of tanagers and honeycreepers in Trinidad (B. K. Snow and D. W. Snow, 1971) it was found that the species taking the largest proportion of insect food were the least abundant; conversely species mostly feeding on nectar or fruit were the most abundant. Skutch's observations in Costa Rica and Panama also suggest that *Threnetes ruckeri* feeds more on insects than nectar.

Besides the flowers shown in Table 2 the Reddish Hermit was seen feeding once or twice at six other species; three different species of Marantaceae with yellow or white flowers, a white-flowered papilionate vine, the greenish yellow flowers of the papaw (*Carica papaya*), and the yellow flowered vine *Mandevilla scabra*, which it exploited by piercing the base of the corolla tube. Of the flowers it fed on only *Costus spiralis* has a red inflorescence with long corolla tube and is probably adapted to pollination by hummingbirds. With a bill length of 23 mm the Reddish Hermit is most likely excluded from *Passiflora longiracemosa*, whose corolla tube is very long, and possibly from the Heliconias. It was once seen probing, apparently unsuccessfully, at the base of the long corolla of the red-flowered acanthaceous vine. The very small hermit *Phaethornis longuemareus*, studied in Trinidad, also differed from the two larger hermits (*G. hirsuta* and *P. guy*) in taking nectar from a larger variety of flowers, and a larger proportion of them were small flowered without red inflorescences. The evidence on the feeding niche of the Reddish Hermit in the Kanakus suggests that the same sort of differences separate its feeding niche from that of the Hairy and Long-tailed Hermits.

In a study of the feeding niche of the Hairy Hermit in Trinidad 50 percent of the 236 nectar records were from *Heliconia bihai.* This plant was scarce in the Kanaku study area compared to Trinidad, which may partly account for the Hairy Hermit's relatively low numbers. The two most abundant nectar source plants in the area, *Costus* and *Trichanthera*, were assessed as having a relatively low nectar potential, particularly the latter, so possibly in terms of energy expenditure were uneconomic for the heavy Hairy Hermit to exploit. *Costus spiralis* also grew in Trinidad but only 7 percent of the Hairy Hermit nectar feeding records were from it.

The lighter weight and longer bill of the Long-tailed Hermit compared to the two other larger hermits of the area (Table 1) are probably advantageous to it in exploiting the available nectar of the area. Its longer bill probably means a more efficient feeding at the flowers with very long corollas, i.e. *Passiflora, Heliconia,* and the acanthaceous vine, and its lighter weight would entail less energy outlay for hovering at such flowers as *Trichanthera gigantea* where there was evidently only a small quantity of honey to be obtained per probe.

ABUNDANCE IN RELATION TO SOCIAL BEHAVIOR

Population density probably has an important influence on the development of lek behavior in hermit hummingbirds. Thus the most abundant hermit in our study area, the Long-tailed, had the biggest lek with the shortest distance between singing males. The next most abundant species, the Reddish Hermit, had a smaller lek with larger individual singing territories within the lek. The relative abundance of these two hermits in the area studied is probably representative of much of Guyana, as Davis (1934, 1958) during his long experience of the forest found 32 leks of the Long-tailed Hermits, many of them large and possibly exceeding 100 birds, and only two leks of the Reddish Hermit, one large, of approximately 60 birds, and one of about a dozen birds.

Neither of the two less abundant hermits of the area, the Hairy Hermit and the Barbthroat, has communal leks. The Barbthroat's relative scarcity probably accounts for its advertising at solitary singing perches, which Skutch's data suggest are traditional and can fulfil the same function as a lek as a meeting place for the sexes. The lack of lek advertising in the Hairy Hermit is because the males hold a section of suitable riverside territory where one or more females nest, the male closely defending these nests (B. K. Snow, 1972). This situation, first studied in Trinidad, also applied to the Kanakus although the species was far less abundant here.

The nests of the Hairy Hermit and the Barbthroat are almost identical, but there is a difference in the siting of the nests which may have influenced their social behavior. The four nests of the Hairy Hermit found in the area were overhanging the river. The same preference was found in Trinidad where 345 nests were all either over or very close to forest streams or to roads through the forest, which are steep banked and have many features similar to a stream (D. W. Snow and B. K. Snow, 1973). On the other hand, none of the three nests of the Barbthroat found in the forest was beside a stream; all were on the fronds of small understory palms which were scattered regularly throughout the forest area studied. Competition between Hairy Hermits for the relatively scarce riverside nest-sites must be quite high and has probably led to the male's participation in nest defense. On the other hand there can be no scarcity, therefore little competition, for the Barbthroat nest-sites, so the male would have no useful role at the nest.

SUMMARY

During a three-month visit to the Kanaku Mountains in southern Guyana (January–April 1970) observations were made on the four species of hermit hummingbirds resident in forest at the foot of the mountains: *Glaucis hirsuta, Threnetes leucurus, Phaethornis superciliosus*, and *P. ruber*. Two other species, *P. augusti* and *P. longuemareus*, were recorded but were scarce and probably not resident. The period of observation coincided with the end of the breeding season.

Observations were made at the solitary song-perch of a *Threnetes leucurus*, which was occupied first by an adult and then by an immature bird and was visited by a third, juvenile bird. In display this species exhibits the contrasting throat-pattern, which seems to serve the same function as the colorful gape exhibited in display by *Phaethornis* species. Its general behavior is similar to that of *T. ruckeri* in Central America.

Regular observations were made at a very large singing assembly of *P. superciliosus*, and a very small assembly of *P. ruber* (five birds). The songs and behavior of these species are compared with previously published accounts.

The relative abundance of the four hermit species was assessed from the size of the singing assemblies, the number of feeding records, and the number of birds trapped. *T. leucurus*, the least abundant of the four, is probably mainly insectivorous. It is suggested that the development of lek behavior (or its absence) is related to the population density of the different species.

Of the two species which do not show lek behavior, *G. hirsuta* has linear nesting territories along streams, while the nests of *T. leucurus* are dispersed throughout the forest. It is suggested that the male's active role at the nest in *G. hirsuta*, in contrast to *T. leucurus*, is related to the relative scarcity and the need for defense of stream-side nest-sites.

ACKNOWLEDGMENTS

I acknowledge with thanks financial assistance from the Frank M. Chapman Memorial Fund of the American Museum of Natural History. I should also like to thank my husband for his field observations and for his help in the preparation of this paper and Dr. R. M. Harley for botanical identifications.

LITERATURE CITED

Davis, T. A. W. 1934. Notes on display in the humming-birds *Phaethornis superciliosus* (Linn.) and *Pygmornis ruber* (Linn.). Ibis, (13) 4:732–738.

Davis, T. A. W. 1958. The displays and nests of three forest hummingbirds in British Guiana. Ibis, 100:31–39.

Haverschmidt, F. 1968. The birds of Surinam. Oliver & Boyd, Edinburgh and London.

Meyer de Schauensee, R. 1949. The birds of the republic of Colombia. Part 2. Caldasia, 5:381–644.

Mobbs, A. J. 1971. Notes on the Reddish Hermit hummingbird. Avicult. Mag., 77: 160–163.

Nicholson, E. M. 1931. Communal display in humming-birds. Ibis, (13) 1:74–83.

Phelps, W. H., and W. H. Phelps, Jr. 1958. Lista de las aves de Venezuela. Bol. Soc. Venezuela Cienc. Natur., 19:5–317.

Skutch, A. F. 1950. The nesting season of Central American birds in relation to climate and food supply. Ibis, 92:185–222.

Skutch, A. F. 1964. Life historics of hermit hummingbirds. *Auk*, 81:5–25.

Skutch, A. F. 1972. Studies of tropical American birds. Publ. Nuttall Ornithol. Club, 10.

Snow, B. K. 1973. Social organization in the Hairy Hermit *Glaucis hirsuta.* Ardea, 61:

Snow, B. K. In Press. A field study of Guy's Hermit *Phaethornis guy.* Ibis.

Snow, B. K., and D. W. Snow. 1971. The feeding ecology of tanagers and honey-creepers in Trinidad. Auk, 88:291–322.

Snow, B. K., and D. W. Snow. 1972. The feeding ecology of hummingbirds in a Trinidad valley. J. Anim. Ecol., 41:471–485.

Snow, D. W. 1968. The singing assemblies of Little Hermits. Living Bird, 7:47–55.

Snow, D. W., and B. K. Snow. 1964. Breeding seasons and annual cycles of Trinidad land-birds. Zoologica, 49:1–39.

Snow, D. W., and B. K. Snow. 1973. The breeding of the Hairy Hermit *Glaucis hirsuta* in Trinidad. Ardea, 61:

Snyder, D. E. 1966. The birds of Guyana. Peabody Museum, Salem, Massachusetts.

OLD FORGE, WINGRAVE, NR. AYLESBURY, BUCKS, ENGLAND, 19 SEPTEMBER 1972.

CORRIGENDUM

The scientific name of the Adelie Penguin, Wilson Bull. 94:309, 1972 should be *Pygoscelis adeliae.*

PUBLICATION NOTES AND NOTICES

A Bibliography of Arizona Ornithology. Annotated. By Anders H. Anderson. The University of Arizona Press, Tucson, Ariz., 1972: 6 × 9 in., x + 241 pp. Paper cover. $7.95.

This book lists an estimated 2,500 references to Arizona ornithology, grouped in ten sections according to subject. Even papers that are marginally about Arizona birds are included, such as morphological studies in which the specimens came from that State. The author has set forth in the Preface his decisions on what to include and what not to include. His annotations are concise and useful. The lack of cross references is a minor inconvenience.—P.S.

FOOD CONSUMPTION AND PELLET FORMATION RATES IN FOUR OWL SPECIES

CARL D. MARTI

QUALITATIVE food habits of Great Horned (*Bubo virginianus*), Long-eared (*Asio otus*), Burrowing (*Speotyto cunicularia*), and Barn Owls (*Tyto alba*) are generally well known from analysis of their regurgitated pellets (see Earhart and Johnson, 1970). Data on quantitative food intake, however, are lacking. A few investigators have estimated food consumption from remains in pellets of wild owls (Evans and Emlen, 1947; Fitch, 1947; Graber, 1962; Hagan, 1965; Marti, 1970). Graber (1962) measured food intake with captive Long-eared Owls caged indoors and Craighead and Craighead (1956) did so with Great Horned Owls tethered outdoors.

The purpose of this study was to measure daily food intake rates of the four species over an extended period and to measure the daily pellet formation rates.

METHODS AND MATERIALS

A downy young of each of the four owl species was obtained from nests in Larimer County, Colorado, raised and later tested in outdoor cages. The size of the cage housing the Great Horned Owl was 2 × 2 × 2.5 m; for the Barn Owl, 1.3 × 1.6 × 1.6 m; and for both the Long-eared and Burrowing Owls, 1 × 1.6 × 1.6 m. These cages allowed only limited activity.

When the owls were almost one year old, I began six test periods of 4 weeks each which were evenly spaced over one year. The owls were offered a known weight of whole laboratory mice (*Mus musculus*) each day which exceeded their daily intake. Food that remained by morning (not over 12 hours) was retrieved and weighed to determine the amount consumed. To minimize disturbance, the birds were weighed only three times during each test to obtain an average body weight for the period. Regurgitated pellets were collected and recorded daily, air dried for one week, and weighed.

RESULTS AND DISCUSSION

The Great Horned Owl (male) consumed an average of 62.6 g of whole mice per day over the year which amounted to 4.7 percent of its body weight; the Long-eared Owl (female) ate 37.5 g or 12.7 percent of its weight; and the Burrowing Owl (male) ate 26.4 g or 15.9 percent of its weight. The Barn Owl (female) ate 60.5 g daily, 10.1 percent of its weight. Although the Barn Owl was only about half the weight of the Great Horned Owl, it consumed almost as much food per day over the year and ate more than the Great Horned Owl during the colder test periods. In view of this, investigation of the metabolic rate of the Barn Owl for comparison with mea-

TABLE 1

FOOD CONSUMPTION AND PELLET FORMATION RATES IN CAPTIVE OWLS

Test* Period	Mean Food Eaten/day g	Mean Owl Weight g	Percent of Body Weight Eaten	Mean Number Pellets/day	Mean air Temperature °C
Great Horned Owl					
1	69.7	1,409.8	4.9	1.1	–1
2	58.8	1,376.1	4.3	1.1	–2
3	60.6	1,311.1	4.6	1.0	13
4	58.3	1,363.3	4.3	1.2	21
5	57.5	1,265.0	4.6	1.3	19
6	70.4	1,287.6	5.5	1.2	4
Long-eared Owl					
1	42.8	304.3	14.0	1.6	–1
2	41.6	301.2	13.8	1.5	–2
3	25.4	265.5	9.6	1.0	13
4	36.9	285.2	12.9	1.2	21
5	35.5	303.1	11.7	1.3	19
6	41.1	287.6	14.3	1.7	4
Burrowing Owl					
1	29.1	177.0	16.5	1.3	–1
2	—**	—	—	—	–2
3	19.9	167.4	11.9	1.4	13
4	26.4	156.6	16.9	1.4	21
5	22.6	160.0	14.1	1.4	19
6	33.7	169.8	19.9	1.9	4
Barn Owl					
1	72.9	661.0	11.0	2.4	–1
2	64.9	639.5	10.1	1.2	–2
3	46.4	542.6	8.6	1.7	13
4	56.7	576.7	9.8	1.6	21
5	47.3	584.5	8.1	1.3	19
6	74.0	614.5	12.0	1.8	4

* Dates: 1, 24 December to 21 January; 2, 18 February to 17 March; 3, 20 April to 21 May; 4, 19 June to 16 July; 5, 19 August to 15 September; 6, 14 October to 11 November.

** Burrowing Owl unavailable for this period.

surements done by Graber (1962), Collins (1963) and Gatehouse and Markham (1970) on other species of owls should be an interesting area for research. Results of food consumption by each test period are given in Table 1.

Wild owls actively searching for prey and carrying out other activities undoubtedly consume food at a greater rate than do sedentary captives. This is supported and the extent of the increase in consumption is indicated in

TABLE 2

PELLET CHARACTERISTICS OF CAPTIVE OWLS WITH RESPECT TO FOOD CONSUMPTION

Owl	Mean weight Eaten/day g	Mean Pellets/day	Mean weight Eaten/pellet Produced g	Mean pellet Weight/day g
Great Horned	62.6 ± 1.8*	1.2 ± 0.04*	54.5	2.6 ± 0.1*
Long-eared	37.5 ± 1.1	1.4 ± 0.1	26.7	1.4 ± 0.1
Burrowing	26.4 ± 0.9	1.5 ± 0.1	18.1	1.0 ± 0.1
Barn	60.5 ± 1.7	1.7 ± 0.1	41.1	3.2 ± 0.1

* Mean ± SE. All N > 100.

estimates made by a number of investigators from remains found in pellets. Graber (1962) estimated that wild Long-eared Owls in Illinois in winter consumed from 47 to 53 g of food per pellet produced. However, in Norway they were thought to eat about 43 g per day (Hagan, 1965). According to Fitch (1947), Great Horned Owls in California averaged 120 g of food each day. Evans and Emlen (1947) estimated that a Barn Owl in California ate 150 g per day. This may be too high as it was based on two pellets per day and available evidence indicates that American Barn Owls average less than that per day (Wallace, 1948 and this paper). Estimates of daily food consumption during summer in Colorado for wild owls were 119 g for the Great Horned Owl, 60 g for the Long-eared Owl and 110 g for the Barn Owl (Marti, 1970). These estimates give a rough indication of how much more wild owls consume on a daily basis than confined ones do, but they lack consideration of such data as how intake might be affected by size of the owl and time of year.

Table 2 summarizes pellet formation data collected during this study. A greater average daily pellet weight was found for the Barn Owl than for the Great Horned Owl. This is probably because the pellets were not equally dry when weighed. Barn Owl pellets are much more compact than those of the other species and may dry more slowly. None of the pellets contained undigested material other than bone and hair.

SUMMARY

Food consumption and pellet formation rates were studied for one year in captive Great Horned, Long-eared, Burrowing and Barn Owls. Mean food consumption for the whole year in the Great Horned Owl was 4.7 percent of its body weight per day; in the Long-eared Owl, 12.7 percent; in the Burrowing Owl 15.9 percent; and in the Barn Owl, 10.1 percent. Average pellet rates per day for the year were 1.2 for the Great Horned Owl, 1.4 for the Long-eared Owl, 1.5 for the Burrowing Owl and 1.7 for the Barn Owl.

ACKNOWLEDGMENTS

This paper is part of a dissertation in partial fulfillment of the Ph. D. degree at Colorado State University. The work was supported by an NSF Traineeship and the International Biological Program Grassland Biome Study.

LITERATURE CITED

Collins, C. T. 1963. Notes on the feeding behavior, metabolism and weight of the Saw-whet Owl. Condor, 65:528–530.

Craighead, J. J., and F. C. Craighead, Jr. 1956. Hawks, owls and wildlife. Stackpole Co., Harrisburg, Pennsylvania.

Earhart, C. M., and N. K. Johnson. 1970. Size dimorphism and food habits of North American owls. Condor, 72:251–264.

Evans, F. C., and J. T. Emlen. 1947. Ecological notes on the prey selected by a Barn Owl. Condor, 49:3–9.

Fitch, H. S. 1947. Predation by owls in the Sierran foothills of California. Condor, 49: 137–151.

Gatehouse, S. N., and B. J. Markham. 1970. Respiratory metabolism of three species of raptors. Auk, 87:738–741.

Graber, R. R. 1962. Food and oxygen consumption in three species of owls (Strigidae). Condor, 64:473–487.

Hagan, Y. 1965. The food, population fluctuations, and ecology of the Long-eared Owl (*Asio otus* (L)) in Norway. Norwegian State Game Res. Inst. Papers Ser. 2, No. 23.

Marti, C. D. 1970. Feeding ecology of four sympatric owls in Colorado. Unpubl. Ph. D. Thesis, Colorado State Univ., Fort Collins.

Wallace, G. J. 1948. The Barn Owl in Michigan. Tech. Bull. 208, Michigan State College Agric. Expt. Sta., East Lansing.

DEPARTMENT OF ZOOLOGY, WEBER STATE COLLEGE, OGDEN, UTAH 84403, 16 AUGUST 1972.

LATE NEWS FROM THE CHAPEL HILL MEETING

On 19 May at the 54th Annual Meeting of the Wilson Ornithological Society in Chapel Hill, North Carolina the following were elected to office: *President*, Kenneth C. Parkes; *First Vice-President*, Andrew J. Berger; *Second Vice-President*, Douglas A. James; *Secretary*, James Tate, Jr.; *Treasurer*, Jerome A. Jackson; *Editor*, John P. Hubbard; *Elective Member of Council*, George A. Hall. Full details of the meeting will appear in the September issue.

METABOLIC RESPONSES OF MOURNING DOVES TO SHORT-TERM FOOD AND TEMPERATURE STRESSES IN WINTER

Donald L. Ivacic and Ronald F. Labisky

The Mourning Dove (*Zenaidura macroura*) breeds throughout Illinois, but usually migrates southward from the state in autumn. Band recoveries indicate that the majority of doves traversing Illinois in autumn reside during the winter in states bordering the Gulf of Mexico (Hanson and Kossack, 1963). However, small numbers of Mourning Doves, either resident breeders or migrants, often winter in contingents within the species' northern breeding range (McClure, 1943; Chambers et al., 1962), including northern and central Illinois (Hanson and Kossack, 1963); these wintering doves are frequently subjected to severe temperature stresses and food shortages. To illustrate, those doves that wintered in the vicinity of Urbana, Illinois (Latitude 40° 10′ N.), in 1970 were subjected to temperature fluctuations of 17° C and 26° C within 8- and 32-hour periods, respectively, on 20 and 21 February. Furthermore, severe storms that deposit glaze or as much as 6 inches of snow, or both, may occur as many as five times each winter in northern and central Illinois (Changnon, 1969), and may frequently render the seed-eating dove's staple winter foods unavailable.

The findings of many investigators of bird metabolism (Kendeigh, 1944; Seibert, 1949; Dawson and Tordoff, 1959; Misch, 1960; Veghte, 1964; and Pohl, 1969) have indicated that acclimatized birds maintain a relatively constant body temperature by increasing their metabolic expenditures as the ambient temperature decreases. Two recent studies, however, have indicated that Mourning Doves, when subjected to decreasing ambient temperatures, exhibited reductions in metabolic rate and body temperature (R. F. Labisky, unpubl. rept.; Hudson and Brush, 1964).

The objectives of this study were to determine: (1) the short-term metabolic responses of Mourning Doves exposed, without food, to rapidly changing ambient temperatures that extended both above and below their usual acclimatized temperature range in winter; and (2) the survival responses of doves of different sex and age exposed to the stresses of low ambient temperatures and the absence of food.

METHODS

The Mourning Doves used in this study were captured in stationary bait traps on the Max McGraw Wildlife Foundation near Dundee, Illinois, during early June 1969. Adults and juveniles were separated on the basis of plumage characteristics, and banded; sex of the birds was determined by internal examination at the conclusion of the tests. The birds were confined near Urbana, Illinois, throughout the summer, autumn, and winter in a 3.6- × 3.6- × 2.1-m outdoor pen, during which time they were fed water and Purina Mixed Pigeon Grains ad libitum. The doves were subjected to experimentation within the period extending from 19 December 1969 to 25 February 1970. The mean maximum and minimum daily temperatures in Urbana during these months were, respectively: December, 1.4° C and –5.1° C; January, –3.4° C and –12° C; and February, 2.5° C and –7.5° C.

Metabolic rates of doves, as indicated by their rates of oxygen consumption, were determined at ambient temperatures of 10°, 0°, –10°, and –18° C. Consumption of oxygen was ascertained by measuring the amount of oxygen needed to maintain oxygen equilibrium in the 8-liter metabolic chambers used to contain the doves individually during the tests; each system remained open to air flow except during measurement. The chambers were kept in a thermostatically controlled cold room. Each chamber contained a commercial carbon dioxide absorbant (Ascarite) and a desiccant (Drierite) to absorb carbon dioxide and water, respectively. The quantity of pure oxygen that was passed into the closed system during the consumption trials was recorded on an oxygen spirometer for 15 minutes at each experimental temperature; the most stable period of 10 consecutive minutes within the 15-minute interval was used as a measure of the rate of oxygen consumed by the test dove. Rates of oxygen consumption are expressed as cubic centimeters of oxygen consumed per gram body weight per hour (cc O_2-g^{-1}-hr^{-1}) under conditions of standard temperature (0° C) and atmospheric pressure (760 mm Hg).

Experimental trials were conducted in the following manner: four doves (two adults and two juveniles) were captured from their outdoor roosts at the onset of darkness and transported to the indoor facilities; there, they were weighed and permitted to rest briefly before being placed in the metabolic chambers. The chamber temperature at the initiation of the experimental cycle, which began at 5 P.M., was 10° C (Fig. 1). Temperatures were lowered, beginning at 6 P.M., approximately 5° C per hour from the initial 10° C to a low of –18° C; the latter was reached at 1 A.M. Three hours were required to reduce the temperature of the cold room from –10° C to –18° C, the lower limit of the cold room. Temperatures were held constant at –18° C from 1 A.M. to 8 A.M. at which time light was restored; the experimental temperature was then raised at the rate of 5° C per hour until the initial temperature of 10° C was reached at 2 P.M. The doves were held at 10° C for 3 hours, or until 5 P.M. (darkness), and then resubmitted to a second identical 20-hour experimental cycle (Fig. 1). Measurements of oxygen consumption were taken under conditions of darkness at 10° C (6 P.M.), 0° C (8 P.M.), –10° C (10 P.M.), –18° C (1 A.M.), –18° C (7 A.M.), and under conditions of light at –18° C (8 A.M.), –10° C (10 A.M.), 0° C (12 N), and 10° C (2 P.M.). Thus, the experimental photoperiod consisted of 9 hours of light (8 A.M. to 5 P.M.) and 15 hours of darkness; this photoperiod approximated the photoperiod of the winter-acclimatized doves, which averaged 9 hours and 27 minutes of daylight, i.e., 7:15 A.M. (sunrise) to 4:52 P.M. (sunset).

The birds were not fed during the 2 days of experimental cycles. The range of experimental ambient temperatures, the photoperiod, and the absence of food were designed to simulate the exposure of wild doves to a winter storm (i.e., a sharp decrease in temperature accompanied by snow or glaze, or both, which could prevent the obtainment of food by the doves). The doves thus entered the second cycle (at darkness) of decreasing ambient temperatures in a 24-hour fasted state.

Initial body weights of doves were recorded from birds with moderately full crops, whereas final weights were taken after the doves had been fasted throughout the 44-hour experiment. The rates of oxygen consumption were computed for each dove at

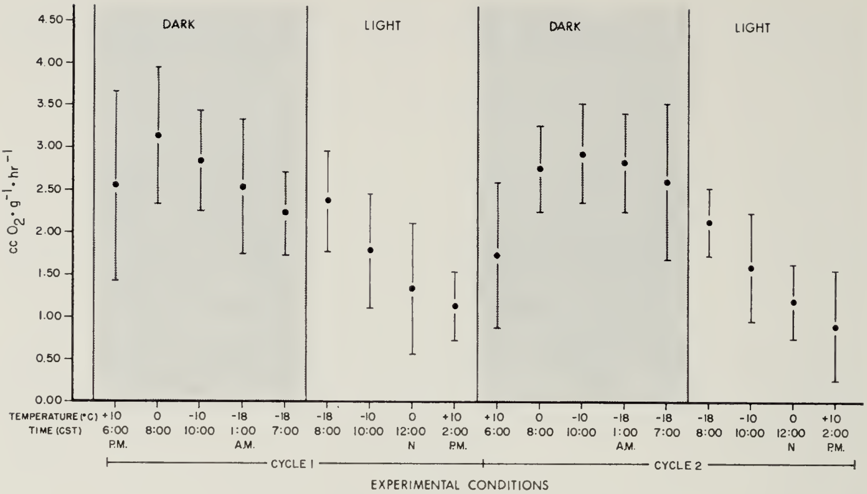


Fig. 1. Oxygen consumption (STP) of all doves (20) during the 44-hour experiment. Circles denote means; vertical lines designate standard deviations.

each test interval after adjustment had been made for a linear loss in body weight between the beginning and end of the 44-hour experiment. Hence, only metabolic rates of doves that survived the experiment, as well as a 24-hour postexperimental period, are reported in this paper; furthermore no individual dove was subjected to an experimental trial more than once during the course of study. The decision to use a linear projection

TABLE 1

MEAN BODY WEIGHTS (G) OF WILD, CAPTIVE DOVES BEFORE AND AFTER EXPOSURE TO 44 HOURS OF EXPERIMENTAL AMBIENT TEMPERATURES WITHOUT FOOD

Age and Sex	Number	Initial Weight (g)	Final Weight (g)	Weight Loss	
				(g)	Percent
Juvenile males	3	136.8 ± 17.3[a]	106.1 ± 3.1	30.7 ± 3.1	22.4 ± 2.3
Juvenile females	7	128.9 ± 7.5[b]	98.6 ± 7.5	30.8 ± 5.8	23.5 ± 4.5
Adult males	3	143.9 ± 7.6[b,c,d]	112.7 ± 7.4[f]	31.2 ± 1.3	21.7 ± 0.9
Adult females	7	130.2 ± 4.0[c]	102.2 ± 3.9[f]	28.0 ± 3.6	21.5 ± 2.8
All males	6	140.4 ± 10.5[e]	109.4 ± 10.5	31.0 ± 2.1	22.1 ± 1.5
All females	14	129.6 ± 6.9[d,e]	100.4 ± 8.9	29.2 ± 5.6	22.5 ± 4.3
All juveniles	10	131.3 ± 9.4	100.8 ± 10.1	30.4 ± 4.8	23.2 ± 3.7
All adults	10	134.3 ± 8.1	105.4 ± 7.6	29.0 ± 3.1	21.6 ± 2.3

[a] Standard deviation.

[b,c,d,e,f] All combinations of means, within columns, were tested for significant differences by *t* analyses; those means followed by the same letter are significantly different ($P < 0.05$).

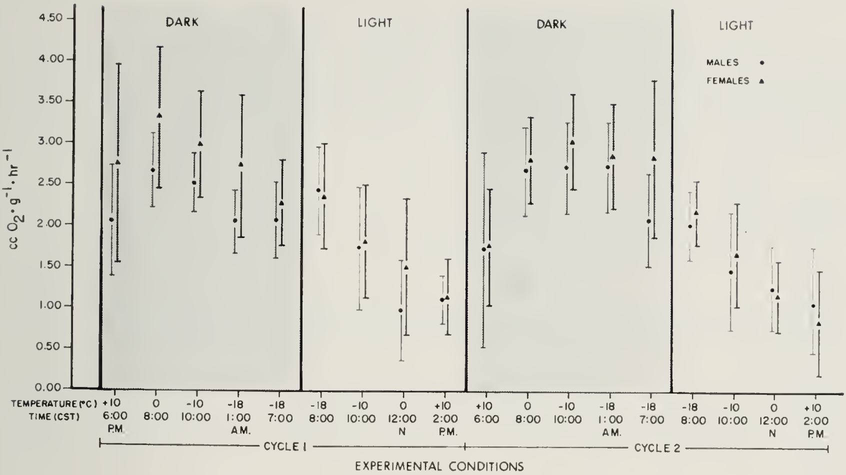


Fig. 2. Comparison of oxygen consumption (STP) of six males (three adults, three juveniles) with 14 females (seven adults, seven juveniles). Symbols denote means; vertical lines designate standard deviations.

of weight loss was considered valid, inasmuch as the weight losses for the doves studied averaged (with attending standard deviations) 18.0 ± 3.6 g and 29.7 ± 4.1 g after 29 and 44 hours of experimentation, respectively. Those metabolic rates measured before the effects of fasting were operative—specifically during the first four test intervals of the first cycle—are the products of counterbalancing factors; the reduction in rates due to those contributions to body weight attributable to metabolically inert components, such as crop contents and alimentary wastes, are principally offset by an increase in rates through specific dynamic action resulting from digestion. The rationale of counterbalancing factors was substantiated by the finding that the overall consumption of oxygen by doves during the first cycle did not differ significantly ($P > 0.05$) from that during the second cycle.

Temperatures in the cloaca and in the pectoral muscle of two doves were measured simultaneously, at each test interval during the 44-hour experiment, with 30-gauge copper-constantan thermocouples, and recorded to the nearest 0.1° C on a battery-operated potentiometer.

The null hypothesis, in all tests for determination of statistical significance, was accepted or rejected at the 0.05 level of probability. When t analyses were used to test for differences between means, appropriate adjustments were made for unequal samples and dissimilar variances.

RESULTS

Weight losses.—The initial mean weights of males, 140.4 g, were 8 percent heavier than those of females, 129.6 g (Table 1). Body weights of adults were similar to those of juveniles, averaging 134.3 g and 131.3 g, respectively. Among specific sex and age groups, significant differences in body weight

Table 2

Mean Oxygen Consumption cc O_2- (g body weight)$^{-1}$-hour^{-1} of Doves at the Different Ambient Temperatures to Which The Birds Were Exposed Without Food During the 44 Hours of Experimentation. Oxygen Measurements are Corrected for STP.

	Time (CST)	6 P.M.	8 P.M.	10 P.M.	1 A.M.	7 A.M.	8 A.M.	10 A.M.	12 N	2 P.M.
Age and/ or Sex	Temp °(C)	10	0	−10	−18	−18	−18	−10	0	10
						Cycle 1				
Juvenile males		1.57	2.66	2.42	1.90	2.00	2.18	1.42	0.79	0.87
(n = 3)		(0.36)[a]	(0.69)	(0.51)	(0.49)	(0.63)	(0.62)	(0.17)	(0.69)	(0.16)
Juvenile females		3.36	3.44	3.00	2.29	2.21	2.30	1.79	1.89	1.33
(n = 7)		(1.11)	(1.09)	(0.80)	(0.47)	(0.41)	(0.57)	(0.72)	(0.93)	(0.42)
Adult males		2.58	2.71	2.64	2.23	2.14	2.68	2.04	1.18	1.35
(n = 3)		(0.49)	(0.17)	(0.17)	(0.17)	(0.33)	(0.37)	(0.76)	(0.57)	(0.13)
Adult females		2.18	3.20	2.95	3.16	2.21	2.41	1.82	1.10	0.96
(n = 7)		(1.04)	(0.61)	(0.49)	(0.96)	(0.63)	(0.74)	(0.69)	(0.45)	(0.45)
All juveniles		2.83	3.21	2.83	2.17	2.15	2.26	1.68	1.56	1.18
(n = 10)		(1.26)	(1.02)	(0.75)	(0.49)	(0.47)	(0.55)	(0.70)	(0.98)	(0.41)
All adults		2.30	3.05	2.86	2.89	2.19	2.49	1.88	1.13	1.08
(n = 10)		(0.90)	(0.56)	(0.44)	(0.91)	(0.54)	(0.64)	(0.68)	(0.46)	(0.41)
All males		2.08	2.68	2.53	2.06	2.07	2.43	1.73	0.98	1.11
(n = 6)		(0.67)	(0.45)	(0.36)	(0.38)	(0.46)	(0.53)	(0.74)	(0.61)	(0.29)
All females		2.77	3.32	2.98	2.72	2.28	2.35	1.81	1.50	1.14
(n = 14)		(0.12)	(0.86)	(0.64)	(0.86)	(0.51)	(0.64)	(0.68)	(0.82)	(0.46)
All doves		2.56	3.13	2.84	2.52	2.21	2.37	1.78	1.34	1.13
(n = 20)		(1.10)	(0.81)	(0.60)	(0.80)	(0.49)	(0.59)	(0.67)	(0.78)	(0.41)

occurred between adult males and juvenile females and between adult males and adult females, the males being heavier than the females.

Weight losses among doves exposed to the 44-hour experimental trial without food were similar both between ages and sexes (Table 1). Interestingly, proportionate weight losses among the sex and age groups were the lowest and least variable for adult males, and the greatest and most variable for juvenile females; the difference, however, was not statistically significant.

Metabolic expenditures.—The doves did not progressively increase their oxygen consumption (and hence, metabolic expenditures) as ambient tem-

TABLE 2—*Continued*

Age and/ or Sex	Time (CST)	6 P.M.	8 P.M.	10 P.M.	1 A.M.	7 A.M.	8 A.M.	10 A.M.	12 N	2 P.M.	Mean Sums
	Temp. °(C)	10	0	−10	−18	−18	−18	−10	0	10	
					Cycle 2						
Juvenile males		1.29	2.36	2.40	2.50	2.07	1.79	1.61	1.39	1.33	32.50[b,c]
(n = 3)		(0.50)	(1.05)	(0.48)	(0.32)	(0.72)	(0.34)	(1.09)	(0.32)	(0.95)	(5.62)
Juvenile females		2.01	2.89	3.39	3.21	3.13	2.10	1.55	1.34	0.65	42.18[b,d]
(n = 7)		(0.63)	(0.43)	(0.61)	(0.72)	(1.18)	(0.44)	(0.63)	(0.43)	(0.45)	(4.42)
Adult males		2.14	3.00	3.03	3.00	2.11	2.25	1.32	1.12	0.81	38.33
(n = 3)		(1.64)	(0.65)	(0.50)	(0.63)	(0.51)	(0.38)	(0.03)	(0.71)	(0.32)	(5.34)
Adult females		1.51	2.72	2.68	2.58	2.55	2.26	1.77	0.97	0.89	37.86
(n = 7)		(0.75)	(0.62)	(0.24)	(0.26)	(0.62)	(0.36)	(0.67)	(0.36)	(0.59)	(5.05)
All juveniles		1.79	2.73	3.10	2.99	2.81	2.01	1.57	1.36	0.95	39.28
(n = 10)		(0.66)	(0.44)	(0.73)	(0.70)	(1.14)	(0.42)	(0.72)	(0.38)	(0.80)	(6.48)
All adults		1.70	2.80	2.79	2.67	2.42	2.26	1.64	1.02	0.87	38.00
(n = 10)		(1.05)	(0.60)	(0.35)	(0.43)	(0.60)	(0.35)	(0.59)	(0.45)	(0.50)	(4.35)
All males		1.72	2.68	2.72	2.74	2.09	2.02	1.47	1.26	1.07	35.42[d]
(n = 6)		(1.18)	(0.54)	(0.56)	(0.53)	(0.56)	(0.41)	(0.71)	(0.51)	(0.69)	(5.81)
All females		1.76	2.81	3.04	2.86	2.84	2.18	1.66	1.16	0.84	40.02[c]
(n = 14)		(0.46)	(0.71)	(0.58)	(0.63)	(0.95)	(0.39)	(0.63)	(0.43)	(0.64)	(4.80)
All doves		1.74	2.77	2.94	2.83	2.61	2.13	1.60	1.19	0.91	38.64
(n = 20)		(0.85)	(0.51)	(0.58)	(0.59)	(0.91)	(0.40)	(0.64)	(0.44)	(0.65)	(5.42)

[a] Standard deviation.

[b,c,d] All combinations of mean sums were tested for significant differences by *t* analyses; those followed by the same letter are significantly different ($P < 0.05$).

peratures decreased from 10° to −18° C during the first cycle (Figs. 1–3; Table 2). The greatest oxygen consumption by doves occurred at 0° C of the first cycle, i.e., during the first exposure to a decreasing temperature gradient and darkness. Oxygen consumption decreased successively at −10°, at −18° C, and during the holding period of 7 hours at −18° C in darkness. Oxygen consumption increased slightly at −18° C after the lights were turned on at 08:00, but then decreased progressively in response to the steadily increasing temperature gradient (−10° C to 10° C) during the subsequent 6 hours. Oxygen consumption during the second experimental cycle followed a pattern similar to that observed during the first cycle (Figs. 1–3; Table 2).

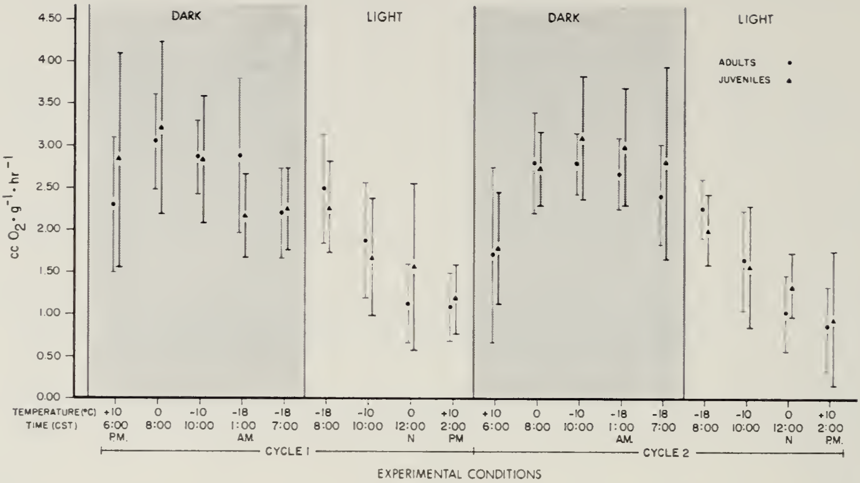


Fig. 3. Comparison of oxygen consumption (STP) of 10 adults (three males, seven females) with 10 juveniles (three males, seven females). Symbols denote means; vertical lines designate standard deviations.

In fact, among the nine measurement periods common to both cycles, the mean consumption of oxygen by doves, sex and age ignored, differed significantly ($P < 0.05$) only under conditions of darkness at 10° C, i.e., the first test of each cycle. In the final analysis, however, there was no significant difference ($P > 0.05$) between the total consumption of oxygen by doves during the first and second cycles. The diurnal pattern of oxygen consumption by the doves subjected to this experiment is best described by a nonlinear model (Fig. 4).

The differences between the rates of oxygen consumption during darkness and a decreasing temperature gradient (excluding the measurement at –18° C. 7 A.M.) and those during light and an increasing temperature gradient were significant ($P > 0.05$) for both cycles, singly and combined. In fact, the rates of oxygen consumption, all doves and both cycles considered, differed significantly ($P < 0.05$) for each test temperature (10°, 0°, –10°, and –18° C) between conditions of darkness and light, being greater in darkness in all cases: the direction of the temperature gradient was ignored in these comparisons. These observations suggested that the rate of oxygen consumption was influenced either by light or by the direction of the temperature gradient, or both.

To investigate the relationship of light and ambient temperature to metabolic expenditures, three birds (juvenile males) were tested under a reverse

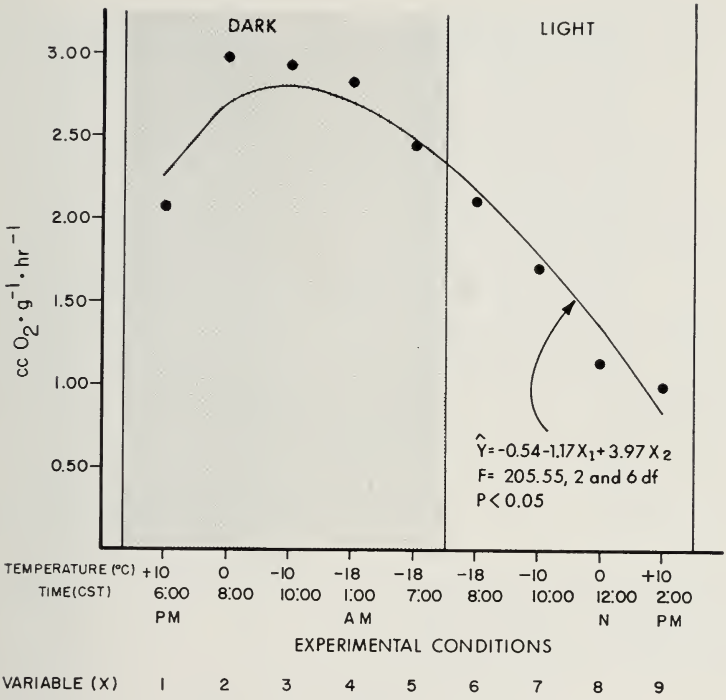


FIG. 4. Diurnal pattern of oxygen consumption (STP) of all doves (20) subjected to a simulated 2-day winter storm in the absence of food; cycles 1 and 2 were combined for this analysis. These data yielded significant departures from linearity ($P < 0.05$).

cycle of light and temperature; that is, temperatures were decreased during light and increased during darkness. These birds showed the same pattern of response to increasing and decreasing temperatures as those juvenile males functioning in the light-temperature conditions of the standard experimental trial employed in this study (Fig. 5). Oxygen consumption by these doves differed significantly ($P < 0.05$) between conditions of light and decreasing temperatures and those of darkness and increasing temperatures, being greater under the former conditions. These findings indicated that the metabolic expenditures of doves were more in response to ambient temperatures than to light. However, an increased response to light is indicated by the greater oxygen consumption during the period of decreasing temperatures and light of this particular test, when compared with the period of decreasing temperatures and darkness of the standard test; this difference was statistically significant also ($P < 0.05$). This latter response reflects the additive effects of light and decreasing temperature on metabolic rates.

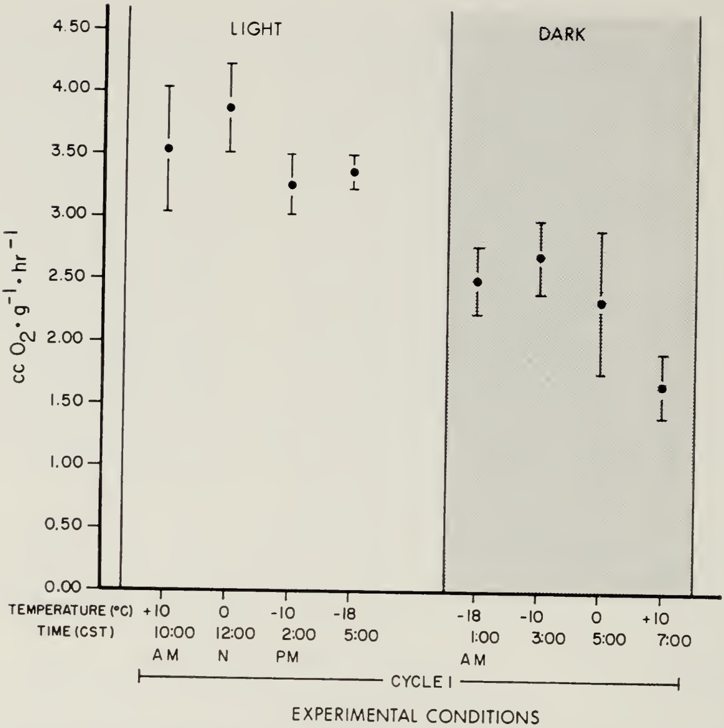


FIG. 5. Oxygen consumption (STP) of three, juvenile male doves subjected to 20 hours of a reversed light-temperature gradient (temperature decreased during light, increased during darkness). Circles denote means; vertical lines designate standard deviations.

The patterns of metabolic responses of doves exposed both to increasing and to decreasing ambient temperatures were related strongly to the direction of the ambient temperature gradient, and not just to temperature per se (Figs. 1–4). In fact, once the directional gradient of either increasing or decreasing ambient temperature was operative, the metabolic responses of the doves were seemingly in anticipation of continuing predictive changes along the thermal gradient.

Female doves had rates of oxygen consumption that exceeded those of males in 15 of 18 tests, but the overall difference between the sexes was not statistically significant (Table 2; Fig. 2). Neither was the rate of oxygen consumption by juveniles significantly different from that of adults. However, rates of oxygen consumption by juvenile males were significantly different—in this case, lower—from juvenile females and from all females, age ignored (Table 2).

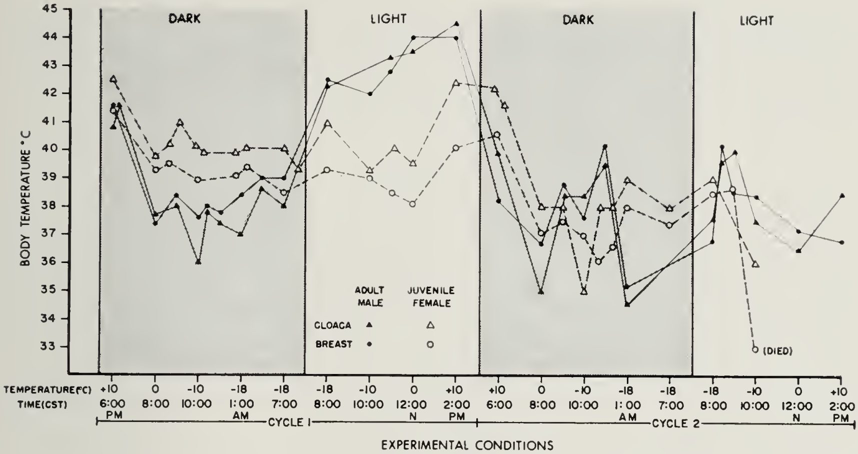


FIG. 6. Cloacal and pectoral temperatures of two doves, fitted with thermocouples, during the 44-hour experiment.

An analysis of variance, testing the mean sums of oxygen consumption at the 18 test temperatures by sex and age groups, revealed a significant interaction between sex and age ($P < 0.05$), although neither the difference due to sex alone nor to age alone was significant ($P > 0.05$).

Body temperature.—Our measurements of body temperature of doves, being limited to one adult male and one juvenile female, were meager. The adult male, however, exhibited noticeably greater flexibility than the juvenile female in reducing body temperature under conditions of declining ambient temperatures, and in increasing body temperature under conditions of ascending ambient temperatures (Fig. 6). Furthermore, the thermoregulatory ability of the juvenile female appeared to decline rapidly after 36 hours of exposure to the simulated winter storm, in the absence of food. The cloacal temperature of the adult male ranged from 34.5° to 44.5° C, whereas that of the juvenile female ranged from 35.2° to 42.5° C. The normal daytime body temperature of a resting Mourning Dove is 41.5° C; the nighttime temperature is about 2 degrees lower (Bartholomew and Dawson, 1954).

The relationship between body temperature and oxygen consumption was principally inverse for the doves exposed to the conditions of this experiment (Figs. 1–6), which propounded the presence of a compensatory feedback mechanism.

Survival ability.—Several doves were deliberately exposed to the previously described experimental cycles until they succumbed. Two juvenile males died after 36 and 67 hours of experimentation, losing, respectively, 31.7 g (24.3

percent) and 42.4 g (30.4 percent) of their initial body weight. Two adult females died after 62 and 72 hours of exposure, with respective weight losses of 32.7 g (26.8 percent) and 35.6 g (28.0 percent). One adult male lost 48.2 g (33.5 percent) prior to death after 108 hours of exposure.

DISCUSSION

Although many investigators have studied the effects of lowered ambient temperature on metabolic rates and body temperatures of birds (Kendeigh, 1944; Steen, 1957; Dawson, 1958; Misch, 1960; Hart, 1962; and Pohl, 1969), most have used a series of stable temperatures to measure the metabolic rates; only a few workers have measured metabolic rates under conditions of fluctuating ambient temperatures (Veghte, 1964; Pohl, 1969).

This study was designed specifically to measure the short-term metabolic responses of winter-acclimatized Mourning Doves to the food and temperature stresses placed on them by a simulated winter storm. Oxygen consumption was measured as ambient temperatures were decreased progressively from 10° C to –18° C in darkness, and then increased progressively to 10° C in light during each day of a 2-day experiment; food was not available to the doves during the 44-hour experimental trial.

The doves, under the prescribed experimental conditions, showed a greater metabolic response to directional gradients of either increasing or decreasing ambient temperatures than to actual temperatures. The rate of oxygen consumption was greater, and significantly different ($P < 0.05$), under a decreasing temperature gradient and darkness than under an increasing temperature gradient and light (Figs. 1–4). Furthermore, the rate of oxygen consumption by doves exposed to cycles of decreasing temperature and light and of increasing temperature and darkness, conditions opposite of those in the standard cycles, was dependent principally on ambient temperature gradients and not on light (Fig. 5). Thus, we concluded that rising or falling temperature gradients had a greater effect on oxygen consumption, under the experimental conditions of this study, than did either ambient temperatures per se or light.

The doves in this study did not exhibit the usual straight-line dependency between metabolic rates and decreasing ambient temperatures as reported for small birds by other investigators (Kendeigh, 1944; Seibert, 1949; Dawson and Tordoff, 1959; Misch, 1960; and West, 1962). In the present study, doves showed an increase in oxygen consumption as ambient temperatures decreased from 10° C to –10° C in darkness (Fig. 4), but then showed a decrease in oxygen consumption as the temperature decreased to –18° C and as the duration of exposure to the latter temperature increased. Thus, we believe that Mourning Doves, when exposed to the stresses of low ambient temperatures and the absence of food during winter, possess a physiological mechanism that allows them to substantially reduce their body temperature and, correspondingly, their metabolic expenditures. These conclusions are supported by the findings of R. F. Labisky (unpubl. rept.) and Hudson and Brush (1964), who studied the metabolic requirements and body temperatures of Mourning Doves in response to decreasing ambient temperatures. Labisky showed lower metabolic rates at 4° C and –1° C than at 10° C in three species of winter-acclimatized small birds, including the Mourning Dove. Although such a pattern of decreased oxygen consumption might be interpreted as indicative of exhausted glucose reserves, Labisky, after testing the birds at 4° C and –1° C, restored the ambient temperature to 10° C and found that the metabolic rate of the doves reverted to its earlier value at the same temperature; the decrease in oxygen consumption at low ambient temperatures was therefore not attributable to a depletion of energy reserves. Labisky hypothesized that the apparent mechanism that allowed the doves and other small birds to reduce their body temperature and metabolic requirements when ambient temperatures were frigid and food was scarce would have positive survival benefits to the species so exposed to winter adversities.

Hudson and Brush (1964) reported that metabolic expenditures, body temperatures, and cardiac rates of Mourning Doves were lowered when the birds were subjected to reduced ambient temperatures. They therefore concluded that below the lower critical temperature (30° C) for the dove, body temperature decreased with a resultant decrease in the value of thermal conductance; hence, a conservation of metabolic effort was executed. (Thermal conductance is the metabolic rate divided by the difference between the body temperature and the ambient temperature: $C = MR/T_B\text{-}T_A$.)

All the physiological measurements that we recorded for the doves subjected to simulated winter storms, i.e., low ambient temperatures coupled with the absence of food, suggested that Mourning Doves wintering in the northern regions of the U.S. possessed sex- and age-associated differences as regards their potential survival ability. To illustrate, among the four sex and age groups of doves exposed to the 44-hour experimental trial, adult males were initially the heaviest and proportionately lost the least body weight, whereas juvenile females were the lightest and lost proportionately the most weight (Table 1). And in the endurance tests, heavier doves, in general, survived longer than lighter doves; one adult male, the heaviest dove subjected to the endurance tests, survived 108 hours of testing prior to death, or 38 hours longer then his nearest competitor. Observations, though only meagerly substantiated, hinted that adult doves possessed a greater ability to thermoregulate under conditions of alternately decreasing and increasing ambient temperatures (Fig. 6)—thereby conserving energy—than did juveniles. Therefore, adult doves (particularly males) because of the influence of age or superior weight, or both, seemed better equipped physiologically than juveniles (particularly females) to withstand the rigors of northern winters.

These findings of differences in the survival abilities of doves offer a potential explanation for the changes in sex and age structure that occur among flocks of doves wintering north of their normal winter range. To illustrate, Chambers et al. (1962), who studied flocks of doves wintering in northern Missouri, found that between November and March, changes in age ratios favored adults and changes in sex ratios favored males. Explanations for changes in sex and age structure among such wintering flocks of doves have included: a higher autumnal migration rate among juveniles than among adults (Austin, 1951; Tomlinson et al., 1960); a greater attachment to northern breeding sites by adults than by juveniles (Chambers et al., 1962); a greater tendency for males to winter farther north than do females (Quay, 1951); and a higher mortality rate among juveniles than among adults (Austin, 1951). Our findings indicate that one of the major factors contributing to the skewness toward males in sex ratios and toward adults in age ratios among flocks of Mourning Doves wintering in the northern U.S. is related to physiological differences in the survival ability among doves of different sex and age.

SUMMARY

Winter-acclimatized Mourning Doves were subjected to a photoperiod and an ambient temperature range designed to simulate conditions of a severe winter storm, common to central Illinois. Metabolic rates were recorded for two daily cycles of decreasing temperatures (10° C to –18° C) in darkness and increasing temperatures (–18° C to 10° C) in light; the doves were fasted throughout the 44-hour experiment.

Juvenile doves had higher metabolic rates than adults, and females had higher rates than males, but neither difference was statistically significant ($P > 0.05$). The metabolic rates of doves were greater during exposure to decreasing ambient temperatures and darkness than during exposure to increasing ambient temperatures and light, the difference being statistically significant ($P < 0.05$). The doves responded metabolically more to the directional temperature gradient than to either actual ambient temperature or light.

The consumption of oxygen by doves did not follow a straight-line increase with concurrent declines in ambient temperatures. Oxygen consumption was not only less at –18° C than at –10° C (in darkness), but also diminished with extended exposure at –18° C. These observations suggested that Mourning Doves employed a physiological mechanism (perhaps reduced body temperature) to decrease their metabolic expenditures at low ambient temperatures; the mechanism permits the conservation of energy and thus augments survival.

The potential survival ability of doves exposed to simulated winter storms was related

to sex and age attributes. Adult doves (particularly males), because of their age or greater weight, or both, were better equipped physiologically than juveniles (particularly females) to survive the stresses of low ambient temperatures without food. Thus, among Mourning Doves wintering in the northern and central U.S., the autumn-to-spring changes in sex ratios and in age ratios, which usually favor males and adults, respectively, probably reflect the differential survival abilities of the sex and age cohorts.

ACKNOWLEDGMENTS

Sincere appreciation is extended to the staff of the Max McGraw Wildlife Foundation, Dundee, Illinois, for their assistance in capturing the doves for study. S. Charles Kendeigh, University of Illinois, Urbana, and Sheldon Lustick, The Ohio State University, Columbus, generously offered advice on the technical presentation of the findings. Helen C. Schultz and Glen C. Sanderson, Illinois Natural History Survey, Urbana, offered editorial suggestions.

LITERATURE CITED

Austin, O. L., Jr. 1951. The Mourning Dove on Cape Cod. Bird-Banding, 22:149–174.

Bartholomew, G. A., Jr., and W. R. Dawson. 1954. Body temperature and water requirements in the Mourning Dove, *Zenaidura macroura marginella.* Ecology, 35: 181–187.

Chambers, G. D., H. M. Wight, and T. S. Baskett. 1962. Characteristics of wintering flocks of Mourning Doves in Missouri. J. Wildl. Mgmt., 26:155–159.

Changnon, S. A., Jr. 1969. Climatology of severe winter storms in Illinois. Illinois State Water Surv. Bull. 53.

Dawson, W. R. 1958. Relation of oxygen consumption and evaporative water loss to temperature in the Cardinal. Physiol. Zoöl. 31:37–48.

Dawson, W. R., and H. B. Tordoff. 1959. Relation of oxygen consumption to temperature in the Evening Grosbeak. Condor, 61:388–396.

Hanson, H. C., and C. W. Kossack. 1963. The Mourning Dove in Illinois. Illinois Dept. Conserv. Tech. Bull. No. 2.

Hart, J. S. 1962. Seasonal acclimatization in four species of small wild birds. Physiol. Zoöl., 35:224–236.

Hudson, J. W., and A. H. Brush. 1964. A comparative study of the cardiac and metabolic performance of the dove, *Zenaidura macroura,* and the quail, *Lophortyx californicus.* Comp. Biochem. Physiol., 12:157–170.

Kendeigh, S. C. 1944. Effect of air temperature on the rate of energy metabolism in the English Sparrow. J. Exp. Zool., 96:1–16.

McClure, H. E. 1943. Ecology and management of the Mourning Dove, *Zenaidura macroura* (Linn.), in Cass County, Iowa. Iowa Agr. Exp. Sta. Res. Bull. 310: 355–415.

Misch, M. S. 1960. Heat regulation in the Northern Blue Jay, *Cyanocitta cristata bromia* Oberholser. Physiol. Zoöl., 33:252–259.

Pohl, H. 1969. Some factors influencing the metabolic response to cold in birds. Federation Proc., 28:1059–1064.

Quay, T. L. 1951. Mourning Dove studies in North Carolina. North Carolina Wildl. Resources Comm.

Seibert, H. C. 1949. Differences between migrant and non-migrant birds in food and water intake at various temperatures and photoperiods. Auk, 66:128–153.

STEEN, J. 1957. Food intake and oxygen consumption in pigeons at low temperatures. Acta Physiol. Scandinavica, 39:22–26.

TOMLINSON, R. E., H. M. WIGHT, AND T. S. BASKETT. 1960. Migrational homing, local movement, and mortality of Mourning Doves in Missouri. Trans. 25th N. Amer. Wildl. and Nat. Resources Conf., 253–266.

VEGHTE, J. H. 1964. Thermal and metabolic responses of the Gray Jay to cold stress. Physiol. Zoöl., 37:316–328.

WEST, G. C. 1962. Responses and adaptations of wild birds to environmental temperature. *In* Comparative Physiology of Temperature Regulation, Part 3, J. P. Hannon and E. Viereck (Ed.) Arctic Aeromed. Lab., pp. 291–333.

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS (PRESENT ADDRESS: DEPARTMENT OF BIOLOGICAL SCIENCES, ROCK VALLEY COLLEGE, ROCKFORD, ILLINOIS 61111) AND SECTION OF WILDLIFE RESEARCH, ILLINOIS NATURAL HISTORY SURVEY, URBANA, ILLINOIS 61801, 25 MAY 1972.

ANNOUNCEMENT

The Nuttall Ornithological Club is sponsoring a symposium, "Avian Energetics," as part of its centennial celebration. This symposium will be presented on 10 October 1973 in conjunction with the 91st Stated Meeting of the American Ornithologists' Union at Provincetown, Cape Cod, Massachusetts. Speakers will include Robert E. Ricklefs (reproductive strategies of birds in relation to energetics), William A. Calder (energetics and size in birds), James R. King (seasonal allocation of energy resources by birds), and Vance A. Tucker (energetics of avian flight). George A. Bartholomew, S. Charles Kendeigh, and Eugene P. Odum will participate as discussants. The symposium has been organized and will be chaired by William R. Dawson. The entire symposium will be published by the Nuttall Club. For further information contact: Nuttall Ornithological Club, c/o Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts 02138.

REPRODUCTIVE FAILURES OF DOUBLE-CRESTED CORMORANTS IN SOUTHERN CALIFORNIA AND BAJA CALIFORNIA

Franklin Gress, Robert W. Risebrough, Daniel W. Anderson,
Lloyd F. Kiff, and Joseph R. Jehl, Jr.

Double-crested Cormorants (*Phalacrocorax auritus*) have been considered a common resident of the Channel Islands of southern California and the islands of western Baja California (Grinnell, 1928; Grinnell and Miller, 1944; Howell, 1917). Because the breeding colonies are frequently on inaccessible terrain, data on the numbers of breeding birds and of breeding biology in general are few. The largest breeding colonies of the Channel Islands apparently were on Prince Island (an islet near San Miguel Island) (Willett, 1910), Anacapa Island (Howell, 1917; Banks, 1966) and Santa Barbara Island (Howell, 1917; Wright and Snyder, 1913). Along the west coast of Baja California, Grinnell (1928) reported that breeding colonies of Double-crested Cormorants were present on virtually every island from Los Coronados south to Santa Margarita. The largest colony, on San Martín Island, was estimated at 350,000pairs (Wright, 1913), an estimate that is likely exaggerated. Bent (1922) considered this to be the largest colony of Double-crested Cormorants ever recorded. The species was also abundant on Los Coronados early in this century (Howell, 1917; Wright, 1909), but there are no published estimates of colony size. L. M. Huey (unpublished field notes) estimated the Los Coronados colony at "fully a thousand pairs" in 1916. By 1920 he noted a great decrease, which he attributed to disturbance by tourists during the nesting season. By 1924 he estimated the colony at 200 pairs; in 1926 he found only "a few" pairs still nesting on North Island.

Double-crested Cormorants in southern California and northwestern Mexico typically nest on steep rocky slopes or hillsides among Brown Pelicans (*Pelecanus occidentalis*). The nests are bulky structures constructed primarily of sticks and resemble those of pelicans. The cormorants generally breed from late April through June, although nesting activities may continue as late as August in some years (Willett, 1933). The clutch usually consists of three or four eggs, but may number up to seven (Bent, 1922). Cormorants, like pelicans, may suffer heavy losses of eggs to gull predation (Howell, 1917).

Breeding failures of Brown Pelicans in several west coast colonies was first observed in 1969, following several suggestions of abnormal reproduction of fish-eating birds in southern California. Virually no young pelicans were fledged on either Anacapa or Los Coronados in 1969 and 1970, and hatching success was reduced in the colonies at San Martín Island and San Benitos Islands. All Brown Pelican colonies in the United States and northwestern Mexico produced thin-shelled eggs in 1969 and 1970. Eggshell thickness in the Florida colonies averaged 9 percent thinner than that of eggs laid before 1945. On the West Coast shell thinning was considerably more severe. Decrease in shell thickness averaged as much as 50 percent in some west coast colonies, and, as a result, most eggs broke during incubation. The degree of shell thinning was shown to be closely dependent upon the concentrations of the DDT metabolite DDE in the lipid of the yolks, but was not influenced by polychlorinated biphenyls (PCB) (Gress, 1970; Jehl, 1973; Risebrough, 1972; Risebrough, Sibley, and Kirven, 1971; Schreiber and Risebrough, 1972).

During visits to the west coast pelican colonies in 1969, we found that the Double-crested Cormorants had also experienced reproductive failures caused by excessive thinning of the eggshells. On the west islet of Anacapa Island there were 76 nesting attempts in two colonies in 1969. Neither colony produced young. The pattern of reproductive failures and nest abandonment was similar to that observed in the pelican colony. Thin-shelled eggs, which had been crushed and discarded from the nests, were strewn about the colony site. Ten of these crushed shells and seven intact eggs were collected on 13 May (L.F.K.). The colony on South Los Coronados Island, too, was littered with crushed, thin-shelled eggs and fragments: 32 active nests produced only one young in 1969. Six intact eggs and 17 broken shells were collected on 6 June (J.R.J.). The cormorant colony on San Martín Island numbered approximately 5000 in 1969 and appeared to be having no reproductive problems. Seven intact eggs from individual clutches were collected on 12 June by J.R.J.

METHODS

The eggshells collected were classified as either "intact" or "crushed." Intact eggs were those which were whole when collected; crushed eggs had been broken during incubation. The intact eggs were measured for shell weight, length, breadth, and thickness using methods described by Anderson and Hickey (1970). An index of shell thickness (Ratcliffe, 1967) was calculated by dividing ten times the weight of the shell (in grams) by the length times the breadth (in cm^2). Thickness of the shell at the girth was the only measurement possible of the crushed eggs. These data were then compared with those of museum specimens originally collected from the coastal islands of southern California and northwestern Baja California prior to 1946 and now preserved in the Museum of Vertebrate Zoology, University of California, Berkeley, and the Western Foundation of Vertebrate Zoology, Los Angeles. The parameters examined, length, breadth, weight, and thickness, showed no significant geographical variation between

TABLE 1

COMPARISON OF MEANS (WITH 95 PERCENT CONFIDENCE LIMITS) OF SHELL MEASUREMENTS BETWEEN INTACT EGGS COLLECTED IN 1969 AND PRE-1946 MUSEUM SPECIMENS

	N	Shell weight (g)	Length (mm)	Breadth (mm)	Thickness (mm)	Thickness index[1]
Museum specimens	134	4.70 ±0.08	60.12 ±0.54	37.56 ±0.23	0.43[2] ±0.01	2.08 ±0.03
Anacapa	7	3.77 ±0.34	58.84 ±2.23	39.87 ±0.56	0.38 ±0.02	1.60 ±0.10
Los Coronados	6	2.97 ±0.44	58.58 ±3.31	37.33 ±2.54	0.30 ±0.03	1.35 ±0.12
San Martín	7	4.90 ±0.59	58.50 ±1.96	38.29 ±1.36	0.44 ±0.02	2.19 ±0.21
All colonies	20	3.93 ±0.44	58.65 ±1.13	38.56 ±0.87	0.38 ±0.03	1.73 ±0.18

[1] weight (g) × 10/length (cm) × breadth (cm)
[2] $n = 29$ (museum thickness measurements)

the colonies in southern California and those in northwestern Baja California. These data were therefore pooled for comparison with recent eggs.

The 20 intact cormorant eggs collected in 1969 were analyzed for chlorinated hydrocarbon residues. The yolks were ground with anhydrous sodium sulphate to a dry, homogeneous mixture from which the lipids were extracted with a 2:1 hexane-acetone mixture refluxing in a Soxhlet apparatus for eight hours. The average amount of lipid extracted from each egg was 1.58 ± 0.17 (95 percent C.L.) or 4.24 percent of the total wet-weight contents. This value is in close agreement with the lipid content of 4.26 percent in the eggs of Double-crested Cormorants from interior North America (Anderson, et al., 1969). A sub-sample of lipid was analyzed using the methodology of Risebrough, Florant, and Berger (1970).

Anderson, et al. (1969) studied the relationships between chlorinated hydrocarbons and shell thinning of populations of Double-crested Cormorants in interior North America. The cormorants breeding in Wisconsin were among the first fish-eating species to show regional population declines (Anderson and Hamerstrom, 1967). A comparison of the residue levels and shell thickness among 11 midwestern colonies showed that thinner shelled eggs contained higher concentrations of both DDE and PCB. To compare the relationship found between shell thinning and residue levels in the fresh-water colonies of the Midwest with those in the west coast marine environment, we have reanalyzed the data from the midwestern colonies studied by Anderson, et al. (1969). Analysis of variance was used to determine the significance of the regression of thickness on DDE. Some of these samples had consisted of pools of two or three eggs. The variance of both DDE and thickness measurements of the group of pooled samples was not significantly different ($p > 0.05$) from those of the group of individual egg samples. Pooled and individual samples were therefore considered together in the consideration of the regression of thickness on DDE among eggs from the Midwest.

TABLE 2

THICKNESS OF CRUSHED EGGSHELLS AND OF SHELLS OF INTACT EGGS FROM ANACAPA AND LOS CORONADOS (1969), WITH PERCENTAGE DECREASE FROM PRE-1946 SPECIMENS

	N	Mean thickness (mm) (± 95% C.L.)	Percentage decrease
		Anacapa	
intact	7	0.383 ± 0.024	–10.5
crushed	10	0.251 ± 0.029	–41.4
combined	17	0.305 ± 0.039	–28.8
		Los Coronados	
intact	6	0.298 ± 0.032	–30.4
crushed	17	0.252 ± 0.017	–41.2
combined	23	0.264 ± 0.016	–38.3

RESULTS AND DISCUSSION

Mean values of measurements of the intact eggs collected in 1969 from each colony and the average of the combined samples, together with museum measurements, are summarized in Table 1. The Anacapa eggs have significantly lowered shell weights and shell-thickness indices and significantly thinner shells than the museum specimens ($p < 0.05$). The length of the Anacapa shells shows no significant differences from the mean length of museum specimens. The recent eggs, however, show a greater breadth, which we attribute to sampling error. The eggs from Los Coronados also have reduced thickness indices and shell weight, and thinner shells ($p < 0.05$). Neither the breadth nor the length of the 1969 Los Coronados eggs are different from those collected prior to 1946. The San Martín eggshells show no significant differences of any of the parameters from the museum specimens.

Mean thickness of both crushed and intact eggs and of the combined samples collected on Los Coronados and Anacapa are given in Table 2. No crushed eggs were found on San Martín. The mean shell thicknesses of crushed eggs collected on both Anacapa and Los Coronados are significantly lower than the thickness of the intact eggs collected from these colonies ($p < 0.05$). The eggshells collected from both islands in 1969 ($N = 40$) show a combined decrease in mean thickness of 34.2 percent from museum eggs taken prior to 1946.

The arithmetic mean and concentration range of values of the DDT compounds and PCB found in the lipids of yolks from eggs of each colony are

TABLE 3

MEAN CONCENTRATIONS OF DDT COMPOUNDS AND PCB IN PARTS PER MILLION IN YOLK LIPIDS OF DOUBLE-CRESTED CORMORANT EGGS COLLECTED IN 1969

(THE RANGE OF CONCENTRATIONS IS LISTED IN PARENTHESES.)

Colony	N	p,p′-DDE	PCB	p,p′-DDD	p,p′-DDT
Anacapa	7	754 (510–1,000)	87 (55–130)	2.1 (0.66–6.8)	7.0 (0.0–11)
Los Coronados	6	574 (180–1,300)	422 (66–1,100)	13.8 (3.6–36)	5.5 (0.0–12)
San Martín	7	41.4 (24–63)	17.6 (12–25)	not detected	0.28 (0.14–0.41)

listed in Table 3. The mean DDE concentrations in the Anacapa and Los Coronados eggs, 754 ppm and 574 ppm respectively on a lipid basis, or about 32 ppm and 24 ppm on a wet-weight basis assuming 4.2 percent lipid, is considerably higher than in the eggs from San Martín where no reproductive failure nor obvious shell thinning was observed. These levels were also much higher than those of eggs of midwest Double-crested Cormorants where the mean DDE concentration from 11 colonies was 10.4 ppm (wet-weight) associated with an 8.3 percent reduction in shell thickness (Anderson, et al., 1969). Other studies of the relationship between organochlorine residues and cormorant reproductive success have reported no apparent reproductive impairment associated with relatively low levels of DDE (Kury, 1969; Potts, 1968). Potts (op. cit.) found a range of 1 to 9 ppm DDE (wet-weight) in eggs of the Shag (*Phalacrocorax aristotelis*) from Great Britain and found no correlation between these levels and embryonic mortality, egg breakage, or fledging success. Kury (op. cit.) reported that a mean level of 6.2 ppm (wet-weight) in Double-crested Cormorant eggs had not apparently reduced breeding success in Maine. These authors, however, did not examine eggs for shell thinning. The comparatively low levels of DDE reported suggest that the degree of thinning, if present, would not be sufficiently great to affect reproductive success.

DDE concentrations in the cormorant eggs of this study show decreasing levels from the Anacapa-Los Coronados colonies southward to San Martín Island. A north-south gradient of DDE concentrations along the West Coast has also been observed in northern anchovies (*Engraulis mordax*) (Risebrough, et al., in press), in sand crabs (*Emerita analoga*) (Burnett, 1971), in the Brown Pelican (*Pelecanus occidentalis*) (Risebrough, 1972), and in the California mussel (*Mytilus californianus*) (Southern California Coastal

Water Research Project, 1973). This gradient, which peaks in the Los Angeles area, is attributed to the effluent of a DDT manufacturing company in Los Angeles (Burnett, 1971; Risebrough, et al., in press; Schmidt, et al., 1971).

Analysis for dieldrin and endrin yielded no concentrations greater than 1 ppm (lipid-basis) for dieldrin and only trace amounts of endrin.

The Spearman rank correlation coefficient (r_s) between increasing DDE concentrations and decreasing thickness in the combined sample of Anacapa, Los Coronados, and San Martín eggs was 0.615 ($p < 0.01$). In these populations, therefore, the thinner shelled eggs also have higher concentrations of DDE. PCB, however, is highly correlated with DDE in these samples ($r_s = 0.804$; $p < 0.01$). Thus eggs that are heavily contaminated with DDE also have high concentrations of PCB and decreasing thickness is also correlated with PCB ($r_s = 0.749$; $p < 0.01$). Because of this close relationship between DDE and PCB, we cannot conclude, as we have done in a study of a much larger sample of eggs of Brown Pelicans breeding in the same areas (Risebrough, 1972), that no relationship exists between PCB and shell thinning. Experimental studies have shown that PCB has no effect on shell thickness of Ring Doves (*Streptopelia risoria*) (Peakall, 1971) or Mallard Ducks (*Anas platyrhynchos*) (Heath, et al., in press). Moreover, PCB does not enhance the thinning induced by DDE in Mallards (Risebrough, 1972).

Measurements of 350 museum eggs from interior North America obtained before 1945 yield a mean thickness of 0.430 ± .003 mm (95 percent C.L.) (Anderson and Hickey, in press). The normal eggshell thickness of the west coast marine populations (Table 1) was therefore identical to that of the fresh-water populations in the interior. We have found that the relationship between thickness and DDE is equivalent in both fresh-water and marine groups. The regression coefficient of thickness of the interior eggs versus ln DDE is –.030 (SE $= 0.005$; $F = 31.8$, df $= 1{,}27$; $p < 0.001$). The west coast eggs show a regression coefficient of –.029 of thickness versus ln DDE (SE $= 0.008$; $F = 14.4$, df $= 1{,}18$; $p < 0.001$). In both groups more than 80 percent of the variation of thickness from the normal can be explained by the regression on the natural log of DDE. As stated above, however, DDE is closely correlated with PCB in the marine samples as well as in those from the Midwest (Anderson, et al., 1969).

CHARACTERISTICS OF THIN-SHELLED CORMORANT EGGS

Normal eggs of Double-crested Cormorants, like those of other pelecaniforms except the Phaethontidae, are unpigmented and possess a "cover" of variable thickness which surrounds the true shell (in the terminology of Tyler, 1965). The cover is white and is chalky in consistency. It may

Fig. 1. Comparison of a Double-crested Cormorant egg collected on Anacapa Island, California, prior to 1940 (left) with one collected in 1969 (right). The 1969 egg, appearing bluish in color, lacks a chalky "cover" that normally surrounds the true shell. A portion of the cover has been scraped away on the earlier eggshell (left), exposing the true shell beneath. Photo by Clark Sumida.

easily be scraped away with a needle or fingernail to expose the underlying true shell which is pale blue in color (Fig. 1). According to Tyler (1969*a*) the cover of cormorant eggs consists of organic matter in which small crystals of calcite are imbedded.

Examination of a series of over 300 pre-1940 Double-crested Cormorant eggs in the collection of the Western Foundation of Vertebrate Zoology showed that all possess a cover, except for a few specimens from which this layer had been removed by the original collector. Typical eggs of the species are creamy-white in color and most shells bear brownish nest stains on their surfaces. In contrast, all Double-crested Cormorant eggs and shell fragments found on Anacapa in 1969 and 1971 and Los Coronados in 1969 were bluish in appearance and nearly all were found to be completely lacking the normal chalky cover (Fig. 1).

In experimental tests on egg strength, Tyler (1969*b*) demonstrated that the eggshell cover of *Pelecanus* sp. was of major importance in protecting the shell when subjected to impact. Thus, it is probable that the absence of a cover on the abnormal cormorant eggs contributed to greater breakage of

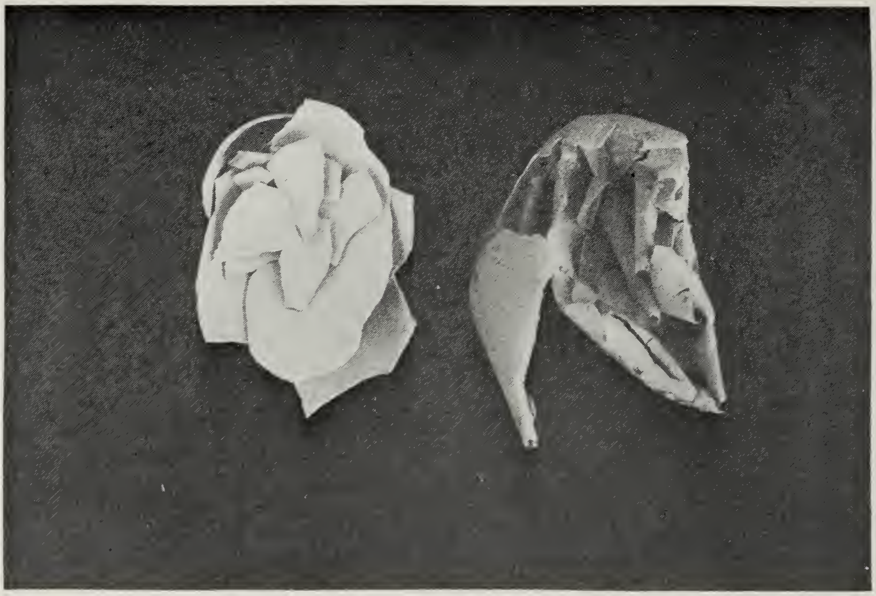


FIG. 2. A broken cormorant eggshell of normal thickness (left) compared with a fragment of an abnormally thin-shelled egg (right). Photo by Clark Sumida.

the eggs by incubating birds. In addition, Tyler (1969*a*) found that the pore channels in the true shell of pelecaniform eggs do not penetrate the cover. Presumably the cover functions to reduce evaporative water loss through the pores and at the same time inhibits the entrance of bacteria into the egg. Eggs lacking the normal cover are therefore not only more likely to break but probably are also more vulnerable to dehydration than normal eggs.

Collapsed eggs and eggshell fragments collected on Anacapa and Los Coronados in 1969 and 1971 could readily be distinguished from broken cormorant eggs of normal thickness by their curled edges. This appears to be due to a crinkling of the shell membranes as they dry out, with the abnormally thin shells conforming to the resulting membrane shapes. Eggshells of normal thickness, whether broken by hand or in normal hatching processes, produce fragments with sharp, jagged edges which do not curl (Fig. 2). In addition, the shell membranes, when attached, conform to the shape of the shell in fragments of normal thickness.

FURTHER OBSERVATIONS ON THE STATUS OF WEST COAST COLONIES

The decline of reproductive success continued on Los Coronados in 1970 and 1971. About 30 pairs of cormorants nesting with pelicans were observed on South Island of Los Coronados in 1970. On 1 June only five nests were still active; no young were observed. Thin-shelled eggs were found around abandoned nests. On 1 June 1971, only five pairs were observed nesting in a deserted colony on South Island; five additional pairs were nesting with pelicans on North Island. No young were observed on either island on that day.

The San Martín colony declined markedly to no more than 1,000 pairs in 1970, presumably because of diminished food resources. Brown Pelicans failed to breed at all on San Martín that year (Jehl, 1973). In 1971, however, the estimated number of breeding cormorants was again at approximately 5,000 pairs. No thin-shelled eggs were observed and all indications were that breeding was normal.

In 1970 observations were made on Anacapa from February to July in the course of a study of Brown Pelicans (Gress, 1970). Of 50 nesting attempts only one was successful, producing three young. To avoid disturbance of the birds the colony area was not entered; thus no egg samples were obtained in 1970. As in 1969, however, the eggs, with the exception of the one nest, did not survive incubation.

In 1971 the Anacapa colony of Double-crested Cormorants was observed monthly between March and August. A total of 48 nests was under observation. To our knowledge there was no human disturbance in the colony until 12 June, when a research group from the Western Foundation of Vertebrate Zoology observed a portion of the colony area at close range. They observed 18 occupied nests of which only one contained intact eggs, a clutch of five. On 29 July only several birds lingered in the colony area at the time of our assessment of reproductive success of both Brown Pelicans and cormorants. Eight occupied nests were observed; three of these contained intact eggs. The clutches consisted of 1, 3, and 4 eggs, all addled. Fragments of 19 crushed eggs, similar to those observed in 1969 and described above, were collected. Mean thickness of these egg fragments was 0.242 ± 0.043 (95 percent C.L.), a reduction of 44 percent from the normal. No young Double-crested Cormorants were therefore fledged on Anacapa in 1971.

In 1972 reproductive success on Anacapa improved. A colony consisting of at least 14 nests was observed by boat on 26 April but was abandoned when the area was surveyed again in May. To our knowledge the birds had not been disturbed by human intruders; moreover, the area was closed to travel by the National Park Service at that time. A second colony was first observed on 29 June. Observations, as on previous occasions, were from a boat. On 15 August, however, the colony area was entered. Eleven recently active nests were counted. Of these, two nests contained two downy young each and a third, one young, the latter about to fledge. Moreover, four young of the year were observed on offshore rocks in the company of adults. Approximately 60 adults were counted along the shores of Anacapa. In spite of the lateness of the season, a majority of them had bright orange gular pouches.

Brown Pelicans breeding in southern California also showed an increase in productivity in 1972. Whereas the pelican colony on Anacapa produced 2 to 4 young from 1272 known nesting attempts in 1969 (Risebrough, Sibley, and Kirven, 1971), one young in 552 nesting attempts in 1970 (Gress, 1970), and 7 young in approximately 540 nesting attempts in 1971 (F.G., D.W.A.), 57 young were produced in 1972 in 260 nesting attempts between two colonies, one on Anacapa and the other on Scorpion Rock near Santa Cruz Island (D.W.A., F.G., R.W.R.).

In April 1970, the DDT manufacturing company in Los Angeles began to dispose of its liquid wastes in a sanitary landfill rather than discharging them into the sewage systems of the Los Angeles County Sanitation Districts. Input of DDT residues into the sea from this sewage system has declined sharply since that time (Carry and Redner, 1970; Redner and Payne, 1971; Risebrough, et al., in press). In anticipating the results of studies now underway, we suggest that the improved reproductive success of both Double-crested Cormorants and Brown Pelicans observed in 1972 is an indication of a decrease of DDE levels in the southern California coastal marine ecosystem.

SUMMARY

Double-crested Cormorants have experienced reproductive failures in colonies on Anacapa Island in southern California and Los Coronados Islands of northwestern Baja California. These failures were characterized by eggs with thin shells that collapsed in the nest during incubation. The pattern of reproductive failures was the same as that observed in Brown Pelicans breeding in the same areas. Shell thinning was not found on San Martín Island, and reproductive success of the cormorant colony there apparently was not affected.

Data are given for eggshell measurements and chlorinated hydrocarbon residues for eggs collected from these colonies in 1969. The eggshells from Anacapa and Los Coronados show a 34 percent decrease in thickness from pre-1946 museum eggs. DDE levels in the yolk lipids show a concentration gradient decreasing southward from Anacapa to San Martín. The values of r_s (Spearman rank correlation coefficient) between decreasing shell thickness and increasing concentrations of both DDE and PCB are highly significant. PCB levels parallel those of DDE; it was not possible therefore to separate the effects of PCB and DDE on eggshell thinning in this study. The relationship between DDE and shell thickness of these eggs, however, was equivalent to that of midwest fresh-water cormorant colonies.

The eggshells from Anacapa and Los Coronados were found to be lacking a chalky cover characteristic of normal eggs, possibly contributing to a greater fragility of the shells.

Further field observations indicate an apparent increase of productivity on Anacapa in 1972. No young were observed on Los Coronados in 1970 and 1971. The San Martín colony suffered a decline in 1970, presumably from lack of food resources, but returned to normal numbers in 1971.

ACKNOWLEDGMENTS

Research was supported by the National Science Foundation, Grant GB-11649, to the Institute of Marine Resources, H. S. Olcott, principal investigator; by the California Department of Fish and Game, the U.S. Bureau of Sport Fisheries and Wildlife, and the National Audubon Society. Transportation to Anacapa was provided by the California Department of Fish and Game and the National Park Service. We thank Howard R. Leach and Henry Hoover of the California Department of Fish and Game, L. R. De Weese, Bureau of Sport Fisheries and Wildlife, and Donald M. Robinson, Superintendent of the Channel Islands National Monument, for their assistance. R. P. Phillips, S. I. Bond, and J. Bradshaw assisted in the Baja California field studies.

LITERATURE CITED

Anderson, D. W. and F. Hamerstrom. 1967. The recent status of Wisconsin cormorants. Passenger Pigeon, 29:3–15.

Anderson, D. W. and J. J. Hickey. 1970. Oological data on egg and breeding characteristics of Brown Pelicans. Wilson Bull., 82:14–28.

Anderson, D. W. and J. J. Hickey. In press. Eggshell changes in certain North American birds. Proc. XV Internatl. Ornithol. Congr., The Hague.

Anderson, D. W., R. W. Risebrough, D. F. Hughes, and R. E. Christenson. 1969. Significance of chlorinated hydrocarbon residues to breeding pelicans and cormorants. Canadian Field-Naturalist, 83:93–112.

Banks, R. C. 1966. Terrestrial vertebrates of Anacapa Island, California. Trans. San Diego Soc. Nat. Hist., 14:173–188.

Bent, A. C. 1922. Life histories of North American petrels and pelicans and their allies. U.S. Natl. Mus. Bull., 121.

Burnett, R. 1971. DDT residues: Distribution of concentrations in *Emerita analoga* (Stimpson) along coastal California. Science, 174:606–608.

Carry, C. W. and J. A. Redner. 1970. Pesticides and heavy metals: Progress Report, County Sanitation Districts of Los Angeles County, 2020 Beverly Boulevard, Los Angeles, California.

Gress, F. 1970. Reproductive status of the California Brown Pelican in 1970, with notes on breeding and natural history. California Dept. of Fish and Game, Wildl. Mgmt. Admin. Report 70–6.

Grinnell, J. 1928. A distributional summation of the ornithology of lower California. Univ. California Publ. Zool., 32:1–300.

Grinnell, J. and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna, No. 27.

Heath, R. G., J. W. Spann, J. F. Kreitzer, and C. Vance. In press. Effects of polychlorinated biphenyls on birds. Proc. XV Internatl. Ornithol. Congr., The Hague.

Howell, A. B. 1917. Birds of the islands off the coast of Southern California. Pacific Coast Avifauna, No. 12.

Jehl, J. R. 1973. Studies of a declining population of Brown Pelicans in northwestern Baja California. Condor, 75:69–79.

Kury, C. R. 1969. Pesticide residues in a marine population of Double-crested Cormorants. J. Wildl. Mgmt., 33:91–95.

Peakall, D. B. 1971. Effects of polychlorinated biphenyls (PCB's) on the eggshells of Ring Doves. Bull. Environ. Contam. Toxicol., 6:100–101.

Potts, G. R. 1968. Success of eggs of the Shag on the Farne Islands, Northumberland, in relation to their content of dieldrin and p,p′-DDE. Nature, 217:1282–1284.

Ratcliffe, D. A. 1967. Decrease in eggshell weight in certain birds of prey. Nature, 215:208–210.

Redner, J. A. and K. Payne. 1971. Chlorinated hydrocarbons: Progress Report (1971). County Sanitation Districts of Los Angeles County, 2020 Beverly Boulevard, Los Angeles, California.

Risebrough, R. W. 1972. Effects of environmental pollutants upon animals other than man. *In* Proc. of the Sixth Berkeley Symposium on Mathematical Statistics and Probability, University of California Press, Berkeley, pp. 443–463.

Risebrough, R. W., G. L. Florant, and D. D. Berger. 1970. Organochlorine pollutants in Peregrines and Merlins migrating through Wisconsin. Canadian Field-Naturalist, 84:247–253.

Risebrough, R. W., D. B. Menzel, J. D. Martin, and H. S. Olcott. In press. DDT residues in Pacific marine fish. Pesticides Monitoring Journal.

Risebrough, R. W., F. C. Sibley, and M. N. Kirven. 1971. Reproductive failure of the Brown Pelican on Anacapa Island in 1969. Amer. Birds, 25:8–9.

Schmidt, T. R., R. W. Risebrough, and F. Gress. 1971. Input of polychlorinated biphenyls into California coastal waters from urban sewage outfalls. Bull. Environ. Contam. Toxicol., 6:235–243.

Schreiber, R. W. and R. W. Risebrough. 1972. Studies of the Brown Pelican. Wilson Bull., 84:119–135.

Southern California Coastal Water Research Project. 1973. The ecology of the Southern California Bight: Implications for water quality management. Vol. II. SCCWRP, 1100 Glendon Avenue, Los Angeles, California.

Tyler, C. 1965. A study of the egg shells of the Sphenisciformes. J. Zool., Lond., 147:1–19.

Tyler, C. 1969*a*. A study of the egg shells of the Gaviiformes, Procellariiformes, Podicipitiformes, and Pelecaniformes. J. Zool., Lond., 158:395–412.

Tyler, C. 1969*b*. The snapping strength of the egg shells of various orders of birds. J. Zool., Lond., 159:65–77.

Willett, G. 1910. A summer trip to the northern Santa Barbara Islands. Condor, 12: 170–174.

Willett, G. 1933. Birds at southwestern California. Pacific Coast Avifauna, 21.

Wright, H. 1909. An ornithological trip to Los Coronados Islands, Mexico. Condor, 11:96–100.

Wright, H. 1913. The birds of San Martin Island, Lower California. Condor, 15: 207–210.

Wright, H. and G. K. Snyder. 1913. Birds observed in the summer of 1912 among the Santa Barbara Islands. Condor, 15:86–92.

BODEGA MARINE LABORATORY, UNIVERSITY OF CALIFORNIA, P. O. BOX 247, BODEGA BAY, CALIFORNIA 94923 (F.G., R.W.R.); U.S. BUREAU OF SPORT FISHERIES AND WILDLIFE, P. O. BOX C, DAVIS, CALIFORNIA 95616 (D.W.A.); WESTERN FOUNDATION OF VERTEBRATE ZOOLOGY, 1100 GLENDON AVENUE, LOS ANGELES, CALIFORNIA 90024 (L.F.K.); SAN DIEGO NATURAL HISTORY MUSEUM, P. O. BOX 1390, SAN DIEGO, CALIFORNIA 92112 (J.R.J.). 9 OCTOBER 1972.

OPTIMAL NICHE SPACE OF THE RED-WINGED BLACKBIRD. III. GROWTH RATE AND FOOD OF NESTLINGS IN MARSH AND UPLAND HABITAT

Raleigh J. Robertson

Red-winged Blackbirds (*Agelaius phoeniceus*) nesting in marshes generally have higher reproductive success than those nesting in uplands (Case and Hewitt, 1963; Robertson, 1972). Marsh habitats and their associated ecological features therefore represent a more nearly optimal part of the fundamental niche of the Redwing than do upland habitats. The difference in survival value between the two habitats is largely due to differences in the proportion of nests destroyed by predators. However, the relative abundance of food for nestlings might also be expected to play an important role in determining the survival value of a nesting habitat. Marshes are usually more productive than upland habitats and have a food source, in the form of emergent aquatic insects, that is rapidly and continually renewed (Orians, 1969). The purpose of this paper is to examine the role of food supply in determining the survival value of a nesting habitat by comparing the types and source of food brought to nestlings, the growth rate of nestlings, and the incidence of starvation in nestling populations of Redwings in marsh and upland habitats.

NESTLING FOOD HABITS

The food brought to nestlings is usually 100 percent animal matter, with a preponderance of insects and occasional arachnids, mollusks, and miscellaneous items (Allen, 1914; Neff and Meanley, 1957; Bird and Smith, 1964; Snelling, 1968; Orians and Horn, 1969; Voigts, 1970). In most cases, only the female feeds the nestlings, but occasionally a male assists (Orians, 1961*b*; Case and Hewitt, 1963). After the young have fledged, the male regularly feeds them (Beer and Tibbits, 1950; Orians, 1961*b*). Some of the food for nestlings is obtained in the vicinity of the nest, but much food is gathered from areas outside the male's territory (Beecher, 1942) and in many cases outside the nesting habitat at some distance from the nest (Orians, 1961*a*; Case and Hewitt, 1963; Wiens, 1965; Snelling, 1968).

METHODS

Two marsh colonies and three upland colonies of Redwings were studied during the breeding seasons of 1968, 1969, and 1970. All of the study areas are within a 25 mile radius of New Haven, Connecticut.

Both marsh habitats are freshwater cattail marshes bordered on at least two sides by large stands of deciduous woodland and in close proximity to pasture or early stages of old field succession. Clarkes Pond is an impoundment on the Mill River that covers an area of 4.65 ha; 1.92 ha is occupied by cattails (*Typha latifolia* and *T. angustifolia*) and the remaining 2.73 ha is open water with some pondlily (*Nymphaea* sp.), pickerelweed (*Pontederia* sp.), and arrowhead (*Sagittaria* sp.). The flow of the Mill River keeps the water at a fairly constant level year-round. All Saints Marsh covers an area of 1.09 ha, all of which is occupied by a moderately dense stand of *Typha latifolia* interspersed with small patches of open water. Buttonbush (*Cephalanthus occidentalis*) forms a dense tangle in some areas. This marsh has no flowing inlet, but in spring and early summer there is a trickling outflow, apparently fed by springs in the marsh. In some years the marsh dried up in late summer. This may account for an apparently low abundance of emergent aquatic insects in this marsh compared with Clarkes Pond.

The upland sites all consist of rather poor quality hayfields supporting a mixture of timothy (*Phleum pratense*), bromegrass (*Bromus* sp.), orchard grass (*Dactylis glomerata*), red clover (*Trifolium pratense*) and alfalfa (*Medicago sativa*). Sturdy "weed" species such as dock (*Rumex* sp.) are quite abundant and frequently were used as nest support. Hyland Farm (2.68 ha) and Augur Jr. (9.85 ha) are bordered on at least two sides by stands of deciduous woodlands and hedgerows. Lyman Golf (2.99 ha) is bordered by hayfields and is located about 200 m from a large stand of mixed deciduous trees bordering a small stream. More complete habitat descriptions are recorded in Robertson (1972).

Throughout the nesting season, except during periods of rainy weather, each colony was visited once every three days. Nests were usually located during construction or egg laying and marked with a numbered bamboo pole. Individual recognition of nestlings was achieved by marking combinations of anterior or posterior, right or left tarsi with water-proof ink from a felt-tipped marking pen. Weights, to the nearest gram, were measured by placing the nestling in a plastic cup and weighing with a 100 g capacity Pesola spring balance. Tarso-metatarsus length to the nearest 0.1 mm was measured with vernier calipers using the method described by Kalma (1970).

Samples of the types of food brought to nestlings were obtained using the pipe-cleaner neck collar technique (Willson, 1966). Collars were placed on all nestlings in a nest for a period of 30 to 60 minutes, during which the female delivered food. The unswallowed food was then removed from the throat of the nestlings, stored in 70 percent alcohol for later identification, and the collar removed. A given brood was sampled no more than once every three days. The effect of food deprivation for one hour every third day on nestling growth was considered negligible. Many nests were never sampled and many were sampled only once. A total of 169 brood samplings were made and food was obtained in samples from 110 nests. Some females reacted negatively to the collars and tried to remove them rather than feeding the nestlings. In some cases, when food was not swallowed, the female would remove it and, if no nestling would swallow it, eat it herself. This technique is not reliable, therefore, as an absolute measure of feeding rates. However, it is assumed that the food items obtained in the samples are representative of the type of food brought to the nestlings, so the technique is very useful for comparative purposes (cf. Orians, 1966; Orians and Horn, 1969). Food sampling was done throughout the nesting season and at times ranging from early morning to evening. Observations from portable blinds were made to determine the habitat origin of food items brought to nestlings.

In 1969 and 1970, several clutch and brood size manipulations were made to determine whether birds in one habitat were more closely faced by food limitation than the other. It was expected that females would be most capable of raising artificially enlarged

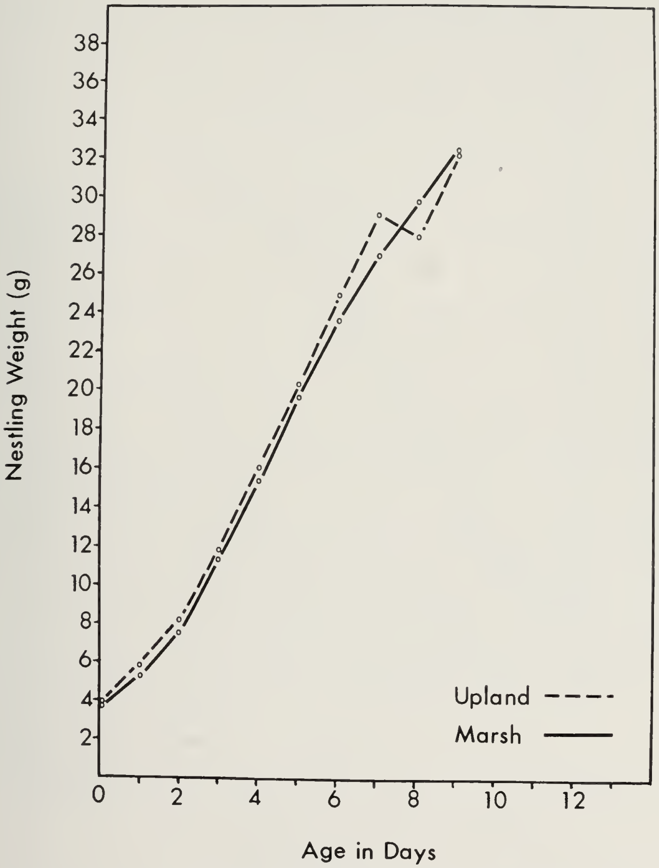


Fig. 1. Growth of Redwing nestlings shown by mean daily weights. Growth curves are composites including nestlings of both sexes for all years of the study.

broods in the habitat that had the highest relative abundance of food. Transfers of eggs or nestlings were made only between nests known to be of exactly the same stage in the nesting sequence.

RESULTS

Growth Rate.—The mean weight of nestlings at 9 days of age, the last day before fledging when most nestlings were still available for weighing, was 32.39 ± 0.34 g (± 1 SE) for nestlings from marshes and 32.19 ± 0.86 g for those from uplands. This similarity in mean weight at fledging suggests the growth rate of nestlings in the two habitats is the same. The composite growth curves for all years of the study and for all nestlings of both sexes from marshes and uplands (Fig. 1) show the form of the curve for the first

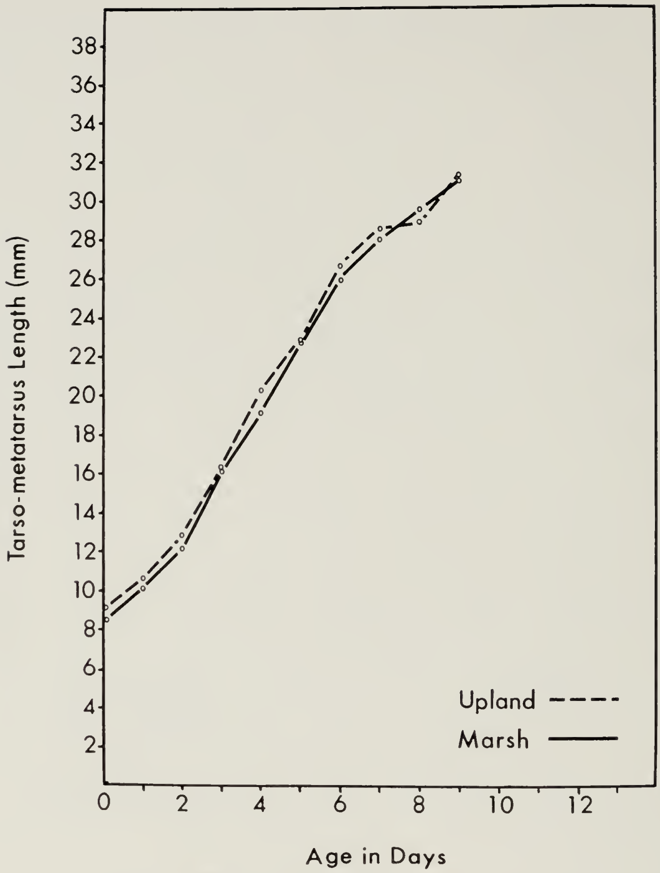


Fig. 2. Growth of Redwing nestlings in 1970 as shown by mean daily tarso-metatarsus lengths (male and female combined).

7 days is similar. The growth rates, as measured by the length of the tarsometatarsus, gives the same result (Fig. 2). Mean weight and mean tarsometatarsus length are not significantly different for marsh and upland nestlings at age 9 days. A decrease in mean weight of upland nestlings from day 7 to day 8, and a period of slow tarso-metatarsus growth from day 7 to day 8, result in the upland nestlings, which were previously slightly larger, fledging at about the same weight and tarso-metatarsus length as marsh nestlings. Growth curves for 1969 and for 1970 analyzed separately have the same form as the combined curve for both years, with the mean daily weight of upland nestlings consistently greater than for marsh nestlings until day 8. In both years, upland nestlings show a decrease in mean weight

TABLE 1

REDWING PRODUCTIVITY IN MARSH AND UPLAND

	Marsh		Upland
Nests			
No. Full Clutches	654		145
Mean Clutch Size	3.50 ± .02	*	3.37 ± .06
Fledged/Successful Nest	2.71 ± .05	ns	2.49 ± .13
Area			
No. Active Nests/ha-yr.	100.5		7.7
Fledged/ha-yr.	132.7		5.4

* $P < 0.05$; ns = not significant.

from day 7 to day 8, resulting in their weight near fledging on day 9 being the same as for marsh nestlings.

To compare the rate of nestling growth in different parts of the nesting season, the season was divided into early, middle, and late portions. The middle, or peak, portion of the nesting season was designated as the smallest number of consecutive days required to include 50 percent of the active nests, dated by day of clutch completions, in each colony. Early and late portions include nests with clutch completion before and after the peak

TABLE 2

FREQUENCY DISTRIBUTION AND SUCCESS OF VARIOUS CLUTCH SIZES IN MARSH AND UPLAND. MANIPULATED CLUTCHES ARE NOT INCLUDED

	Clutch Size				
	1	2	3	4	5
Percent (No.)					
Marsh	0.3(2)	4.7(28)	43.0(254)	50.0(295)	2.0(12)
Upland	0.7(1)	10.1(14)	43.5(50)	43.5(60)	2.2(3)
Percent Successful					
Marsh	100.0	50.0	59.8	61.7	41.7
Upland	0.0	57.1	31.7	43.3	33.3
Fledged/Successful Nest					
Marsh	1.00	1.64	2.33	3.09	3.80
Upland	0.00	1.38	2.11	3.08	4.00
Fledged/Egg					
Marsh	1.00	0.41	0.46	0.48	0.32
Upland	0.00	0.39	0.22	0.33	0.27

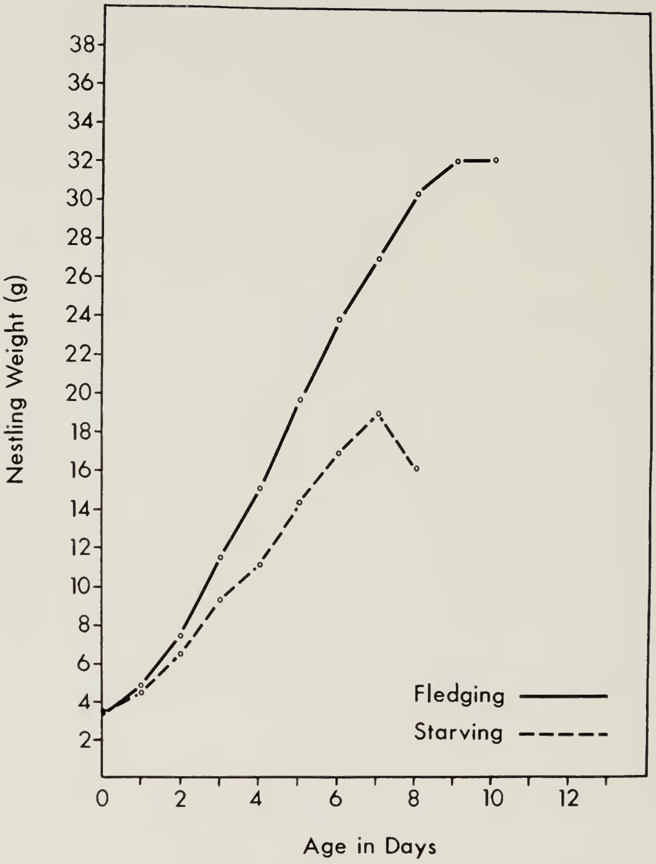


FIG. 3. Comparison of growth (mean daily weight) of nestlings that eventually fledge and those that die of starvation for all marsh nestlings in 1970.

respectively. Separate analyses indicated that within habitat types there were no significant differences in over-all growth rates, nor in growth rates of nestlings of a given brood size, for nestlings hatched in different parts of the season. Also, within a given habitat, there were no consistent or significant differences in growth rate or mean weight at fledging between individuals in different sized broods.

Redwing Productivity.—The initial productivity of individual Redwing females, as measured by clutch size, is on the average significantly ($P < 0.05$) greater in marsh than upland habitats (Table 1). The larger mean clutch size in marshes results from a frequency distribution in which four is the most common clutch size (Table 2). In uplands, clutches of three and four are equally common and clutches of two are more common than in marshes. Ignoring the clutches of one because of small sample size, the most common clutch size in marshes (four) is also most successful both in the proportion of nests that fledge at least one young and the number fledged per egg laid. However, for those nests that fledged at least one nestling, clutches of five are more productive than clutches of four; the mean number of young fledged per successful nest is directly related to clutch size.

The larger mean clutch size of marsh nesting Redwings may make some contribution to the productivity as measured by mean number of young fledged per successful nest (Table 1). Although this figure is not different statistically between the two habitats, because of higher variability and smaller sample size of fledging nests than clutch sizes, marsh nests tend to have a larger number fledged per successful nest than those in uplands.

The combination of greater nesting density and larger number of young fledged per active nest results in productivity measured by the number of young Redwings fledged per hectare being much greater in marshes than in upland habitats (Table 1).

Starvation.—Mortality of a small and nearly equal portion of nestlings in both marsh and upland habitats was attributed to starvation or a starvation-diarrhea syndrome. The nestlings dying from starvation showed a lower rate of growth than those that eventually fledged (Fig. 3). Many of them also failed to form fecal sacs and as a result the nest became fouled (see also Haigh, 1968). This sometimes led to a deterioration of condition of the entire brood. Bacterial-culture analyses from gastrointestinal tracts of nestlings that failed to form fecal sacs were done at the University of Connecticut Department of Animal Pathology. These tests provided no evidence of pathogens responsible for the diarrhea aspects of this syndrome (S. Wyant, pers. comm.), but this possibility cannot be ruled out. However, since this condition was often preceded by poor weight gain, nestlings in this condition were combined with those dying of starvation per se into a starvation-diarrhea syndrome category, subsequently referred to as "starvation."

Starvation occurred in 18.8 percent of the broods in marshes and in 17.2 percent of those in uplands (cf. Table 3), and 10.8 percent of the marsh nestlings and 7.5 percent of the upland nestlings died of starvation (cf. Robertson, 1972). Neither of these proportions are significantly different between habitats. Comparisons of the proportion of broods having some starvation also reveal no differences between habitat for each brood size, and no statistically significant differences within habitat between broods of one, two, three, four, and five (data are recorded in Robertson, 1971). Broods of six, which have not been found to occur naturally in Connecticut, were

TABLE 3

PERCENTAGE OF BROODS WITH SOME NESTLINGS STARVING AS A FUNCTION OF TIME OF EGG-LAYING

See text for explanation of categories. The total number of broods in each category is in parentheses.

	Percent Broods with Some Starvation				
Site	Early	Peak		Late	Total
Marsh #					
CP '68	0 (18)	3.5(57)		4.0(25)	3.0(100)
CP '69	0 (12)	2.9(69)	**	43.7(48)	17.8(129)
CP '70	0 (14)	0 (46)	**	24.4(41)	9.9(101)
AS '69	5.9(17)	23.2(56)	**	76.5(17)	30.0(90)
AS '70	0 (14)	*35.9(53)		51.7(29)	35.4(96)
Total					18.8(516)
Upland					
HF '69	0 (1)	11.1(9)		25.0(12)	18.2(22)
HF '70	0 (0)	0 (6)		25.0(4)	10.0(10)
AJ '70	0 (8)	18.2(11)		0 (6)	8.0(25)
LG '70	12.5(8)	50.0(14)		0 (2)	33.3(24)
Total					17.2(99)+

* $P < 0.05$, **$P < 0.01$ that difference between adjacent categories is due to chance. + Total includes 18 nests from other upland sites, # CP = Clarkes Pond, AS = All Saints Marsh, HF = Hyland Farm, AJ = Augur Jr., LG = Lyman Golf, '68 = 1968, '69 = 1969, '70 = 1970.

obtained by clutch or brood size manipulations. In marshes, a significantly higher proportion of broods of six had some mortality by starvation than the smaller brood sizes.

Although the rate of growth and size of nestlings at fledging is the same in different parts of the nesting season, the incidence of starvation increases throughout the season (Table 3). All nine colonies studied showed a trend of a larger proportion of nests with starvation during the peak of activity than before, and seven of nine colonies had a larger proportion of nests with starvation after the peak than during the peak of activity.

Type and Source of Food.—The proportionate distribution of food types by sample and by food item in the diet of nestling Redwings in marsh and upland habitats is shown in Table 4. Lepidopteran larvae were found in about the same proportion of samples from the two habitats, but they comprised a greater fraction of the individual food items brought to marsh than to upland nestlings. A smaller fraction of the marsh samples contained

TABLE 4

PROPORTIONATE DISTRIBUTION OF FOOD TYPES BY SAMPLE AND FOOD ITEM IN THE DIET OF NESTLING REDWINGS IN TWO HABITATS

A sample includes the food delivered to all individuals in a brood during a sampling period.

	Samples		Items	
	Marsh	Upland	Marsh	Upland
Number	89	21	500	135
Percentage with Terrestrial food source				
Lepidopteran larvae	74	71	42	26
Misc. terrestrial	29	71	13	72
Total	–	–	55	98
Aquatic food source				
Odonata	37	5	21	1
Misc. aquatic	31	0	12	0
Total	–	–	33	1
Unidentified food source				
Misc.	40	5	12	1

All pairwise proportionate differences are significant ($P < 0.01$) determined by χ^2, except samples of lepidopteran larvae.

miscellaneous items such as arachnids, spittle insects, and beetles that were known to have a terrestrial origin; these items made up a significantly smaller portion of the marsh nestling's diet. Conversely, a larger proportion of marsh than upland samples contained odonates and other food items of aquatic origin, as well as items of uncertain habitat origin, and these items also comprised a significantly larger portion of the diet of marsh nestlings. Many single samples from marsh nests contained both items from aquatic and terrestrial habitats. At least 55 percent of the items in the diet of marsh nestlings were obtained from terrestrial habitats and 33 percent were from aquatic habitats. Ninety-eight percent of the food items in the upland nestling's diet were from terrestrial habitats.

There were also differences in the proportionate distribution of nestling food items between individual marshes. Lepidopteran larvae comprised a significantly ($P < 0.01$) larger proportion of individual food items brought to nestlings in All Saints Marsh (57 percent) compared with Clarkes Pond (34 percent) and odonates comprised a larger proportion ($P < 0.01$) in Clarkes Pond (31 percent) compared with All Saints Marsh (1 percent). No differences in proportionate distribution of food items occurred between upland habitats.

DISCUSSION

The growth rates of nestlings in marshes and uplands are similar in that they result in the same average weight at fledging for nestlings in both habitats. This suggests that the relative abundance of food is roughly equal for females nesting in marshes and uplands. Holcomb and Twiest (1970) also reported that there was no difference in growth of Redwings raised in either marsh or upland habitat, but they noted some brood reduction in uplands that was apparently attributed to starvation (cf. Parker, 1968). Although there was no differential starvation or brood reduction between habitats in this study, there was an increase in the occurrence of starvation late in the season (cf. Table 3) while the growth rate showed no seasonal trends. Rate of growth, and mean weight at fledging, when used alone, are therefore not necessarily good indicators of the availability of food for nestlings. A difference between habitats in the proportion of broods with some nestlings starving is a better indicator of the relative abundance of food.

Measured by either index, the relative abundance of food was apparently equal for nestlings in marsh and upland habitats. The fact that there was no differential starvation between habitats in broods of a given size, especially large broods, is also indicative of similarity in relative abundance of food.

Within a given habitat, the growth rate and incidence of starvation were the same for broods of different size (cf. Royama, 1966; Ricklefs, 1968). Brenner (1964) made similar observations and also noted a constancy of growth rate throughout the season. This relationship, and the fact that, compared with smaller broods, a significantly larger ($P < 0.01$) proportion of the artificially enlarged broods of six had some nestlings starve, suggest the brood size of females is adapted to the number of offspring that the parents can nourish (Lack, 1954).

Starvation resulted in the mortality of about 10 percent of the nestlings in both marsh and upland habitats. Predation accounted for a greater proportion of mortality in both habitats, but especially in uplands where 34 percent of the nestlings were taken by predators (Robertson, 1972). In a study of Redwings nesting in marshes in Illinois, starvation accounted for the mortality of less than 1 percent of the nestlings (Smith, 1943). In Wisconsin, Young (1963) recognized no starvation; however, some of the mortality where nestlings were found dead in the nest (5.2 percent) or had disappeared (24.1 percent) may have been due to starvation (Haigh, 1968). During a three-year study in eastern Washington, Haigh (1968) found that between 40.7 percent and 58.6 percent of the nestlings died of starvation, the most common single cause of nestling mortality.

The difference in the incidence of starvation between marsh habitats in eastern Washington and habitats in Illinois or Connecticut may be ultimately due to competitive interactions between Redwings and Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*) in western North America where the two species are sympatric. Marshes in general are more productive in the arid and semiarid regions of the West than in the humid regions of central and eastern North America (Orians and Horn, 1969), and the geographic range of the Yellowhead is limited to those regions where the productivity of lakes and marshes is high (Willson and Orians, 1963). In the zone of sympatry, Redwings are excluded by Yellowheads from the most productive marshes, or at least are forced to nest near wooded shores (Willson and Orians, 1963; Orians, 1966; Miller, 1968). Therefore, Redwings are not able to take advantage of the food supply of the most productive western marshes and must rely on upland habitats as a source of a large portion of their food (Orians and Horn, 1969). Since the upland foraging areas in the West are probably not as productive as the eastern deciduous forests, where Redwings obtain large numbers of lepidopteran larvae, the relative availability of food is perhaps lower, and the incidence of starvation higher, in the arid regions of the Redwings' geographic range.

In both marshes and uplands, female Redwings spend a large portion of their foraging time in mixed deciduous woodlands that border the nesting habitat. Observations revealed these woodlands to be the source of lepidopteran larvae that occurred in over 70 percent of the food samples from nests in either habitat. Wiens (1965) found that Redwings nesting on Lake Wingra in Wisconsin obtained the bulk of their food (lepidopteran larvae) in the hardwood forests bordering the marsh, and Snelling (1968), on the same marsh, reported that female Redwings spent 16 percent of their time foraging on the marsh and 45 percent of their time off the marsh, presumably foraging a large portion of this time. This would suggest that marsh-nesting Redwings have little advantage over upland birds in terms of the availability of food within the nesting territory. However, the time and energy expenditure for food gathering would perhaps be lower for marsh than upland nesting females because the largest food items (odonates) are obtained near the nest site. Also, comparisons between two marshes of different productivity indicate the emergent insects, especially odonates, are an important component of the diet in the dense marsh nesting colonies. Odonates comprised a significantly larger portion of the diet of nestlings in Clarkes Pond than in All Saints Marsh. Both marshes are bordered by deciduous woodlands that are probably equally productive of Lepidoptera, but subjective observations of the abundance of adult odonates indicate All Saints Marsh was less productive of Odonata than Clarkes Pond. This difference in marsh productivity is likely responsible for a larger proportion ($P < 0.01$) of the nests having some mortality due to starvation in All Saints Marsh than in Clarkes Pond (cf. Table 3).

As I indicated earlier the relative abundance of food seems to be similar for nestlings in marshes and uplands, therefore the absolute abundance of food must be much greater in marshes that support much larger and denser nesting colonies than are found in uplands (cf. Table 1). Since clutch size and the number fledged per successful nest is nearly the same in both habitats, while nesting density differs considerably, it would appear that breeding populations may be adjusting their density to suit local conditions of food availability (cf. Brenner, 1966). The occurrence of some starvation in all colonies suggests that no breeding populations were nesting at a density far below the maximum level possible for the available food. On the other hand, it is possible that in a sample of nests from any breeding population, regardless of the relative abundance of food, there will be some starvation due to individual differences in food-getting ability of females. In any case, the relationship between breeding density and food is not simple because complex patterns of social behavior are often the proximate regulators of density and the ultimate factors are difficult to determine (Willson and Orians, 1963). Obvious differences in the phenology of vegetation used as nest support are also correlated with differences in nesting density. However, the absolute abundance of food is likely another ultimate factor in the determination of nesting density as regulated by territory size.

SUMMARY

Growth rates of Red-winged Blackbird nestlings in marsh and upland habitats are similar in that they result in the same mean weight at fledging.

The percentage of nests with some nestlings starving, and the percentage of nestlings that die from starvation are similar in both habitats. The mean number fledged per successful nest is also similar between habitats. There is, however, in both habitats, a trend of increasing nestling starvation as the season progresses.

It is suggested that the relative abundance of food is approximately the same for nestlings in either marshes or uplands, but that a higher absolute abundance of food in marshes makes large, dense nesting colonies possible. The relationship between nesting density and food supply is not simple because obvious differences in the phenology of vegetation used as nest support are also correlated with colony size and density.

ACKNOWLEDGMENTS

I am grateful to Richard S. Miller for his assistance throughout this study, N. P. Ashmole, G. E. Hutchinson, and P. A. Jordan for critically reading the manuscript, T. G. Siccama for assistance in computer programming, Barry Bryan, Patsy Freund, and Al Scopp for help with the field work, and my wife Lois for assistance in all aspects of the study. This study was supported in part by NSF Grant GB-12936 to R. S. Miller, and represents part of a thesis submitted to the Faculty of the Graduate School of Yale

University, New Haven, Connecticut in partial fulfillment of requirements for the Ph.D. degree.

LITERATURE CITED

ALLEN, A. A. 1914. The Red-winged Blackbird: a study in the ecology of a cat-tail marsh. Proc. Linnaean Soc. New York, 24–25:43–128.

BEECHER, W. J. 1942. Nesting birds and the vegetation substrate. Chicago Ornithol. Soc.

BEER, J. R., AND D. TIBBITTS. 1950. Nesting behavior of the Red-wing Blackbird. Flicker, 22:61–77.

BIRD, R. D., AND L. B. SMITH. 1964. The food habits of the Red-winged Blackbird, *Agelaius phoeniceus*, in Manitoba. Canadian Field-Naturalist, 78:179–186.

BRENNER, F. J. 1964. Growth, fat deposition, and development of endothermy in nestling Red-winged Blackbirds. J. Sci. Labs. Denison Univ., 46:81–89.

BRENNER, F. J. 1966. The influence of drought on reproduction in a breeding population of Red-winged Blackbirds. Amer. Midland Nat., 76:201–210.

CASE, N. A., AND O. H. HEWITT. 1963. Nesting and productivity of the Red-winged Blackbird in relation to habitat. Living Bird, 2:7–20.

HAIGH, C. R. 1968. Sexual dimorphism, sex ratios and polygny in the Red-winged Blackbird. Unpubl. Ph.D. Dissertation. Univ. of Washington, Seattle.

HOLCOMB, L. C., AND G. TWIEST. 1970. Growth rates and sex ratios of Red-winged Blackbird nestlings. Wilson Bull., 82:294–303.

KALMA, D. L. 1970. Some aspects of the breeding ecology and annual cycle of three populations of the Rufous-collared Sparrow (*Zonotrichia capensis*) in western Panama. Unpubl. Ph.D. Dissertation, Yale University, New Haven, Connecticut.

LACK, D. 1954. The natural regulation of animal numbers. Clarendon Press, Oxford.

MILLER, R. S. 1968. Conditions of competition between Redwings and Yellow-headed Blackbirds. J. Anim. Ecol., 37:43–61.

NEFF, J. A., AND B. MEANLEY. 1957. Blackbirds and the Arkansas rice crop. Univ. Arkansas Agr. Exp. Sta. Bull., 584.

ORIANS, G. H. 1961*a*. Social stimulation within blackbird colonies. Condor, 63: 330–337.

ORIANS, G. H. 1961*b*. The ecology of blackbird (*Agelaius*) social systems. Ecol. Monogr., 31:285–312.

ORIANS, G. H. 1966. Food of nestling Yellow-headed Blackbirds, Cariboo Parklands, British Columbia. Condor, 68:321–337.

ORIANS, G. H. 1969. On the evolution of mating systems in birds and mammals. Amer. Naturalist, 103:589–603.

ORIANS, G. H., AND H. S. HORN. 1969. Overlap in food and foraging of four species in blackbirds in the potholes of central Washington. Ecology, 50:930–938.

PARKER, G. H. 1968. On the development of temperature regulation in Red-winged Blackbird (*Agelaius phoeniceus*) nestlings from two habitats. Unpubl. M.S. Thesis. Univ. Guelph, Guelph, Ontario.

RICKLEFS, R. E. 1968. Patterns of growth in birds. Ibis, 110:419–451.

ROBERTSON, R. J. 1971. Optimal niche space of the Red-winged Blackbird. Unpubl. Ph.D. Dissertation. Yale University, New Haven, Connecticut.

ROBERTSON, R. J. 1972. Optimal niche space of the Red-winged Blackbird (*Agelaius phoeniceus*). I. Nesting success in marsh and upland habitat. Canadian J. Zool., 50:247–263.

ROYAMA, T. 1966. Factors governing feeding rate, food requirement, and brood size of nestling Great Tits, *Parus major*. Ibis, 108:313–347.

SMITH, M. 1943. Size of breeding populations in relation to egglaying and reproductive success in the Eastern Redwing (*Agelaius phoeniceus*). Ecology, 24:183–207.

SNELLING, J. C. 1968. Overlap in feeding habits of Red-winged Blackbirds and Common Grackles nesting in a cattail marsh. Auk, 85:560–585.

VOIGTS, D. K. 1970. Comparative food habits of two Iowa marsh icterids. Unpubl. M.S. Thesis. Iowa State University, Ames.

WIENS, J. A. 1965. Behavioral interactions of Red-winged Blackbirds and Common Grackles on a common breeding ground. Auk, 82:356–374.

WILLSON, M. F. 1966. Breeding ecology of the Yellow-headed Blackbird. Ecol. Monogr., 36:52–77.

WILLSON, M. F., AND G. H. ORIANS. 1963. Comparative ecology of Red-winged and Yellow-headed Blackbirds during the breeding season. Proc. XVI Internatl. Congr. Zool., 3:342–346.

YOUNG, H. 1963. Age specific mortality in the eggs and nestlings of blackbirds. Auk, 80:145–155.

DEPARTMENT OF BIOLOGY, QUEENS UNIVERSITY, KINGSTON, ONTARIO, CANADA,
12 SEPTEMBER 1972.

NEW LIFE MEMBER

A recent addition to the Life Members of The Wilson Ornithological Society is Edward J. Danforth of Orono, Maine. Mr. Danforth has retired from a job with the New York Telephone Company, and now spends his time in a variety of activities involving ornithology and outdoor recreation. His interests extend to nature photography, and lectures on nature. He writes a weekly column on nature for a local newspaper, and is currently writing a book on nature. He holds a degree from Rutgers University, and is a member of the A.O.U. Mrs. Danforth is also interested in nature, and the Danforths have two children and one grandchild. Our picture shows him exhibiting a sapsucker hole to a group of school children, another of his variety of activities.

STANDARD METABOLIC RATE AND LOWER CRITICAL TEMPERATURE FOR THE RUFFED GROUSE

Gerald Rasmussen and Robert Brander

Studies on thermoregulation in the Tetraonidae (Grouse family) have not often been undertaken. *Lagopus* (ptarmigans) and *Dendragapus* (Blue Grouse) have received some detailed attention in this respect (Veghte and Herreid, 1965; West, 1968; Stiven, 1961) but there is a definite lack of information on the Ruffed Grouse (*Bonasa umbellus*). For the Ruffed Grouse we cannot, in fact, find a single documentation on the most basic aspect of thermoregulation—the standard (or basal) metabolic rate. Lack of such studies may be attributed to the difficulty of obtaining and raising grouse for experiments.

In this paper we report on body temperature, standard metabolic rate, and lower critical temperature as determined on captive Ruffed Grouse.

METHODS

Experimental birds were hatched from artificially incubated eggs collected from four nests in Hampshire County, Massachusetts, during May of 1968. They were kept in individual wire-mesh cages (0.5 × 0.5 × 1 m in size) in an open-fronted lean-to, and thus exposed to atmospheric temperature. Snow or water and turkey finisher supplemented with cracked corn and corn oil were provided ad libitum. Individuals were handled frequently and, we believe, were reasonably tractable during the experiments. Sex determination was by external criteria described by Bump et al. (1947) and Palmer (1959).

Metabolic measurements were made at night, when grouse are least active, during February and March, 1969. Oxygen consumption was determined in an open-circuit system adapted from Dawson (1958). Outdoor air flowed, in sequence, through a garden hose, a respiration chamber, then through tygon tubing to a variable speed tubing pump, a desiccant, and a flowmeter. A 200 ml-min^{-1} sample of air at the flowmeter was continuously shunted to a Beckman F3 paramagnetic oxygen analyzer. The analyzer's electrical potential, generated in proportion to the volume of oxygen in the air sample, was continuously recorded on a strip-chart potentiometer.

Air-flow through the respiration chamber varied from 1,000 to 1,300 ml-min^{-1} (not corrected to S.T.P.), but was held constant in a given experiment. Flow-rate was adjusted for each animal so that the volume percentage of oxygen in the outlet air did not fall below 19.9, the point at which oxygen-stress may begin.

The respiration chamber was a five-gallon galvanized pail with side fittings for inlet and outlet tubes. An airtight seal was assured by placing the chamber open-side downward in a saturated solution of calcium chloride. Subjects stood on 0.6 cm wire-mesh. The chamber was housed in a thermostatically-controlled cold-box.

Air-temperature in the respiration chamber was lowered in 5° steps from 20° to –40° C over a period of 4 hours. Temperature was held at each 5° step for a minimum of 20 minutes, to allow time for the subject to respond and for the oxygen-analysis system to detect this response. Data were taken at the beginning of each step and at five-minute intervals until oxygen consumption stabilized.

Response time, which we consider that time necessary to detect a complete turnover of a volume of air in the respiration chamber, was 8 minutes at 1105.0 ml-min^{-1} (uncorrected to S.T.P.). Therefore, to avoid error due to contamination by air exhaled in the preceding temperature step, we excluded oxygen-consumption values for the first 10 minutes within a step. Consumption values, corrected to S.T.P., were calculated from the appropriate equation of Depocas and Hart (1957).

Cloacal temperature was measured with a copper-constantan thermocouple glued within a 30.5 by 0.3 cm diameter tygon tube. The tube was passed through a styrofoam block and 3 cm into the bird's cloaca; the block was then taped to the central rectrices for support.

To test the significance of the heat increment of food digestion (or specific dynamic action) in thermoregulation, birds in 12 trials were not allowed to eat for at least 5 hours before an experiment ("postabsorptive condition"), while birds in 10 trials were allowed food until a maximum of 3 hours before testing ("non-postabsorptive condition"). Work (Duke et al., 1968) done on the Ring-necked Pheasant (*Phasianus colchicus*) suggests that food will pass through a wild galliform in 1 to 8 (average 5) hours. On this basis we defined the postabsorptive condition as 5 hours without food.

Subjects were selected randomly, without regard to sex. They were allowed a minimum of 2 hours for habituation at the initial temperature. In total, seven trials were obtained from four females and 15 trials from 11 males.

RESULTS AND DISCUSSION

Effect of Experimental Conditions.—We used covariance analysis to test the effect on oxygen consumption due to absorptive condition, sex, and month. Regressions describing the relationship between a bird's oxygen consumption (ml 0_2 consumed-min^{-1}-g body wt^{-1}) and air temperature in the chamber were transformed to linearity by a logarithmic transformation of oxygen consumption. After preliminary analysis data for individuals within a subclass (e.g., postabsorptive males in February) were combined.

We concluded that all the experiments could be described by one regression, since there were no clearcut differences in oxygen consumption assignable to sex, absorptive condition, or the month in which the data were collected. If significant differences due to these variables did in fact exist, we believe they were masked by the differences between individuals within the subclasses.

Cloacal Temperature.—Cloacal temperature was used as an approximation of deep-body temperature during the experiments. For the nine birds from which readings were obtained, temperatures remained fairly constant at exposures from 20° to –40° C. Mean temperature in 63 determinations was 41.5° C (standard error 0.19, range 40.4° to 42.6° C). This is slightly lower than 42.5° C reported by Bernard et al. (1944) for a single Ruffed Grouse.

Standard Metabolic Rate.—King and Farner (1961) define standard meta-

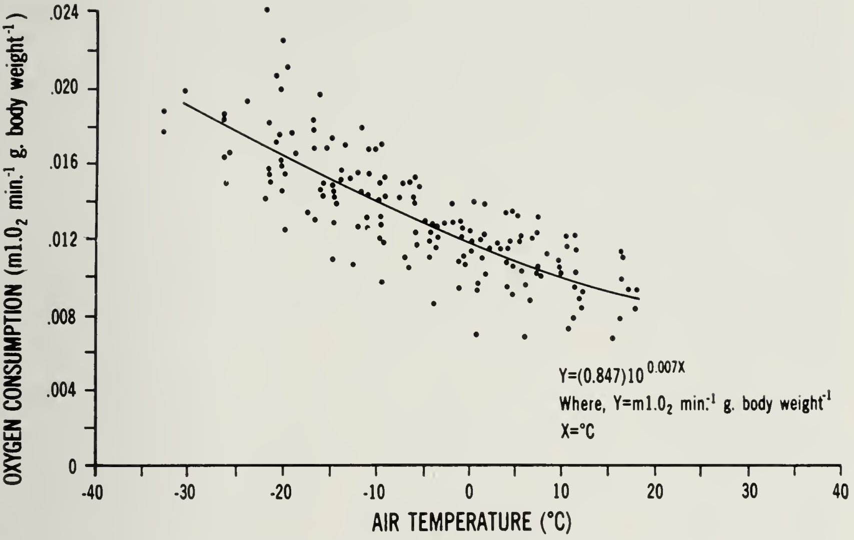


Fig. 1. Regression of oxygen consumption on air temperature, all grouse. Each datum represents the average of 3 to 4 readings. Line fitted by method of least-squares.

bolic rate (SMR) as the heat production per unit time when the homeotherm is in a postabsorptive condition (i.e., not digesting or absorbing food), in thermoneutral surroundings, and as completely as possible at muscular and psychical rest.

The standard metabolic rate was determined by averaging the oxygen consumption values above the lower critical temperature. In a few cases where the oxygen consumption vs. temperature graph was hyperbolic the minimum point on the curve was taken as the standard metabolic rate.

Average values for smallest subclasses, were lumped according to sex, month, and absorptive condition and subjected to paired *t*-tests. There were no statistically significant differences ($P < 0.05$). The standard metabolic rate for grouped data was 0.61 ml 0_2 consumed-min^{-1}-g body weight^{-1}. Variance in terms of mean standard deviation ($n = 14$) was 0.09.

We assumed the test subjects maintained a respiratory quotient of 0.8 and, therefore, were generating 4.8 kcal for each liter of oxygen consumed during standard metabolism. A grouse at mean weight (644 g) would then produce 46.1 ± 1.8 kcal-day^{-1}. The variance indicated is one standard error of the estimate, S_{yx}. Comparative analysis with published predictors (King and Farner, 1961; Lasiewski and Dawson, 1967; Zar, 1968*a*, 1968*b*) is most valid in the case of Zar's (1968*a*) equation for Galliformes:

$$M = 72.6W^{0.698} \pm 15.3$$

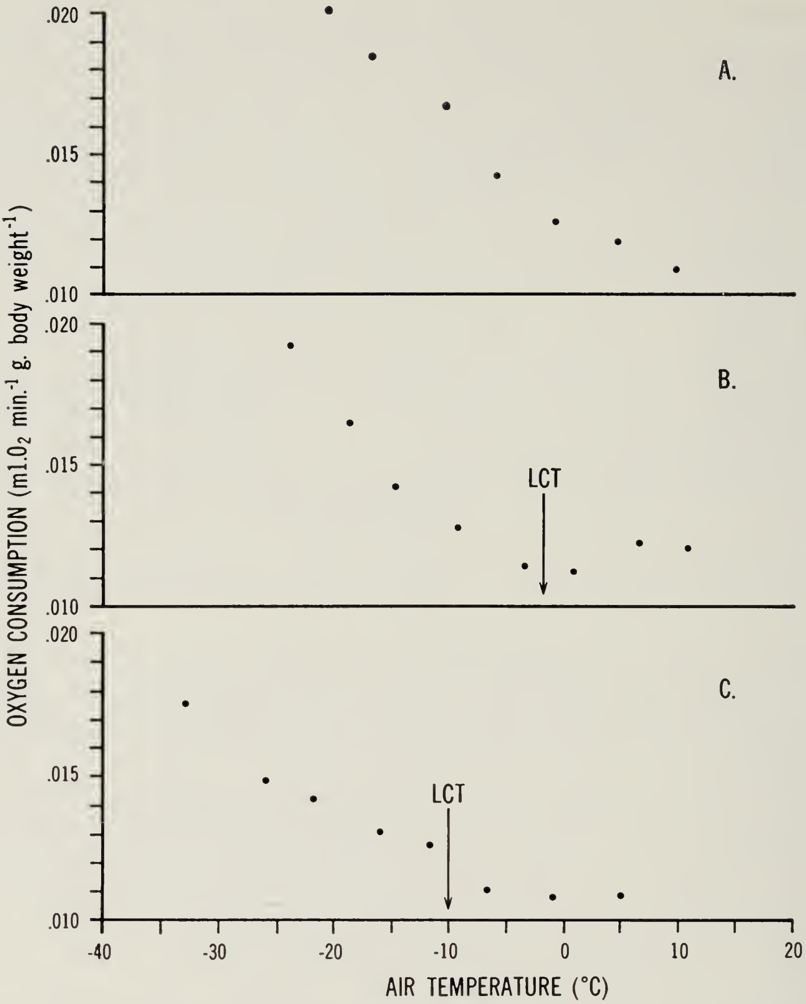


FIG. 2. Selecting the point of lower critical temperature (LCT), actual data on 3 individuals. (A) Linearity, LCT not apparent. (B) Hyperbolic metabolic response; LCT = -2.0° C. (C) Classic, discontinuous response; LCT = -10.0° C.

where M = kcal bird-day^{-1}, W = body weight in kg, and the variance is the standard error of estimate. Zar (1968*a*) used data from Lasiewski and Dawson (op. cit.) which involved 13 determinations of metabolic rates from eight species of Galliformes. While our determination (46.1) is 14 percent lower than 53.4 kcal-day^{-1} for a 644 g bird as predicted by the equation, there is marked overlap when our upper confidence limit (mean plus two standard errors), 49.7, is compared with 22.8, the lower limit ($\bar{x} - 2s_{\bar{x}}$) of Zar's prediction. The statistical picture is not entirely clear (Zar, 1968*b*), but this degree of overlap strongly suggests that our estimate for the Ruffed Grouse fits predictions from regressions concerning the relationship between metabolic rate and body weight in birds in general.

Lower Critical Temperature.—Lower critical temperature (LCT) is defined as the temperature below which a resting animal must increase its metabolic rate from the basal level (i.e., the SMR) to meet environmental demands for heat. In classic theory metabolic activity increases quite abruptly as environmental temperature shifts into the zone below thermoneutrality and the transition can be identified by graphical procedures. Data from Scholander et al. (1950), Steen (1958), Dawson and Tordoff (1959), King (1964), Veghte (1964), and West and Hart (1966) confirm this view.

But our data more closely agree with those of West (1962) in that the transition from constant to increasing metabolism occurred over an extended range of temperature. While we did not test our animals at temperatures above 20° C, we suspect that the extended shape of the metabolic response is hyperbolic (Fig. 2b) and not discontinuous as classic theory holds (Fig. 2c).

Therefore, we chose Barott and Pringle's (1946) visual method of describing the lower critical temperature, rather than the Scholander method (Scholander et al., op. cit.) of extrapolating a tangent along the ascending oxygen-consumption curve to body temperature. The method of our choice, in its adapted form, is a visual estimation of the midpoint of the curve connecting the values for oxygen consumption in the zone of relative constancy with the portion of the graph with an increasing and constant slope. Three representative sets of data illustrate the method (Fig. 2).

Even by this method we could not assign values for the lower critical temperature in eight of the 22 trials (Fig. 2a). In those eight cases there was no apparent zone of constant oxygen-consumption and the graphs were essentially linear with no transformation of data. We believe that initial experimental temperature was, in these cases, at or below the critical temperature.

We did assign values for the lower critical temperature to 14 of 22 grouse. Average values for the smallest subclasses were lumped according to sex, month, and absorptive condition. *T*-tests ($P < 0.05$) did not indicate statistically significant differences attributable to sex or absorptive condition.

The LCT for all grouse combined was −0.3° C. The linear equation describing oxygen consumption *below* this point is

$$Y = 0.011 - 0.0002X$$

where $Y = \text{ml } O_2\text{-min}^{-1}\text{-g body weight}^{-1}$, and $X = {}^\circ\text{C}$.

SUMMARY

Cloacal temperature, standard metabolic rate, and lower critical temperature were determined for 16 Ruffed Grouse in February and March. Oxygen consumption values were determined over a temperature range of 20° C to –40° C. Differences were not statistically significant when results were arranged by sex, month, and absorptive condition. A regression describing the relationship of oxygen consumption to air temperature was derived for the combined results of all grouse.

Standard metabolic rate for a grouse of average body weight (644g) was 0.01 ml O_2 consumed-min^{-1}-g body weight^{-1}. There was a small change in the lower critical temperature from February (–6.0° C) to March (0.3° C); the LCT for all subclassifications combined was –0.3° C.

Cloacal temperature averaged 41.5° C in 63 determinations on nine grouse.

ACKNOWLEDGMENTS

This work was supported by a grant from the McIntire-Stennis Cooperative Forestry Research Program, administered as Study 5 ("Food and Shelter Requirements of Ruffed Grouse in Relation to Energy Regimes") by the Department of Forestry and Wildlife Management, University of Massachusetts, Amherst.

LITERATURE CITED

Barott, H. G., and E. M. Pringle. 1946. Energy and gaseous metabolism of the chicken from hatch to maturity as affected by temperature. J. Nutr., 31:35–50.

Bernard, R., R. Cayouette, and J. Brassard. 1944. Measure de la temperature normale des oiseaux au moyen de thermometres a mercure. Rev. Canadian Biol., 3:251–277.

Bump, G., R. W. Darrow, F. C. Edminster, and W. E. Crissey. 1947. The Ruffed Grouse: life history, propagation, management. New York State Conserv. Dept., Albany.

Dawson, W. R. 1958. Relation of oxygen consumption and evaporative water loss to temperature in the Cardinal. Physiol. Zoöl., 31:37–48.

Dawson, W. R., and H. B. Tordoff. 1959. Relation of oxygen consumption to temperature in the Evening Grosbeak. Condor, 61:388–396.

Depocas, F., and J. S. Hart. 1957. Use of the Pauling oxygen analyzer for measurement of oxygen consumption of animals in open-circuit systems and in a short-lag, closed-circuit apparatus. J. Appl. Physiol., 10:388–392.

Duke, G. E., G. A. Petrides, and R. K. Ringer. 1968. Chromium-51 in food metabolizability and passage rate studies with Ring-necked Pheasant. Poultry Sci., 47: 1356–1364.

King, J. R. 1964. Oxygen consumption and body temperature in relation to ambient temperature in the White-crowned Sparrow. Comp. Biochem. Physiol., 12:13–24.

King, J. R., and D. S. Farner. 1961. Energy metabolism, thermoregulation, and body temperature. *In* Biology and comparative physiology of birds. Vol. II A. J. Marshall (Ed.), Academic Press, New York. pp. 215–288.

Lasiewski, R. C., and W. R. Dawson. 1967. A re-examination of the relationship between standard metabolic rate and body weight in birds. Condor, 69:13–23.

Palmer, W. L. 1959. Sexing live-trapped juvenile Ruffed Grouse. J. Wildl. Mgmt., 23:111–112.

SCHOLANDER, P. F., R. HOCK, V. WALTERS, E. JOHNSON, AND L. IRVING. 1950. Heat regulation in some arctic and tropical mammals and birds. Biol. Bull., 99:237–258.

STEEN, J. 1958. Climatic adaptation in some small northern birds. Ecology, 39:623–629.

STIVEN, A. E. 1961. Food energy available for and required by the Blue Grouse chick. Ecology, 42:547–553.

VEGHTE, J. H. 1964. Thermal and metabolic responses of the Gray Jay to cold stress. Physiol. Zoöl., 37:316–328.

VEGHTE, J. H., AND C. F. HERREID. 1965. Radiometric determination of feather insulation and metabolism of arctic birds. Physiol. Zoöl., 38:267–275.

WEST, G. C. 1962. Responses and adaptations of wild birds to environmental temperature. *In* Comparative physiology of temperature regulation, J. P. Hannon and E. Viereck (Ed.), Arctic Aeromed. Lab., pp. 291–321.

WEST, G. C. 1968. Bioenergetics of captive Willow Ptarmigan under natural conditions. Ecology, 49:1035–1045.

WEST, G. C., AND J. S. HART. 1966. Metabolic responses of Evening Grosbeaks to constant and to fluctuating temperatures. Physiol. Zool., 39:171–184.

ZAR, J. G. 1968*a*. Standard metabolism comparisons among orders of birds. Condor, 70:278.

ZAR, J. G. 1968*b*. Calculation and miscalculation of the allometric equation as a model in biological data. Bio-Science, 18:1118–1120.

DEPARTMENT OF FORESTRY AND WILDLIFE MANAGEMENT, UNIVERSITY OF MASSACHUSETTS, AMHERST 01002 (PRESENT ADDRESS: (RB), NORTH CENTRAL FOREST EXPERIMENT STATION, USDA FOREST SERVICE, FOLWELL AVE., ST. PAUL, MINNESOTA 55101) 17 JULY 1972.

IMPORTANT ANNOUNCEMENT

All manuscripts for publication in *The Wilson Bulletin* should be sent to Dr. John P. Hubbard, Delaware Museum of Natural History, P.O. Box 3937, Greenville, Delaware 19807. Dr. Hubbard will be the editor of the *Bulletin* starting with the March issue of Volume 86, 1974. The present editor has enough material on hand to complete Volume 85.

GENERAL NOTES

Spring migration of Common Loons from the Gulf of Mexico.—During the past 15 years, I have spent many hours of early morning outdoors in northern Florida within 50 miles north of the Gulf of Mexico while listening intently for wild Turkeys (*Meleagris gallopavo*) to gobble. On especially quiet mornings I sometimes heard swishing wings of Common Loons (*Gavia immer*) flying northward overhead at high altitude. The birds were easily identified with binoculars.

During the last two weeks of March and the first half of April on mornings with clear skies, a few flocks of loons usually passed overhead at an altitude I estimated to be 1,500 feet. In the approximately 60 times that I have seen this, I have not seen or heard a flock of loons earlier than one-half hour after sunrise or later than about 09:30. I have occasionally watched and listened for loons flying overhead at other hours of the day, including late afternoon, but have not seen any except in the morning. My observations are not sufficient to conclude that no loons depart northward later in the day, but I believe that most loons depart in early morning. Usually two to six loosely associated flocks of two to 15 loons were involved, headed approximately north. I have also seen this during early May, but the amount of time I have spent watching for loons in early morning after mid-April has not been sufficient to describe the seasonality of this migration.

It is doubtful that this has been seen regularly farther inland because loons are not very conspicuous at 1,500 feet. I may never have noticed them either had I not first heard their wing beats under the ideal hearing conditions of quiet spring mornings.

The ground speed of Common Loons has been clocked at about 60 mph (Bent, Life Histories of North American Diving Birds, U.S. Natl. Mus. Bull., 107, 55–56, 1919). Continuous northward flight at this speed during 12 hours of daylight would carry loons more than 700 miles north of the Gulf on the first day of migration, or to about the Great Lakes. The relative scarcity of surface records of loons south of Ohio (Palmer, Handbook of North American Birds, Vol. 1, Yale University Press, p. 28, 1962) indicates that they do not normally alight during the first day of migration. This may have caused overland migration to go largely undetected, while it may, in reality, be of substantial magnitude or even the rule for loons wintering on the Gulf of Mexico.—LOVETT E. WILLIAMS, JR., *Game and Fresh Water Fish Commission, Wildlife Research Projects Office, Gainesville, Florida 32601. 10 July 1972.*

White Ibis nesting in the Florida Everglades.—White Ibises (*Eudocimus albus*) usually nest on islands—either true islands surrounded by open water or islands of woody growth surrounded by marshland. In the spring of 1972 I discovered an unusual nesting colony of White Ibis in the Florida Everglades. Located at 26° 0′ N latitude and 80° 30′ W longitude, approximately 40 km west of the city of Hollywood, Florida, the colony is notable in several respects. It was located not in an isolated island of vegetation but within a continuous marsh composed primarily of sawgrass (*Mariscus jamaicensis*). It is the first colony reported from within the true Everglades although a number of colonies have existed on its periphery, and it is the largest nesting colony of White Ibis reported in over 20 years south of Lake Okeechobee. This area which includes the Everglades, Big Cypress Swamp, and the Florida mangrove swamps at one time supported colonies of White Ibis numbering in the hundreds of thousands of birds (see e.g., Holt, Bird Lore, 35:372, 1933). In recent years the White Ibis population has sharply declined and years of successful nesting have been increasingly irregular (Kushlan, unpubl.).

The colony was active from March through June 1972 and near its peak held 17,800 nests. The birds fed primarily in the Everglades but also in other areas at considerable distances away from the colony. The distribution of feeding sites and the food consumed by birds breeding at this colony were studied in detail and will be discussed in a future paper.

Although a small percentage of the nests (approximately 150) were located in cattail (*Typha* sp.), most were in sawgrass. This is the first report of White Ibis using sawgrass as a nesting site and as nesting material. Nests were built within the mass of blades projecting from the base of the sawgrass plants. They were constructed primarily of sawgrass, but twigs, particularly willow (*Salix caroliniana*) and strangler fig (*Ficus aurea*), were also used in small numbers. Some of these were brought from trees growing on levees up to 5 km from the nesting colony. Sawgrass blades are characterized by their sharp, spiny edges which make manipulation difficult. Nonetheless, sawgrass over the entire colony area was broken off and used in nest construction. It is of interest that some White Ibises at another colony, Rookery Branch in Everglades National Park, Florida, also nested in sawgrass during the spring of 1972. The majority of the ibises at this colony, however, nested in and under mangroves which is the usual nesting habitat for the species in extreme southern Florida.

These observations were made as part of a study of the ecology of White Ibis and Glossy Ibis in southern Florida supported by the Maytag Chair of Ornithology, University of Miami. I thank J. W. Dineen and the Central and Southern Florida Flood Control District for cooperation in my study of this colony.—James A. Kushlan, *Department of Biology, University of Miami, Coral Gables, Florida, 33124, 8 August 1972.*

Sparrow Hawk predation on Bank Swallows.—The Sparrow Hawk (*Falco sparverius*) is known to be highly adaptable in its food habits, preying upon a variety of insects, small mammals, birds, and occasional reptiles. The following observations are offered as evidence that under certain circumstances Bank Swallows (*Riparia riparia*) may be an important food item.

At 14:30 on 25 June 1972 a male Sparrow Hawk was seen attacking a Bank Swallow that was caught in a mist net placed across a Bank Swallow colony near Ellenville, New York. The hawk was not captured. The net had been in place only a few minutes, and it contained only four birds. They were all removed, banded, and released. The attacked bird, an immature Bank Swallow, was released last; it did not appear to be seriously injured, and flew quite strongly. As I watched it fly away, it was suddenly snatched from the air by a Sparrow Hawk. The hawk was flying in the same direction as the swallow; it appeared to simply overtake the swallow and grab it with its talons. Without pausing, the hawk carried the swallow some distance to the edge of a woods above the colony, where it was lost from sight.

I continued to band, using one net, and catching mostly adult birds. At 16:15 another young bird (the fifth of the day) was banded and released. As it flew away, it too was taken from the air by a Sparrow Hawk. The method of capture was the same: the Sparrow Hawk overtook the young swallow and snatched it from the air.

I took down the mist net and began to search the area for further evidence of Sparrow Hawk predation. A rock at the base of the colony was surrounded by partially sheathed flight feathers; a hawk had evidently perched there and plucked young Bank Swallows.

Five such "plucking perches" were located by the colony. By counting the tails, I estimated that at least nine young birds had been plucked at these perches. All must have been taken on the 24th or 25th, since they were not covered with mud from the heavy rains of tropical storm Agnes during 21–23 June.

At 16:50 as I watched the colony from the car, a male Sparrow Hawk landed at the entrance of a hole in the colony (apparently pursuing young which had been peering out of several holes). He remained a second or two, and then abruptly flew about 100 yards to a smaller cluster of holes. He briefly touched a near-vertical surface and took off immediately carrying a Bank Swallow.

At 17:00 a fourth swallow was caught, this time from the air. I heard a loud rush of wings over the car, a sudden thunk! and then saw a Sparrow Hawk flying away, carrying another bird. Although I did not witness the actual strike, I assume the prey was another Bank Swallow, since there were many of them in the air around the car.

I visited the colony four more times during the next week. On 26 June a Sparrow Hawk was observed as it carried an unidentified bird, but no attacks on swallows were seen. On the 27th, a net was set again. Out of 25 birds caught, only two were young. Sparrow Hawks were seen in the vicinity, but no attacks were observed. A new "plucking rock" was found above the colony and about 25 yards from the edge of the bank. It was a boulder about 4 feet high with many Bank Swallow feathers scattered on and around it. Frank Fish and I estimated that 10 to 12 birds had been plucked there since the heavy rains of the night before.

On succeeding visits, no new evidence of Sparrow Hawk predation was observed, but the hawks evidently had taken a heavy toll of the young swallows from this colony. In four banding sessions between 17 June and 2 July, 99 adult and only eight young birds were caught. (In other years many more young birds have been banded at this and other Bank Swallow colonies; after the third week in June, most new birds caught have been young.)

Frank Fish and I had previously watched a Sparrow Hawk at a Bank Swallow colony several hundred yards from the colony just described. We were banding swallows on 22 June 1971, when a Sparrow Hawk landed on the top of the bank and proceeded to walk along the edge, apparently watching the swallows with great interest. Additional evidence of Sparrow Hawk activity at Bank Swallow colonies came from Harriet Marsi and Gail Corderman, who caught four Sparrow Hawks in mist nets at Bank Swallow colonies in the Binghamton, New York area on 19 June 1966, 27 June 1966, 24 June 1968, and 4 July 1972 (pers. comm.).

I have been unable to locate any other account of Sparrow Hawks taking Bank Swallows, although Heintzelman (Wilson Bull., 76:323–330, 1964) refers to one capture of a Cliff Swallow by a Sparrow Hawk.

It may well be that the specialization of this Sparrow Hawk on Bank Swallows represents a case of the development of a "specific searching image" (Mueller, Nature 233: 345, 1971, and pers. comm.). This tendency to specialize in a given type of prey at a given time was a successful strategy for this Sparrow Hawk or Hawks as evidenced by the large number of prey taken and by the fact that three aerial attacks observed resulted in captures—a remarkably high rate of success as compared with observations by others (Rudebeck, Oikos 2:63–88, 1950). Incidentally, aerial captures by Sparrow Hawks have not often been recorded; Heintzelman (Linnaean News-Letter, 20: Nos. 6 and 7, 1966) found that the only prey species previously recorded as captured in the air included a Starling, a Ruby-throated Hummingbird, two species of bats, and insects.

Mueller (pers. comm.) observed aerial captures of many House Sparrows by a nesting pair of Sparrow Hawks in downtown Milwaukee.

Appreciation is extended to Frank L. Fish who assisted in banding operations and observations, and to Dr. John Phillips and Kenneth Niven who read the manuscript and suggested improvements.—Valerie M. Freer, *Biology Department, Sullivan County Community College, Loch Sheldrake, New York 12759, 6 August 1972.*

First specimen of Laughing Gull for Illinois.—Although there are many sight records of the Laughing Gull (*Larus atricilla*) for Illinois, there has never been a specimen taken previously. The American Ornithologists' Union's Check-list of North American Birds (1957) does not list the species as occurring in Illinois and "A Distributional Check List of the Birds of Illinois" (Smith and Parmalee, 1955) indicates that there is no specimen—only sight records. On 26 May 1971, I observed a Laughing Gull near the north end of Lake Springfield, Sangamon County, Illinois. On the following day (27 May) I collected the bird just north of the dam at Lake Springfield (No. 604789, ISM Coll., Springfield). The gull was a male in breeding plumage, the testes measuring, right, 12 mm × 7 mm and left, 15 mm × 7 mm. The gizzard contained one small fish.

There are nineteen sight records from northern Illinois, 14 fall and five spring records. There are three other records from downstate Illinois: Alton Dam, Madison County, 30 May 1955, by Sally Vasse (Anderson and Bauer, A Guide to Finding Birds in the St. Louis Area, 1968:35); along the Mississippi River near Nauvoo, Hancock County, 12 June 1971, by James Funk, four adults and one immature (Kleen and Bush, Amer. Birds, 25:864, 1971); and Lake Springfield, Sangamon County, 30 April and 1 May 1972, by myself.

In light of these sight records and the specimen from Springfield, the Laughing Gull should be considered a rare migrant in Illinois.—H. David Bohlen, *Illinois State Museum, Springfield, Illinois 62706, 17 August 1972.*

Common, Arctic, Roseate, and Sandwich Terns carrying multiple fish.—It has been well documented that the Fairy Tern (*Gygis alba*) carries more than one fish at a time in its bill. Howell (Natl. Geogr. Mag. 140:417, 1971) reports a Fairy Tern carrying as many as 15 small fish and a Fairy Tern carrying a number of fish is pictured by Walker (Natl. Geogr. Mag. 90:807–814, 1946).

In 1969 Dunn observed Common Terns (*Sterna hirundo*), Arctic Terns (*S. paradisaea*). Roseate Terns (*S. dougallii*), and Sandwich Terns (*S. sandvicensis*), bringing in more than one fish at a time to the Coquet Island Colony in Northumberland, England.

In 1971 observers on Great Gull Island, New York, noted both Common and Roseate Terns bringing in multiple fish. Having found nothing in the literature on this behavior for the above species we felt it would be worthwhile to combine our observations in a note.

Dunn's sightings of fish carried by all four species during 10 days in July are given in Table 1. In all but two cases the birds carrying more than one fish brought in two-inch sand-eels (*Ammodytes marinus*). The exceptions were a Common Tern carrying two two-inch sprats (*Clupea sprattus*) and in another case an Arctic Tern carrying two three-inch sprats.

Most of the Great Gull Island observations were made by a team monitoring fish brought to two young Common Terns between 17 June and 30 July, and fish brought to two young Roseate Terns between 30 June and 14 August. Observers each took two-

TABLE 1

NUMBER OF TIMES DIFFERENT TERN SPECIES CARRY 1, 2, 3, 4, AND 5 FISH COQUET ISLAND

Frequency of sightings for each species	Numbers of fish carried					Total sightings	Percent with multiple fish
	1	2	3	4	5		
Common	1,735	15	6	6	3	1,765	1.70
Arctic	516	5	4	0	0	525	1.71
Roseate	261	2	1	1	0	265	1.51
Sandwich	446	6	3	1	0	456	2.19
Totals and Mean	2,958	28	14	8	3	3,011	1.76

(Note: no bird was ever seen to carry more than 5 fish.)

hour watches so as to cover the period from 05:00 EDST to 21:00 EDST daily. Additional notes on Common Terns carrying multiple fish were made by the senior author 15–30 August.

During the team's 59 days of observation terns were seen carrying more than one fish per trip only during the last 13 days of the Roseate watch, 2–14 August. The Roseate young were in a section where a number of Roseate Terns nested and most of the birds seen in the area carrying multiple fish were Roseates. These sightings are shown in Table 2. Thirteen Roseate Terns carried two fish; nine carried three; five, four; and one, nine fish.

Of a total of 28 cases of Roseate Terns carrying multiple fish during the 13-day period 18 cases were noted 12–13 August between 18:26 and 19:30 EDST. All fish carried by the Roseates during the two-day period were small menhaden (*Brevoortia tyrannus*). The fish varied in size from less than an inch to about an inch in length. The terns usually held the fish in their bills with most of the heads on the same side, as can be seen in Fig. 1.

As one of the parent Roseate Terns landed carrying several fish, the young usually

TABLE 2

NUMBERS OF FISH CARRIED PER TRIP BY ROSEATE TERNS IN AUGUST GREAT GULL ISLAND

Numbers of fish carried	Date in August					
	2	4	10	12	13	14
9					1	
8						
7						
6						
5						
4			1		3	1
3	1	2		3	2	1
2	1	1	1	6	3	1

FIG. 1. Adult Roseate Tern carrying four fish for its young. Photograph taken by A. Poole.

responded in one of two ways. Either, the bird receiving the fish would walk to the parent and take one fish at a time from its bill, or it would dash toward the parent, appearing to knock the bill of the parent with its bill, as it attempted to take the fish. The parent then dropped the fish and the young picked them up one at a time and ate them.

In August a few observations were made of Common Terns carrying multiple fish landing in the colony. Two Common Terns were seen each carrying two mackerel, (*Scomber scombrus*) on 12 August, a Common Tern was noted holding two unidentified fish 13 August, and a Common Tern holding two fish, both about three inches long, landed in the dusk gatherings of terns on the island 18, 19 and 30 August. It is probable that if observations had been made at the nest of a Common Tern in August, as well as at a Roseate nest, more cases of the former carrying multiple fish could have been collected.

Of the instances of terns carrying more than one fish at a time to the Coquet Island Colony, 40 percent were made on two of the 10 days of observation. On Great Gull Island 64 percent of the cases of Roseate Terns carrying multiple fish occurred during two days of the 13 day period during the watch that the behavior was noted. Observations at both colonies suggest that, bringing in multiple fish is an exceptional, opportunistic behavior which occurs when small fish are present at the surface of the water in large numbers.

The question arises as to how the terns pick up a number of fish. Dunn, in three years of studying fishing success in terns, has only once seen a bird dive with a fish already in its bill. This was a Sandwich Tern in Sierra Leone, January 1970. The regular arrangement of fish in the bills of birds noted on Great Gull Island suggests that the terns may pick them up rapidly from a school of fish at the surface when the fish are all heading in the same direction. Whether this is done by rapid diving or rapid dipping, or some other way remains to be seen.

We would like to thank Grace Donaldson, Lauren LeCroy, and Roger Pasquier, all of whom noted multiple fish, as well as others who participated in the watch, making complete coverage possible at the nests on Great Gull Island. We would also like to thank Lavett Smith for identifying fish collected on Great Gull Island, and the Department of Photography at The American Museum of Natural History, for reproducing the photograph.—HELEN HAYS, *Great Gull Island Project, The American Museum of Natural History, Central Park West at 79th Street, New York, New York 10024,* EUAN DUNN, *Department of Zoology, Durham University, South Road, Durham, England, (Present address: Department of Zoology, Edward Grey Institute of Field Ornithology, South Parks Road, Oxford, England.) and* ALAN POOLE, *Bellwood Farm, Geneva, New York 14456, 31 July 1972.*

Encrusted wings causing flightlessness in young terns.—While banding young Common Terns (*Sterna hirundo*) at West End Beach, Jones Beach State Park, New York, as part of a study of mortality, I have encountered several abnormalities which render the birds flightless. The commonest abnormality in 1969 and 1970 was fracture of the humerus apparently due to collisions with automobiles. The West End Beach colony lies on both sides of a U-shaped road, and auto traffic is heavy. Normal terns become capable of flight at 4–5 weeks of age, and at this age they congregate on open surfaces including the road, and many are killed or crippled by cars (Gochfeld, Newsletter of Linnaean Society of N.Y., 19(9):1–3, 1966). Flightlessness due to premature feather-loss (Gochfeld, Kingbird, 21:206–211, 1971; Hays and Risebrough, Auk, 89:19–35, 1972) first appeared at West End Beach and also at Gull Island in 1969. In 1970 and 1971 about one percent of chicks hatched at West End suffered premature feather-loss.

A third cause of flightlessness, feather encrustation, was observed first in 1969. Of about 1,600 Common Tern chicks banded that season five were found with several primaries of one wing matted and damaged. In late July I captured the first of these, a banded chick known to be at least 39 days old. It flapped vigorously but could not fly. Close examination revealed that the primaries of the right wing were encrusted with a white cement-like substance and were badly frayed. The shafts were denuded of barbs in some places. The substance appeared to be dried avian excrement which I was unable to remove with a knife. Although the material was not water soluble a forceful jet of water removed some of it, but caused further damage to the primaries. I released the bird. I found the bird on several subsequent visits and damage to the feathers progressed, while those on the other wing appeared normal. The other four birds were first found in August, after most normal young and adults had left the colony. Parents of flightless chicks attended them at least until 1 September, but on 15 September the adults were gone and I found remains of two of these chicks. One case of severely encrusted primaries was seen in 1970. In 1971 I found a bird estimated to be more than 5 weeks old which was unable to fly due to mild encrusting of the three outer left primaries. The bird was kept in captivity and after 6 days normal feather growth had progressed sufficiently to allow it to fly.

Harrison (Bull. Brit. Ornithol. Club, 75:113–114, 1955) reported a Guillemot (= Common Murre, *Uria aalge*) which had rectrices denuded of barbs for most of their length. He suggested that this was due to defective feathers rather than traumatic preening. The terns with encrusted feathers preened vigorously and very frequently in vain attempts to remove the crusts. It seems likely that actual damage resulted from both brittleness of the caked feathers and vigorous preening. W. R. P. Bourne (pers. comm.) believes that Harrison's example was not well chosen, and that his bird may have had feather wear normal for that season. I have found no mention of encrusted feathers in the literature, neither in the detailed report by the Marples (Sea Terns or Sea Swallows, Country Life Ltd., 1934), Palmer (Proc. Boston Soc. Nat. Hist., 42:1–119, 1941) or in numerous papers by Oliver L. Austin and O. L. Austin, Jr. I have not learned how the feathers become encrusted. Young terns frequently huddle together under small bushes of seaside goldenrod (*Solidago sempervirens*) which provide the main cover in parts of the West End Beach colony. When disturbed they may defecate, possibly fouling the plumage of nearby chicks. It is also possible that chicks may occasionally be showered by jets of excrement which flying adult terns emit when attacking intruders. Observations are needed to explain why only the primaries seem to be involved. Perhaps matting of other parts of the plumage escapes notice since the birds are not rendered flightless.—Michael Gochfeld, *Department of Ornithology, American Museum of Natural History, New York, New York 10024, 7 June 1972.*

Barn Swallows use freshwater and marine algae in nest construction.—Dixon (in Bent, U.S. Natl. Mus., Bull. 179:447, 1942) reports the occurrence of seaweed in Barn Swallow nests in caves along the California coast. In 1972, I found that Barn Swallows nesting on Great Gull Island used a large quantity of freshwater algae and some marine algae in constructing their nests. Great Gull Island, originally a fort, is a tern sanctuary at the eastern end of Long Island Sound, 72° 07′ W, 41° 12′ N.

I studied these nests from 23 May through 3 June 1972. Active nests were visited each day to check their progress, and possible nest sites were examined for indications of building activity. On 24 May I observed a piece of damp kelp on the rim of a Barn Swallow nest. Upon closer examination of the nest, I observed that it was composed primarily of globs of moist freshwater algae (*Schizomeris*). A subsequent examination of all other active nests revealed that they also contained varying amounts of freshwater algae. Old nests were repatched with algal rims and new nests were begun with algal globs.

I observed three nests that were in early stages of development. One was being constructed on a vertical surface within an open-ended wooden tunnel. It appeared to be initially supported by a small projection of the wall, and was at first a mass of algal globs into which several stalks of grass were stuck. Mud was not detected in this early construction. The nest was first observed on 27 May. On 28 May a mass of algae and grass was found directly under the nest, which had apparently been rebuilt after it had collapsed. On 29 May it appeared that part of the nest had fallen again. It continued to fall down and be rebuilt. After a collapse on 1 June the nest had not been rebuilt by 3 June when observations ceased. An examination of the fallen nest material revealed the presence of club mosses (*Lycopodium*) obtainable only at one flooded gun emplacement located approximately 1,000 feet away from the nest site.

Another new nest built directly on a vertical surface and composed of algae and grass was more successful. This nest was constructed within a brick-walled bunker. The first stage was the plastering of globs of algae directly onto the eroded brick surface. This was noted on 27 May. On 28 May several stalks of grass were present, protruding from the algal masses. On 3 June a two-foot-long grass stalk was hanging from the nest's outer surface, and a cup had been formed.

I also observed the construction of a nest on a flat beam inside a wooden porch in one of the unoccupied brick buildings on Great Gull Island. Small algal globs had been placed in a ring on a flat surface; several stalks of grass were present. This nest was first discovered on 30 May. The algae formed a ring about a bare hollow of wood. On 3 June I found several dried wads of algae in the hollow.

Great Gull Island offers several possible sources of freshwater algae. After exploring these, I found that the single actual source was one flooded, roofless cement bunker. The alga (*Schizomeris*), which formed a surface mat covering a depth of approximately two feet of stagnant water, was easily separated into small pieces. I saw Barn Swallows obtaining small algal masses from the bunker, and watched while one swallow flew to the bunker, disappeared within, and emerged with algae in its bill. It then added the algae to the rim of a nest located approximately 250 feet away.

I did not detect mud in the early construction stages of nests although nests that were being reused had bases of dried sandy soil. I dissected a deserted Barn Swallow nest that had been active in 1970 and observed the presence of dried *Schizomeris* algae and several different kinds of marine algae that are commonly found in the vegetation deposit along the high tide line. There are few reliable sources of mud on the island. It would be interesting to note whether or not the relative amounts of freshwater and marine algae employed vary significantly from year to year, how the use of the algae affects nesting success, and whether or not algae are employed as a nesting material by the Barn Swallow in areas where both algae and mud are amply available.

I am indebted to Helen Hays for assistance in preparing this note. I would also like to thank Dr. Kenneth Parkes for suggesting possible references and critically reading the manuscript. I would like to acknowledge the assistance of Isabelle Fries and Bill Schiller for help in identifying algal samples.—KATHLEEN DUFFIN, *211 Montross Road, Yorktown Heights, New York 10598, 30 August 1972.*

Immature Robin gathering nest material.—On 22 August 1972 a Robin (*Turdus migratorius*) with throat and extreme upper breast still in the spotted juvenal plumage was foraging on my lawn in Larchmont, Baltimore County, Maryland. At one place it tore off, sometimes tugging hard to do so, about half a dozen blades of fine, dead grass. It carried these in its bill for several steps, then dropped them and foraged again. A minute later it ran at an immature Song Sparrow (*Melospiza melodia*) on the lawn and put it to flight.

Nice (Trans. Linnaean Soc. New York, 6:78–79, 1943) has assembled records of nest-material carrying by young birds of some other species. Other breeding behavior known for immature Robins includes attempts at copulation (Young, Amer. Midl. Nat., 53: 332, 1955) and, in captivity, the feeding of still younger birds (Favell, Wilson Bull., 47: 298, 1935).—HERVEY BRACKBILL, *2620 Poplar Drive, Baltimore, Maryland, 21207, 11 September 1972.*

The nesting of the Apapane in lava caves on the island of Hawaii.—The Apapane (*Himatione sanguinea*) is one of the few members of the Hawaiian honeycreeper family (Drepanididae) that is still found in any numbers throughout the state. It inhabits the wet native forests and is a permanent resident of these areas.

Fig. 1. Apapane nest on Hualalai.

Most authors have said that this bird nests high in the native ohia (*Metrosideros collina*) or other suitable trees. Henshaw (Birds of Hawaiian Islands. Thos. G. Thrum, Honolulu, 1902) writes: "The akakani (Apapane) usually nests in the tall forest ohias . . ." Perkins (Aves. Part IV, Fauna Hawaiiensis or the Zoology of the Sandwich (Hawaiian) Islands, 1903) and Munro (Birds of Hawaii, Tongg Publ. Co., Honolulu, 1944) also mention that it often nests in the tops of ohia trees. Eddinger (unpubl. Ph.D. thesis, Univ. Hawaii, 1970) found 67 Apapane nests on Kauai and all were placed 12 to 24 inches below the terminal cluster of leaves in ohia trees. None of his nests were found below 17 feet seven inches and most were located at heights of 30 or more feet. Many of the Apapane nests I have observed were placed high in the tops of trees.

Berger (Hawaiian Birdlife, Univ. Press of Hawaii, 1972), however, mentions four nests he found on the fronds of the tree fern (*Cibotium glaucum*) in the Kilauea forest on the slopes of Mauna Loa. In the Wailuku River region the Apapane also utilizes the tree fern as a nesting site. I have also found a number of nests in lava tubes on both Mauna Loa and Hualalai. Insofar as I have been able to determine, there appear to be no published data on the Apapane nesting in lava caves on Hawaii.

This situation was first brought to my attention on 22 June 1971, by Mr. George Schattauer of Kona, Hawaii. The area was on the southwest slope of Mauna Loa at an elevation of approximately 5,300 feet. On the wall of a lava tube, he pointed out a nest that he had visited on occasion for three years. He had never actually observed the bird; but, since the nest was only seven feet from the ground, he believed it belonged to the Hawaiian Thrush (*Phaeornis obscura*). The nesting site presumably had been used by the same bird on four different nesting occasions. Each new nest was superimposed directly on top of the last, and an accumulated height of 5¾ inches had been reached.

One unhatched egg in the nest had a whitish background with tan markings scattered irregularly over the surface. Reddish-brown markings formed a dense ring around the larger end. The egg measured 19.4 × 14.1 mm. There was a powerful musky scent noticeable about the nest, which Henshaw (op. cit.) considers as perfectly distinctive of the family Drepanididae. Neither the nest nor the egg fit the description Berger (Living Bird, 8:243–250, 1969) gives for that of the Hawaiian Thrush.

I was curious whether this was a local specialization or was a common practice for birds in other areas. I examined lava tubes on Mt. Hualalai, a dormant volcano, and, on 9 August 1971, found six deserted nests in five different lava tubes. I began to make periodic trips to this study area in January 1972. On 12 February, as I approached a lava tube, I saw an Apapane fly from the entrance. I entered it and found a nest directly above the opening (Fig. 1).

The nest was seven feet five inches from the ground, supported by a lava ledge overhanging the entrance to the tube. The back of the nest, built against the wall, was flat while the front sloped downward to the base. The nest measured 2 inches from top to bottom on the backside and 5.8 inches on the inclined front side. This declivity was due to an accumulation of three separate nests placed one on top of the other with each consecutive nest situated closer to the wall.

The width across the top of the most recent nest varied from 3.5–4.8 inches; the rim of the nest, from 0.6–1.3 inches; the inside diameters of the nest cup were 1.5 inches on the narrow side and 2.8 inches from front to back. The nest cup had a depth of 1.5 inches.

Both the body and lining of this nest were primarily composed of grasses. There were a few large ohia twigs around the base. Interwoven throughout the main part of the nest were fine dark rootlets, one strip of ohia bark, and a few pieces of moss. The bottom nest had a base composed of mosses.

When I found the nest, it contained two eggs and contour feathers with crimson tips. I climbed out of the lava tube and moved off a short distance. Forty-five minutes later the Apapane returned to the nest to incubate the eggs.

I returned to the study area on 19 February, and the Apapane was still incubating the eggs. On two subsequent visits there was no adult at the nest. On 28 February I found both eggs broken and the nest deserted.—Charles van Riper III, *Department of Zoology, University of Hawaii, Honolulu, Hawaii 96822, 8 August 1972.*

New host records for the Bronzed Cowbird.—While recently engaged in field studies in Costa Rica, I found nests of three species, Black-billed Nightingale-Thrush (*Catharus gracilirostris*), Yellow-billed Cacique (*Amblycercus holosericeus*), and Scarlet-rumped Tanager (*Ramphocelus passerinii*), which contained one or more eggs of the Bronzed Cowbird (*Molothrus aeneus*). In his summaries of cowbird host records, Friedmann (U.S. Natl. Mus. Bull., 233, 1963; Smiths. Misc. Coll., 149, no. 11, 1966; Auk, 88:239–255, 1971) does not list any of these species as hosts of the Bronzed Cowbird.

All of the records discussed here refer to the nominate race of the cowbird. Identification of the parasite was made on the basis of the color, texture, and dimensions of eggs which I collected. Upon comparison, my specimens appear to be virtually identical in these regards to a series of 107 *Molothrus aeneus* eggs in the collection of the Western

Foundation of Vertebrate Zoology. All egg measurements in this report are given in millimeters.

Catharus gracilirostris.—A nest containing two eggs of this species and one of the Bronzed Cowbird was found near the summit of Volcan Poas, Alajuela Province on 3 May 1972. An incubating nightingale-thrush was flushed from the nest, and all three eggs were found to contain small embryos. The cowbird egg measured 22.9 × 17.4.

This record is of particular interest because of the unusually high altitude, ca. 2,400 meters, at which it occurred. No Bronzed Cowbirds were found in the immediate vicinity of the *Catharus* nest, although a male was seen on the same day at an elevation of 2,100 meters on Volcan Poas. Because of the scarcity of cowbirds in the high montane habitat of *Catharus gracilirostris* in Costa Rica and western Panama, this nightingale-thrush is probably an infrequent victim of *Molothrus aeneus.*

Amblycercus holosericeus.—During April–May, 1970 near Sierpe, a village 13 km. SW of Palmar Sur, Puntarenas Province, I found five nests of this species which contained Bronzed Cowbird eggs. At least one cacique was in attendance at each nest, either incubating, or, in two instances, scolding me vigorously only an arm's length away as I checked the nest contents.

The nest dates and their contents were as follows: 16 April (1 cacique egg and 3 cowbird eggs); 17 April (3 cowbird eggs); 2 May (2 cacique eggs and 3 cowbird eggs); 7 May (2 cacique eggs and 5 cowbird eggs); 12 May (2 cacique eggs and 3 cowbird eggs).

Average measurements of the 16 cowbird eggs (with extreme measurements in parentheses) were 23.0 (22.0–25.0) × 18.6 (17.1–19.5).

Friedmann (U.S. Natl. Mus. Bull., 233:173–174, 1963) noted the tendency of *Molothrus aeneus* to utilize icterid hosts, particularly species of the genus *Icterus*, and J. S. Rowley found that the colonial Yellow-winged Cacique (*Cassiculus melanicterus*) is heavily parasitized by the Bronzed Cowbird in southern Mexico (Friedmann, Auk, 88:252–253, 1971). It is apparent that the Yellow-billed Cacique, a non-colonial icterid, is a frequent victim of the Bronzed Cowbird at the Sierpe locality, since all nests of the species which I found there contained at least three cowbird eggs. The paucity of *Amblycercus holosericeus* nest records from other portions of its extensive range, however, makes it impossible to evaluate this cacique's importance as a host of *Molothrus aeneus.*

The disparity in size between the cowbird eggs found in each cacique nest suggested that they were laid by more than one female. Single *Molothrus* eggs in each of the nests discovered on 16 and 17 April were punctured when found, possibly the result of having been pecked by a cowbird, a behavioral trait which has been suggested, but not documented for this species (Friedmann, The Cowbirds, C. C. Thomas, Springfield, Ill., p. 327, 1929).

I found Bronzed Cowbirds to be very common in the Sierpe area even though Slud (Bull. Amer. Mus. Nat. Hist., 128:339, 1964) reported that the species was unknown from the southwestern portion of Costa Rica. Flocks of up to 200 individuals were seen in communal roosts along the major tributary in the area, the Rio Sierpe, even during the breeding season, and I saw smaller foraging flocks several times daily during my stay at Sierpe.

Ramphocelus passerinii.—I found a nest of this species which contained two *Molothrus aeneus* eggs and no eggs of the tanager on 21 April 1970, also near the village of Sierpe. The cowbird eggs hatched on 25 April, and on 1 May I observed the female tanager feeding the nestlings. When I checked the nest on 2 May, however, it was empty, presumably the work of an unknown predator. Another Scarlet-rumped Tanager nest discovered on 20 May 1970 at the same locality apparently suffered the same fate. It also contained only two cowbird eggs when found, but was empty when I visited it on the following day. Of 35 nests of the Scarlet-rumped Tanager which I found in the Sierpe area between 15 March to 31 May 1970, these were the only observed instances of cowbird parasitism.

My field work in Costa Rica was supported by the Western Foundation of Vertebrate Zoology, and all specimens mentioned here are deposited in the collection of that organization.—Lloyd F. Kiff, *Western Foundation of Vertebrate Zoology, 1100 Glendon Ave., Los Angeles, California 90024, 20 July 1972.*

Extreme overlap between first and second nestings in the Rose-breasted Grosbeak.—The adaptive value of raising more than one brood per year is obvious and one might expect broods to be closely spaced or even to overlap so as to maximize reproductive output. But countering this is the fact that it may be impossible to meet successfully the demands of two broods at the same time. In most multiple-brooded birds these conflicting selection pressures result in little overlap between nestings although in some species such as the Cactus Wren (*Campylorhynchus brunneicapillus*) (Anderson and Anderson, Condor, 62:351–369, 1960) and the Cedar Waxwing (*Bombycilla cedrorum*) (Putnam, Wilson Bull., 61:141–182, 1949) some females lay the first egg of their second clutch on about the day the young from the first clutch fledge. Although the Rose-breasted Grosbeak (*Pheucticus ludovicianus*) is generally thought to be single brooded (Forbush *in* Bent, Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies, Part one, New York, Dover Publications, 1968:39), I have noted one instance in which two nestings overlapped to a greater extent than is apparently known for any other North American passerine.

The first nest was found at 15:45 on 2 July 1969 in a thicket of tall alders (*Alnus* sp.) in Emmet County, Michigan. An adult female was on the nest and a well-grown nestling fledged when I attempted to place a mirror over the nest. Additional nestlings may have been present but I was not able to inspect the contents of the nest at this time. At about 16:00 nest 2 was found about 12 meters away in the same thicket. When inspected an hour later nest 2 contained three eggs and a male grosbeak was incubating. On 3 July at 08:50 another observer and I were able to inspect both nests by using a ladder (the nests were each at least four meters up in the alders). Nest 1 was empty but a fledged grosbeak was on a branch about two meters from the nest. A female was now incubating the three eggs in nest 2. I replaced one of the eggs in nest 2 with an artificial cowbird egg (see Rothstein, An experimental investigation of the defenses of the hosts of the Brown-headed Cowbird (*Molothrus ater*), unpubl. thesis, Yale University, 1970). The grosbeak egg contained a four to five-day-old embryo. During the 10 minutes we visited these nests on 3 July, we searched intensely for adult grosbeaks but, as on 2 July, only one female and one male were seen. The scolding of these two grosbeaks on 3 July was sufficiently intense to induce two Catbirds (*Dumetella carolinensis*) and a female American Redstart (*Setophaga ruticilla*) to join in the scolding, so if additional grosbeaks were participating at the two nests they would almost certainly have also been seen. Therefore, there is little doubt that both nests were being maintained by one pair.

Clutch initiation at nest 2 occurred six or seven days before the nest was found or when the young in nest 1 were only two to six days old (this is calculated using the nine to 12 day nestling period cited by Bent [op. cit.:40]). The male and female did not tend exclusively to one nest since on 2 July at nest 2 the male was incubating while the female was incubating on 3 July. Nest 2 remained active until at least 6 July but was empty when next visited on 9 July. Although Rose-breasted Grosbeaks are not thought to be double brooded in nature two pairs studied by Ivor (Wilson Bull., 56:91–104, 1944) under conditions of semicaptivity successfully raised two broods each. But the degree of overlap in nestings was minimal, with the building of the second nest not starting until a "short time" before the young of the first nest fledged. Davison (Auk, 6:191–192, 1889) described nests that may have been comparable to the ones I observed. He noted two nests a "few rods" (a rod equals five meters) apart and according to his estimation of the age of the young, the first egg in the second nest was laid when the young in the first nest were not more than a day old. Unfortunately, Davison did not determine whether both nests were from one pair. Dunham (Z. Tierpsychol., 23:438–451, 1966) described certain behaviors occurring during the breeding cycle but the actual nesting of the Rose-breasted Grosbeak has not been intensely studied in the field and possibly it quite commonly has two broods. It remains to be seen, however, whether the extreme degree of nest overlap observed by myself and possibly by Davison occurs with any regularity.

Nesting overlap by grosbeaks, especially if it is more extreme than in most birds, may explain the unusual behavior commonly shown by this species of singing while on the nest. Both sexes are known to engage in this practice (Bent, op. cit.:46) as is the closely related Black-headed Grosbeak (*Pheucticus melanocephalus*) (Bent, op. cit.:61). Possibly when stages of the nesting cycle normally accompanied by singing occur during the second nesting the demands of the first nest may also require the singing bird to incubate or brood. This interpretation imparts an overall adaptive value to singing on the nest even though such behavior may on occasion reveal the nest's location to a predator.

I thank Eugene S. Morton for his comments on this paper. The observations reported here occurred during field work supported by The Frank M. Chapman Memorial Fund, Yale University, and the University of Michigan. I gratefully acknowledge the University of Michigan Biological Station for the use of its facilities and Dr. Olin Sewall Pettingill, Jr. for his aid during my stay at the station.—STEPHEN I. ROTHSTEIN, *Chesapeake Bay Center for Environmental Studies, Smithsonian Institution, Edgewater, Maryland (Present address: Department of Biological Sciences, University of California, Santa Barbara, California 93106.) 28 June 1972.*

First recorded specimens of the White-winged Crossbill from Utah.—On 2 August 1965 a flock of eight White-winged Crossbills (*Loxia leucoptera*) was observed by Everett C. Peck and me on a sidehill immediately south of Pioneer Ranger Station, 9,300 feet elevation, Pavant Mountains, Millard County, Utah (39° 00′ N, 112° 08′ W). The area is a moderately dense forest of predominantly Englemann spruce, *Picea englemanii* (70 percent); alpine fir, *Abies lasiocarpa* (10 percent); and aspen, *Populus tremuloides* (20 percent) on an approximately 35° north facing slope. The flock moved largely as a unit, first feeding on cones in one tree and after several minutes flying to another tree to feed. While the birds were thus engaged, I collected three of them before the remainder of the flock was sufficiently alarmed to fly off across the valley. The three birds were prepared as study skins and are now in the University of Utah Museum of Zoology. The female (No. 19578) had heavy fat, the two males (Nos. 19577 and 19579) had relatively little fat, and none showed signs of molting.

Crossbills breed at odd times of the year reacting primarily to an abundant food supply rather than strictly to photoperiod (Tordoff and Dawson, Condor, 67:416–422, 1965). Presence during the summer months is, therefore, an insufficient criterion for breeding.

Short of actual nesting observation, only the presence of a brood patch offers conclusive evidence of reproductive activity in crossbills. Gonadal size is not as indicative but is still a moderately good indicator. The single female collected possessed no brood patch and her ovary was relatively small (5 mm), indicating that she was not in a reproductive state when collected. The two males, however, were mature and had testes of 5 × 4 and 6 × 5 mm. These approximate the testicular sizes of known breeding White-winged Crossbills from Canada and Alaska (6–7.5 [6.7 mm] $n = 4$). (These data were supplied by W. E. Godfrey, National Museum of Canada; and J. C. Barlow, Royal Ontario Museum).

In any event, this account reports the only specimens recorded for the species in Utah; the only other record being of three birds observed on a Christmas Bird Count on 21 December 1969 near Salt Lake City (Kashin, Audubon Field Notes, 24:416, 1970).—Gary L. Worthen, *Museum of Natural History, University of Kansas, Lawrence, Kansas 66044, 9 August 1972.*

A short method for treating avian breeding data in regional accounts.—The manner in which breeding evidence is presented in distributional surveys varies considerably. If little information is available or if space limitations do not preclude detailed treatment, all evidence may be given. In most cases, however, such data must be abbreviated. The classical method of abbreviation, the employment of a single symbol, usually an asterisk, to denote "breeding species" is inadequate for many types of surveys because a symbol cannot be defined to account for widely differing opinions as to what type of evidence constitutes proof of breeding.

The system proposed here allows the reader to make this decision according to his own concepts and at the same time satisfies the requirement of brevity. It is based on a scale that allows each of the major types of breeding evidence to be reported in a standardized *word phrase.* The sequence employed, a minimal modification of that occurring in nature, proceeds from the strongest to the weakest evidence.

In applying the system in faunal works, it is necessary only to determine the highest ranking datum known for a species and present a caption followed by the word phrase: "Breeding evidence: nest with young." When available data do not fully meet the requirements of the most similar entry on the scale, the next highest category for which there is evidence may be added. The breeding evidence section is included in a species account only if the data satisfy at least two of the last three points on the scale (range, habitat, and dates). The scale employed for breeding evidence is presented below, with the standardized word phrases listed first.

Prejuvenal.—The term *prejuvenal,* coined herein, denotes an individual that has left the nest but has not yet attained full growth of its first set of adult-sized remiges and rectrices. The possession of fully-grown flight feathers as the terminal point for this state is preferable to the cessation of the juvenal molt because of the difficulty of determining the presence or absence of molting body feathers in the field or in museum specimens, and because the completion of flight feather growth renders the young bird fully capable of traveling long distances from the nest site. This term has been coined because the only other word available, fledgling, has several nebulous definitions, is usually applied only to nidicolous species, and is restricted by some authors to the stage after completion of juvenal feather growth. When evaluating distributional breeding data, especially for very small areas, one must allow for highly mobile prejuvenals, such as precocious flyers (e.g., Galliformes), walkers (Charadriiformes), and swimmers (Anseriformes). Some species (e.g., certain hummingbirds and swifts) probably lack a prejuvenal state, remaining in the nest (nestlings) until their flight feathers are fully grown. When using this category, it is advisable to state whether the record is based on a specimen or field observation.

Nest with young.—An examined specimen of a nestling is considered sufficient evidence for this category.

Nest with egg(s).

Active nest completed, contents unknown.—This and the following three categories imply nests known to be used for breeding; if doubt exists, details may be presented and the next highest category added.

Active nest completed but empty.

Nest under construction.

Active nest, condition unknown.—This category is useful for inaccessible nests, especially those in holes.

Adult(s) carrying nest material.—Repeated observations may be necessary to determine beyond reasonable doubt that carried material is for nest construction.

Hard-shelled egg in oviduct.

Soft-shelled egg in oviduct.

Egg without shell in oviduct.

Ruptured follicle(s).

Enlarged follicle (. . . mm).—Usually, measurements are given only for the largest follicle. Care must be exercised to avoid treating as breeders those species known to attain enlarged follicles or testes, or engage in copulation or courtship, outside their normal breeding grounds. See enlarged testes category.

Enlarged oviduct.

Copulation observed.

Courtship display observed.

Territoriality observed.

Enlarged cloacal protuberance.

Enlarged testes (. . . mm).—If measurements of the testes or enlarged follicle are unknown, or if either follicles or testes are only "slightly" or "moderately" enlarged, evidence is considered insufficient, and the next highest known category should also be given. Two sets of dimensions are given if the testes are different in size and one set if the testes are equal or the size of only one is known; in the last case, notation to that effect should be made.

Range.—This and the following two categories are considered to be on an equal level at the bottom of the scale and are always presented together. In each of the three, usage is determined by the amount of evidence that suggests breeding. If all information indicates breeding, the unmodified name of that category is given; if some, either "probably" or "possibly" is added; if none, the modifier "not" is used. For example, the breeding evidence section might read "range, habitat, and possibly dates." A phrase such as "range, probably habitat, and probably dates" could not be used because only one of the categories is unqualified, and the breeding evidence section thus would be omitted.

Considered in evaluating range as breeding evidence are the distance from the region under investigation to the nearest area of known breeding; whether the species breeds on only one or on two or more sides of the region; whether continuity in habitat exists between the region and the known breeding range; and the degree of localness exhibited by the species. In the last case, a species known to be local in its breeding distribution is considered a less likely breeding prospect than a wide-ranging species.

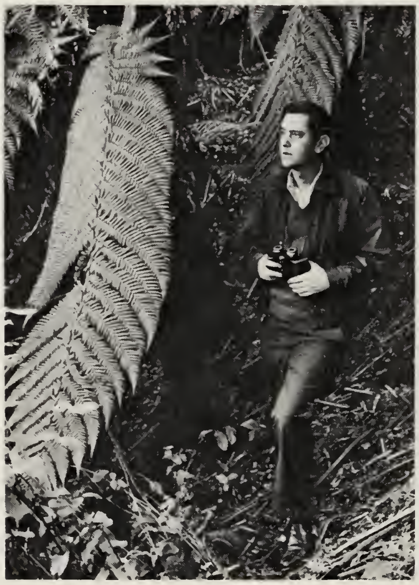
Habitat.—Habitat is used as breeding evidence if the species has been recorded in proper breeding habitat in the region.

Dates.—A species is considered a more likely breeding prospect if it is sedentary rather than migratory or wandering in its habits, if breeding season dates have been recorded, or if the distribution of dates indicates that the species is a permanent resident. For sedentary species, a single occurrence within the region, whether or not it is during the breeding season, is regarded as excellent evidence, in most cases conclusive, for inclusion of the date category. For a non-sedentary species, lack of a breeding season date negates the date category.

This system is easily modified. Only major categories have been listed here, but additional word phrases may be added, in their proper sequence, if an author so desires. The author may decide what evidence should be considered proof of breeding by so stating in his introduction; but deleting what he considers inconclusive categories would defeat the major function of the system. The scheme is useful even in monographic treatments, since information such as dates (especially egg dates), localities, habitats, elevations, or references to publications or specimen labels may be added conveniently to the standardized word phrases. In the case of unusual breeding records, all details may be given, at least for those categories high on the scale.

This paper represents a portion of a doctoral dissertation completed at Louisiana State University. Research was supported by the L. S. U. Museum of Zoology, Mr. John S. McIlhenny, and the National Science Foundation. I am grateful to George H. Lowery, Jr. and Robert J. Newman for their generous aid and direction. Diana R. Young made helpful suggestions on the manuscript.—LAURENCE C. BINFORD, *California Academy of Sciences, Golden Gate Park, San Francisco, California 94118, 20 June 1972.*

NEW LIFE MEMBER



Laurence C. Binford, Assistant Curator of Birds and Mammals at the California Academy of Science, San Francisco is a new Life Member of the Wilson Ornithological Society. Dr. Binford earned his bachelor's degree from the University of Michigan and his doctorate at Louisiana State University. He has published numerous papers on a variety of ornithological subjects and has carried out a major study on the birds of Oaxaca, Mexico. Some years ago he had the unusual experience for present-day ornithologists of adding a new species to the Check-list area list. the Five-striped Sparrow. Dr. Binford is an Elective Member of the A.O.U., a member of the Cooper Society, Louisiana Ornithological Society, Michigan Audubon Society, and is Vice President of the Board of Directors of the Point Reyes Bird Observatory. Besides his ornithological work he lists his hobbies as birding, golf, and bowling.

ORNITHOLOGICAL NEWS

The editor of *The Ring*, Dr. Wladyslaw Rydzewski, has compiled and published an "Index Ornithologorum," a sort of "Who's Who" of ornithology. It contains a listing of 711 names representing 59 countries. Each entry gives biographical information, occupation, address, and principal ornithological interests of the ornithologist. A special feature is a subject index in which the persons listed in the main body of the work are tabulated under the subject headings of their principal interests. This feature is intended to make possible world-wide contacts among persons holding the same interests. Copies of the "Index Ornithologorum" may be obtained by sending a check, bank draft, or International Money Order for U.S. $3.00 to: The Editor of the Ring, Laboratory of Ornithology, Sienkiewicza 21, Wroclaw, Poland. Checks should be payable to The Polish Ornithological Society.

As we go to press we are saddened to learn of the death on 21 March 1973 of E. Alexander Bergstrom, a Life Member of the Wilson Society, who edited *Bird-Banding* for 21 years.

A 10-minute color film entitled "Kirtland's Warbler, Bird of Fire" is available for purchase, rent, or preview from: Walter and Myrna Berlet, 6998 Surrey Lane, Jackson, Michigan 49201. The film was produced by the Berlets with the consultation of W.O.S. member Dr. Nicholas Cuthbert.

Autumn Hawk Migration Monograph.—Research and the writing of a comprehensive book detailing autumn hawk migrations in eastern North America is nearing completion. An exhaustive literature search has been conducted, and considerable amounts of unpublished data have been gathered from institutions and private individuals. Persons who have not yet forwarded unpublished data for 1971 or earlier are urged to do so immediately if they wish to have their work recognized and considered for inclusion in this monograph. Please send all information to: Donald S. Heintzelman, 629 Green St., Allentown, Pa. 18102.

Request for Information: Herring Gulls.—Herring Gulls ranging in age and color plumage from first year through fourth year are being individually marked at Groton and Stonington, Connecticut sanitary landfill areas. The gulls are marked with dumbbell shaped wing tags of different colors and carrying different number-letter combinations. The tags can be read with a spotting scope up to a distance of 100 yards.

Reports of sight records of these marked gulls would be greatly appreciated. Please include date, time and location of sighting, color of tag and letter-number series.

The purpose is to study the patterns of behavior at the dumps, dispersal from the sites and along the Connecticut shore line, as well as nesting and roosting locations.

Reports should be sent to: Frank R. Haeni, Chief Naturalist, Thames Science Center, Center Gallows Lane, New London, Connecticut 06320.

ORNITHOLOGICAL LITERATURE

Studies of Tropical American Birds. By Alexander F. Skutch. Publications of the Nuttall Ornithological Club, No. 10, Cambridge, Mass., 1972: 6¼ × 9¼ in., vi + 228 pp., 15 photos, 2 tables. $12.00. (Obtainable from the Nuttall Ornithological Club, c/o Museum of Comparative Zoology, Harvard Univ., Cambridge, Mass. 02138.)

I am certain that future ornithologists will be heaping praises upon Alexander Skutch long after most current, fashionable research endeavors are forgotten. In our ever more restricted environment, the depletion of avifaunas, particularly in tropical forest areas, makes it incumbent upon today's ornithologists to seek out, and study birds in their natural habitats. Indeed, I know of no more important responsibility facing us. Alexander Skutch has borne this responsibility, selflessly, for many of us, by dedicating the bulk of his life to field studies of neotropical birds. Whatever faults might be found with his behavioral interpretations, and whatever the gaps may be in his studies, his efforts have proved most fruitful and we are deeply in his debt. The present volume, his fifth of this type (in addition to many articles in scientific journals), contains life history observations of more than 50 species, including some not treated in separate accounts, but mentioned within sections dealing with related species.

Dr. Skutch's writing is eminently readable and flowing. One familiar with tropical forest birds perhaps will appreciate more than others the enthusiasm, stamina, and effort of the author, barely hinted at, or not suggested at all—the sitting motionless for many hours at a stretch (as watching a kingfisher's nest entrance, p. 92, "a sort of yogic exercise in the contemplation of nothingness"!), and at times in heavy rain or burning sun—is accepted without a hint of complaint by this dedicated researcher. The results of his observations in the present volume include 28 species accounts of birds representing six non-passerine and nine passerine families. Especially interesting to this reader, either because of the depth of coverage, the lack of previous information concerning the genus involved, or special interest were: the lengthy treatment of the Pauraque, coverage of no fewer than six hummingbirds of five genera (the longest section for any family in this book), the detailed accounts of the Ringed Kingfisher and the White-fronted Nunbird, the Shining Honeycreeper section, the observations of four tanagers (three genera), and the write-up of the Black-faced Grosbeak.

We learn many details from these accounts, and facts of diverse biological interests. A case of bigamy is described in detail for *Thraupis episcopus*, and occurrence of song dialects is suggested for populations of that tanager. The sometimes successful fly-catching (!) efforts of the large toucan *Ramphastos swainsonii* after winged termites are described. Dr. Skutch mentions (pp. 126–127) some instances of predation by this toucan on various nestling birds, and eggs, and he proposes that the large, usually brightly colored bill of toucans in general serves to intimidate (as a form of "supernormal stimulus") parent birds of other species defending their nests and young against the toucan. Another "supernormal stimulus" seems to be an oropendola's nest to a Piratic Flycatcher, which utilizes such (large) nests, but is unsuccessful in raising young in them. The White-fronted Nunbirds sing in choruses composed of an adult pair, and, apparently, other adults destined to be helpers-at-the-nest, for the author found three nests involving three or four adults apiece. The rate of feeding nestling hummingbirds at various stages is summarized in tabular form for no fewer than 10 species of nine genera. Dr. Skutch argues convincingly for the strong influence of learning of song patterns in hummingbirds, based on studies of singing assemblies among 15 hummingbird species, and other data including the singing of a song and uttering of a call of *Amazilia tzacatl* by a male *Amazilia amabilis* that over the years fashioned from the song one more like that of its own species. A 48-hour incubation cycle is documented for the Ringed Kingfisher. Interspecific aggression seems to be the rule among dacnid honeycreepers such as *Cyanerpes lucidus*, which fights over food with other honeycreepers, but not with conspecific birds. Helpers were noted at nests of several species other than the nunbird mentioned above, including the grosbeak *Caryothraustes poliogaster*—the author reemphasizes his view that helpers are much more prevalent in less territorial birds, and are uncommon in such territorial birds as finches. But I continue to stress the unusual, which could go on for some pages. Suffice to say that packed within this relatively small book are observations galore, some indeed unusual, giving us pause and perhaps forcing a reconsideration of views, and many others filling in details and extending by another species or even another genus our knowledge of the biology of various avian groups.

The text is essentially free of errors. Each account is adequately summarized, but the writing easily entices one to read through the accounts rather than skimming the summaries. The photographs are not of excellent quality, but are satisfactory generally (figure 14 is questionably satisfactory). Only two of the photographs grace the portion of the book treating passerine families. Scientific names of extraneous species are listed after the common names of these species in the Index, which covers only bird names, and, unfortunately, no subject headings. A criticism of the publications of this series is the failure to give the price of each book, or to include the prices for previous publications in the list on the back of the title page.

I recommended this book to all interested in avian biology. Hopefully, the stimulation of reading it will encourage others to share in the responsibility of extending our knowledge of neotropical birds beyond the foundation so ably, and all too largely laid by Alexander Skutch.—LESTER L. SHORT.

COMMUNICATION AND OTHER SOCIAL BEHAVIOR IN *PARUS CAROLINENSIS*. By Susan T. Smith. Publications of the Nuttall Ornithological Club, No. 11, Cambridge, Mass., 1972: 6¼ × 9¼ in., ix + 125 pp., 2 maps, many sonagrams. $7.75. (Obtainable from the Nuttall Ornithological Club, c/o Museum of Comparative Zoology, Harvard Univ., Cambridge, Mass. 02138.)

W. J. Smith's (e.g. 1969) distinction between "message" and "meaning" brought important advances to the study of animal communication. Most previous investigators, and especially perhaps ethologists (with the notable exception of Andrew, 1951, 1961, 1972), had attempted to interpret signal movements and vocalizations in terms of major "drives" or "tendencies" such as attack, escape and sex, or in terms of conflict between them. W. J. Smith has shown, in effect, that this may involve attempts at analysis at too high a level. For instance, the "Locomotory Hesitance Vocalization" of tyrannid flycatchers is used in a wide variety of situations that involve locomotion in conflict with some other tendency, no matter whether that locomotion is likely to lead to attack or food. Many signals are used in a similar variety of situations, and the state of the sender that they describe (i.e. the "message") can be deduced only by abstracting those features of its behavior that are common to all the situations.

In interpreting this message, the recipient has available also contextual information. Thus the "meaning" varies with the context in which the signal is emitted and the nature of the recipient; for example, the response to the Locomotory Hesitance Vocalization given by the caller's mate is different from that given by a rival male. While a message can contain only about 14 different types of information (e.g. identification, location, attack, escape, frustration, etc.), each message may contain several of these, and contextual information may endow it with a more specific meaning for a recipient.

This approach is used here by S. T. Smith in a study of the vocalizations and other displays of the Carolina Chickadee. The study extended over about nine months, and was conducted in a suburban area. The author was concerned primarily with obtaining good behavioral data coupled with tape recordings suitable for sound spectrographic analysis. Her descriptions of the physical characteristics of the calls, illustrated by tracings of sonagrams, will provide useful material for other workers, especially those engaged in comparative studies. There is, however, some confusion in the terminology, since some of what she refers to as "closely stacked harmonics," "lower harmonics," and "resonance harmonics" would seem to be not harmonics but artifacts arising from the relationship between the characteristics of the calls and those of the sonagraph (see Marler, 1969).

She describes also the situation in which each of 20 vocalizations is used, and makes deductions as to its message and meaning(s). The field priorities (see above) prevented the acquisition of many quantitative data, but the deductions follow convincingly from the qualitative descriptions of usage. Nearly all the vocalizations appear in conflict situations. In many of them the value of the message/meaning approach is apparent. For example, the common feature in situations in which the "Lisping Tee" is used is the presence of a tendency to associate with another chickadee in conflict with some other locomotory activity, and the message of "Broken Dee" appears to be "I am prepared to engage in appropriate bond-limited activities." Such interpretations would not easily have been reached by the earlier ethological approach. However, in other cases, and especially those calls which are interpreted as involving conflict between attack and escape or some other tendency, there seems little to choose between the author's approach and those of some ethologists, especially Andrew (op. cit.) and Blurton-Jones (1968, 1972). The author refers to a paper by W. J. Smith (in press) in which the motivational approach is "contrasted" with his own, but the issue would seem rather to be one of defining where one approach is useful and where the other. This reviewer, for one, looks forward to seeing the new paper, but if the two approaches are merely "contrasted" it would seem that both there and in the paper at present under review, an opportunity has been lost for relating the use of the message/meaning approach to recent developments of the ethological methods.

Less complete descriptions of 15 visual displays are interpreted in a similar way. This provides some interesting additional material on parid signal movements, but the treatment is somewhat less satisfactory than that of the vocalizations, in part because it is primarily in terms of their displays rather than the display components. Their interpretation would perhaps have been facilitated by reference to Stokes's (1962) work on the related Blue Tit (*Parus caeruleus*).

This monograph, the eleventh publication of the Nuttall Ornithological Club, fully maintains the high standards set by its predecessors. It also demonstrates that important scientific data can still be obtained through careful observation of common species.

LITERATURE CITED

ANDREW, R. J. 1956. Some remarks on behaviour in conflict situations, with special reference to *Emberiza* spp. Brit. J. Anim. Behav., 4:41–45.

ANDREW, R. J. 1962. The situations that evoke vocalization in primates. Ann. New York Acad. Sci., 102:296–315.

ANDREW, R. J. 1972. The information potentially available in mammal displays. *In* R. A. Hinde (Ed.), Non-verbal communication, Cambridge Univ. Press.

BLURTON-JONES, N. G. 1968. Observations and experiments on causation of threat displays of the great tit (*Parus major*). Anim. Behav. Monogr., 1:2.

BLURTON-JONES, N. G. 1972. Non-verbal communication in children. *In* R. A. Hinde (Ed.), Non-verbal communication, Cambridge Univ. Press.

MARLER, P. 1969. Tonal quality of bird sounds. *In* R. A. Hinde (Ed.), Bird vocalizations, Cambridge Univ. Press.

SMITH, W. J. 1969. Messages of vertebrate communication. Science, 165:145–150.

SMITH, W. J. (in press) Zoosemiotics. *In* T. A. Sebeok (Ed.), Current trends in linguistics, Vol. 12, Mouton, The Hague.

STOKES, A. W. 1962. Agonistic behaviour among Blue Tits at a winter feeding station. Behaviour, 19:118–138.

R. A. HINDE

PHILIPPINE BIRDS. By John Eleuthère duPont. Monograph Series No. 2, Delaware Museum of Natural History, Greenville, Del., 1971: 8 × 11¾ in., x + 480 pp., 85 col. pls. by George Sandström and John R. Peirce. $32.50.

In his Introduction to this book, the author acknowledges the limitations of his work and sets the objective by which it must be judged—"to present a ready identification guide to all the known Philippine birds with a colored illustration of most." Broadly, the double objective is met. This book will undoubtedly become a standard work on the area, and both author and artists deserve high praise, as do the printers for an excellent job of color reproduction.

The task which must have confronted John duPont is understated by the author himself, and although it is put in better perspective by Dean Amadon in his Foreword, it is yet worth more reflection. The Bibliography whilst listing principal earlier papers, concentrates on the period 1947–71, for which it lists 138 papers. These papers included proposals for 12 new species and 164 races; whilst the studies they contained may have helped in the task of assessing the status of many races, they did not diminish the task, for older and newer taxa alike required evaluation. Finally, the Philippines constitute an archipelago with more than 7000 islands; keeping track of the distribution records of all species even for the main islands is a major task in itself.

The author's statement of his objective contains two important adjectives—"ready" identification and "all" birds. It omits, however, a third—"field" as a qualification to identification. Indeed, the generous size of this book precludes its use in the field. Cost will prevent it from reaching a wide Filipino audience but the work will be a "must" for bird tourists despite a few other shortcomings, chiefly lack of a map, lack of data on habitat, and lack of a measurement of overall length for each species or of a scale on the plates.

The color plates depict all except four of the 518 species; three vagrant seabirds and a rather local bulbul are omitted. Of these, 48 plates are signed by George Sandström, 13 by John R. Peirce, and the rest are composites of work by both men. The plates by Sandström are, on the whole, the better executed, and he is at his best on the Palawan Peacock Pheasant (pl. 15), terns (pl. 27), parrots (pls. 33–34), warblers (pls. 65–67), and white-eyes (pl. 83). Other difficult groups such as babblers, bulbuls, and flycatchers are also well rendered. Only his waders are somehow less pleasing. Amongst the plates by Peirce, that of the Monkey-eating Eagle (pl. 12) excels, and he seems more at home with hornbills (pl. 47) and pittas (pl. 49) than with the smaller birds. The plates on kingfishers (pls. 44–45) are not absolutely accurate in detail but should not cause misidentifications. Some of the plates are not going to help with field identification, admittedly on difficult groups such as *Collocalia* swiftlets and *Cuculus* cuckoos. In hardly any of the plates do shapes or stances seem wrong.

Not all plumages are illustrated—for example, eclipse and female plumages of ducks are omitted—and small problems could arise. Anyone seeing a member of the fork-tailed race of the Spangled Drongo might think it a Balicassiao, and anyone seeing members of the white-bellied races of the latter would have no luck in identifying them from the plates. More seriously, there are errors in lettering the plates to accord with their caption pages. The following corrections appear necessary: on plate 34 reverse D and E, on plate 42 reverse A and C, on plate 56 reverse D and E, on plate 68 reverse B and C, on plate 80 reverse C and F and also D and G, on plate 81 reverse E and F.

As regards completeness, the author has taken into account all newly proposed species and races, including two species proposed in the early 1940's which were not listed by Delacour and Mayr (Birds of the Philippines, 1946). One species listed by them, *Anthreptes rhodolaema*, has been removed from the list. In the present book, however, there appear to be two omissions, as follows: *Phylloscopus coronatus ijimae* was reported by Gilliard (Bull. Amer. Mus. Nat. Hist. 94:457–504, 1950) from Bataan; *Pycnonotus plumosus* subsp. was listed—as *P. p. plumosus*—from Calayan (*sic*) Sulu by Delacour and Mayr (1946) and—as *P. p. hackisukae*—from Cagayan Sulu by Deignan in Peters (Check-list of Birds of the World, 9:221–300, 1960). The text and plates will certainly serve as excellent tools for museum workers, though one would have liked to see ranges of measurements given instead of single averages.

There seem to be very few errors or misprints in the text. This reviewer noted "upperparts" in place of "underparts" in the text on *Puffinus leucomelas* (p. 1) and *Tringa ochrophus* for either *ocrophus* or *ochropus*, depending on the dogma of one's choice. The term "hybrid" is used in certain cases where "intergrade" would have been better.

Some points could have been added to the text with profit. For example, *Ptilinopus arcanus* is known from one specimen, a female, and the male plumage may well differ but neither the text nor the plate caption suggests this or even says "female," and few readers will pick up the comment in Dean Amadon's Foreword. The caption pages in particular could have benefited from scrutiny to ensure that the captions drew attention to species in which the sexes differ in plumage or there are color phases (e.g. *Egretta sacra*).

Finally, some of the English names are unfortunate, although all seem to have been retained from Delacour and Mayr (1946), occasionally—as with *Asiatic* Honey Buzzard—wrongly retained.

The comments above detract little from an attractively presented, thorough, concise work on the species and races of Philippine birds and their distribution through the scattered archipelago. This book cannot fail to contribute measureably to the relief of conservation problems in the Philippines, in particular local apathy and destruction of the habitat.—Edward C. Dickinson.

Birds of Idaho. By Thomas D. Burleigh. The Caxton Printers, Ltd. Caldwell, Idaho, 1972: 7 × 10 in., xiii + 467 pp., 1 map, 33 photos, 1 appendix table. $17.50.

"Birds of Idaho" is the result of eleven years of diligent field work and 14 years of preparation on the part of the author. Mr. Burleigh spent tens of thousands of hours in the field and walked thousands of miles in personally "covering the state." In the course of his studies he collected countless specimens, described nine new races and, in general, made an enormous contribution to our knowledge of the taxonomy and distribution of northern rocky mountain birds. I can't help but wonder how many ornithologists of the future will show Mr. Burleigh's drive, patience, and field skills.

The book includes a county map, a brief preface recounting accomplishments of various ornithologists in Idaho, species accounts, a list of birds originally described from the state, a bibliography of Idaho ornithology, as well as 12 color and 21 black and white photographs. By far the bulk of the book is devoted to the accounts of 303 fully recognized (based upon specimen collection with one exception) and 13 hypothetical species (by my count). Each species account is subdivided into General Distribution, where the total range of the species is discussed; Status in Idaho, which, after an overall statement, is discussed in detail in a very convenient north-south arrangement; and Habits, where the author recounts various points of interest regarding behavior and/or ecology. In addition, accounts of polytypic species include subspecific accounts covering the overall range of the race, its distribution in Idaho, and usually a brief mention of racial characters. The Wild Turkey (*Meleagris gallopavo*) is omitted from the book despite successful introduction along the Salmon River.

General Distribution sections are brief, accurate, and worthwhile. Sections on Status in Idaho are fairly complete summaries of Burleigh's own data together with published records of Idaho birds. Apparently the book was already well along in preparation when Oring (Murrelet, 43(3):2–12, 1962) appeared for, with the exception of two species added to the hypothetical list, species falling before Upland Plover (*Bartramia longicauda*) in the phylogenetic listing, which were mentioned in that paper, are omitted from review in the book. In most cases these omissions are of little importance, however for the following species, distributional statements should have been changed: Ring-necked Duck (*Aythya collaris*), Bufflehead (*Bucephala albeola*), Pigeon Hawk (*Falco columbarius*), Semipalmated Plover (*Charadrius semipalmatus*), and Golden Plover (*Pluvialis dominica*). In addition, the range of *Bonasa umbellus incana* should have been expanded. Judging from Burleigh's work, the report of *Dendragapus obscurus richardsonii* from Bonneville County (Oring, op. cit.) was probably in error. The consistent omission of records reported by Oring (op. cit.), falling before the Upland Plover in the species list indicates that a similar omission from Levy (Murrelet, 43(1):10–14, 1962) may have occurred. I have not checked on this.

The Habits sections are highly variable in content. In some cases such important and useful information as extreme dates of occurrence, dates of nests and/or young, flock sizes, nesting habitats, nest descriptions, and descriptions of various behaviors are included. In other cases they are not. Life history information of considerable value is included for a number of little known montane species. Statements on such subjects as palatability, wariness, hardiness, and crop damage are of questionable value as the subjects are not equally treated, even among the most appropriate species for such discussions. Most information included in this section is general and accurate, however several questionable statements were noticed:

Spotted Sandpiper (*Actitis macularia*). "Both male and female incubate and are equally concerned with the welfare of the young." This is a false statement. Males do far more incubating and care of young than do females.

Black Tern (*Chlidonias niger*). "The food of the Black Tern in Idaho is apparently entirely insectivorous." While nearly true, in Idaho as elsewhere, females are fed small fish as well as large insects at the nest-site during nest establishment and building.

Snowy Owl (*Nyctea scandiaca*). "Where available, the preferred food is rodents, so it can be considered a beneficial species during its sojourn in the state." This infers either that they aren't beneficial elsewhere or that other predatory birds are not beneficial. Considering the demonstrated importance of predatory birds in the functioning of ecosystems, this strikes me as a naive statement at best.

I found subspecific discussions of considerable value in view of the paucity of information available on the distribution of various subspecies in the northern rockies. Personally, I would have appreciated more detailed information on gradients in subspecific characteristics in view of Mr. Burleigh's expertise in this area, and the attention he has paid to this aspect of ornithology.

Illustrations are highly variable in quality and value. Of 12 color plates, the color is of questionable quality in at least three, and six have poor definition. I found it very disturbing to look at color plates out of phylogenetic position, e.g. the Cassin's Finch (*Carpodacus cassinii*) is portrayed between discussions of mergansers. The 21 black and white photos are fair to excellent in quality and are placed in the appropriate positions among species accounts. Such captions as "A Melancholy Killdeer on its Nest in a Gravel Pit" and "A Saw-whet Owl in an Artistic Setting" provided far less useful information than space would have allowed. I found myself wondering which of the photographs were actually taken in Idaho, for while I know that many were, the photograph of a White-faced Ibis (*Plegadis chihi*) at its nest certainly was not, since there are no breeding records for the state.

In the back of the book is a useful listing of the 22 species and races of birds described from Idaho, together with the original literature citation, type locality, and present status of the name. I found this list informative and well done. The bibliography is extensive and carefully presented, the one glaring error which I noticed being that Ligon's paper is listed for 1918 rather than 1968. The combined common and Latin name index is useful but it would have been far more useful had generic names been included.

Birds of Idaho is disappointing in its very slight emphasis on the ecology of the state. No habitat photos are included nor is there a physiographic map. Neither is there any discussion of the state's biotic zones, climate, or geology. These subjects are sometimes briefly mentioned in species accounts, but there is a serious need for an introductory section on what Idaho is like. It would have been very useful, for example, if Burleigh, after having included an introductory section on the state's physiography and climate, had correlated the unique features of Idaho's avifauna with certain of the state's ecological characteristics. Isn't it fascinating to think of a state where Hawk Owls (*Surnia ulula*) and Ash-throated Flycatchers (*Myiarchus cinerascens*), Great-gray Owls (*Strix nebulosa*) and Black-throated Sparrows (*Amphispiza bilineata*) breed? Isn't it interesting that woodpeckers (10 of 11 species breed), owls (10 or 11 of 13 species breed), and hawks (13 of 19 species breed) compose such a high proportion of the state's avifauna? Why are there 42 species of fringillids and only 17 parulids known from Idaho? Do the same features which virtually eliminate the Purple Martin (*Progne subis*) from Idaho affect other species similarly? A discussion of these and similar phenomena in conjunction with an ecological discussion of the state would have greatly enhanced this book.

In summary, Birds of Idaho is a carefully prepared and pleasant work on the avifauna of a little known part of the country. Its principal contributions are in filling gaps about our knowledge of bird distribution and taxonomy in the northern Rocky Mountain region. As such it is worth the price. It is disappointing in that so little attention is paid to the features of the state which have influenced bird distribution and which have brought about the racial variations which occur.—Lewis W. Oring.

Birds of the Lake Tahoe Region. By Robert T. Orr and James Moffitt. California Academy of Sciences, San Francisco, Cal., 1971: 10¼ × 6¾ in., ix + 150 pp., 1 col. pl., 16 figs. $5.00.

Lake Tahoe is a large deep lake situated at about 6,225 feet elevation in the Sierra Nevada Mountains of California and Nevada, and is surrounded by mountains reaching from 8,000 to over 9,700 feet. Formerly the lake was a quiet place in which to spend the summer, but it has developed into a popular year-round recreational area. The combination of varied mountain habitats and a large body of water attracts a large variety of birds to the area.

This book is intended to help persons interested in the birdlife of Lake Tahoe, and provide a record of the ornithological history of the area. It consists of three sections—a historical review, a description of the major plant associations, and the species accounts. The area covered by the book is nowhere delimited (a map would have been an asset), so the reader is left to guess at the boundaries of the Lake Tahoe Basin.

The historical summary includes a list of persons who studied birds in the Tahoe Basin, from the time of its discovery in 1844. It is evident that few early ornithologists did any serious work there, and Milton S. Ray appears to be the only one to have published much more from the area. The list also includes the names of a few local residents, such as J. E. Pomin, a trapper and guide who had an interest in birds and whose observations have been used in the book. John Ward Mailliard started gathering the information presented in this book, and all his notes and manuscripts were given to his collaborator, James Moffitt, after his death. Moffitt gathered additional data to complete a study of the birds in the Tahoe region, but met an untimely death in 1943. Robert T. Orr then organized the data, added more findings, and put the book together for publication.

The second portion of the book describes the five principal plant associations in the area and discusses where each association occurs. Some of the commoner summer resident species of birds in each association are mentioned.

The species accounts make up most of the book, as they cover 195 species, listed in strict accordance with the A.O.U. Check-list of North American birds (5th ed.). Subspecific forms are indicated in those cases where specimens have been examined. The information given for each species varies from three lines, for stragglers recorded only once, to nine pages for the Common Merganser (*Mergus merganser*). Specific records and information follow a concise statement of status for each species. Much of the information has been taken from the notes of Mailliard and the authors, but observations by some of the early residents and published records have also been included.

This book provides a thorough record of the ornithological history for the Lake Tahoe region until about 1930, but not thereafter. It is fairly easy to determine the status of most birds in the 1920's by reading the species accounts, and the book could be helpful in determining changes in the status of birds around Lake Tahoe due to the development of the area.

On the other hand, the book may mislead persons interested in the present birdlife of Lake Tahoe because little effort has been made to consider recent records. The House Sparrow (*Passer domesticus*) is stated to be an "uncommon vagrant," citing a single bird seen in Tahoe City on 7 April 1927, and two more seen there on 1 May 1927. In reality, the species is now fairly common in all the towns along the lake shore. The Starling (*Sturnus vulgaris*), now a resident species around the lake, is not included in the species accounts, and the present status of many other species is different from that indicated in the book. Dr. Orr apparently made no effort to contact active observers around the lake as had Mailliard and Moffitt, with the result that much potential information was omitted. In addition, the records have not been carefully screened, with the result that such species as the Red-necked Grebe (*Podiceps grisegena*) and Ross' Goose (*Chen rossii*) have been included on the basis of very weak evidence. Current information on the birds of California indicates that both species are most unlikely on Lake Tahoe.

Records published since 1940 have been mostly overlooked, resulting in some inaccuracies. For instance, it is stated that "there is no evidence at hand to indicate that Willets have bred in the Tahoe region within historic times," yet William K. Kirscher (Condor, 56:361, 1954) reported finding a Willet nest at the south end of Lake Tahoe on 31 May 1954. Only one positive record is said to exist for the Flammulated Owl (*Otus flammeolus*) in the Tahoe region, but Ned K. Johnson and Ward C. Russell (Condor, 64:513–514, 1962) reported hearing some twelve birds, three of which were collected, around Martis Peak and Crystal Bay during 1960 and 1961. Additional species such as the Oldsquaw (*Clangula hyemalis*) reported by Fred G. Evenden (Condor, 57:304–305, 1955) at the mouth of the Upper Truckee River on 16 May 1955, should have been included in the species accounts.

The book is well laid out and pleasing to the eye. The print is easy to read, the paper is of high quality, and I detected no obvious editorial errors. The volume is worth the five dollars being asked. Unfortunately, it should have been published 40 years ago, for its information would then have been current.—Guy McCaskie.

A Guide to Northeastern Hawk Watching. By Donald S. Heintzelman. Published privately, 1972: 5¼ × 7¾ in., 64 pp., photographs, maps, diagrams. Paper cover. $1.50 plus 25¢ postage and handling. (Order from: Donald S. Heintzelman, 35 Church Street, Lambertville, N. J. 08530.)

The sight of hawks in migration gives most birders a thrill, and this booklet can help them to have that experience. It is a guide to hawk watching in the northeastern United States, where are to be found some of the finest hawk lookouts in the world. Novices can learn much from it about migrations and weather conditions, field equipment and methods, and secrets of hawk identification. One chapter gives information about each of 21 lookouts—there *are* other places besides Hawk Mountain and Mount Tom—with maps and directions for finding them. The booklet is attractive and well-written. It should prove useful to hawk watchers, and should lure newcomers to the sport.—P.S.

This issue of *The Wilson Bulletin* was published on 14 June 1973.

SUGGESTIONS TO AUTHORS

See Wilson Bulletin, 84:513, 1972 for more detailed "Suggestions to Authors." Manuscripts intended for publication in *The Wilson Bulletin* should be neatly typewritten, double-spaced, with at least one inch margins, and on one side only of good quality white paper. Tables should be typed on separate sheets, and should be designed to fit the normal page width, i.e., narrow and deep rather than wide and shallow. Before preparing these, carefully consider whether the material is best presented in tabular form. Follow the AOU Check-list (Fifth Edition, 1957) insofar as scientific names of United States and Canadian birds are concerned unless a satisfactory explanation is offered for doing otherwise. Use species names (binomials) unless specimens have actually been handled and subsequently identified. Summaries of major papers should be brief but quotable. Where fewer than five papers are cited, the citations may be included in the text. All citations in "General Notes" should be included in the text. Follow carefully the style used in this issue in listing the literature cited; otherwise, follow the "CBE Style Manual" (1972, AIBS). Photographs for illustrations should be sharp, have good contrast, and be on gloss paper. Submit prints unmounted and attach to each a brief but adequate legend. Do not write heavily on the backs of photographs. Diagrams and line drawings should be in black ink and their lettering large enough to permit reduction. Extensive alterations in copy after the type has been set must be charged to the author.

NOTICE OF CHANGE OF ADDRESS

If your address changes, notify the Society immediately. Send your complete new address to the Treasurer, William A. Klamm, 2140 Lewis Drive, Lakewood, Ohio 44107. He will notify the printer.

The permanent mailing address of the Wilson Ornithological Society is: c/o The MUSEUM of Zoology, The University of Michigan, Ann Arbor, Michigan 48104. Persons having business with any of the officers may address them at their various addresses given on the back of the front cover, and all matters pertaining to the Bulletin should be sent directly to the Editor.

WILSON ORNITHOLOGICAL SOCIETY

ANNUAL MEETINGS

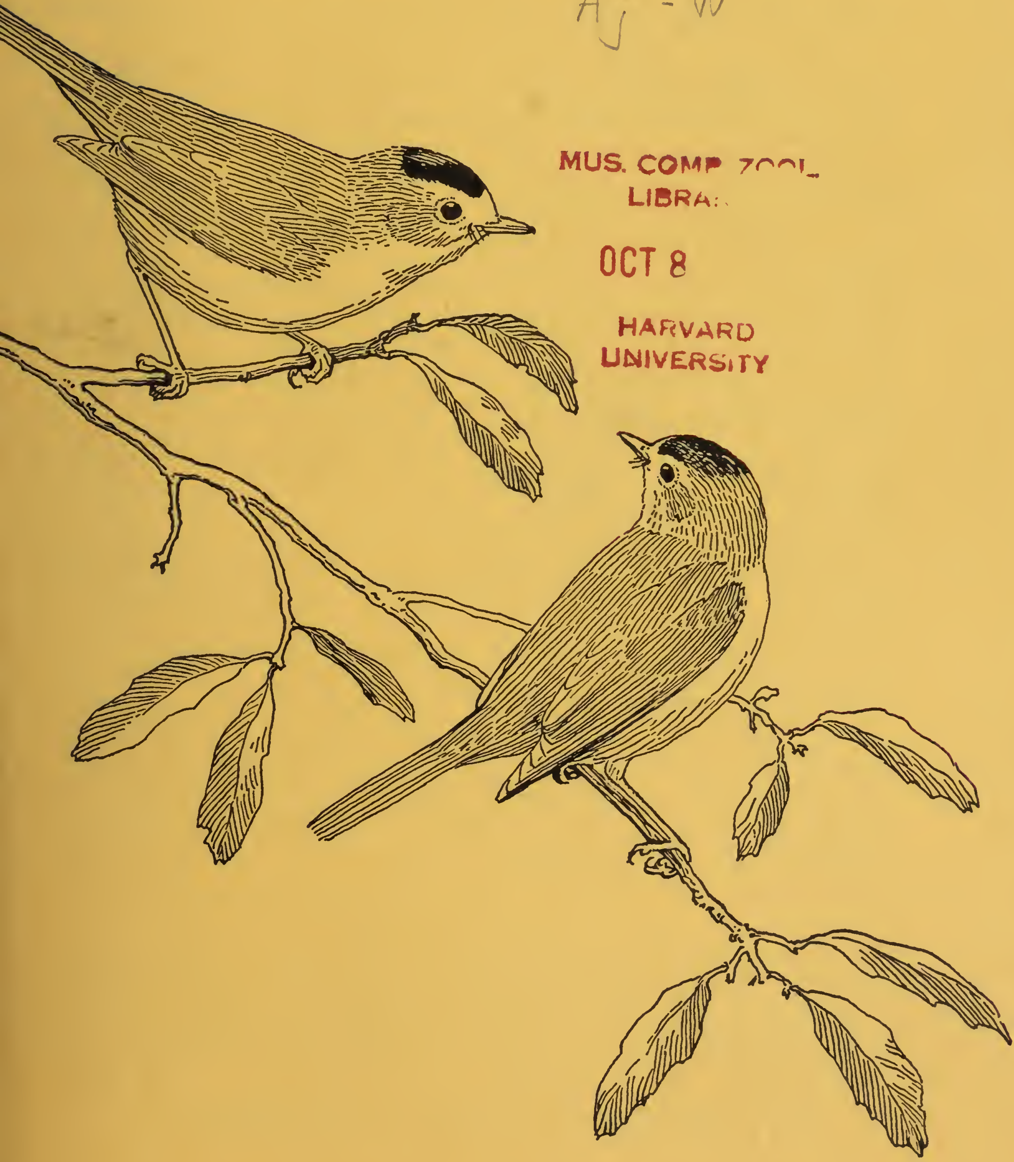
1st	1914	Chicago, Illinois
2nd	1914	Chicago, Illinois
3rd	1915	Columbus, Ohio
4th	1916	Chicago, Illinois
5th	1917	Pittsburgh, Pennsylvania
6th	1919	St. Louis, Missouri
7th	1920	Chicago, Illinois
8th	1921	Chicago, Illinois
9th	1922	Chicago, Illinois
10th	1923	Cincinnati, Ohio
11th	1924	Nashville, Tennessee
12th	1925	Kansas City, Missouri
13th	1926	Chicago, Illinois
14th	1927	Nashville, Tennessee
15th	1928	Ann Arbor, Michigan
16th	1929	Des Moines, Iowa
17th	1930	Cleveland, Ohio
18th	1931	New Orleans, Louisiana
19th	1932	Columbus, Ohio
20th	1934	Pittsburgh, Pennsylvania
21st	1935	St. Louis, Missouri
22nd	1936	Chicago, Illinois
23rd	1937	Indianapolis, Indiana
24th	1938	Ann Arbor, Michigan
25th	1939	Louisville, Kentucky
26th	1940	Minneapolis, Minnesota
27th	1941	Urbana, Illinois
28th	1946	Omaha, Nebraska
29th	1947	Columbus, Ohio
30th	1949	Madison, Wisconsin
31st	1950	Jackson's Mill, West Virginia
32nd	1951	Davenport, Iowa
33rd	1952	Gatlinburg, Tennessee
34th	1953	Cheboygan, Michigan
35th	1954	Cape May, New Jersey
36th	1955	Stillwater, Oklahoma
37th	1956	Buffalo, New York
38th	1957	Duluth, Minnesota
39th	1958	Wheeling, West Virginia
40th	1959	Rockland, Maine
41st	1960	Gatlinburg, Tennessee
42nd	1961	Huntsville, Ontario, Canada
43rd	1962	Lafayette, Indiana
44th	1963	Charleston, South Carolina
45th	1964	Kalamazoo, Michigan
46th	1965	Sylvan Lake, South Dakota
47th	1966	University Park, Pennsylvania
48th	1967	Crawford Notch, N. Hampshire
49th	1968	Carbondale, Illinois
50th	1969	Williamsburg, Virginia
51st	1970	Fort Collins, Colorado
52nd	1971	Dauphin Island, Alabama
53rd	1972	Cape May, New Jersey
54th	1973	Chapel Hill, North Carolina
55th	1974	Cheboygan, Michigan

The Wilson Bulletin

PUBLISHED BY THE WILSON ORNITHOLOGICAL SOCIETY
WEST VIRGINIA U. · MORGANTOWN, W. VA.

VOL. 85, NO. 3 SEPTEMBER 1973 PAGES 257–378

Aj -W



THE WILSON ORNITHOLOGICAL SOCIETY

FOUNDED DECEMBER 3, 1888

Named after ALEXANDER WILSON, the first American Ornithologist.

President—Kenneth C. Parkes, Carnegie Museum, Pittsburgh, Pennsylvania 15213.

First Vice-President—Andrew J. Berger, Dept. of Zoology, University of Hawaii, Honolulu, Hawaii 96822.

Second Vice-President—Douglas A. James, Dept. of Zoology, University of Arkansas, Fayetteville, Ark. 72703.

Secretary—James Tate, Jr., Dept. of Natural Resources, Fernow Hall, Cornell University, Ithaca, New York 14850.

Treasurer—Jerome A. Jackson, Dept. of Zoology, Mississippi State University, Mississippi State, Mississippi 39762.

Elected Council Members—Robert D. Burns (term expires 1974); Harvey I. Fisher (term expires 1975); George A. Hall (term expires 1976).

Membership dues per calendar year are: Active, $8.00; Sustaining, $15.00; Life memberships, $200 (payable in four installments).

THE WILSON BULLETIN is sent to all members not in arrears for dues.

THE JOSSELYN VAN TYNE MEMORIAL LIBRARY

The Josselyn Van Tyne Memorial Library of the Wilson Ornithological Society, housed in the University of Michigan Museum of Zoology, was established in concurrence with the University of Michigan in 1930. Until 1947 the Library was maintained entirely by gifts and bequests of books, reprints, and ornithological magazines from members and friends of the Society. Now two members have generously established a fund for the purchase of new books; members and friends are invited to maintain the fund by regular contribution, thus making available to all Society members the more important new books on ornithology and related subjects. The fund will be administered by the Library Committee, which will be happy to receive suggestions on the choice of new books to be added to the Library. William A. Lunk, University Museums, University of Michigan, is Chairman of the Committee. The Library currently receives 104 periodicals as gifts and in exchange for *The Wilson Bulletin.* With the usual exception of rare books, any item in the Library may be borrowed by members of the Society and will be sent prepaid (by the University of Michigan) to any address in the United States, its possessions, or Canada. Return postage is paid by the borrower. Inquiries and requests by borrowers, as well as gifts of books, pamphlets, reprints, and magazines, should be addressed to "The Josselyn Van Tyne Memorial Library, University of Michigan Museum of Zoology, Ann Arbor, Michigan." Contributions to the New Book Fund should be sent to the Treasurer (small sums in stamps are acceptable). A complete index of the Library's holdings was printed in the September 1952 issue of *The Wilson Bulletin* and newly acquired books are listed periodically.

THE WILSON BULLETIN

The official organ of the Wilson Ornithological Society, published quarterly, in March, June, September, and December, at Morgantown, West Virginia. The subscription price, both in the United States and elsewhere, is $10.00 per year. Single copies, $2.50. Subscriptions, changes of address and claims for undelivered copies should be sent to the Treasurer. Most back issues of the *Bulletin* are available (at $2.50 each) and may be ordered from the Treasurer. Special prices will be quoted for quantity orders.

All articles and communications for publications, books and publications for reviews should be addressed to the Editor. Exchanges should be addressed to The Josselyn Van Tyne Memorial Library, Museum of Zoology, Ann Arbor, Michigan.

Second class postage at Lawrence, Kansas, U.S.A. 66044

PRINTED IN U.S.A. Allen Press, Inc., Lawrence, Kansas 66044

NEW MEMBER NOMINATIONS—
WILSON ORNITHOLOGICAL SOCIETY

. . . know anyone who would enjoy joining the WILSON ORNITHOLOGICAL SOCIETY

— your friends who study birds
— fellow members of local bird clubs
— your colleagues
— your students in bird study

Now is the time for WOS members to recommend non-members interested in birds for membership in the Society. Clip out and use the attached nomination forms. The Membership Committee Chairman then will issue the individual invitations to join the Society.

One form is for college and pre-college students, the other is for other nominations. Students have a special incentive to join the W.O.S. while still in school or college: at graduation, they can apply the total amount of dues paid while they were students toward a Life Membership in the Society.

An organization such as the W.O.S., which does not have the close contacts provided by regional or local chapters, depends on the initiative of the individual members for nominations of new members. Thank you for your help in finding new members and thus assuring the continued existence and growth of the Society.

Please mail all nominations to:

Douglas James, Chairman
W.O.S. Student Membership Committee
Department of Zoology
University of Arkansas
Fayetteville, Arkansas 72701

W.O.S. NOMINATIONS:

Name

Address

Name

Address

Name

Address

Nominated by

(For additional names
use the reverse)

W.O.S. *STUDENT* NOMINATIONS:

Name

Address

Name

Address

Name

Address

Nominated by

(For additional names
use the reverse)

THE WILSON BULLETIN

A QUARTERLY MAGAZINE OF ORNITHOLOGY

Published by The Wilson Ornithological Society

VOL. 85, NO. 3 SEPTEMBER 1973 PAGES 257–378

CONTENTS

Monk Parakeet *(Myiopsitta monachus)*. A recent colonizer in eastern North America. Painting by Murrell Butler.

RADAR OBSERVATIONS OF BIRD MOVEMENTS ALONG THE ARCTIC COAST OF ALASKA

Warren L. Flock

Six DEW (Distant-Early-Warning) radars, located along the northern arctic coast of Alaska, have been used to observe bird movements. The DEW radars, operating in the upper portion of the L frequency band (wavelengths near 23 cm), comprise a chain which extends from Alaska eastward across the Canadian Arctic and Greenland and terminates in Iceland. The northern arctic coast of Alaska is characterized by large low areas of tundra, and the Alaskan radars are all located at only slight elevations above sea level. From west to east, the radar locations and their DEW designations are Pt. Lay (LIZ-2), Wainwright (LIZ-3), Pt. Barrow (POW-Main), Lonely (POW-1), Oliktok (POW-2), and Barter Island (BAR-Main). These locations are shown in Figure 1.

The initial purpose of the investigation reported here was to determine if the DEW radars could provide useful information about the eider migration along the coast, and this question appeared to be answered in the affirmative after the first year of observations (1969) at Pt. Barrow and Lonely. The general trend of the northern arctic coast of Alaska is east-west, and bird migration is predominantly parallel to the coast, the eiders migrating to the east in the spring and to the west after about the middle of July. The well-known summer eider migration past Pt. Barrow can be observed readily visually and has been described by Murdoch (1885), Thompson and Person (1963), and Johnson (1971). It was estimated by Johnson that 95 percent of the birds migrating past Pt. Barrow in July-August are eiders and that 95 percent of the eiders are King Eiders (*Somateria spectabilis*) and 5 percent are Common Eiders (*Somateria mollissima*). At Oliktok in 1971 it was discovered also that there is a significant summer migration to the east in the direction opposite to that of the eiders. In addition, extensive east-west migrations not believed to involve eiders were recorded in the spring of 1972 at Oliktok. The concept of migration along the northern arctic coast that has developed from the studies is considerably more complex than the picture envisaged in the earlier stages.

The use of radar for bird study is well known by now (Eastwood, 1967; Myres, 1970), but each radar differs in technical characteristics or location or both from others, and the only way to determine for certain what bird movements a particular radar will detect is to actually observe and record its radar echoes. Following a short preliminary inspection of the Pt. Barrow radar in 1967, longer visits were made to Alaskan DEW radars during parts

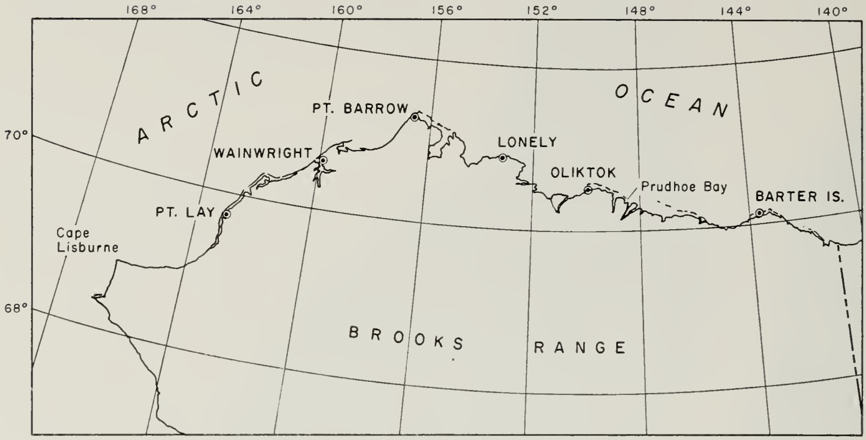


FIG. 1. Map of northern arctic coast of Alaska, showing radar locations.

of late July and early August in 1969, 1970, and 1971 and in late May–early June in 1972. The data reported represent the first use of DEW radars for the study of bird movements. Similar data have also been obtained by the author by utilizing radars of the Alaskan Air Command at Cape Prince of Wales (Flock, 1972), Cape Romanzof, and Cold Bay. The Alaska investigations through 1971 were part of a larger program of analyzing the role that radar can play in reducing the hazard of collisions between birds and aircraft.

PROCEDURES

The radar scopes at all six sites were observed visually and photographed by use of a Polaroid camera. In addition data were obtained from an automatic 35 mm camera, utilizing 100 foot reels, at the Pt. Barrow radar site. During test runs from 24 September to 27 October 1968 and from 11 to 29 June, 1969, most automatic-camera exposures were for one antenna rotation except when some time exposures were obtained accidentally. After that time the automatic camera took successive 5.6-minute time exposures. This latter type of record was obtained for 27 days in 1969 (during 8 August to 8 September), 72 days in 1970 (during 27 May to 5 October), and 64 days in 1971 (during 2 August to 5 November). Altogether about 40,000 frames of 35 mm film and 420 Polaroid prints (mostly 5.6-minute time exposures also) were exposed and examined. Radar displays showing 20 or 40 nautical mile (nmi) ranges were used generally, but some use of the 80 nmi range was made as well. One time exposure alone allows a 180° ambiguity as to direction, but the ambiguity can be resolved by watching individual targets on the radar screen or by examining successive time exposures. When a figure legend lists an eastward movement, for example, the illustration itself does not show if the movement was to the east or west and the eastward notation is based on notes written when the photograph was taken or comparison of successive frames on 100 foot reels.

The 35 mm films were studied by use of a microfilm viewer. For most of the days when time exposures were available, the numbers of tracking targets were counted for the hours of 02:00, 05:00, 08:00, etc. ADT, these being times when weather data were available from Barrow. The target directions were also recorded, and the numbers of targets with headings in each 10° interval were tabulated, an example being shown in Table 1.

One additional numerical illustration of the possibilities of the radar data is included in this paper. For certain times or periods the numbers of targets counted were used to obtain estimates of the numbers of birds crossing a line extending 40 nmi in opposite directions from the Pt. Barrow site. The numbers of targets counted (the sums of eight counts spaced three hours apart) were used to determine target densities, the average speed of the targets was somewhat arbitrarily taken as 40 knots, and it was assumed that the average target consisted of 80 birds, on the basis of data supplied by Johnson (1971). [Example, using figure from Table 2: Total of 220 targets for the eight hours considered divided by eight gives 27.5 targets on the radar screen on the average during the day considered, on an area of $\pi(40)^2 \cong 5000$ nmi^2, corresponding to a density of 27.5/5000 or 0.0055 targets/nmi^2. In one hour (0.0055) (40 knots) (80 nmi) = 17.5 targets cross a line 80 nmi in length centered at the radar. (17.5) (80 birds per target) = 1400 birds/hr and (1400) (24) = 33,600 birds/day.]

The tilt angles of the DEW antenna beams are adjustable. Fortunately the low tilt angle needed for recording echoes from birds at low altitudes was not inconsistent with normal operational requirements. A beam of low tilt angle was available at Pt. Barrow when continuous records were made and, at least temporarily, as needed at the other sites as well. Thus it is believed that the radars were capable of recording migrations taking place at quite low altitudes at the times most of the data were taken.

OBSERVATIONS

On the first trip to DEW sites between 22 July and 1 August 1969, the radars at Pt. Barrow and Lonely were observed to record at least a significant fraction of the eiders migrating past them. Radar echoes at these sites are especially numerous when many migrating eiders are seen visually. The visit to Lonely on 29 July 1969 coincided with a major eider movement that was very obvious and spectacular, both visually and on the radar (Fig. 2). Radar

Fig. 2. POW-1 radar screen, Lonely, Alaska, 00:34 ADT, 30 July 1969. Five-minute time exposure, 40 nmi range, echoes moving NW.

echoes were recorded at distances beyond 40 nmi to the south of the site. Observers at Pt. Barrow also reported heavy eider movement that night.

Winds during much of the latter part of July, 1969 were strong and from the west and not favorable for the westward migration of eiders past Pt. Barrow and Lonely. However late on 26 July 1969, the wind speed at Barrow was reduced to about 4 knots at a time when the wind was blowing from a direction of 220°. Considerable movement was observed visually and on the POW-Main radar that night. On the following two days the wind directions and speeds were less favorable, but the wind shifted to the northeast (to come from a direction of 60°) in the late evening of 29 July 1969. It was at this time that the major migration shown in Figure 2 took place. A calculation of numbers passing the Lonely radar at the time of Figure 2, utilizing the method described under Procedures, gave a result of 8000 birds per hour, based on a count of 157 targets.

Between 27 July and 5 August 1970, observations were made at Point Barrow and Lonely again and also at Wainwright, about 70 miles to the west of Barrow. Figure 3 shows the Pt. Barrow screen on 30 July 1970 at a time

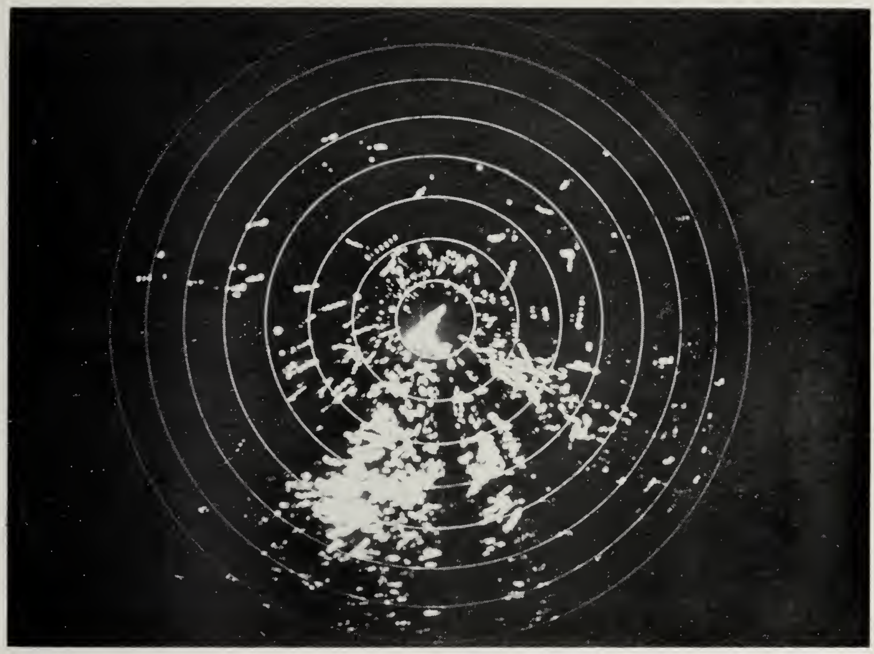


FIG. 3. POW-Main radar screen, Pt. Barrow, Alaska, 21:05 ADT, 30 July 1970. Five-minute time exposure, 40 nmi range. The overlapping echoes 10 to 30 nmi to the south are caused by birds moving W.

when westward overland migration was taking place in the area 10 to 30 nmi to the south of Pt. Barrow. At Lonely considerable movement to the south of the site was seen on the radar screen again, as in 1969, but migration was less evident visually. One reason for visiting Wainwright was to determine if significant overland migration took place there, perhaps between the general areas of Lonely and Wainwright and to the south of Point Barrow. At Wainwright, however, the migration is typically between 5 and 10 nmi offshore, consistent with the statement of local resident, Bill Patkotak, as to where the eiders are known to migrate.

In 1970, Johnson (1971) studied the eider migration at Point Barrow visually, and automatic-camera photography of the Point Barrow radar was requested by the writer so that simultaneous radar and visual data would be available. The radar and visual data were correlated in general (in that periods of intense movement as indicated visually were also periods of intense movement as indicated by the radar). However the radar and visual data could not be correlated in detail (not precisely as to location or numbers and not on a flock by flock basis) as the DEW radars, like other long-range

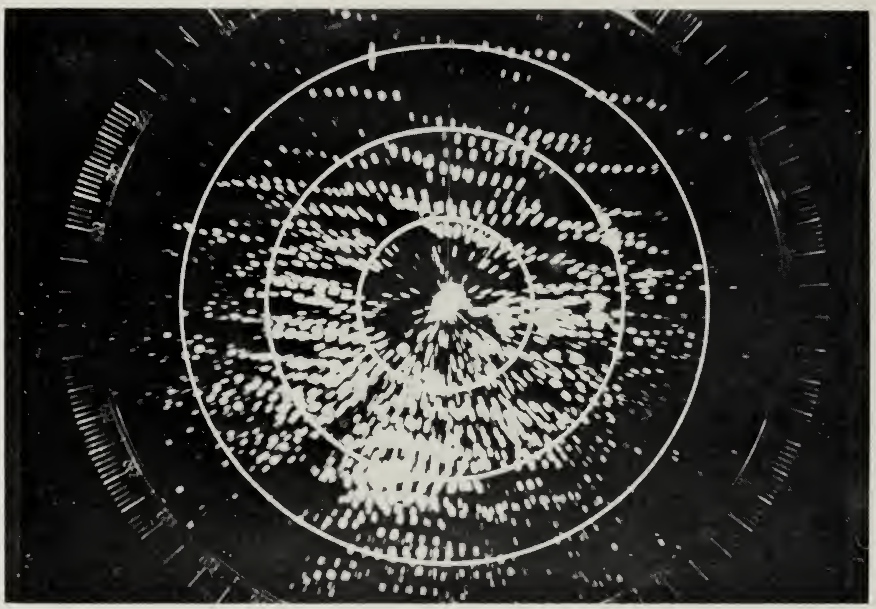


FIG. 4. POW-2 radar screen, Oliktok, Alaska, 21:15 ADT, 2 Aug. 1971. 5.6-minute time exposure, 20 nmi range, echoes moving E.

surveillance radars, do not give satisfactory coverage within the first few miles and the visual observations were made about a mile from the radar.

In 1971 the three active DEW radar sites in Alaska that had not been inspected previously were visited between 26 July and 16 August. The observations at Barter Island and Oliktok were of particular interest in that they showed predominant eastward migration during the visits to these locations (27 July to 3 August). This movement was aided by a west wind and took place at a rather high altitude. Movement was greater over the land to the south of the sites than over the water. It was not possible to see these birds visually with binoculars or the unaided eye, and it is not known what species are involved. Figure 4 is an illustration of the Oliktok radar screen during this period. Photographs taken at Barter Island were similar.

Some eastward movement was also seen at Pt. Lay in August 1971, and some of these birds arrived from the direction of Siberia. At Pt. Lay, however, most echoes were of birds that were proceeding in a southerly direction. In the area of Pt. Lay the coast trends north-south and the birds traveling to the south there were generally off shore and presumed to be mostly eiders which had been following the coastline from the east.

The first spring visit by the writer to a DEW site was made at Oliktok

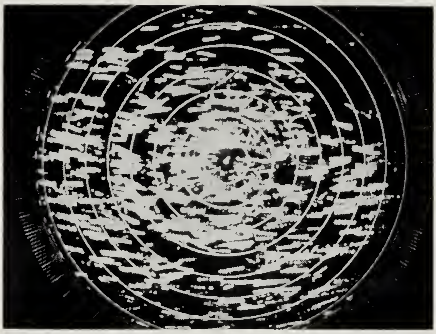


FIG. 5. POW-2 radar screen, Oliktok, Alaska, 20:05 ADT, 28 May 1972. 5.6-minute time exposure, 40 nmi range, echoes moving E.

from 27 May to 5 June 1972. This location was chosen because of the proximity of the Oliktok radar to the Prudhoe Bay oil area and because of the interest of Bureau of Sport Fisheries and Wildlife personnel and others in the area. Both the tundra and ocean were frozen and covered with snow throughout the time of the visit but echoes from the birds showed profusely on the radar screen. The wind was from the east most of the week, but on 28 and 29 May there was a period of west wind. Bird movement tended to correspond to the wind direction, but not entirely. A very heavy movement towards the east took place with the favorable west wind on 28 and 29 May (Fig. 5). Westward movement tended to dominate otherwise, but at times there was movement towards the east in opposition to the east wind, especially on 4 June when the opposing wind was slight and especially in an area from 20 to 50 nmi to the south of the radar site. This region to the south showed on the radar screen as an important corridor for east-west migration. The rise in height of the ground to the south may tend to make the birds in that region conspicuous on the radar. Another feature of interest of the radar record was that birds were observed to approach the coastline from the north, or from over the Arctic Ocean, on 29 and 30 May (Fig. 6).

Visibility was generally rather poor during the period at Oliktok, a low ceiling being the principal limiting factor, and few migrating birds were seen visually. Jaegers, flying to the east a few at a time, were the most common bird actually seen flying purposely in a given direction. The low ceiling also limited observation from aircraft as well as from the ground. J. Larry Haddock and James Bartonek of the U.S. Bureau of Sport Fisheries and Wildlife visited Oliktok from 2 to 5 June and attempted to identify the source of the radar echoes by aircraft flights in the vicinity. On 3 June, an effort was made to direct their aircraft to particular bird targets but practical

FIG. 6. POW-2 radar screen, Oliktok, Alaska, 09:00 ADT, 30 May 1972. 5.6-minute time exposure, 20 nmi range. Visual monitoring of the radar screen at this time indicated that a large percentage of the echoes shown were approaching the coastline from over the Arctic Ocean.

difficulties were encountered. On 4 June, the aircraft landed on two lakes to the south and observations of birds were made from the lakes. The observers saw a number of geese, jaegers, and shorebirds, which were probably indicative of what some of the migrating birds were or had been, but a large percentage of their observations were of birds so close to the ground that it is doubtful that the radar received echoes from the same individual birds.

By the time of the return flight from Oliktok to Pt. Barrow on 5 June, water was flowing over the ice at the mouth of the Colville River, and large numbers of White-fronted Geese (*Anser albifrons*) were seen in the Colville delta area. These birds were also seen regularly in small numbers (10–16) at Oliktok itself. Other birds which were seen at Oliktok regularly or in significant numbers and could have caused radar echoes included the Whistling Swan (*Olor columbianus*), Parasitic Jaeger (*Stercorarius parasiticus*), Pomarine Jaeger (*Stercorarius pomarinus*), Glaucous Gull (*Larus hyperboreus*), Am. Golden Plover (*Pluvialis dominica*), Ruddy Turnstone (*Arenaria interpres*), Dunlin (*Calidris alpina*), and Semipalmated Sandpiper (*Calidris pusillus*). Two pairs of swans were regularly at the site and apparently intended to nest there. A flock of 12 Snow Geese (*Chen caerulescens*) was seen at Oliktok on 2 June.

The birds cluttered the Oliktok radar scope quite seriously at times, and it was difficult to detect or follow small aircraft in the cluttered areas. Echoes from birds were detected at ranges at great as 75 nmi.

AUTOMATIC-CAMERA DATA FROM PT. BARROW

Spring Migration.—Only limited automatic-camera data are available concerning the spring migration, and they were for late May and the month

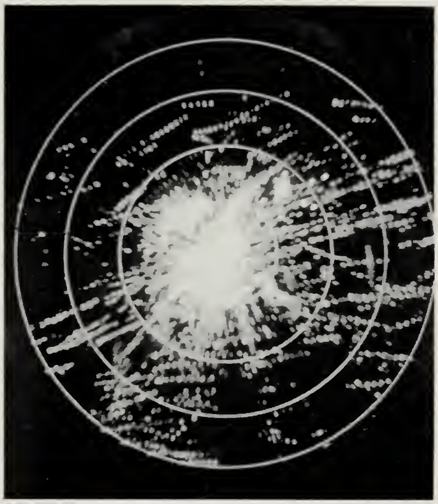


FIG. 7. POW-Main radar screen, Pt. Barrow, Alaska, 20:15 ADT, 11 June 1969. About eight-minute time exposure, 20 nmi range, echoes moving E-NE.

of June. Time exposures were obtained on 11 June 1969 and from 27 May 1970 through most of June, 1970. Migration continues into June, as shown in Figure 7, which also shows the very interesting feature that birds are proceeding generally in a direction of about 70° (measured clockwise from geographic north). The same general directions are also shown in the June 1970 records. Headings were commonly in the 60° and 80° range from 27 May to 17 June, though in very slight numbers on 8–10 June, when westward movement predominated. A 40 nmi sweep was used in 1970, and targets were often seen over the ocean to the north-east at ranges of 25 nmi and greater.

Summer Westward Migration.—No sharp dividing line appeared between the spring and summer migrations in 1970, and there was no time when birds were not moving. No data were obtained from 17 to 25 June 1970, and mixed or alternating east-west movements were recorded from 25 June to 6 July. From that date on, migration to the west predominated.

The birds taking part in the summer migration past Pt. Barrow generally follow along the shore or the offshore islands from the southeast as they approach the area of the point. They commonly have a heading of about 290° as they approach and gradually change direction to achieve a heading of about 250° to the west of Pt. Barrow. This route takes the birds quite far out over the ocean to the west, as they would need a heading of about 225° to follow the coastline closely to the west of Barrow. The overwater route followed is shorter and more direct than one close to the shore west of Barrow and is

TABLE 1

NUMBERS OF TARGETS HAVING DIRECTIONS WITHIN SPECIFIED ANGULAR LIMITS

1. 26 Aug. 1969		2. 28 Aug. 1969	
Angular Range	Number of Targets	Angular Range	Number of Targets
0°–220°	10	0°–220°	10
220°–240°	1	220°–240°	3
240°–250°	1	240°–250°	12
250°–260°	4	250°–260°	12
260°–270°	13	260°–270°	34
270°–280°	21	270°–280°	47
280°–290°	32	280°–290°	25
290°–300°	43	290°–300°	19
300°–310°	44	300°–310°	12
310°–320°	25	310°–320°	4
320°–330°	19	320°–330°	2
330°–340°	10	330°–340°	1
340°–350°	2	340°–350°	0
350°–360°	1	350°–360°	0

consistent with the offshore migration observed at Wainwright. Some data on the summer migration past Pt. Barrow for late August, 1969 are shown in Tables 1 and 2.

Some caution is needed in interpreting Table 1, as birds approaching from the east are more readily detected than those leaving to the west, so that data may be weighted towards the approaching birds. Another complication is that some birds bypass Pt. Barrow itself by migrating overland in the area to the south of the point. Much data of the type shown has been accumulated,

TABLE 2

ESTIMATED NUMBERS OF BIRDS PASSING PT. BARROW
(Assuming an average speed of 40 knots and 80 birds per flock)

Day (Aug. 1969)	Number of Targets	Direction of Movement	Estimated No. of Birds
25	220	SW	33,600
26	500	NW	76,500
27	475	NW	72,500
28	495	W	75,500
29	465	W	71,000
			Total ≅ 329,000

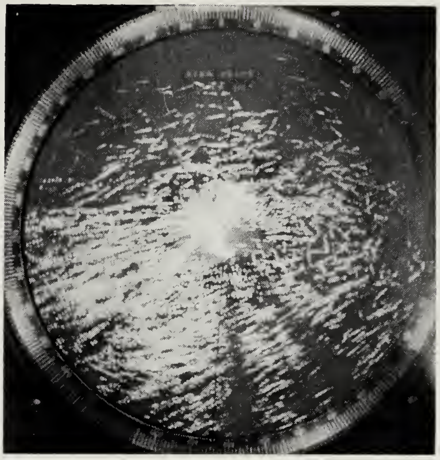


Fig. 8. POW-Main radar screen, Pt. Barrow, Alaska, 00:40 ADT, 7 Oct. 1970. 5.6-minute time exposure, 40 nmi range, echoes moving W-SW.

but it is practical to include only a few illustrations at this time. A second paper concentrating primarily on numerical summaries and analyses would be appropriate at a later date.

Summer Eastward Migration.—The photographs taken at Barter Island and Oliktok in the summer of 1971 (Fig. 4) drew attention to an eastward migration of unknown species that were flying too high to be seen visually. Automatic-camera data from Pt. Barrow also showed eastward migration at about the same time, specifically on 3–6 August 1971 when eastward movement predominated, on 2 August when westward and eastward movement were comparable, and on 7 and 8 August when westward movement predominated but eastward movement was also evident. The winds were from the west and strong (greater than 17 knots at Barrow) from 1 to 5 August 1971. Very little westward movement of eiders was observed during this period. The films for 1969 and 1970 also show some eastward movement at the general times of the more obvious westward summer migration.

Fall Migration.—Migration is conspicuous on the radar films into the first week of November 1971 after which no radar data are available. Migration was quite intense in the first week of October in both 1970 and 1971, as shown in the example of Figure 8. A cold spell took place during the first week of October 1970, and a mass exodus of birds took place then. Some birds were reported to have died of starvation and cold. The temperature dropped below 0°F (to –2°F) on 7 October for the first time in the fall of 1970, and the temperature was about 2°F at the time of Figure 8. The birds were then flying with a slight favoring wind (6 knots towards 230° at 04:00 ADT at Barrow, Alaska).

DISCUSSION

The radar record suggests that some of the late-migrating birds in spring (as in Fig. 7) fly directly from the region of Pt. Barrow to some of the Canadian Arctic islands (Manning, Höhn, and Macpherson, 1956; Parmelee, Stephens, and Schmidt, 1967). The evidence is not conclusive but these birds may well be eiders. It appears that some of the birds which migrate past Pt. Barrow and nest near Oliktok may stay rather far out over the ocean after passing Pt. Barrow and may rest on open leads, before heading south to nesting areas (Fig. 6). The peak of the spring eider migration past Pt. Barrow is reported by Johnson (1971) to take place in May, but few eiders were seen at Oliktok between 27 May and 5 June 1972. The lakes at that time were frozen and the eiders which frequent the lakes later in June were not present. Eiders returning from the Canadian islands and other locations east of Pt. Barrow follow the coastline of Alaska as they approach Pt. Barrow from the east. No radar echoes have been seen to approach from far out over the ocean to the east. The summer migration of the eiders at Pt. Barrow has received the greatest attention from both the native Eskimos who hunt the eiders and from previous investigators. It is the male eiders that migrate first to the west in the summer. These male birds leave the breeding grounds as soon as laying starts (Delacour, 1959). By mid-August females begin to predominate in the migration past Pt. Barrow, and young birds migrate past Pt. Barrow at still later dates in September and October.

A limitation of conventional surveillance radars is that they are incapable of identifying bird echoes as to species. About the only occasion for which the identity of bird echoes can be established with reasonable certainty is when essentially only one species (or genus) is believed to be migrating in significant numbers in a certain area, on the basis of visual observations. The early summer eider migration along the coast as recorded by the Pt. Barrow, Lonely, and Wainwright radars seems to fall in this category. Radar observations in these areas near the coast correspond generally in number and location with visual reports of eider movements and there is no good evidence of major westward migration of other species during the early summer migration of the eiders. Some eiders fly low over the water, or over the land near the water, but others fly higher and the higher birds, at least, should be detectable by a radar beam having the low tilt angle employed. For example at Lonely on 30 July 1969 (Fig. 2), some eider flocks almost collided with a tracked vehicle crossing the tundra while it was estimated that others might have been as high as 1000 feet. The writer is of the opinion that the DEW radars mentioned do at least a reasonable job of monitoring the eider migration along the Arctic Ocean coastline and believes that the majority of radar echoes recorded near the coastline during the summer westward migration are due to eiders.

The case of the radar echoes observed as much as 40 nmi south of the coastline at times of peak eider migration near the coast is very interesting but difficult to assess. As eiders are commonly believed to fly only at low altitudes near the coastline, suggestions that some of the inland birds are eiders have met with general skepticism. Neither the literature or personal discussions with native Eskimos or biologists with experience in Alaska, however, provide very clear or convincing evidence one way or the other on this question or suggest clearly what other birds are migrating at these times.

Factors favoring the eider hypothesis in situations like that depicted in Figure 2 are the same as those stated above for believing the echoes near the coastline are eiders plus the fact that eiders are commonly seen flying over land south of Lonely and near the natural gas well near Barrow. This latter location is only about 5 miles from water but even that distance is significant and there is no reason to believe all eider movement ceases immediately south of that point, especially when a major large-scale movement is taking place. In addition the fact that some eiders have been seen visually at moderate heights at Lonely, such that they might be detectable by radar at a considerable distance, needs to be emphasized. Also whatever the inland birds were in cases like Figure 2, they were migrating in synchronism in time and space with the coastal eiders, displaced to the south but with no clear gap in between, which suggests that they might have been eiders themselves. Of the possibilities other than eiders, Black Brant (*Branta nigricans*) are perhaps the most likely. The writer leans towards the eider hypothesis for dates as early as that of Figure 2, but the evidence is not convincing and the identity of the inland migrants must be considered to be unresolved.

In the case of the fall migration past Pt. Barrow, birds other than eiders must be responsible for many of the echoes. Oldsquaw (*Clangula hyemalis*), Black Brant and loons are among the other birds that migrate in the fall. The identity of most of the migrants observed with the Oliktok radar between 27 May and 5 June 1972 cannot be established definitely but White-fronted Geese must be prominent among the birds moving west, especially in the case of some of the echoes which seemed to terminate in the Colville delta area. Frank Bellrose (pers. comm.) has suggested that the birds moving east on 28 and 29 May may have been Black Brant and that Snow Geese and Whistling Swans may have been important sources of westward moving echoes. Some Snow Geese migrate to Wrangel Island via Cape Prince of Wales (Flock, 1972), but others apparently travel to Wrangel Island via the Mackenzie Valley and the northern arctic coast of Alaska. The identity of the summer migrants traveling east at Oliktok and Barter Island in 1970 is not known but it can be conjectured that they were shorebirds which later headed to the south along the Mackenzie River Valley.

The vertical coverage of a radar is a function of antenna beamwidth, antenna tilt angle, meteorological conditions, and range. Surveillance radars tend to have broad vertical beamwidths such as to provide little information about target altitudes. Thus only qualitative statements about altitudes can be made about most of the observations reported here. There is very clear evidence, however, that the DEW radars commonly detect birds which are so high that they cannot readily be seen visually. At Barter Island and Oliktok in the summer of 1971, for example, the radar showed birds passing directly overhead, when the antenna tilt was sufficiently high to preclude most ground clutter. In these particular cases it can be estimated roughly that some of the birds were at altitudes near 10,000 feet. At no time were these birds seen with binoculars or the unaided eye, though the sky was clear. A carefully planned program of visual observations at such times using fixed telescopes (Gauthreaux, 1970) might, however, result in sightings.

Radar can provide accurate flight directions quite readily, although there are always a fairly large number of targets which cannot be tracked or followed from one frame to the next. Radar is less well suited for providing numbers of birds, but procedures have been devised for particular situations (Nisbet, 1963; Gauthreaux, 1970). The radar record for Pt. Barrow has numerous gaps and for that reason alone is not capable of providing an accurate total number of migrants. Also a careful study of techniques for determining numbers, using DEW radars, has not yet been made. However it is clear that the Pt. Barrow and other DEW radars can monitor movements over a much larger area than visual observers, and the radar record shows that many birds migrate over the water to the north of Pt. Barrow and overland to the south of Pt. Barrow. One approach to estimating numbers by radar would be to use data on flock sizes from visual observations. Johnson (1971) reports average sizes of 91, 82, and 43 for conditions of favorable, neutral, and unfavorable winds. Thompson and Person (1963) report a mean flock size of 105.

Using a number of 80 birds per flock, estimates of the numbers of birds passing Pt. Barrow were made for the period of 25–29 August 1969, as shown in Table 2. Dividing the daily fourth column figures of Table 2 by 24 and averaging gives an average hourly rate of 2740 birds/hr for the five day period. Johnson (1971) reported figures from visual observations at Pt. Barrow on a weekly basis. His maximum movement was 1100 birds/hr for the week of 23–30 July 1970, and he quoted 500 per hour for the week of

23–30 August 1970. Unfortunately, there is no one entire week of good radar data which can be compared with Johnson's figures, but the radar figures are significantly higher than those that he quotes. The Duck Camp location at Pt. Barrow, where the visual observations have been made, is an excellent location for visual studies of migration, and large numbers of eiders pass close by it. As a rough guess, however, it appears that three or four times or more as many birds migrate past the entire Pt. Barrow area as can be seen at Duck Camp.

CONCLUDING REMARKS

The DEW radars are capable of continuously monitoring bird migration along the northern arctic coast of Alaska and presumably elsewhere along the DEW chain as well. Thus these radars can be utilized on a multipurpose basis. Cameras which are permanently installed on scopes in the maintenance areas are suitable for this purpose. Radar can provide continuous coverage of bird movements in overcast and over a much greater volume of space than visual observers. This latter point is illustrated by the fact that radar detected movement at distances up to 75 nmi from the DEW sites and also detected high flying birds which could not be seen visually.

The use of the DEW radars has shown a number of features of bird migration along the arctic coast, in addition to the rather well documented westward migration of eiders past Pt. Barrow after the middle of July. Some of the other birds fly higher and make larger radar echoes than do the eiders (Fig. 5). The picture of bird migration in Alaska that has been developed over the years by visual observations and banding operations includes many of the interesting and important characteristics of migration in the area, but the radar data show impressive migratory movements which have gone largely unseen by man. Banding recoveries suggest but do not positively establish the identity of the birds participating in some of these movements, as they only very roughly indicate possible migration routes. Radar data are essential to any attempt to adequately describe bird migration in Alaska.

The positive identification of the radar echoes appearing profusely on the DEW radar screens is a difficult problem at the present time. Work is proceeding at Boulder on radars for recording amplitude and Doppler signatures of bird echoes for identification purposes (Konrad, 1968; Schaefer, 1968). A principal feature of the signatures is modulation at the wingbeat frequencies, and the latter vary inversely with wing lengths (Greenewalt, 1960). Eventual development of such signature radars in Alaska, for identification of echoes detected by surveillance radars, would be advantageous.

Radar studies of birds in the Arctic are pertinent at this time because of the interest that has developed in the Arctic because of oil discoveries, etc., (Fish and Wildlife Service, 1971). In this respect, radar can assist in the function of environmental monitoring (of bird activity). It would seem highly appropriate to monitor bird activity by radar, especially perhaps at Oliktok near Prudhoe Bay or at Pt. Barrow, to obtain a record of how bird numbers and activity are affected over a period of time by man's activities or natural causes.

SUMMARY

Radar records of bird movements along the northern arctic coast of Alaska appear to document the westward summer migration of eiders past Pt. Barrow, Wainwright, and Lonely. In addition the records show a sometimes heavy fall westward migration that persists into November at Pt. Barrow. An extensive spring east-west migration and a high-altitude eastward summer migration have also been observed by radar at Oliktok, near Prudhoe Bay east of Pt. Barrow.

At the time of the summer westward eider migration, identification of radar echoes as due to eiders was based on correlation with visual observations and on the fact that no major westward migration of other species is known to take place then. In the other cases positive identification by visual or other means was not accomplished. The spring migration at Oliktok was complex in nature, presumably involved at least several species, and took place at a time of heavy overcast when the ocean and tundra were frozen and covered with snow. The summer eastward migration recorded at Oliktok took place at a sufficiently high altitude that it could not be seen visually by naked eye or binoculars in clear weather.

The results reported represent the first application of DEW radars to the study of bird movements.

ACKNOWLEDGMENTS

The work was supported through 1971 by Research Grant 68-1377 from the Air Force Office of Scientific Research. The 1972 trip was financed by the Smithsonian Institution and Air Force contract F44620-67-C-0063. I wish to express my thanks to Colonel William R. Menzie, Commander, 4785th Air Base Squadron, Department of the Air Force, to Colonel Robert O. Gruetzemacher (former commander), and to their staffs for their help in arranging the visits to the DEW sites and the recording operations at Pt. Barrow. Also, I thank the radicians, station chiefs, and other personnel of ITT Arctic Services, Inc., for their assistance. Special mention in this respect should be made of Mr. William Newman, Lead Radician, POW-Main, at the times most of the automatic camera data were obtained. The fine cooperation received from Mr. John F. Schindler, Director, Dr. Max C. Brewer, former director, and the staff of the Naval Arctic Research Laboratory, Barrow, Alaska, is much appreciated. Finally, the assistance of Mrs. Terry Cormack, in analyzing the data from the POW-Main radar, was essential to the completion of the work.

LITERATURE CITED

Delacour, J. T. 1959. The waterfowl of the world. Volume 3. Country Life Ltd., London.

Eastwood, E. 1967. Radar ornithology. Methuen & Co. Ltd., London.

Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, 1971. To have and to hold, Alaska's migratory birds. U.S. Government Printing Office, Washington, D.C.

Flock, W. L. 1972. Radar observations of bird migration at Cape Prince of Wales. Arctic, 25: 83–98.

Gauthreaux, S. A. 1970. Weather radar quantification of bird migration. Bioscience, 20: 17–20.

Greenewalt, C. H. 1960. Hummingbirds. Doubleday and Co., Inc. Garden City, N.Y.

Johnson, L. L. 1971. The migration, harvest and importance of waterfowl at Barrow, Alaska. Unpubl. M.S. thesis. Univ. Alaska, Fairbanks.

Konrad, T. G. 1968. Radar as a tool in meteorology, entomology, and ornithology. *In*, Proceedings of the Fifth Symposium on Remote Sensing of the Environment. Willow Run Labs., Univ. Michigan, Ann Arbor.

Manning, T. H., O. E. Höhn, and A. H. Macpherson. 1956. The birds of Banks Island, Natl. Mus. Canada Bull. 143.

Murdoch, J. 1885. Birds. *In*, P. H. Ray, Report of the International polar expedition to Point Barrow, Alaska. U.S. Government Printing Office, Washington, D.C.

Myres, M. T. 1970. The detection of birds and insects, and the study of bird movements, with radar. Proceedings of the World Conference on Bird Hazards to Aircraft, 2–5 Sept. 1969: 501–519, Associate Committee on Bird Hazards to Aircraft, National Research Council of Canada, Ottawa.

Nisbet, I. C. T. 1963. Quantitative study of migration with 23-centimetre radar. Ibis, 105:435–460.

Parmelee, D. F., H. A. Stephens, and R. H. Schmidt. 1967. The birds of southeastern Victoria Island and adjacent small islands. Natl. Mus. Canada Bull., 222.

Schaefer, G. W. 1968. Bird recognition by radar. A study in quantitative radar ornithology. *In*, The problems of birds as pests. Academic Press, London.

Thompson, D. Q., and R. A. Person. 1963. The eider pass at Point Barrow, Alaska. J. Wildl. Mgmt., 27:348–356.

DEPARTMENT OF ELECTRICAL ENGINEERING, UNIVERSITY OF COLORADO, BOULDER, COLORADO 80302, 1 AUGUST 1972.

SINGING HABITS OF TRAILL'S FLYCATCHER IN NORTHWESTERN MONTANA

WINTON WEYDEMEYER

MUCH has been written concerning the calls, songs, and singing habits of Traill's Flycatcher (*Empidonax traillii*) in the eastern and midwestern states. Limited published data from the Rocky Mountain region suggest some noteworthy differences in these attributes of the species in that area, indicating the need for additional comparative information. The purpose of this paper is to meet some of that need.

My acquaintance with Traill's Flycatcher (presumably *E. t. brewsteri*) in northwestern Montana covers a period of more than 50 continuous years. The species breeds regularly at my ranch near Fortine (15 miles south of the Canadian border and 54 miles east of the Montana-Idaho line), where songs can be heard from the fields where I work. Many dawn and twilight hours over a period of several years were devoted to observation of the singing habits of the species.

While my notes contain records of a great variety of songs indulged in by birds of this area, no attempt will be made here to transcribe them all into phonetic interpretations. In order to discuss some aspects of singing habits, however, it will be necessary to identify general song types—use of which varies with the season, time of day, and accompanying action—and to include a few phonetic transcriptions. Description of these song types follows.

SONG TYPES

Type 1. Perch song: two-syllabled, accent on second; first beginning with a *wh* or *th* consonant sound, second beginning with *k*, *ch*, or *th*, shading into *ēēr*. Many variations, the commonest being *wheeth-keér*, given during both daytime and evening hours, especially during the early part of the season; sometimes used almost exclusively during evening singing.

Type 2. Perch song: similar to Type 1 but with equal stress on the two syllables. Example: *wheé-deér*, given frequently at all seasons and hours.

Type 3. Perch song: two-syllabled, accent on first, second slurred downward; first syllable opening with *wh*, second rhymes with first syllable of word *urgent*. Example: *wheét-rrr*, a fairly common evening form, given especially after the general chorus ends; given at all seasons.

Type 4. Perch song: a variation of Type 3. Three-syllabled, accent on second, third slurred downward; first note deliberate, second rising and emphatic: *wh-wheét-rrr*. Given occasionally, daytime and evening, all seasons.

Type 5. Perch song series: variable, rapidly repeated single- or double-note phrases. Given more commonly in daytime than in evening choruses.

Type 6. Perch-to-perch flight song: variable, series of rapidly repeated two-, three-, and four-syllable phrases, with varying accent.

Type 7. Chase song: an open trill, decreasing in tempo and volume.

Type 8. True flight song: variable, often a rapid repetition of single syllables, but may be a series of phrases with as many as five syllables.

SEASONAL VARIATION

In my experience, less seasonal change in singing habits occurs with Traill's Flycatcher than with most breeding birds of the locality. Regular singing begins as soon as birds arrive in spring (late May or early June), and continues until they leave in August. In general, early morning and evening singing occurs throughout the period, with variation in the extent of daytime singing occurring on a daily rather than a seasonal basis. In some years there has been a seasonal decrease in daytime singing during the average time of incubation of eggs (late June), but insufficient observations have been made to determine if the singing continued then may be done only by unmated males or those of pairs whose nesting cycle has been disrupted.

With one exception, I have been unable to identify any definite seasonal change in the type of short perch songs given. Variations due to hours of the day (to be described) remain rather uniform throughout the season. The exception, which might be disproved by more extensive observation, is found in the use of Type 1 songs *whee-keér* and *whip-keér* in late July only.

WEATHER INFLUENCES

In this locality, the singing habits of this species are less subject to weather influences than are those of most song birds. I have observed Traill's Flycatchers singing normally during light and heavy rains and thunderstorms, on unusually cold mornings and during hot, sultry summer afternoons. My records indicate that following heavy rains during which some birds are singing, change to a light rain or drizzle will stimulate an increased total volume of singing. During hot July and August days when most birds are silent this flycatcher may continue to sing commonly.

HOURS OF SINGING

From several "listening posts" on my ranch can be heard the sound productions of as many as 56 species of birds nesting in fields, about buildings, in conifer woods, along streams and ponds, and in deciduous brushy flats.

From these sites, as well as from fields where I work, Traill's Flycatchers can be clearly heard. The large number of species heard in the same area furnishes a comparison with *E. traillii* as hours of singing are considered.

Dawn Singing.—In the locality studied Traill's Flycatcher is not noted as a dawn singer. Participation in early morning song, though it occurs at all seasons, is sporadic. Neither is this flycatcher one of the earlier singers, usually being preceded in vocal or other sound expressions by a dozen to 25 or 30 other species. Upon spring arrival birds can be heard as early as 03:20 local mean time, well before civil twilight. In mid-July singing has been recorded at 04:05. More often than not, birds do not commence singing until after sunrise.

Daytime Singing.—Among the more than 50 species with which direct comparisons are available, Traill's Flycatcher at my ranch is one of the most consistent and persistent daytime singers, especially in midsummer. From the time of dawn or post-sunrise beginnings, song usually can be heard throughout the day, dwindling to provide a two- or three-hour intermission before the evening chorus opens. Often during hot summer days this is the only species singing frequently at midday and during afternoon hours. Time has not been available to determine what pauses may be taken by individual birds during the day. It has been observed, however, that a particular bird often repeats its song at short but sometimes irregular intervals for several hours at a time.

Twilight Singing.—Although, judging from published reports, daytime singing is exceptionally common in the Fortine area, even here the "grand finale" is reserved for twilight hours. This is the time of true responsive singing, with timing, tempo, and song selection reflecting an interchange of communication between participating birds. From season to season and decade to decade, twilight singing shows certain rather unchanging characteristics.

Typically, in an area inhabited by several pairs of Traill's Flycatchers, not long after sunset birds will begin giving occasional *whit* calls, and a few scattered two-syllabled perch songs. Over a period of 20 to 70 minutes calls and songs gradually become more frequent, with only one or two birds contributing. Then when darkness has deepened (well past civil twilight), suddenly all birds break into song. Each gives notes rapidly, vigorously. Usually the chorus continues unabated for about 20 minutes, except for one or two periods of sudden complete silence lasting from 10 seconds to as long as three minutes. On other occasions, two or three birds will continue singing during these general pauses. I have not detected any specific seasonal change in the duration of the chorus.

The general chorus usually ends quite suddenly. I have records where no further sounds were heard, but generally scattered calls and songs are given for a period as long as 10 minutes after the general chorus ends.

During the responsive singing period, with only occasional variation all birds repeat the same song. Usually this is the common Type 1 *whith-keér.* Yet perhaps the next night all will use the variation *wheeth-keér.* Interspersed occasionally some nights have been other expressions, principally Type 2 *wheé-deér.* With the closing of the chorus, a definite change is made. The final scattered songs then given are Type 3 or Type 4 songs: *wheé-derr, wheét-rrr,* or *wh-whéet-rrr,* all with the downward slurred final syllable. When the variation *wheeth-keér* (as normally accented) is given, it too has the second syllable fading downward with decreasing emphasis. Occasionally one of these "final" type songs will be interjected into an earlier intermission silent period (as though the bird assumed that the chorus had ended?).

During the intensive song period, individual birds usually repeat two- or three-syllabled songs at 1½ to 3-second intervals. While several birds are singing it is difficult to determine the timing. On one occasion I clocked a male that sang without interruption for 18 minutes, 20 to 36 songs per minute, for a total of about 600 songs. Another was timed at 6 to 7 songs each 10 seconds. Occasionally during the evening song period a few birds will indulge in the Type 5 perch song series. The Type 6 perch-to-perch rendition may be heard at times, although as a rule during chorus birds remain at one perch except when engaging in song-flight.

Evening observations over a long period of years have disclosed that of the 56 species of birds to be heard from listening posts on the ranch, at all times during its seasonal residence Traill's Flycatcher is almost always the latest bird to be heard. Usually all other species are silent for several to as much as 20 minutes before the last flycatcher songs and calls are given. Interestingly, the birds most likely to rival the flycatcher's position on the "late show" are not songbirds, and include aeolian and percussion performers: Killdeer (*Charadrius vociferus*), Common Snipe (*Capella gallinago*), Blue Grouse (*Dendragapus obscurus*), Ruffed Grouse (*Bonasa umbellus*), Common Nighthawk (*Chordeiles minor*), and American Bittern (*Botaurus lentiginosus*). Latest songbirds to be heard, one or another occasionally outlasting Traill's Flycatcher, are Robin (*Turdus migratorius*), Swainson's Thrush (*Hylocichla ustulata*), and Catbird (*Dumetella carolinensis*).

Without equipment to measure light intensity, I have observed that usually at the cessation of twilight singing darkness finds me making final notes blindly, or straining to distinguish pencil marks six inches from my eyes. A composite of many observations during a period of years yields these approximate figures for ending of the singing period (local mean time): 1 June, 20:53; 3 June, 20:59; 8 June, 21:15; 13 June, 21:17; 21 June, 21:05;

17 July, 21:00; 27 July, 20:50; 4 August, 20:10. Surprisingly, a graphic presentation of this data would show a seasonal curve only slightly influenced by light intensity.

SONG-FLIGHT

Only occasionally and unpredictably do Traill's Flycatchers on my ranch indulge in a special song-flight. I may watch birds for several seasons without observing this interesting performance, then find it given by several birds during a single evening. Or a repeated performance may be given by an individual bird during daytime hours.

From a perch a bird will rise upward in fluttering, zigzag flight to a height of 30 to 50 feet, then descend in a similar erratic manner to the same or a nearby perch, while in the air continually voicing a rapid series of emphatic notes. These may be single-syllable notes: *whew-whit-whew-whew-whit-whit-whew. . . .* At other times a bird will give a mixture of two-, three- and four-note phrases, such as *whee-theer, whee-theer, whit-whee-theer, whee-whee-whit-theer. . . .*

Occasionally a bird will vary this performance by giving a similar song while flying from one perch to another without rising above the shrubbery. It is distinguished from normal and common perch-to-perch movement by slower jerky, zigzag flight.

DISCUSSION

Detailed comparison of songs and calls recorded in the Fortine locality with other published information will not be attempted in this paper; neither will space be taken with an extensive listing of pertinent literature. Yet it may be helpful to professional workers examining the puzzling taxonomic and distributional questions posed by *E. traillii* to comment briefly on differences reported among western populations.

Despite the confusion which may arise from the attempts of observers to record phonetic descriptions of the songs of this species—so well discussed by Allen (1952:108)—, a great variation in vocal expressions of *E. traillii* in western areas is evident. Thus songs conforming to the midwestern *fitz-bew* type have been ascribed to the West in general (Peterson, 1941:115), and specifically to sites in North Dakota (Kellogg and Stein, 1953:77), southwestern Washington (King, 1955:167), and southern British Columbia (Godfrey, 1966:255). Yet at Fortine, centrally located among these three areas, while I have listened to literally thousands of song expressions during a period of 53 years, I have never recorded a two-syllabled song even remotely resembling *fitz-bew*! The only *bew* sounds have occurred in an infrequent call note *whew* and in flight song combinations.

McCabe (1951:91) describes the call note of this species as a clear, melodious *wheet*, adding "there is virtually no difference of opinion or interpretation among ornithologists as to the sound of the call." Yet in my experience the dominant call note at all seasons is a sharp *whit*; as a variation, *wheet* is heard only rarely.

King (1955:169) found that in the Palouse country of Washington Traill's Flycatchers sing only infrequently during midday; at Fortine they are one of the most persistent daytime songsters. He reports also that in that locality cessation of evening song occurs within three minutes of the end of civil twilight; here the period at all seasons continues well beyond that time. This later singing agrees with McCabe's findings in Wisconsin (1951:95).

King (1955:168) observed that during the courting season a three-syllabled song (*whip-a-deer*) predominates, giving way during the nesting season to a two-syllabled song. In my experience I have not heard a three-syllabled song with a *deer* ending, and no seasonal change in dominant songs has been noted.

In Wisconsin, the song-flights described by McCabe (1951:92) appear to be indulged in fairly commonly, although not previouly reported from other areas. He reports that birds preface the flight with a series of rapid notes, and cease singing upon reaching the summit of the upward flight. In my experience in extreme northwestern Montana, song-flights are rarely made, perch introductory singing is usually lacking, and birds sing throughout both upward and return downward flights.

In conclusion, it must be admitted that my records leave gaps to be filled by further observation. Detailed study in different locations in the West by the same phonetician, aided by modern recording methods, might disclose a lesser extent of geographical variation than now seems evident. Though singing habits are subject to change, the information presented here has remained pertinent for a half century in the specific locality involved.

SUMMARY

Observations of the singing habits of Traill's Flycatcher at the author's ranch in extreme northwestern Montana cover a period of 53 years. The great variety of songs given in that locality are classified among four types of short perch songs, a perch song series, a perch-to-perch flight song, a chase song, and a true flight song. Use of these types varies with the season, hour of the day, and action of the birds.

Little seasonal change in singing habits or types of short perch songs given occurs. Birds sing quite commonly throughout their summer residence period. Weather conditions have little effect on singing habits. Singing may continue during storms, on unusually cold mornings, and during hot summer days.

In the locality studied Traill's Flycatcher is not among early dawn singers; generally song does not commence until after sunrise. But among species present it is one of the most consistent and persistent daytime singers, being heard commonly at midday and on hot afternoons when other birds are silent.

Twilight hours are the time of true responsive singing, with timing, tempo, and song selection reflecting an interchange of communication among birds participating in a "chorus" period. Though prefaced by scattered calls and songs, the general chorus, usually lasting about 20 minutes, begins and ends quite suddenly. As a rule during the chorus all birds render the same song, which may be replaced by another on the succeeding night. Following the general chorus, occasional songs of a particular type are given. Singing ceases well after dark, usually after all other birds are silent. Time of cessation appears to be little influenced by light intensity.

Occasionally birds engage in a distinctive song-flight, rising in an erratic manner to a height of 30 to 50 feet, then descending in a similar zigzag course to a perch, while in the air continually voicing a rapid series of notes or one- to four-syllabled phrases.

Comparison with published data from the West and Midwest discloses a considerable variation among localities in the calls, songs, and singing habits of this species.

LITERATURE CITED

Allen, F. H. 1952. The song of the Alder Flycatcher. Wilson Bull., 64:107–109.

Godfrey, W. E. 1966. The birds of Canada. Natl. Mus. Canada Bull. 203.

Kellogg, P. P. and R. C. Stein. 1953. Audio-spectrographic analysis of the songs of the Alder Flycatcher. Wilson Bull., 65:75–80.

King, J. R. 1955. Notes on the life history of Traill's Flycatcher (*Empidonax traillii*) in southeastern Washington. Auk, 72:148–173.

McCabe, R. A. 1951. The song and song-flight of the Alder Flycatcher. Wilson Bull., 63:89–98.

Peterson, R. T. 1941. Field guide to western birds. Houghton Mifflin, Boston.

FORTINE, MONTANA. 12 MARCH 1973.

THE TIMING OF MATERNAL BEHAVIOR OF THE BROAD-TAILED HUMMINGBIRD PRECEDING NEST FAILURE

William A. Calder

Attachment to nest or contents is strong in birds, as is exhibited by the vigorous defense by a female hummingbird, despite her being several orders of magnitude smaller than the intruder. Although cause and effect may not be positively distinguished, profound physiological changes in birds coincide with the stages of the breeding season (Eisner, 1960; Lehrman, 1961; Yapp, 1970). At this time of the year, the reproductive objectives appear to dominate every aspect of the bird's behavior. Therefore, observation of the breakdown of such a compelling pattern should be of interest.

The literature on incubation, parental behavior, and nesting success is extensive. However, I find little information on the behavior of females just prior to the abandonment of nests, eggs, or chicks except for information on the incubation of infertile eggs (Kelly, 1956; Skutch, 1962). Maintenance of the individual (maternal welfare) may compete with maintenance of the species (welfare of potential offspring) when time or resources are limiting. Maternal behavior may entail sacrifices made only when there is a good chance that chicks or eggs will survive. If the nest fails, continued sacrifice of maternal welfare is without benefit, and a return to the pattern of self-maintenance will come, abruptly or gradually. How does an incubating or brooding bird budget her time as nest failure becomes inevitable? Davis (1955) stated: "Problems of animal behavior exist in the relation of perception of the contents of the nest to behavior." How does timing of behavior reflect her perception of the situation?

I report here continuous recordings of sessions and recesses (Skutch, 1962) obtained from sensors in synthetic eggs, during a study of thermoregulation and microhabitat selection of hummingbirds (Calder, 1971; 1972; 1973*a*,*b*). I have analyzed recordings of activity preceding abandonment of seven nests of the Broad-tailed Hummingbirds (*Selasphorus platycercus*). One of these nests was abandoned after 23 days of incubation of infertile eggs (normal incubation is 15 to 19 days). One was abandoned after death of the young. The other five were apparently abandoned because of a food crisis, coinciding with the decline of flowers used by hummingbirds and with the invasion by migrant Rufous Hummingbirds (*S. rufus*), competing for the dwindling resources.

MATERIALS AND METHODS

I have modified the technique of Howell and Dawson (1954) and Kendeigh (1963) to monitor presence and absence of female hummingbirds at their nests. Nest temperatures were sensed from synthetic eggs (Silastic 382, Dow Corning) within which either a thermocouple or a thermistor had been implanted (Calder, 1971, 1973*a*). The "egg" sensors were then placed in the nests of the Broad-tailed Hummingbird without removal of natural eggs. These were tolerated well. From the "egg," leads extended to recording potentiometers (EA 171B, ICA 400, L & N Speedomax W, or Bristol Dynamaster) for continuous recording. Each departure of the female was thus clearly recognizable by an abrupt cooling of the "egg," and her return was recorded as rewarming.

I observed 41 completed nests during the summers of 1971 and 1972 at the Rocky Mountain Biological Laboratory, Gothic, Colorado, elev. 2900 m. The outcome was determined for 35; temperature/activity recordings were obtained from 17 of the nests. Since a maximum of five recorders were operational at a time, they had to be shifted from nest to nest as cycles were completed or nests abandoned. Obviously, a smaller proportion of 18 active nests could be monitored in mid-season than when eight or fewer were active in late July. The nests with sensors were 41 percent successful, those without recorders; 59 percent. This difference does not represent disruption by the technique, but rather a consequence of the bias due to equipment limitations. Most of the nestings were terminated before 2 August, with 53 percent success (one or two chicks fledged) for those nests, but there was only 20 percent success for nests terminated after 2 August. Thus the recorder sampling was proportionately greater from the failure-prone late nests. Also, recorder-nests which failed did so an average of 18 days after the sensor was placed in the nest, during which interval, attentive behavior and hatching (from fertile eggs) were normal. Four nests of other species of hummingbirds have been similarly monitored, following which all chicks fledged successfully.

The nests were numbered in sequence of discovery, with exceptions to preserve the numbering of the previous season when possible. Thus nest 3-72 occupied the same branch in 1972 as nest 3-71 in 1971.

Times of first departure from the nest in the morning and last return in the evening are expressed relative to almanac sunrise (0° horizon; Anon., 1971, 1972). The local topography intercepted the sunrays and cast shadows on the various nest sites considerably later than sunrise and earlier than sunset times in the almanac.

RESULTS AND DISCUSSION

Abandonment of Infertile Eggs.—Nest 3-72 was approximately 11 m up on a crook of an aspen branch (*Populus tremuloides*). Nest construction extended from 1–3 June atop the remains of nest 3-71 (which was successful; see Figure 3 in Calder, 1973*a* for an illustration; and Calder, 1972, for other natural history of this site). Incubation began 4 June. A temperature sensor was placed in the nest on 9 June. Normal incubation behavior was sustained until the 23rd day (27 June), with the first departure from the nest between ½ and 14 minutes before almanac sunrise, the last arrival 9 to 52 minutes before sunset until the 21st day, with all absences less than 10 min each. During mid-day the warmer air temperature and sunlight plus a gradual pushing of the synthetic egg into the nest wall and thus further from the brood-patch, abolished the cooling spikes, so that the number of feedings could no longer be counted in mid-day. The longest successful incubation period I have recorded from this species was 19 days, and the shortest was 16 days. Skutch (1962) stated: "Most birds seem to remain faithful to their eggs for an interval at least 50 percent longer than is normally required to hatch them. . ." For this hummingbird the "margin of safety" was only 21 to 44 percent, and far short of the record of 95 days attentiveness by a female Anna's Hummingbird (*Calypte anna*) with sterile eggs (Kelly, 1956).

On 27 June, the female began lengthening her recesses to 10, 10, 20, 13 min, a period of normal shorter trips and a series of 36, 21, 78, 22, and 3 min duration. The last trip ended slightly late, 4 min after sunset, as had been the case for the previous two nights. She incubated overnight and departed 9 min before sunrise for 6 min. The trips which insued were 71, 6, 30, 3, and 23 min. At 08:50 she departed, never to return. The eggs were collected; one was infertile. The other had been finely pierced; conceivably, she might have inserted her bill and extracted some of the nutrients within.

It is interesting to compare timing of nesting at site 3 in 1972 with 1971. The snow melted out unusually early in 1972, hummingbirds began to nest earlier, and their flowers commenced blooming earlier. Nest 3-72 was 17 days earlier than 3-71. With reference to the local population, the first incubation of 1972 was 22 days earlier than in 1971. The mean hatching and fledging dates were 9 and 11 days earlier, respectively, in 1972. If the onset of flowering of *Delphinium nelsoni*, the first major hummingbird flower in Gothic, is influenced by the disappearance of snow, and, if hummingbird nesting is in turn related to the nectar supply of *D. nelsoni*, an early season could conceivably instigate nesting before the mates were completely ready. physiologically, leading to such infertility. One of two eggs in next nest to be discussed was also infertile; that nest was also early. Two other nests were found with abandoned eggs, one on 6 June and one on 12 July.

Abandonment of a Dead Nestling.—Nest 5-72 was ⅓ m above ground in a small spruce (*Picea engelmanii*) in an open wet-meadow. It was discovered and outfitted with a sensor-egg on 5 June. The hen became hypothermic at 02:45–05:00 on 9 June (see Calder and Booser, 1973, for ecological correlations). One egg hatched 20 June. The other was infertile when found later beneath the nest. The one chick developed normally for 10 days. At this age, the normal clutch of two are homeothermic, at least when their calorigenic capacities are consolidated by huddling. The female no longer broods them at night. On the tenth night (1 July) the lone chick possibly entered torpor, as the "egg" registered a low of 4°C which is below minimum body temperatures for spontaneous arousal in adult hummingbirds (Lasiewski, 1963, 1964; Dawson and Hudson, 1970). At 05:35 the nest began warming more rapidly than would be likely from air temperature rise.

Recordings for 1–3 July suggest that either the female came and brooded several times daily or that the chick was still capable of thermoregulation, intermittently contacting the sensor "egg." On 4 July the chick was dead when examined for the first time in several days. From 12:15–15:45, the nest was brooded with periodic departures of normal feeding duration. From 15:45 to 18:50 the nest was unwarmed, but at 18:50 the nest was rewarmed, interrupted by five departures and abandoned for the night. At 05:38, normal for onset of activity (10 min before sunrise), the sensor was steadily rewarmed from –1°C to 25°C in 15 minutes, before solar radiation could have had any significant effect at that location. There were two cooling spikes (foraging?) before final abandonment at about 06:50, after which the "egg" went to 2°C and followed air temperature with the addition of any direct solar radiation.

Late Season Abandonments of Live Chicks.—Nest 17-72 was being built on 27 June, 12⅔ m above the ground on a crook in an aspen branch, the highest nest discovered in this study. A temperature sensor was placed in the nest on 29 June. The nest was not warmed overnight. The hen returned at 05:30 on 30 June to warm the nest. The record was somewhat irregular for two hours, with departures about 30 min apart. After 07:30, a regular session/recess pattern was exhibited. Thus it appears that the second egg was laid that morning, followed by onset of incubation. Young were being fed by the adult on 20 July and had probably hatched 2 or 3 days previously.

The attentive behavior of the female appeared normal through the morning of 28 July, the first feeding departures were 23, 20, and 23 min before sunrise on 26, 27, and 28 July, respectively. The temperature began dropping at about 17:45 on 28 July and appeared to follow ambient temperature thereafter. The nest was collected 31 July. Both chicks were dead, with one partially eaten, apparently by insects.

Two other nests were abandoned on 31 July, nests 28-72 and 35-72. Both were low nests in stream-side spruce trees. Behavior at 28-72 was apparently normal on 27 July when the chicks were 9 days old. Recorder batteries ran down on 28 July and were replaced at 16:52. The following absence was nearly 2 hr in duration, with a gradual cooling, a rewarming, a last trip and a warm nest until about 01:00. Then, a period of hypothermia began, consisting of apparently exponential cooling for 1½ hr to a stable minimum of 7 to 7½°C for 1¼ hr, and an exponential rise to a normal 29°C in the morning. This was followed by 6 recess periods of 13 to 45 min duration, then by 10 hr of stable warmth, whether from the chicks metabolism or brooding by the adult. There was one more exponential cooling-rewarming cycle of about 65 min before 3 hr of nocturnal homeothermy. Then, ca 00:45, on 30 July, a 3½ hr cycle of hypothermia occurred again. As in the preceding night, the pattern was typical of energy-crisis hypothermia reported by Calder and Booser (1973). This was followed by inattentive-coolings of 15, 35, and 90 min, a 09:40 warming and slow decline to apparent equilibrium with air temperature the rest of the day and overnight. At 06:17 on 31 July, the sensor was suddenly and rapidly rewarmed from 5° to 25°C in 15 min, then left to cool for 38 min, rewarmed and finally abandoned permanently. At 20:32 the nest was examined. One chick was dead, the other cold and lethargic but alive. An attempt was made to hand-rear it. When rewarmed, it gaped eagerly and was fed an improvised diet for two days over which it gradually weakened and died.

Recording began on 23 July at nest 35-72. The eggs hatched on 26 July. Live young were abandoned on 31 July. The temperature record preceding abandonment appears normal through the morning of 31 July. At 05:46, the hen was feeding the chicks upon return from her first trip of the day. At 12:40, she departed and the nest equilibrated to the air temperature. She did not return. At 20:06, the abandoned chicks were transferred to a thermoregulated chamber for hand-rearing which was unsuccessful.

The abandonment of live chicks, which are still capable of gaping when warm, is difficult to understand, but this occurred at two other nests also.

Nest 8-71 was under a crook in the trunk of a large aspen (see Figure 4, Calder, 1973*a*), about 2½ m above the ground. The second egg was laid and incubation commenced on 21 July. The eggs hatched on 5 August, 19 days after the latest egg date for Broad-tailed Hummingbirds in Colorado cited by Bent (1940). A normal pattern for attentive and feeding behavior was recorded through 7 August. The recorder malfunctioned 8 August. The first departure on 9 August was on time, but was followed by abnormally and progressively longer absences (Fig. 1). The female abandoned the chicks at 15:12, made a brief appearance without feeding them at about 19:15. At 06:30 on 10 August, the chicks were still alive, having chilled to 6°C from peak overheating of 44.5°C in the unprotected nest on 9 August. Attempts to hand-rear the chicks were unsuccessful.

The gilia and larkspur flowers, from which the adult fed, had been fading rapidly in the nearby meadow. The lengthening recesses may reflect the need to range farther and farther in search of an energy supply. Higher in the mountains where flowers were still spectacularly abundant, there was intense agonistic behavior between abundant hummingbirds. The Rufous Hummingbirds had established territories as described by Armitage (1955). Thus even if a brooding female could visit distant flower patches, she would have to compete there with territorial birds at a severe disadvantage. Having to return to the nest frequently, she would not be able to continuously defend her food supply.

Nest 36-72 was located 1½ m above the ground in an isolated spruce in an aspen-forb ecotone. The nest was discovered on 23 July and was being

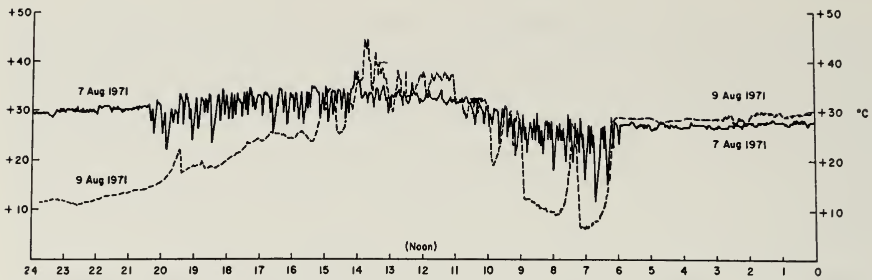


FIG. 1. Records of normal behavior (Nest 8-71, 7 August, solid trace, chicks 2 days old) and pre-abandonment behavior (9 August, dashed trace) superimposed for comparison. Note that the overnight nest temperature was normal for the brooding of chicks, and that first feeding departure was on schedule on 9 August. This was followed by three prolonged inattentive, cooling periods of presumed foraging, overheating of the nest during mid-day sunlit period, some brooding before abandonment at 15:12. The warming spike at 19:30 was an artifact.

incubated then. A sensor was placed in the nest and recording began on 1 August. The eggs hatched on 5 August. Normal temperature cycles continued until about 17:00 on 13 August, at which time the nest temperature dropped to ambient. The chicks were found dead but intact on the ground beneath the nest at 17:39.

When last checked previous to this (14:54, 11 August) the nest wall had been torn open. Very frequently the hens repaired their nests when they returned from feeding to incubate or brood. That this damage to 36-72 went unrepaired leads me to speculate that there was late-season weakening of brooding behavior, the lack of maintenance making the nest less safe for the young. Predators, on the other hand, would probably have eaten part or all of the chicks.

CONCLUSIONS

The behavior of birds prior to abandonment of nesting failures does not appear to have been described with reference to the dimension of time, nor is it likely that any one will bother to acquire a large sample of such observations in the near future. Hence an attempt to generalize or to see any pattern in this fortuitously-recorded behavior seems justifiable.

Of 26 nests, 53 percent which were terminated before 29 July were successful, while only 29 percent were successful after that date in 1972. This excludes nests which were not completely built or at which the success or failure was undetermined. Nesting was later in 1971 than in 1972, with no observed fledging until 29 July, and all fledging completed by 2 August 1971. Pooling the two years, 53 percent were successful on or before 2 August, but only 20 percent thereafter. The greater liklihood of failure of late nesting is not correlated with significant temperature changes. The only abiotic factor is that the daylength for foraging purposes has decreased about 38 min, but a winter-nesting Anna's Hummingbird of similar size was successful in weather as cold but with much shorter daylengths (Calder, unpubl.). It appears likely that biotic factors cause this greater likelihood of failure. Dramatically obvious are the disappearance (going to seed) of the tubular flowers that the Broad-tails used and the abundance of Rufous Hummingbirds which compete for the same flower patches, even claim them with aggressive behavior. Counts were not made of flowers or Rufous Hummingbirds, but the qualitative facts were inescapable to the casual observer. (A scientist who shall remain nameless confessed to killing a Rufous Hummingbird because it was so domineering at his feeder!)

With that background, the recorded nest failures can be divided into early (27 June, 4 July) and later (29 July–9 August) abandonments. In both early abandonments (3-72, 5-72), there was a persistence in attentiveness after the reality of failure. Infertile eggs were incubated 4 days beyond the longest observed incubation period for that species, and a dead chick was brooded at least intermittently for one day or more after its death. The persistence can be regarded as a safety factor that precludes abandonment if there is any chance of success (Skutch, 1962).

Of the later failures, the records for two show no hint of abandonment or irregularity beforehand (17-, 35-72), the cessation of attentiveness being sudden, as if the result of predation or other disaster to the adults. The other two (8-71, 28-72) showed a lengthening of inattentive periods, as did the earlier incubator of sterile eggs, indicative of a gradual cessation of broodiness. In the cases of the latter two, I suspect that the lengthened recesses represent longer foraging trips in unsuccessful attempts to attain energy balance. The hypothermia two nights in a row at 28-72 is further circumstantial evidence of an energy crisis.

SUMMARY

The temporal behavior of female Broad-tailed Hummingbirds is described for the period preceding natural abandonment of nests. Nesting failure can be considered in two classes: early and late failures. The early failures were due to infertile eggs and the death of a chick. Attentiveness persisted four days beyond normal incubation period and at least one day after the chick was dead. In the latter nest, abandonment was preceded by a lengthening of the recess periods.

Of the late failures, three hens abandoned suddenly, while the other two exhibited a series of lengthened recesses. One of the latter two became hypothermic for a portion of the two nights preceding abandonment. The lengthened recesses are thought related to the declining food supply. Live chicks remained in both of those and one of the suddenly-abandoned nests.

ACKNOWLEDGMENTS

This research was supported by NSF Grant GB13249 and by an instructional staff position at R.M.B.L. I am indebted to Joanna Booser and Nickolas Waser for assistance in the field.

LITERATURE CITED

Anonymous. 1971, 1972. The Air Almanac. U.S. Naval Observatory, Washington.

Armitage, K. B. 1955. Territorial behavior in fall migrant Rufous Hummingbirds. Condor, 57:239.

Bent, A. C. 1940. Life histories of North American cuckoos, goatsuckers, hummingbirds, and their allies. U.S. Natl. Mus. Bull., 176:420–429, 387–398.

Calder, W. A. 1971. Temperature relationships and nesting of the Calliope Hummingbird. Condor, 73:314.

Calder, W. A. 1972. Piracy of nesting materials from and by the Broad-tailed Hummingbird. Condor, 74:485.

Calder, W. A. 1973*a*. Microhabitat selection during nesting of hummingbirds in the Rocky Mountains. Ecology, 54:127–134.

Calder, W. A. 1973*b*. An estimate of the heat balance of a nesting hummingbird in a chilling climate. Comp. Biochem. Physiol., (in press).

Calder, W. A., and J. Booser. 1973. Hypothermia of Broad-tailed Hummingbirds during incubation in nature with ecological correlations. Science, 180:751–753.

Davis, D. E. 1955. Breeding biology of birds. p. 288 in Recent studies in avian biology (A. Wolfson, Ed.). Univ. Illinois Press, Urbana.

Dawson, W. R., and J. W. Hudson. 1970. Birds. pp. 223–310 in Comparative physiology of thermoregulation. I. Invertebrates and non-mammialian vertebrates (G. C. Whittow, Ed.). Academic Press, New York.

Eisner, E. 1960. The relationship of hormones to the reproductive behavior of birds, referring especially to parental behavior: a review. Anim. Behav., 8:155.

Howell, T. R., and W. R. Dawson. 1954. Nest temperatures and attentiveness in the Anna Hummingbird. Condor, 56:93–97.

Kendeigh, S. C. 1963. Thermodynamics of incubation in the House Wren, *Troglodytes aedon*. Proc. XIII Internatl. Ornithol. Congr., 884–904.

Kelly, J. W. 1956. Prolonged incubation by an Anna Hummingbird. Condor, 58:163.

Lasiewski, R. C. 1963. Oxygen consumption of torpid, resting, active and flying hummingbirds. Physiol. Zool., 36:122–140.

Lasiewski, R. C. 1964. Body temperatures, heart and breathing rate, and evaporative water loss in hummingbirds. Physiol. Zool., 37:212.

Lehrman, D. S. 1961. Sex hormones and parental behavior in birds and infra-human mammals. pp. 1268–1382 in Sex and internal secretions, vol. 2 (W. C. Young, Ed.). Williams and Wilkins, Baltimore.

Skutch, A. F. 1962. The constancy of incubation. Wilson Bull., 74:115–152.

Yapp, W. D. 1970. The life and organization of birds. pp. 77, 101–104, 123–124. American Elsevier Publishing Co., New York.

DEPARTMENT OF BIOLOGICAL SCIENCES, UNIVERSITY OF ARIZONA, TUCSON, ARIZONA 85721 AND ROCKY MOUNTAIN BIOLOGICAL LABORATORY, CRESTED BUTTE, COLORADO 81224. 26 FEBRUARY 1973.

REPLACEMENT OF CAVITY-HUNTING STARLINGS AND HOUSE SPARROWS AFTER REMOVAL

Paul A. Stewart

As was demonstrated by Stewart and Aldrich (1951) and Hensley and Cope (1951) through work during two nesting seasons in a Maine spruce-fir forest, many non-breeding birds are often available in wild populations to replace lost breeding birds. The present paper gives data on replacement of cavity-hunting Starlings (*Sturnus vulgaris*) and House Sparrows (*Passer domesticus*) following continuous removal of birds visiting a nest box throughout the 1972 nesting season. The data were collected in a residential area of Oxford, North Carolina.

MATERIALS AND METHODS

During the period 25 January to 14 July 1972 I operated an automatic nest-box trap on the pole of my martin house in an effort to protect the Purple Martins (*Progne subis*) from competition with Starlings and House Sparrows. The captured birds were killed, thus removing them as potential nesting birds. The nest-box trap, earlier described (Stewart, 1971, 1972), was checked for captures each day at 07:45, noon, and more or less continuously during the period from 17:15 until darkness. Captures were limited to one bird per setting.

Starlings were sexed by the colors of their lower mandibles and eyes (Kessel, 1951).

RESULTS

Although the nest-box trap was set on 25 January, no captures were made until mid-February. Starlings, House Sparrows, and other birds sometimes perched on top of the nest-box trap, but birds not entering the box were assumed not to be exploring it for a nesting place. A pair of Starlings reared two broods in a crevice of a dwelling house about 20 m from the nest-box trap, indicating that the captured birds were non-breeding birds rather than birds from nearby nests.

Starling.—These birds visited the nest box during a period of 124 days from 16 February through 19 June, with a total of 56 birds captured. Captures were made on 51 different days, with two birds captured in three days and three in one day.

Of the 56 Starlings, 39 were males and 17 females. Twice a male and a female, assumed pairs, were captured during the same days, and eight times a male and a female were captured in the forenoons of successive days. Thus, with 10 probable mated pairs captured, the birds may have sometimes explored cavities as pairs; however, with 22 more males than females captured, males also explored cavities alone, presumably being unpaired.

Thirteen males and 12 females were captured in the morning before 07:45; 21 males and four females were captured between 07:45 and noon: five males and one female were captured in the afternoon. Thus, exploration of nest cavities was chiefly in the forenoon but sometimes in the afternoon.

Fledgling Starlings were first seen on 18 May, indicating completion of the first nesting. Cavity-hunting Starlings continued visiting the nest box 32 days after fledglings were first seen, and only six Starlings were captured after that date.

The four Starlings captured after 6 June were females, with two captured on 15 June and one each on 18 and 19 June; whereas, more males than females were earlier captured. It thus appears that cavity hunting persisted somewhat longer among females than males.

House Sparrow.—During the 137 days from 17 February through 3 July, 14 House Sparrows were removed from the nest-box trap. Captures were made on 11 different days. Three House Sparrows were captured the first day, 17 February, indicating an early effort to occupy available cavities. Also, two birds were later captured during the same day. Otherwise, the House Sparrows were captured at intervals of four to 21 days, with an average of about one bird every 13 days.

Six of the 14 House Sparrows were males, and eight were females. The first two birds, a male and a female, were captured only 15 min apart; thus they were presumably a mated pair. Likewise, on 8 April a male and a female were taken from the trap at 07:45 and noon, respectively, of the same day, presumably also a mated pair. However, two females were separated from males with longer intervals between captures, suggesting independent cavity hunting.

Captures were made chiefly in the forenoon, with only two birds, one male and one female, captured in the afternoon. Of the birds captured in the forenoon, five were captured before 07:45, and seven were captured between 07:45 and noon. None was captured in the afternoon after 17:15.

DISCUSSION

That adult Starlings and House Sparrows entered the nest-box trap only during the nesting season and never at roosting time is taken to indicate that the captured birds entered the box only to explore its suitability for a nest cavity. Presumably all of the 56 Starlings and 14 House Sparrows captured in the nest-box trap were seeking nest cavities. The capture of three House Sparrows on 17 February, the date when a capture of these birds was first made, indicated an early effort to find unclaimed cavities. Likewise, the capture of three Starlings on 28 February indicated that Starlings then made a special effort to find unclaimed cavities. Probably few cavities were left unclaimed by the start of March. The continuous replacement of Starlings suggests the existence of a large number of non-breeding birds in the population.

With only 14 House Sparrows captured as compared with 56 Starlings, there may have been fewer non-breeding House Sparrows than Starlings. Perhaps the relatively small number of non-breeding House Sparrows resulted from the fact that, unlike Starlings, House Sparrows build nests outside of cavities as well as inside and thus have less of a shortage of acceptable nesting places.

Stewart and Aldrich (1951) and Hensley and Cope (1951) censused the birds on a 40-acre tract by spot mapping the singing males before and after collecting birds, thus noting with censuses changes or lack of changes in the population. While a much smaller sample, only one nest site, was used in the present study, the method of measuring replacement was much more precise. In the present study, replacements totaled 54 Starlings, including 38 males and 16 females, and 12 House Sparrows, including five males and seven females. Replacement was thus 27-fold among Starlings and six-fold among House Sparrows.

The rate of replacement of male Starlings was twice as high as that for females. With eight female and six male House Sparrows removed, more females than males were removed, but relatively few House Sparrows were removed. Stewart and Aldrich (1951) found that the number of replacement males was slightly more than twice the number of females. However, their method of removing the birds, shooting, may have biased the results, with a greater probability of their shooting the more conspicuous males.

Both Starlings and House Sparrows were captured chiefly in the forenoon, indicating that these birds search for nest cavities chiefly at this time of day. Stewart and Aldrich (1951) also noted that replacement of woodland birds was during the night or early morning.

SUMMARY

An automatic nest-box trap was operated at one site throughout a nesting season, with the captured birds continually removed. Seventy birds were captured, including 39 male and 17 female Starlings and six male and eight female House Sparrows. As indicated by captures in the nest-box trap, cavity hunting by Starlings continued from 16 February through 19 June, with captures on 51 days. Scattered captures of House Sparrows continued from 17 February through 3 July, with captures on 11 days. Starlings and House Sparrows explored the nest box both as pairs and unpaired individuals. Nest box visits were made chiefly in the forenoon, but some visits of both Starlings and House Sparrows were made in the afternoon. A reduction in nest box visits by Starlings started 10 days after fledged young were first seen, but scattered visits continued another three weeks.

LITERATURE CITED

Hensley, M. M., and J. B. Cope. 1951. Further data on removal and repopulation of the breeding birds in a spruce-fir forest community. Auk, 68:483–493.

Kessel, B. 1951. Criteria for sexing and aging European Starlings (*Sturnus vulgaris*). Bird-Banding, 22:16–23.

Stewart, P. A. 1971. An automatic trap for use on bird nesting boxes. Bird-Banding, 42:121–122.

Stewart, P. A. 1972. Prevention of Starlings from lifting shutter on automatic nest-box trap. Bird-Banding, 43:214.

Stewart, R. E., and J. W. Aldrich. 1951. Removal and repopulation of breeding birds in a spruce-fir forest community. Auk, 68:471–482.

203 MOORELAND DRIVE, OXFORD, NORTH CAROLINA 27565, 16 OCTOBER 1972.

NEW LIFE MEMBER

A recent addition to the roster of Life Members of The Wilson Ornithological Society is Donald C. Alexander of Rowley, Massachusetts. Mr. Alexander, who joined the Society in 1937, is also a member of the AOU and several state and local bird clubs as well as an active member of the Nuttall Ornithological Club. He is a Certified Public Accountant and serves as the Assistant Treasurer for two business firms. His principal interests in birds are in observing ducks and shorebirds in the marshes near his home. His other hobbies include mountain climbing, and canoeing (the picture showing him on a portage during a canoe trip). He is married with two grown children.

LOCOMOTOR MECHANISMS IN NORTH AMERICAN DUCKS

Robert J. Raikow

The Anatinae of North America may be divided into two general adaptive types, the dabbling ducks and the diving ducks. The dabbling ducks (Tribe Anatini) are primarily surface feeders, and feed from the bottom only as deep as they can reach by tipping up, without entirely submerging. Thus they feed mainly in shallow, inshore waters. In contrast, the diving ducks (Tribes Aythyini, Mergini, and Oxyurini) feed mainly by diving in deeper offshore waters. The dabbling ducks can walk on land with relative ease, and different species feed there to a greater or lesser extent. The diving ducks, however, walk on land poorly at best, and seldom feed there. The dabblers frequently utilize areas bordered by trees or containing emergent vegetation, where the extent of open water is limited. Their flying abilities are suited to the use of these spatially restricted areas, particularly in taking off and landing. They take off by "rocketing" upward, aided by an initial jump and climbing vertically clear of obstructions. This requires the immediate production of powerful lift forces. Most diving ducks cannot take off in this manner, but must instead use the method called "skittering." They travel across the water surface paddling with their feet and flapping their wings, gaining speed and lift until they are able to rise from the surface. This is adequate for their needs because they usually remain in open water where the necessary space is available. Rocketing and skittering may be compared to the takeoff of helicopters and fixed-wing aircraft respectively. In landing the dabbling ducks are again more proficient. They can fly more slowly than divers and thus drop with greater agility into restricted spaces. Diving ducks typically use a faster, flatter approach and generally land only on water. Weller (1964) describes these movements in some detail.

Several workers have studied the locomotor system of birds by means of quantitative comparisons. The most extensive study is that of Hartman (1961) who measured heart, muscle, and body weights as well as wing and tail areas in many groups. Poole (1938) recorded weights and wing areas for 143 species. Greenwalt (1962) reprinted similar data from several earlier workers. All of these studies contain some data on the Anatidae but are primarily concerned with formulating general principles of dimensional relationships with respect to flight. None concentrates on a single group of birds. Storer (1955) studied weight, wing area, and skeletal proportions in three species of hawks. No comparable study has been done on waterfowl.

This paper will describe certain morphological variations in ducks which are correlated with differences in locomotor abilities. The muscular and

TABLE 1

MEASUREMENTS OF FIFTEEN SPECIES OF NORTH AMERICAN DUCKS

Species	No. of Specimens	Body Weight (gr.)		Wing Area (cm²)		Paddle Area (cm²)	
		Mean	Range	Mean	Range	Mean	Range
			Anatini				
Anas cyanoptera	1	320.0		481.7		28.1	
Anas clypeata	2	514.6	457.1–572.0	578.8	566.9–590.6	37.4	36.2–38.6
Anas acuta	2	712.5	625.0–800.0	800.7	701.3–900.1	46.4	45.9–46.8
Anas americana	2	800.4	743.6–857.1	638.5	629.5–647.6	39.7	39.0–40.4
Anas platyrhynchos	5	961.3	828.5–1057.1	869.8	752.0–1018.4	56.9	48.2–64.4
			Aythyini				
Aythya affinis	1	665.0		454.4		63.4	
Aythya valisineria	1	910.0		700.8		93.6	
			Mergini				
Somateria fischeri	1	1457.1		718.6		67.6	
Somateria spectabilis	2	1700.0	1571.4–1828.5	824.4	748.0–900.7	76.5	74.4–78.5
Somateria mollisima	1	2342.7		1014.9		108.6	
Melanitta perspicillata	5	826.9	614.3–977.0	649.2	517.0–699.7	81.3	72.6–88.9
Melanitta fusca	2	1167.8	1164.0–1171.5	735.4	710.8–760.0	104.1	100.6–107.6
Bucephala albeola	5	396.2	343.2–486.2	326.9	259.2–368.6	47.8	44.6–51.6
Bucephala clangula	3	764.0	618.0–914.2	566.0	499.4–621.0	75.7	59.8–80.6
			Oxyurini				
Oxyura jamaicensis	12	520.8	414.3–714.3	325.7	301.2–374.8	65.4	54.5–73.2

skeletal systems are very important in locomotion, and have been discussed elsewhere (Raikow, 1970, 1971). In the present paper I will consider size, shape, and slotting of the wings, and the size of the paddles relative to the behavioral distinction noted above between dabbling and diving ducks.

MATERIALS AND METHODS

Measurements were made on forty-five specimens collected in the vicinity of San Francisco Bay, California, and (*Somateria*) Barrow, Alaska. These represent six genera and fifteen species. The wing was spread and pinned down on a sheet of paper, and its outline traced. The outline was then measured with a planimeter to obtain the wing area. In several specimens both wings were measured but gave nearly identical results, so in most cases only one wing was measured and this value was doubled to give the wing area of the specimen (Table 1). The wing was spread so that the leading edge was as nearly as possible perpendicular to the body axis, and the wing extended to the maximum degree possible short of damaging the tissues. This standardized method gave repeatable results, insuring that a comparable measurement was made in each case. This is important since wing area varies continuously with the degree of wing spreading, and comparisons are valid only if a uniform method is used. For this reason I have not attempted to pool my data with those of other authors (noted above) who have also measured wing areas in waterfowl.

Relative wing area is expressed as Buoyancy Index following Hartman (1961). This equals the square root of the wing area divided by the cube root of the body weight.

Paddle area (Table 1) was determined by spreading one foot and pinning it to a piece of paper. The outline was then traced around all four digits and their webbing. The area was measured with a planimeter and doubled to give the paddle area of the specimen. Relative paddle size is expressed as the Paddle Index, which equals the square root of the paddle area divided by the cube root of the body weight. The length of the alula and the areas of wingtip slots were measured on the wing tracings. The primary emarginations were measured on study skins.

RESULTS

Wing Size.—The wing area relative to body weight (Buoyancy Index) is larger in *Anas* than in the diving ducks (Table 2). The highest value for diving ducks equals the lowest value for *Anas*. Other things being equal, the amount of lift produced by a bird is proportional to its wing area. The larger area in *Anas* is one factor providing for the greater lift needed in its special flying abilities as discussed above.

Since the species studied varied considerably in weight (Table 1) it is possible that differences in Buoyancy Index are related merely to body size and not to behavioral differences. It is well known that larger birds tend on the whole to have relatively smaller wings than do smaller birds (Poole, 1938). (See Storer (1955) for an example among hawks.) This follows from the surface-volume relationship, i.e. that area varies as the square of a linear dimension while weight varies as the cube.

TABLE 2

BUOYANCY INDEX AND PADDLE INDEX IN FIFTEEN SPECIES OF NORTH AMERICAN DUCKS

Species	No. of Specimens	Buoyancy Index		Paddle Index	
		Mean	Range	Mean	Range
		Anatini			
Anas cyanoptera	1	3.20		0.77	
Anas clypeata	2	3.02	2.87–3.16	0.77	0.73–0.81
Anas acuta	2	3.17	2.85–3.50	0.77	0.73–0.80
Anas americana	2	2.73	2.64–2.81	0.48	0.47–0.50
Anas platyrhynchos	5	2.99	2.70–3.24	0.77	0.68–0.86
		Aythyini			
Aythya affinis	1	2.44		0.91	
Aythya valisineria	1	2.73		1.00	
		Mergini			
Somateria fischeri	1	2.36		0.73	
Somateria spectabilis	2	2.40	2.35–2.45	0.73	0.72–0.73
Somateria mollisima	1	2.40		0.79	
Melanitta perspicillata	5	2.72	2.48–3.05	0.97	0.92–1.00
Melanitta fusca	2	2.58	2.53–2.62	0.97	0.95–0.98
Bucephala albeola	5	2.46	2.24–2.67	0.94	0.88–0.96
Bucephala clangula	3	2.65	2.57–2.74	0.95	0.91–0.98
		Oxyurini			
Oxyura jamaicensis	12	2.26	1.96–2.41	1.01	0.92–1.10

The Buoyancy Index equals the square root of wing area divided by the cube root of body weight. The Paddle Index equals the square root of the paddle area divided by the cube root of the body weight.

I plotted the weight against the wing area for the forty-five specimens of fifteen species considered in this study, and then connected the outside points for all individuals of each genus to give a polygon for each genus (Fig. 1). It is apparent that at any given body weight, the different genera have different wing areas. In a given weight range *Anas* has the largest wings and *Oxyura* the smallest, the other diving ducks being intermediate. *Somateria* falls outside the weight range of the other genera, yet its wing areas fall almost entirely within the range of *Anas*. Figure 1 shows that the relative wing area *between* genera is independent of body weight, so the correlation between wing area and habits is not an artifact of the surface-volume relationship, but is presumably biologically significant. *Within* a genus, however, wing area does increase with weight in a ratio roughly consistent with that expected from the surface-volume relationship, namely that weight increases more rapidly than area.

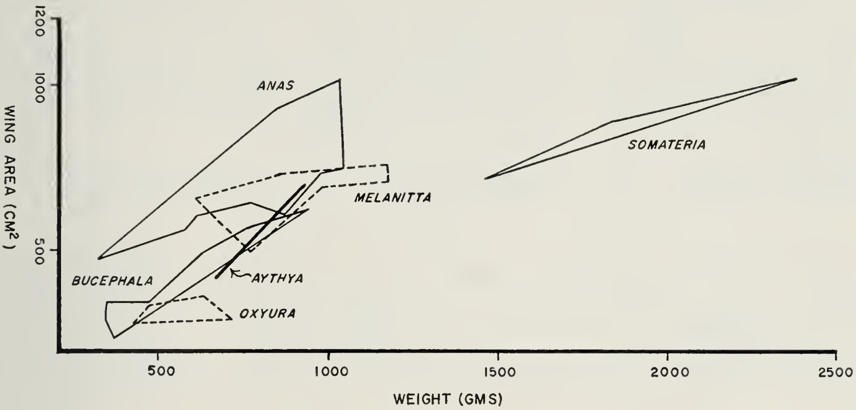


FIG. 1. The weights and wing areas for 45 specimens of 15 species of ducks were plotted, and the outermost points for each genus connected. *Aythya* is represented by a line since only two specimens were measured. The species and number of specimens included here are listed in Table 1. The illustration demonstrates that wing area is not a simple function of weight, but is different in genera with similar weights. The functional significance of the relationship between weight and wing area in the different genera is discussed in the text.

Wing Shape.—The shape of a bird's wing is aerodynamically suited to its method of flight. Savile (1957) recognized four basic wing shapes which have evolved many times in different avian groups. The *slotted soaring wing* and the *high aspect-ratio wing* are characteristic of terrestrial and oceanic soaring birds respectively. The *elliptical wing* is "adapted to operation in confined spaces" (Savile, 1957:224) since it provides high lift and good control under various conditions. It is found in birds which fly through restricted areas in the vegetation of forest or scrub, such as many Passeriformes, Galliformes, Piciformes, and Columbiformes. This wing type commonly has well-developed slotting, which increases lift at low speeds. The *high-speed wing* has a moderately high aspect ratio, a slender elliptical tip, a swept-back leading edge, a lack of tip slots, and other features. It is efficient for relatively direct, rapid flight, but not for slow flight or great maneuverability.

Savile (1957) reported that ducks have a moderately developed high-speed wing. While this is adequate to characterize the subfamily of ducks as a whole, detailed comparison shows that within this group the different genera have subtle differences in wing shape which are of functional importance (Fig. 2). In general, the diving ducks have a more typical high-speed wing, with reduced slotting (discussed below), and a more pointed tip resulting from a relatively straight trailing edge. *Anas* has a more rounded trailing edge, with greater wingtip slotting. Thus its shape more closely approaches the elliptical type

Fig. 2. Outline tracings of the wings and paddles of eight representative species of ducks and a grebe. The drawings are adjusted to equal wing lengths, so that the relative size of wing and paddle may be directly compared between species. The evolution of diving habits is accompanied by an increased paddle size, and by a more pointed, less slotted wing. *Anas americana* and *Oxyura jamaicensis* illustrate extremes of these features in dabbling and diving ducks respectively. The wing of *Oxyura* more closely resembles that of a grebe (*Podiceps*) than that of a dabbling duck (*Anas*).

than does that of divers, especially when the wing is extended, as during take-off. In level flight the wing is less fully extended, so that the ends of the primaries converge to close the slots, and the wing presents a more pointed appearance.

Wing Slotting.—Wing slots are devices which increase lift and lower the minimum flight speed by delaying stalling. Their aerodynamic characteristics are described by Savile (1957) and Jack (1953). Avian wing slots occur along the leading edge and at the wing tip. The leading-edge slot is formed when the alula is lifted away from the wing. In order to compare the size of the leading-edge slot between species I measured the length of the alula and divided this by the total wing length, from shoulder to tip, and by the standard

TABLE 3

RELATIVE LENGTH OF THE ALULA IN FIFTEEN SPECIES OF NORTH AMERICAN DUCKS

	Alula/Total Wing Length			Alula/Standard Wing Length		
Species	Mean	Range	No. of Specimens	Mean	Range	No. of Specimens
		Anatini				
Anas cyanoptera	0.24		1	0.35		1
Anas clypeata	0.23		1	0.32		1
Anas acuta	0.21	0.19–0.23	2	0.31	0.29–0.33	2
Anas americana	0.22		1	0.29		1
Anas platyrhynchos	0.24	0.21–0.27	5	0.33	0.32–0.35	4
		Aythyini				
Aythya affinis	0.23		1	0.34		1
Aythya valisineria	0.24		1	0.36		1
		Mergini				
Somateria fischeri	0.24		1	0.32		1
Somateria spectabilis	0.22		1	0.33		1
Somateria mollisima	0.27		1	0.36		1
Melanitta perspicillata	0.22	0.20–0.25	5	0.32	0.31–0.33	5
Melanitta fusca	0.23	0.23–0.23	2	0.33		1
Bucephala albeola	0.24	0.22–0.29	4	0.36	0.34–0.38	4
Bucephala clangula	0.23	0.22–0.24	2	0.33	0.32–0.35	3
		Oxyurini				
Oxyura jamaicensis	0.24	0.19–0.28	9	0.38	0.32–0.43	12

Total Wing Length is measured from shoulder to wing tip; Standard Wing Length is measured from wrist to wing tip.

measurement of wing length, from wrist to tip (Table 3). Measured either way the length of the leading-edge slot varies but little between species. Thus it does not seem to be functionally significant in the different flying abilities of dabbling and diving ducks. The scoters (*Melanitta*) have the peculiar habit of holding the alula extended while diving (Brooks, 1945), possibly as a diving plane. This habit is not associated with any change in length of the alula (Table 3).

Wingtip slots are formed by the spaces between the separated tips of the primaries. They are usually accentuated by emargination of the feathers. The size and shape of the slots depends on the length of the emarginated segment, the depth of the emargination, and the shape of the proximal end of the slot. I measured the length of the emargination of the outer primary and divided this value by the wing length (Table 4). There is a slight increase in

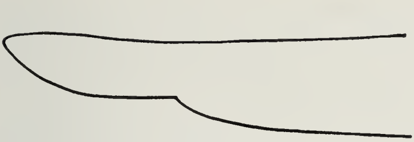
TABLE 4

MEASUREMENTS OF WINGTIP SLOTS IN FIFTEEN SPECIES OF NORTH AMERICAN DUCKS

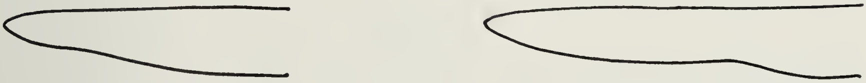
	Emarginated Segment/Wing Length			Wingtip Slot Area/Wing Area		
Species	Mean	Range	No. of Specimens	Mean	Range	No. of Specimens
		Anatini				
Anas cyanoptera	0.14	0.13–0.15	5	0.023		1
Anas clypeata	0.16	0.15–0.17	5	0.027		1
Anas acuta	0.14	0.12–0.15	5	0.021	0.021–0.021	2
Anas americana	0.16	0.15–0.16	5	0.053	0.030–0.075	2
Anas platyrhynchos	0.16	0.14–0.17	5	0.031	0.022–0.040	5
		Aythyini				
Aythya affinis	0.12	0.11–0.13	5	0.022		1
Aythya valisineria	0.15	0.12–0.18	5	0.026		1
		Mergini				
Somateria fischeri	0.16	0.15–0.18	3	0.014		1
Somateria spectabilis	0.15	0.13–0.17	5	0.009	0.006–0.011	2
Somateria mollisima	0.17	0.15–0.18	5	0.024		1
Melanitta perspicillata	0.24	0.22–0.27	5	0.021	0.006–0.033	5
Melanitta fusca	0.16		1	0.014	0.009–0.018	2
Bucephala albeola	0.16	0.14–0.18	5	0.008	0.004–0.010	4
Bucephala clangula	0.18	0.15–0.20	5	0.030	0.018–0.037	3
		Oxyurini				
Oxyura jamaicensis	0.15	0.12–0.17	5	0.010	0.003–0.017	12

Melanitta perspicillata, but the difference is small. In general there is no pattern of increased emargination in any genus or tribe. In contrast to this there are great differences in the depth of the emarginated region (Fig. 3). It is very deep in *Anas*, thus forming well defined slots. In divers the emarginated portion is more shallow, though varying between genera (Fig. 3). Furthermore among divers the emargination may be nearly or entirely obliterated in worn plumage, a condition which I did not note in *Anas*.

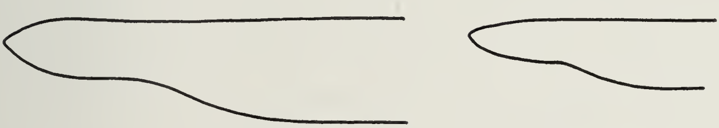
In an attempt to quantify the somewhat subjective impression of differences in depth of emargination, I measured the area of the slots as shown on the wing tracings. This was divided by the wing area to give a measurement of relative wingtip slot area (Table 4). A complete division between dabblers and divers was not found, but the largest slot areas are in some species of *Anas*, while some divers have considerably smaller slot areas. This is most marked in the smaller species, *Bucephala albeola* and *Oxyura jamaicensis*.



ANAS PLATYRHYNCHOS BUCEPHALA CLANGULA



AYTHYA AFFINIS MELANITTA PERSPICILLATA



SOMATERIA MOLLISIMA OXYURA JAMAICENSIS

Fig. 3. Outline tracings of the distal end of the outer primary in six species of ducks. One species of each genus studied is included. All are from fresh plumaged birds. The efficiency of wingtip slots depends upon the depth of the emargination, and on the shape of the proximal end of the emarginated region of the feather. This region is deepest in *Anas*, and shallower in diving ducks. The transition from emarginated to unemarginated regions is abrupt in *Anas*, but more gradual in diving ducks. The emarginated region is unusually long in *Melanitta perspicillata.*

Anas cyanoptera and *A. clypeata* are in the same weight range as these diving species, but have more than twice the wingtip slot area. The largest slots were in *Anas americana*, which also has the smallest wings in its genus (Table 2) among the species studied. Possibly the increased slot area compensates for this to some extent.

In *Anas* the transition from emarginated to unemarginated regions is abrupt, so that the proximal end of the slot is U-shaped. In contrast the transition in divers is more gradual, giving a more V-shaped slot. The latter condition denotes a less efficient slotting mechanism (Savile, 1957).

Paddle Area.—Ducks are propelled through the water by the use of their feet, though dabblers and eiders may use the wings as an aid in diving. The main propulsive structure is thus the paddle, by which I mean the second through fourth digits and their webbing, plus the hallux, whose surface area is slightly increased in diving ducks by having an enlarged lobe. The Paddle Index indicates the surface area of the paddles relative to body weight. Table 2 shows that in most divers the surface area of the paddles is relatively larger than in *Anas*, which is of obvious functional significance in increasing the efficiency of swimming and diving. It results primarily from a lengthening of the second through fourth digits and a corresponding increase in web area. The progressive evolution of this feature in the tribe Oxyurini has been discussed previously (Raikow, 1970).

DISCUSSION

Ecological isolation in *Anas* is accomplished largely by differences in feeding habits and correlated structural specializations of the head and bodily proportions. Differences in feeding behavior which reduce interspecific competition have not been studied in detail, but some broad differences are obvious. For example, the long-necked Pintail (*Anas acuta*) can feed from the bottom in deeper water than other species, the Shoveler (*A. clypeata*) is specialized for straining food through its well-developed lamellae, etc. (Kortwright, 1942; Lack, 1971). Most such differences are not reflected in the locomotor features considered here. A large deviation from the generally similar measurements in the five species of *Anas* studied is the relatively small paddle in the Am. Widgeon (*A. americana*) (Table 2). This is correlated with the fact that the Am. Widgeon is the most terrestrial species studied, a good deal of its feeding being done by grazing. Kortwright (1942) says that "they are active on land, where they trot about and graze like little geese." The smaller paddle is clearly an adaptation to agility on land. Reduced foot size is characteristic of cursorial forms, e.g. the Secretarybird (*Sagittarius serpentarius*) has toes only one-fifth as long as those of most hawks (Welty, 1964).

The diving ducks as a group have smaller wings and larger paddles than do the dabbling ducks. The larger wings of dabblers, together with their more elliptical shape and increased slotting, are adapted to the use of small bodies of water, and inshore areas of larger bodies which may be spatially broken up by surrounding or emergent vegetation. This type of wing is aerodynamically suited to permit their habit of rocketing upward from these areas where a long clear distance for a running start may be absent. This relationship between wing type and habitat was pointed out by Savile (1957:218) who, however, did not document his statement. The paddle size in ducks is for each species a compromise between the optimally small paddle best suited for walking on land, and at the other extreme, the optimally large paddle best suited for aquatic locomotion.

Among the diving ducks studied two genera deserve special mention. The eiders (*Somateria*) alone among the divers, lack an enlarged paddle (Table 2). Its relative size is comparable to that of *Anas*, although a lobed hallux is present. This implies that eiders are less efficient divers than other members of the Mergini. Little is known about their underwater actions, but Humphrey (1958) reports that they use their wings underwater like Anatini, a sign that foot propulsion alone is not adequate. The eiders are ground nesters and walk efficiently on land, so the *Anas*-like paddle size is clearly adaptive. The wing size of eiders is reduced as in other divers (Table 2), which is correlated with the open waters which they frequent.

The Ruddy Duck (*Oxyura jamaicensis*) has the relatively smallest wings of the fifteen species studied. In shape they most nearly conform to Savile's (1957) characterization of the high-speed type, being small, pointed, and minimally slotted. Bent (1925:158) comments on the "grebelike" nature of the flight, swimming, and diving habits of Ruddy Ducks. Figure 2 shows that the wing shape in Ruddy Ducks is more like that of a grebe that that of a dabbling duck. Ruddy Ducks have the relatively largest paddles of all species studied except *Aythya valisineria* (Table 2). While they swim excellently, both on the surface and beneath it, they are clumsy and incompetent on land, being unable to walk more than a few steps (Kortwright, 1942: 369). This is in part due to the posterior placement of the feet and their specialized musculoskeletal system (Raikow, 1970), but the very large paddles undoubtedly add to their clumsiness on land. The Ruddy Duck represents an extreme in a spectrum of specialized conditions illustrated by the species investigated in this study.

It is believed that the diving ducks evolved from dabbling ducks, i.e. that the common ancestor of present-day dabblers and divers closely resembled the former. Thus the differences between the two represent primitive conditions in the dabblers and derived conditions in the divers. The divers are not a monophyletic group, however (Delacour and Mayr, 1945), rather it is probable that the three tribes of divers studied here arose separately from the Anatini and evolved into divers independently of one another. The similarity of their modifications is a result of parallel evolution. Nevertheless, while the general pattern is similar in each case, the details vary. Each character has diverged from the primitive condition to different degrees in different groups. Relative paddle size, for example, has not increased at all in *Somateria*, but has increased from a lesser to a greater degree in the other diving genera studied. The same is true of the reduction of wing area and slotting, and conversion to a more pointed wing shape. In each species a particular combination of characters is thus in a sense a visible reflection of its ecological niche.

SUMMARY

The relationship between locomotor morphology and feeding ecology was studied in fifteen species of North American ducks. Two general adaptive types are recognized. Dabbling ducks (Anatini) feed on the surface, seldom dive, walk and feed on land, feed in shallow, inshore waters, and take off from restricted areas by rocketing upward. Diving ducks (Aythyini, Mergini, Oxyurini) feed underwater by diving, walk on land poorly if at all, feed in open, offshore waters, and take off by running along the surface. These ecological differences are correlated with morphological differences.

Dabbling ducks have the largest wing areas relative to body weight, the most rounded wings, and the best developed wingtip slotting. This improves their ability to land and take off from spatially restricted areas. They have the relatively smallest paddles, which is correlated with their lesser aquatic adaptations but giving them greater agility in walking on land. The smallest paddles are in *Anas americana*, the most terrestrial of the species studied.

Diving ducks have smaller, more pointed, less slotted wings. These are adequate for rapid, direct flight, but inadequate for a rocketing take-off, thus limiting these birds to more open waters. They have the relatively largest paddles, however, in relation to their efficient diving abilities. The Ruddy Duck (*Oxyura jamaicensis*) is a superb diver but helpless on land. Its structural characteristics reflect this condition. Eiders, the most cursorial diving ducks studied, have paddle areas comparable to those of dabbling ducks. Similarities in the different tribes of separately derived diving ducks are due to parallel evolution in relation to similar adaptive specializations.

ACKNOWLEDGMENTS

I am grateful to Kenneth C. Parkes and Mary H. Clench of the Carnegie Museum for allowing me to examine study skins in their care, to James Lynch, Paul Covel, William Arvey, and John Cowan for assistance in collecting specimens, and to Harvey I. Fisher for suggesting improvements in the analysis of the data.

LITERATURE CITED

Bent, A. C. 1925. Life Histories of North American Wild Fowl, Part II. Reprint Ed. 1962. Dover Publications, Inc., New York.

Brooks, A. 1945. The underwater actions of diving ducks. Auk, 62:517–523.

Delacour, J. and E. Mayr. 1945. The family Anatidae. Wilson Bull., 57:3–55.

Greenwalt, C. H. 1962. Dimensional relationships for flying animals. Smithsonian Misc. Coll., 144:1–46.

Hartman, F. A. 1961. Locomotor mechanisms of birds. Smithsonian Misc. Coll., 143:1–91.

Humphrey, P. S. 1958. Classification and systematic position of the eiders. Condor, 60:129–135.

Jack, A. 1953. Feathered wings. Methuen & Co., Ltd., London.

Kortwright, F. H. 1942. The ducks, geese, and swans of North America. Amer. Wildlife Inst., Washington, D.C.

Lack, D. 1971. Ecological isolation in birds. Harvard Univ. Press, Cambridge, Mass.

Poole, E. L. 1938. Weights and wing areas in North American birds. Auk, 55:511–517.

Raikow, R. J. 1970. Evolution of diving adaptations in the stifftail ducks. Univ. California Publ. Zool., 94:1–52.

RAIKOW, R. J. 1971. The osteology and taxonomic position of the White-backed Duck, *Thalassornis leuconotus*. Wilson Bull., 83:270–277.

SAVILE, D. B. O. 1957. Adaptive evolution in the avian wing. Evolution, 11:212–224.

STORER, R. W. 1955. Weight, wing area, and skeletal proportions in three accipiters. Acta XI Congr. Internatl. Ornithol., 287–290.

WELLER, M. W. 1964. General Habits, *in* Delacour, J., 1964. The waterfowl of the world, vol. 4. Country Life Ltd., London, pp. 15–34.

WELTY, J. C. 1964. The life of birds. W. B. Saunders Co., Philadelphia and London.

DEPARTMENT OF BIOLOGY, UNIVERSITY OF PITTSBURGH, PITTSBURGH, PENNSYLVANIA, PENNSYLVANIA 15213. 9 NOVEMBER 1972.

NEW LIFE MEMBER

Dr. Clait E. Braun, of Fort Collins, Colorado, has recently become a Life Member of The Wilson Ornithological Society. He holds degrees from Kansas State University, University of Montana, and Colorado State University, and is currently a Research Biologist for the Colorado Division of Game, Fish and Parks. Besides the Wilson Society Dr. Braun also belongs to the AOU, the Cooper Society, The Wildlife Society, American Society for Mammalogists and Sigma Xi. He is a recognized authority on the White-tailed Ptarmigan (our picture shows him holding one in winter plumage) and has also published work on the Blue Grouse and the Band-tailed Pigeon. Some members of the Society will remember him as the leader of the high country field trip following the 1970 Meeting in Fort Collins. Dr. Braun is married with one daughter, and lists photography, and stamp and coin collecting as his hobbies.

EFFECT OF TEMPERATURE ON ENERGY REQUIREMENTS AND NORTHWARD DISTRIBUTION OF THE BLACK-BELLIED TREE DUCK

Brian W. Cain

A buildup in the south Texas breeding population of Black-bellied Tree Ducks was first noticed in 1955 (Henze, 1962). Further expansion of this species' breeding range may possibly be limited by competition with Wood Ducks (*Aix sponsa*) or the exotic Muscovy Duck (*Cairina moschata*) as suggested by Bolen (1971).

Temperature was suggested by Kendeigh (1944) as one of the most important environmental factors controlling a species distribution. The energy requirements of Black-bellied Tree Ducks may be a major limiting factor to their northern breeding-range extension. According to Janzen's (1967) suggestion, the tropical Black-bellied Tree Duck may not be able to tolerate a range of environmental temperatures as extreme as temperate waterfowl.

The objectives of this study are to determine the effect of temperature on the energy requirements of this species and to compare these with other waterfowl, specifically the Canada Goose (*Branta canadensis*) and the Blue-winged Teal (*Anas discors*).

METHODS

Adult tree ducks were captured near Kingsville, Texas, transported to Illinois, and placed in metabolism cages similar to those described by Owen (1970) but enlarged to 54 × 43 × 48 cm. Two weeks were allowed for the ducks to adjust to these cages. A series of constant temperatures between −20°C and 42°C were used with photoperiods similar to the winter (11 hours) and breeding (15 hours) seasons in south Texas. Humidity was not controlled in the large walk-in cabinets used as environmental chambers but was low enough at warm temperatures so as not to affect metabolism (Salt, 1952).

At 2- or 3-day intervals the ducks were fed 300 g of milo (*Sorghum vulgare*) that was oven-dried (65°C) to a constant weight. The ducks were weighed to the nearest 0.1g on a triple-beam balance. Both the unused food and the excreta were collected at 2- or 3-day intervals and oven dried at 65°C to a constant weight. Caloric values were determined with a Parr oxygen bomb calorimeter.

The relationship between photoperiod, temperature, and metabolism were determined using the method developed by Kendeigh (1949). This procedure involves subtracting the caloric value of the excreta (excretory energy) from the caloric value of the food eaten (gross energy intake). This value is the amount utilized (metabolized energy) and during a period of constant weight (change within ± 1.5 percent) is called existence metabolism. As the temperature was lowered and the birds gain weight, the existence energy measurements were made only after the birds stabilized at the new weight.

Limits of temperature tolerance were determined by lowering or raising the temperature

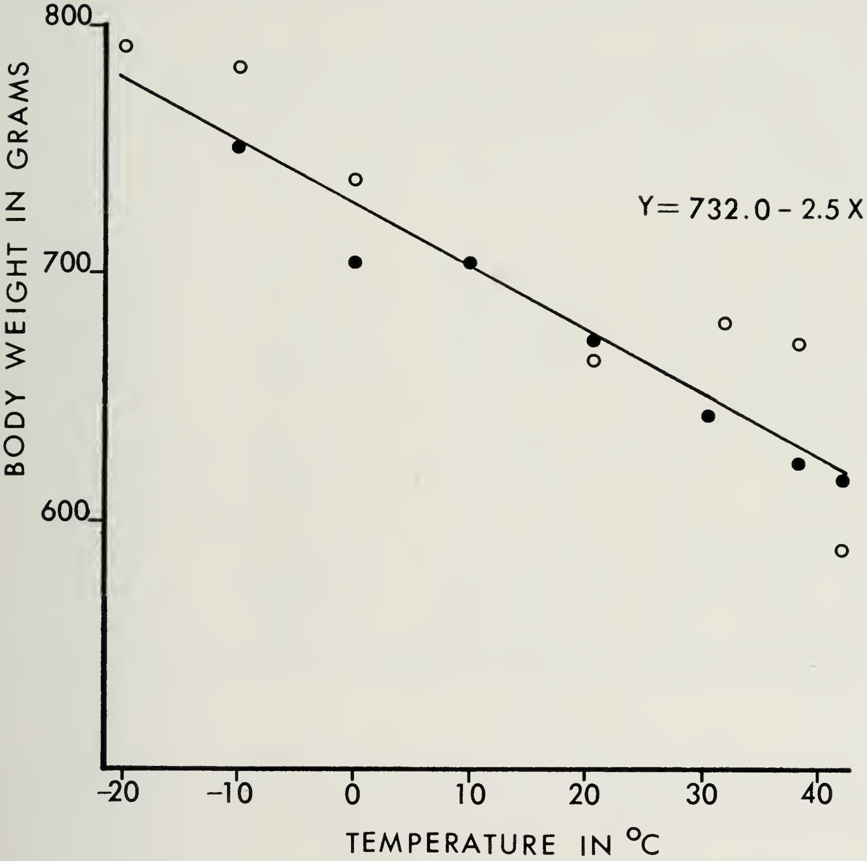


FIG. 1. The linear relationship between body weight and temperature. Solid circles represent the 11-hour photoperiod and the clear circles the 15-hour.

2°C at 3-day intervals until the tree ducks died or could not maintain constant weight. The initial temperature that the tree ducks were acclimated to before these experiments started was 35°C for the upper limit and 0°C for the lower limit.

A probability level of 0.05 was required for significance. Statistical analysis included least squares linear regression with *F*-values for significance and *t*-test between means.

RESULTS

Body Weight.—The body weight of Black-bellied Tree Ducks increased as the temperature was lowered (Fig. 1). Weights at the 11-hour photoperiod were generally lower than at 15-hours but were not significantly different. The weights of all caged tree ducks were lower than the average of 72 free-living adults (i.e. 827.8 g) measured by Bolen (1964).

TABLE 1

GROSS ENERGY INTAKE (GEI), EXCRETORY ENERGY (EE), AND THE UTILIZATION COEFFICIENTS (UC) FOR ADULT TREE DUCKS AT TWO PHOTOPERIODS.
Energy expressed as kcal/bird-day and parentheses enclose ± 2 standard errors.

Temperature	N	GEI	EE	UC
11-hour				
38	10	81.9 (10.1)	12.9 (1.6)	84.0 (0.9)
30	12	*96.2 (7.7)	*17.7 (1.5)	81.5 (1.3)
20	20	*160.0 (14.5)	*25.1 (2.4)	84.1 (0.3)
10	5	*181.0 (20.8)	28.8 (3.6)	84.1 (1.0)
0	8	*226.9 (27.8)	*39.4 (6.0)	82.2 (2.7)
–10	7	*258.5 (16.7)	39.4 (1.8)	84.3 (1.1)
15-hour				
42	8	84.4 (10.5)	13.5 (1.8)	83.9 (0.7)
38	5	*114.3 (8.2)	17.0 (2.7)	85.2 (1.3)
32	8	*125.5 (15.5)	16.8 (2.8)	86.6 (1.7)
25	7	128.1 (18.4)	16.8 (3.0)	86.9 (1.5)
21	24	*163.0 (12.4)	*21.7 (1.5)	86.2 (1.1)
0	11	*259.4 (23.9)	*38.2 (4.8)	85.9 (0.6)
–10	7	*331.3 (12.0)	*48.9 (1.6)	85.2 (1.1)
–20	5	376.1 (31.6)	*54.3 (4.4)	85.4 (1.6)

* The difference between the value at this temperature and the preceding one is significant at $P = .05$.

Males and females did not differ significantly in body weight during the metabolic trials. However Canada Geese (Williams, 1965) and Blue-winged Teal (Owen, 1970) males were heavier than their respective females at all temperatures and photoperiods.

Gross Energy Intake.—Gross energy intake increased with lowering temperatures at both photoperiods (Table 1). These linear relationships are expressed by the equations, $Y = (224.9 - 3.70\ X) \pm 59.48$ and $Y = (268.9 - 4.68\ X) \pm 59.50$ for the 11- and 15-hour photoperiods respectively. The slopes and elevations of these lines are significantly different and may reflect the greater amount of activity and a longer maintenance of high body temperature at the longer photoperiod, as suggested by Kendeigh (1969) for other birds.

Excretory Energy.—Excretory energy increased in a linear relationship with decreasing temperatures (Table 1). These relationships for the 11- and 15-hour photoperiods are expressed by the equation $Y = (34.9 - 0.56\ X) \pm 6.4$ and $Y = (38.6 - 0.65\ X) \pm 9.6$ respectively. The elevations of these lines are different but the slopes are not significantly different. Excretory energy shows similar relationships to temperature in Canada Geese (Williams, 1965) and passerine birds (Kendeigh, 1969; Davis, 1955; and West, 1960).

The caloric values of the feces from Black-bellied Tree Ducks averaged 4.2 ± 0.8 kcal/g. The values were slightly higher for birds on the 11-hour photoperiod but not significantly different. There was no relationship between temperature and the caloric value per gram of feces. Canada Geese showed a decreasing caloric value per gram of excrement with decreasing temperatures (Williams, 1965). Owen (1970) reported higher caloric values at intermediate temperatures (0° to 30°C) and lower values at the high and low extremes for Blue-winged Teal.

Utilization Coefficient.—The utilization coefficient is the ratio of metabolized energy to gross energy intake. These coefficients were lower and more variable for the 11-hour than for the 15-hour photoperiod (Table 1). Significant differences occurred at 0°, 20°, and 30°C between the two photoperiods. On the 15-hour photoperiod the coefficients were higher at intermediate temperatures and lower at both high and low temperature extremes. This is reversed to the response of Canada Geese (Williams, 1965) and Blue-winged Teal (Owen, 1970).

Existence Metabolism.—Existence metabolism increased with decreasing temperature is a linear relationship for 11- and 15-hour photoperiods (Figs. 2 and 3). The regression lines are significantly different both in slope and elevation. A steeper slope for the 15-hour photoperiod indicates that summer-acclimated tree ducks are more sensitive to decreasing temperature than those winter acclimated.

The difference in elevations of the two regression lines may be due both to increased activity at the longer photoperiod and a decrease in feather insulation. Some molting of body feathers occurred while the tree ducks were acclimating to the longer photoperiod. No measurement of insulation values of the two plumages were made in this study.

Existence metabolism for Blue-winged Teal (Owen, 1970) and Canada Geese (Williams, 1965) at temperatures above 0°C did not differ between 12- and 15-hour photoperiods. Only at high temperatures (38° and 42°C) was the difference in existence metabolism between the 11- and 15-hour photoperiods significant for Black-bellied Tree Ducks.

Temperature Tolerance.—The lowest tolerated temperature by adult tree ducks is –20°C. Below –15°C the legs of male ducks froze stiff within 3 days. Females endured –20°C for 3 days before their legs froze. One male and one female died within 24 hours after their legs froze. No tree duck survived more than 4 days after its legs froze, even if removed to above 0°C. There was no apparent difference in cold tolerance between photoperiods.

Two of six adults left outdoors in a semi-wild condition on the Vivarium ponds at the University of Illinois died after 4 days of –12°C. These two birds were not allowed into the pond's open water by the other four. The

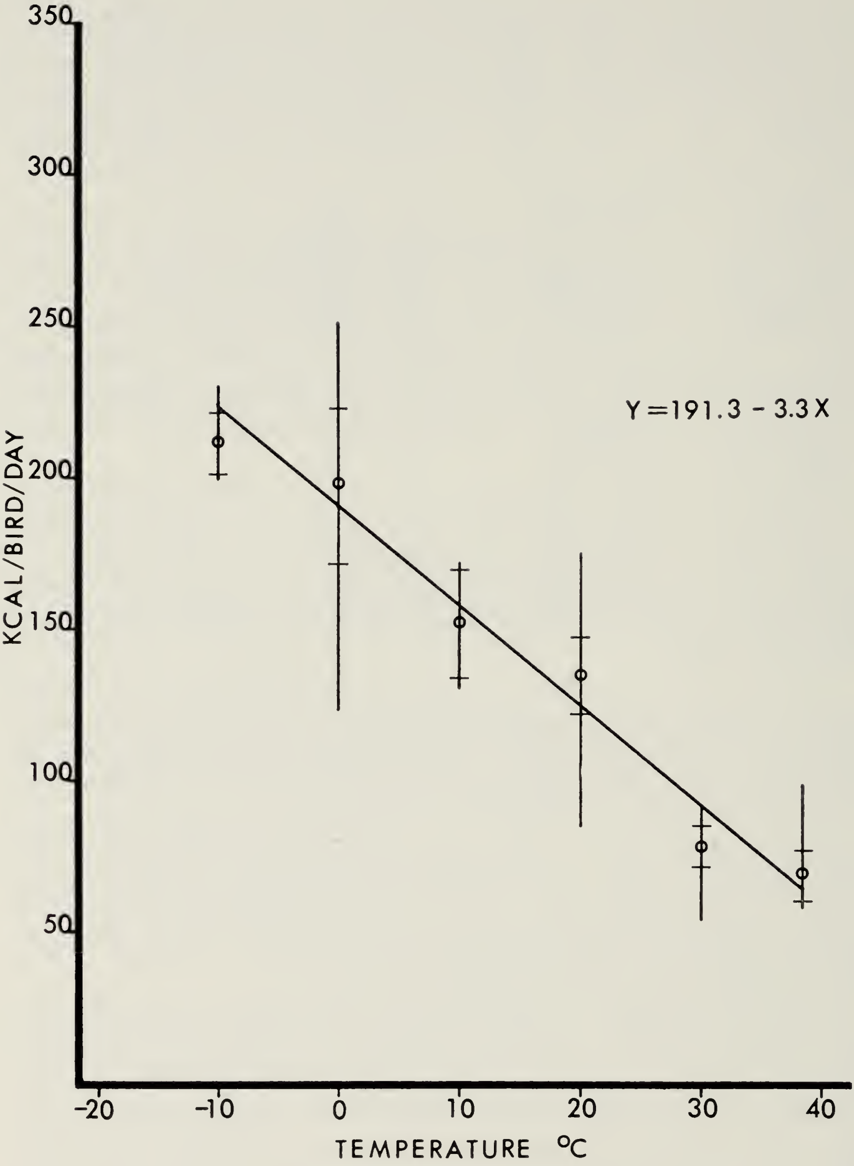


Fig. 2. Relationship between existence energy and temperature at an 11-hour photoperiod. The vertical line is the range, the circle the mean, and the two bars are ± 2 standard errors.

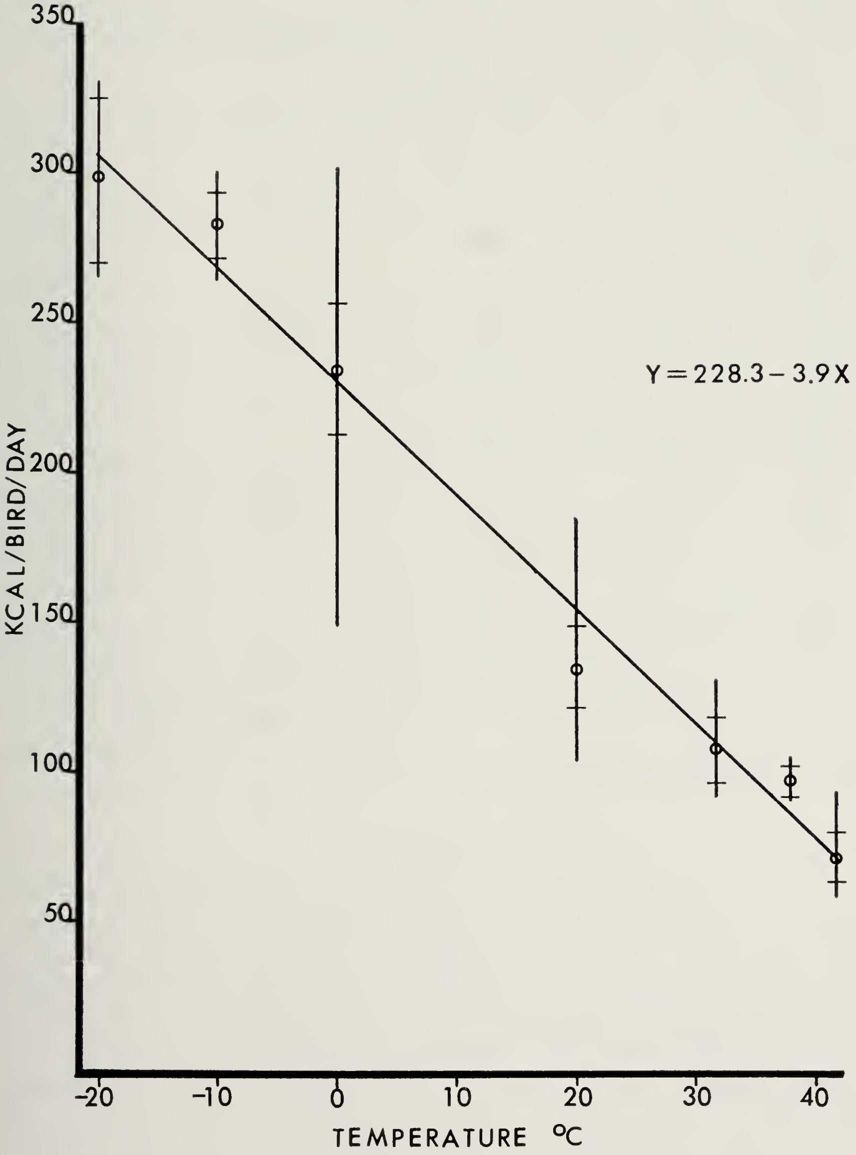


Fig. 3. Relationship between existence energy and temperature at a 15-hour photoperiod. Symbols as on Fig. 2.

open water was maintained by an inflow of water at 5°C. Canada Geese (Williams, 1965) and Blue-winged Teal (Owen, 1970) withstood –40°C without apparent physical stress. Gulls are also capable of tolerating extreme low temperatures (Scholander, et al., 1950).

Adult Black-bellied Tree Ducks at both 11- and 15-hour photoperiods lost 23 percent of their body weight within 9 days when they were exposed to 42°C. One of the four ducks at 15-hour photoperiod died, and two were obviously weakened as evidenced by their lack of activity. No panting or gular fluttering was noticed. Tree ducks at 11-hour periods were also weakened but to a lesser extent.

Canada Geese could not tolerate constant temperatures of 40–43°C (Williams, 1965). However Blue-winged Teal tolerated temperatures up to 48°C (Owen, 1970). The tropical Black-bellied Tree Duck shows evidence then of having a narrower temperature tolerance than temperate waterfowl, thus supporting Janzen's (1967) suggestion.

Maximum Potential Metabolism.—Maximum potential metabolism occurs at the lower limit of temperature tolerance (Kendeigh, 1969). Substituting –20°C, the lowest tolerated temperature, into the regression equations (Figs. 2 and 3), the maximum potential metabolism is 277 kcal/bird-day and 307 kcal/bird-day for the 11- and 15-hour photoperiods respectively. These values must be accepted conditionally as the bird's death was hastened by the freezing of its legs and not certainly due to intolerable metabolic stress. These values must be very near the maximum, however, because the efficiency of utilization had begun to drop and the birds stopped gaining weight at –20°C. The two ducks that died outdoors did not show indications of their legs being frozen the day before they died at –12°C.

DISCUSSION

Existence metabolism for free-living birds has been estimated to cost an additional 50 percent over cage existence (Kahl, 1964, and Uramoto, 1961). Blue-winged Teal, not able to fly, used 13 percent more metabolized energy in a semi-wild condition (Owen, 1970). To include the energy cost of flight I am assuming an additional minimum cost of 25 percent for free existence in Black-bellied Tree Ducks. Free-living metabolism was calculated for a 15-hour photoperiod at 3 locations in Texas (Table 2). Two of the locations are within the breeding range of this species and the other, Dallas, is 4° north of this range. The difference between the maximum potential and free-living metabolism at any temperature gives the potential productive energy at that temperature which is available for reproduction and other activities associated with survival of the individual.

The expected free-living metabolism is 173 and 157 kcal/bird-day for

TABLE 2

THE PREDICTED FREE-LIVING METABOLISM (FLM) AND POTENTIAL PRODUCTIVE ENERGY (PPE) AT THREE LOCATIONS IN TEXAS.

The energy values expressed at kcal/bird-day were calculated by extrapolation between 11- and 15-hour photoperiods.

Geographic location	Month of Year	Mean temp.[1] °C	FLM	PPE
Dallas	March	13.9	227	80
Kingsville		21.7	179	128
Harlingen		22.2	176	131
Dallas	April	18.9	192	115
Kingsville		20.6	184	123
Harlingen		22.8	173	134
Dallas	May	22.8	173	134
Kingsville		26.1	160	150
Harlingen		26.1	160	150
Dallas	June	27.2	151	156
Kingsville		28.3	146	161
Harlingen		26.7	154	153
Dallas	July	30.0	138	169
Kingsville		29.4	141	166
Harlingen		27.8	149	158

[1] From "Climatological Data-Texas Section: U.S. Dept. Commerce, Wash., D.C.

the month of May at Dallas and Kingsville, Texas, respectively. Subtracting these values from the maximum potential metabolism leaves 134 and 150 kcal/bird-day as the potential productive energy for these two locations during May (Table 2). This month was selected for calculations because the Black-bellied Tree Duck begins egg laying in May (Bolen, 1967).

Caloric values of Black-bellied Tree Duck eggs averaged 100.5 kcal (Cain, 1972). If this represents 80 percent efficiency (see Brody, 1945), the energy cost of producing one egg per day would be 125 kcal/bird-day. Subtracting this value from 134 kcal/bird-day leaves 9 kcal/bird-day surplus energy for tree ducks as far north as Dallas, Texas. This may be too narrow a margin to insure successful egg laying because a drop of only 2.5°C below the average monthly temperature, used for these calculations, would require an additional 9.7 kcal/bird-day.

It thus appears that the northward distribution of the Black-bellied Tree Duck may be limited by low temperatures decreasing the amount of energy available for successful reproduction in the spring. There is a need for research to determine if a delayed nest initiation would still permit time for egg-laying, incubation, and successful raising of broods prior to low temperatures in November at more northerly latitudes.

SUMMARY

Energy requirements of Black-bellied Tree Ducks were studied at 2 photoperiods (11- and 15-hours) and a series of temperatures between –20°C and 42°C. Body weight did not differ significantly between sexes or photoperiods but increased with decreasing temperatures at both photoperiods.

Gross energy intake, excretory energy and existence metabolism increased linearly with decreasing temperature. Existence metabolism increased more rapidly with decreasing temperature for birds on the 15-hour photoperiod.

Black-bellied Tree Ducks could not tolerate –20°C in a caged condition beyond 3 days. Their legs froze stiff and death followed within 24 hours. High temperature (42°C) resulted in a 23 per cent loss of body weight within 9 days.

Temperature may limit the northward distribution of the Black-bellied Tree Duck's breeding-range by restricting the amount of productive energy available for egg formation. Research is needed to determine the effects of other factors that contribute to this limitation.

ACKNOWLEDGMENT

This project was funded by the National Science Foundation, by a grant to Dr. S. Charles Kendeigh and the University of Illinois. Dr Kendeigh supervised the research, reviewed the manuscript, and provided laboratory space. His help is gratefully acknowledged. This contribution is part of the research carried out for the Doctor of Philosophy degree at the University of Illinois.

The Caesar Kleberg Chair for Wildlife Ecology at Texas A&I University, the Texas Parks and Wildlife Department, the Welder Wildlife Foundation at Sinton, Texas, and the Bureau of Sport Fisheries and Wildlife provided equipment and collecting permits. The Celanese Corporation allowed access to their property for capturing birds. The help of these organizations is appreciated.

Bernard Najvar, Steve Labuda, John Morris, Edwin Pentecost and several laboratory technicians provided invaluable help. I thank also Frank Bellrose for his review of the manuscript.

LITERATURE CITED

Bolen, E. G. 1964. Weights and linear measurements of Black-bellied Tree Ducks. Texas J. Sci., 15:257–260.

Bolen, E. G. 1967. The ecology of the Black-bellied Tree Duck in southern Texas. Unpubl. Ph.D. Thesis, Utah State Univ., Logan.

Bolen, E. G. 1971. Some views on exotic waterfowl. Wilson Bull., 83:430–433.

Brody, S. 1945. Bioenergetics and growth. Reinhold, New York.

Cain, B. W. 1972. Bioenergetics of Black-bellied Tree Ducks in relation to their growth and distribution. Unpubl. Ph.D. Thesis, Univ. Illinois, Urbana.

Davis, E. A. 1955. Seasonal changes in the energy balance of the English Sparrow. Auk, 72:385–411.

Henze, F. 1962. Autumn Tree Swan. Texas Game & Fish, 20:14–15.

Janzen, D. H. 1967. Why mountain passes are higher in the tropics. Amer. Naturalist, 101:233–249.

Kahl, M. P., Jr. 1964. Food ecology of the Wood Stork (*Mycteria americana*) in Florida. Ecol. Monogr., 34:97–117.

Kendeigh, S. C. 1944. Effect of air temperature on the rate of energy metabolism in the English Sparrow. J. Exp. Zool., 96:1–16.

Kendeigh, S. C. 1949. Effect of temperature and season on the energy resources of the English Sparrow. Auk, 66:113–127.

Kendeigh, S. C. 1969. Energy responses of birds to their thermal environments. Wilson Bull., 81:441–449.

Owen, R. B., Jr. 1970. The bioenergetics of captive Blue-winged Teal under controlled and outdoor conditions. Condor, 72:153–163.

Salt, G. W. 1952. The relation of metabolism to climate and distribution in three finches of the genus *Carpodacus*. Ecol. Monogr., 22:121–152.

Scholander, P. F., V. Walters, R. Hock, and L. Irving. 1950. Body insulation of some arctic and tropical mammals and birds. Biol. Bull., 99:225–236.

Uramoto, M. 1961. Ecological study of the bird community of the broad-leaved deciduous forest of central Japan. Misc. Rept. of the Yamashima's Inst. for Ornithol. and Zool., 3:1–32.

West, G. C. 1960. Seasonal variation in the energy balance of the Tree Sparrow in relation to migration. Auk, 77:306–329.

Williams, J. E. 1965. Energy requirements of the Canada Goose in relation to distribution and migration. Unpubl. Ph.D. Thesis, Univ. Illinois, Urbana.

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF ILLINOIS, CHAMPAIGN, ILLINOIS. (PRESENT ADDRESS: DEPARTMENT OF WILDLIFE AND FISHERIES SCIENCES, TEXAS A&M UNIVERSITY, COLLEGE STATION, TEXAS 77843). 25 SEPTEMBER 1972.

PUBLICATION NOTES AND NOTICES

Birds of Pennsylvania: When and Where to Find Them. (2nd Ed.) By Merrill Wood, The Pennsylvania State University, Agricultural Experiment Station, University Park, 1973: 4½ × 8½ in., paper covered, [xxi] + 103 pp., 186 drawings by Dorothy L. Bordner. $2.00.

This is an updated version of the 1967 edition (reviewed, Wilson Bull, 81:342, 1969). Brief paragraphs give frequency, abundance, seasonal occurrence, habits, status changes, and general ranges for 378 species. The reduction of 14 species since 1967 comes partly from the recent changes announced by the AOU Check-list Committee and partly by a somewhat more rigorous standard of acceptance of records.—G.A.H.

FOOD MANIPULATION BY YOUNG PASSERINES AND THE POSSIBLE EVOLUTIONARY HISTORY OF IMPALING BY SHRIKES

SUSAN M. SMITH

The ability of shrikes of the genus *Lanius* to impale their prey is an effective behavioral substitute for the talons they lack. The ontogeny of impaling behavior of various European shrikes in this genus has been described in detail by Lorenz and von Saint Paul (1968); and both Wemmer (1969) and Smith (1972) have described its development in the North American Loggerhead Shrike (*L. ludovicianus*). In each species, the first motor pattern recognizable as being related to impaling consisted of taking an object in the bill, turning sideways, and placing it on the perch beside the bird. This was called "*Tupfbewegungen*" (spot-movements) by Lorenz and von Saint Paul (1968) and "dabbing" by Smith (1972). Both captive and wild young shrikes between three and four weeks old performed this behavior readily; typically after this age a pulling component appeared and the behavior was then called "dragging." These motor patterns were apparently innate.

The present study involves observations made during a comparative investigation of the ontogeny of feeding behavior of hand-reared Black-capped Chickadees (*Parus atricapillus*), Blue Jays (*Cyanocitta cristata*), and Catbirds (*Dumetella carolinensis*). None of these three is predatory or impales food, but nevertheless certain aspects of their early behavior bear remarkable resemblance to that of young Loggerhead Shrikes. The data will be interpreted in terms of the light they may shed on the possible evolutionary history of impaling by shrikes.

METHODS

Four chickadees from one brood, four Catbirds from two broods, and five jays from two broods were hand-reared in the summer of 1971. The chickadees were approximately eleven days old when they were taken from their nest; the Catbirds six to seven days old, and the jays approximately twelve days old.

The young birds were kept in cages made of half-inch hardware cloth attached to wooden frames 30 inches long and 18 inches in height and width. All four chickadees were kept in one cage. Two catbirds were kept in each of two cages. The jays were kept in double cages joined end to end making units 60 inches long. Two such double units housed two jays each and one contained a single bird.

The birds were all fed high protein diets with vitamin and calcium supplements. All three species were given canned dogfood regularly, as well as chopped fresh meat such as pork kidney or lamb heart. The birds were all initially hand-fed with forceps. The data reported here involve records made of the birds' behavior immediately after having received pieces of food.

Fig. 1. Black-capped Chickadee performing dabbing behavior.

RESULTS

All three species raised in this study performed behavior that was indistinguishable from dabbing behavior of young Loggerhead Shrikes. Figures 1, 2, and 3 were drawn from photographs of captive birds performing this behavior. Each species behaved in this way with a variety of different kinds of food; as there were no differences in behavior obviously correlated with type of food, all records of dabbing behavior will be treated together.

Chickadees were first seen deliberately placing an item of food on their perch when they were 17 days old. These food items were apparently not aimed at any particular kind of location. Such undirected dabbing was observed 12 times, the last case being by a bird that was 28 days old. Later this behavior became modified to include a lateral component. This was usually a pushing movement; at the same time the behavior became directed to corners or knotholes: areas where food could be stored.

Blue Jays were recorded performing undirected dabbing on eight occasions. The youngest jay seen dabbing was 19 days old; the oldest, 27 days old. As with the chickadees, in jays this behavior later became modified to include a lateral pushing component; the jays also often included a forceful bill-opening or wedging motion as well. Again, the movements became directed toward corners or holes similar to places where adult Blue Jays store food.

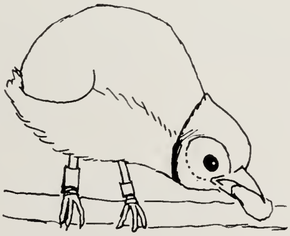


Fig. 2. Blue Jay performing dabbing behavior.

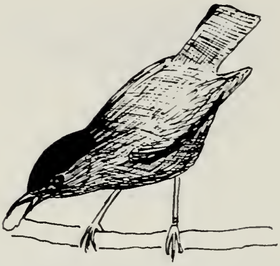


FIG. 3. Catbird performing dabbing behavior.

Catbirds were only seen performing this behavior on four occasions. The earliest record was from a 12 day old bird; the latest, from a 19 day old bird. No lateral component was ever observed associated with this behavior, nor was dabbing by Catbirds ever seen directed toward any particular kind of location.

In every record for each species, the individual that performed dabbing had swallowed at least three pieces of food immediately beforehand.

DISCUSSION

Since behavior indistinguishable from dabbing was performed by all three species studied, it clearly is not restricted to species that impale their prey. It is true that young shrikes performed this behavior even when hungry, whereas chickadees, jays and catbirds showed it only when apparently satiated. Nevertheless the motor patterns themselves appeared to be identical.

The dabbing observed performed by young jays and chickadees in this study might be interpreted simply as an early form of food storing. This hoarding has been recorded for many species of jays, including the Blue Jay (Hardy, 1961). Similarly, it is well documented for many species of *Parus* (see, for example, Hinde, 1952 and Hart, 1958).

The records for young Catbirds are more difficult to explain. Adult Catbirds certainly do not regularly store food; indeed, I am unaware of any published records of hoarding for this species. Perhaps the dabbing by these birds was simply modified bill-wiping, or merely one way of getting rid of unwanted food accepted from the keeper as a conditioned social response. The underlying motivations of dabbing are really irrelevant to the present study; the important thing is that Catbirds could and did perform motor patterns apparently identical to those of the other two species and of Loggerhead Shrikes. Furthermore, it is extremely unlikely that these motor patterns are part of the natural ontogeny of hoarding behavior in this species.

Similarity in behavior does not necessarily indicate homology. Nevertheless, hand-reared young of all four species have shown, at approximately the same age, remarkably similar behavior. Shrikes, chickadees, jays, and Catbirds are not particularly closely related. Further experiments with other passerine species should be done to find out just how widespread this behavior really is.

It might be that dabbing behavior is a very general phenomenon, performed by any young passerine that is not hungry, regardless of whether or not adults of that species manipulate food as in impaling or storing. If this motor pattern is in fact widespread among modern passerines, it might even be a very old behavior, and may actually have been performed by ancestors of *Lanius*. Tropical Africa, the center of shrike species abundance, is the probable center of shrike evolution; much of this area has abundant thorny vegetation. Dabbing may have originally been performed by an ancestor of *Lanius* simply when not hungry enough to eat its prey. Such dabbing in thorny vegetation may have occasionally caused pieces of food to become caught accidentally on thorns. If this made a sufficient difference in the bird's ability to deal with larger prey, then any modification that increased the likelihood of dabbing being directed toward a suitable location (and hence impaling) would yield a selective advantage. This is particularly applicable to sit-and-wait hunters like shrikes, that spend approximately the same amount of energy in the capture of each prey item, regardless of its size.

Certain species of *Lanius* such as the European Woodchat Shrike (*L. senator*) rarely if ever impale their prey (Ullrich, 1971). It would be extremely interesting to find out if young Woodchat Shrikes ever perform dabbing behavior. Certainly a great deal more experimental evidence is needed before any conclusions can be made. Nevertheless, it is possible that the generalized behavior "dabbing" may have been the original motor pattern that eventually became modified into the specialized impaling behavior typical of most modern species of *Lanius*.

LITERATURE CITED

Hardy, J. W. 1961. Studies in behavior and phylogeny of certain New World jays (Garrulinae). Univ. Kansas Sci. Bull., 42:13–149.

Hart, D. 1958. Hoarding of food by Willow and Coal Tits. Brit. Birds, 51:527.

Hinde, R. A. 1952. The behaviour of the Great Tit (*Parus major*) and some other related species. Behaviour Suppl., 2:1–201.

Lorenz, K. and U. von Saint Paul. 1968. Die Entwicklung des Spiessens und Klemmens bie den drei Würgerarten *Lanius collurio*, *L. senator* und *L. excubitor*. J. Ornithol., 109:137–156.

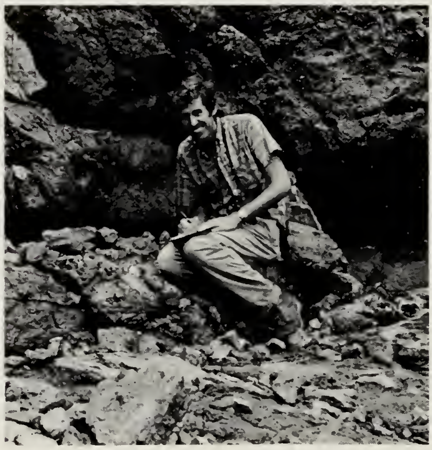
Smith, S. M. 1972. The ontogeny of impaling behaviour in the Loggerhead Shrike, *Lanius ludovicianus* L. Behaviour, 42:232–247.

Ullrich, B. 1971. Untersuchungen zur Ethologie und Ökologie des Rotkopfwürgers (*Lanius senator*) in Südwestdeutschland im Vergleich zu Raubwürger (*L. excubitor*).

Schwarzstirnwürger (*L. minor*) und Neuntöter (*L. collurio*). Die Vogelwarte, 26:1–77.

Wemmer, C. 1969. Impaling behaviour of the Loggerhead Shrike, *Lanius ludovicianus* Linnaeus. Z. Tierpsychol., 26:208–224.

DEPARTMENT OF BIOLOGICAL SCIENCES, WELLESLEY COLLEGE, WELLESLEY, MASSACHUSETTS 02181. 4 APRIL 1973 (ORIGINALLY RECEIVED 1 MAY 1972).



NEW LIFE MEMBER

Dr. Cameron B. Kepler, a Research Biologist with the Endangered Species Program of the Bureau of Sport Fisheries and Wildlife is a recent addition to the list of Life Members of The Wilson Ornithological Society. After earning two degrees at the University of California, Santa Barbara, he obtained his doctorate at Cornell University. His work on the Blue-faced Booby on Kure Atoll while a part of the Pacific Program of the Smithsonian Institution has been published by the Nuttall Ornithological Club. After leaving Cornell he spent three years in Puerto Rico studying the Puerto Rican Parrot. While on that island he and his wife discovered the Elfin Woods Warbler (*Dendroica angelae*) (named for Mrs. Kepler), the most recent new species to be discovered in the northern half of the Western Hemisphere. Dr. Kepler is a member of the AOU, the BOU, the Cooper Society, and the Association of Tropical Biology. The picture shows him at the first nest of the Red-billed Tropicbird to be discovered in Puerto Rico.

EXPONENTIAL RELATIONS OF STANDARD METABOLIC RATES OF BIRDS AND THE WEIGHTS OF EGGS

Charles A. Long

Apparently no one has investigated a relation in birds between calculated standard metabolic rate and empirically determined egg weight. To predict standard metabolism from egg weights depends on the one hand upon the well-documented relation between metabolism and bird weights (Lasiewski and Dawson, 1967; Scholander et al., 1950; Steen, 1958; Kendeigh, 1969, 1972; and others), but also upon a mathematical relation between species weight and egg weight. Heinroth (1922), Huxley (1927), Romanoff and Romanoff (1949), and Lack (1968) have discussed direct proportions between body and egg weights, and Amadon (1943) demonstrated a linear relation between egg and species weights for the Fringillidae. In any case, linear curves of the logarithms of numerous egg weights plotted against the logarithms of metabolic rates would reveal exponential relations (Huxley, 1927).

METHODS

Eggs available of the species for which standard metabolism has been calculated (see Lasiewski and Dawson, 1967) were weighed on a top pan balance after the eggs had been filled with water by means of a hypodermic needle (following the procedure of Romanoff and Romanoff, 1949). (Since the ostrich egg was too heavy for the balance, the value for its weight was taken from Romanoff and Romanoff.) The eggs are preserved in the August J. Schoenebeck collection of eggs in the University Museum at Stevens Point (see Alexia, 1970) and are listed in Table 1. Slight error might arise from air bubbles, etc., but as mentioned by Huxley (1927) the "regularity of the curves is in itself a presumption that the errors are not great." Logarithms of shell, egg, and body weights were plotted (Fig. 1) against log metabolic rate to determine from linearity if exponential relations exist. Twelve non-passerine birds and 15 passerine species were available. Slopes and y-intercepts were determined by the method of least squares for passerines and all available birds.

RESULTS

Bird weights, egg weights, and shell weights are shown in Table 1. The logarithms for these variables produced nearly linear scatter diagrams shown in Fig. 1. The passerines' line was above the line for non-passerine species as in graphs on body weights by Lasiewski and Dawson (1967) and Kendeigh (1972: 81, 84). Only one curve was calculated for the combined data on shell weights.

Equations relating standard metabolic rates to egg weights of passerines, and of all the available birds, and to egg shell are as follows:

Table 1

Body Weights, Standard Metabolic Rates, Egg Weights, and Shell Weights for Available Passerine and Non-Passerine Birds.

Metabolic rates after Lasiewski and Dawson (1967), who also listed the body weights.

	Standard Metabolism (kcal/24 hr)	Egg Weights (g)	Shell Weights (g)
Passerines			
Troglodytes aedon	5.3	1.39	0.11
Spizella arborea	6.8	2.17	0.12
Junco hyemalis	6.1	2.50	0.14
Melospiza melodia	7.8	2.61	0.18
Zonotrichia albicollis	7.1	2.70	0.31
Zonotrichia leucophrys	8.0	2.90	0.19
Loxia curvirostra	10.5	2.10	0.22
Passerella iliaca	11.3	3.89	0.23
Molothrus ater	11.0	3.10	0.31
Cardinalis cardinalis	12.2	5.32	0.37
Pipilo fuscus	13.7	4.75	0.39
Cyanocitta cristata	17.6	6.4	0.42
Corvus caurinus	73.2	17.22	1.2
Corvus cryptoleucus	79.0	21.59	1.55
Corvus corax	92.0	26.4	1.91
Non-passerines			
Archilochus colubris	1.6	0.50	0.01
Calypte anna	2.2	0.49	0.01
Scardafella inca	5.2	2.74	0.18
Chordeiles minor	9.5	9.18	0.68
Zenaida macroura	13.4	6.1	0.38
Colinus virginianus	23.0	7.50	0.60
Asio otus	19.7	23.40	1.51
Catharacta skua	98	87.6	6.58
Bubo virginianus	108	62.70	4.82
Ardea herodius	128	77.0	7.18
Aquila chrysaetos	102	128.4	13.8
Struthio camelus	2,350	1,400	301

$$\log_{10}M(\text{passerines}) = 1.067 \log E + 0.51 \tag{1}$$

$$\log_{10}M(\text{all birds}) = 0.83 \log E + 0.57 \tag{2}$$

$$\log_{10}M(\text{all birds}) + 0.694 \log S + 1.487 \tag{3}$$

where M is the standard metabolism of resting birds at normal temperatures, E is the weight of the water-filled egg, and S of the dry shell. Standard errors of estimates are ± 0.1 for equation (1), ± 0.3 for (2), and ± 0.5 for (3).

The slopes of the curves agree with the range of constants (0.63–1.0)

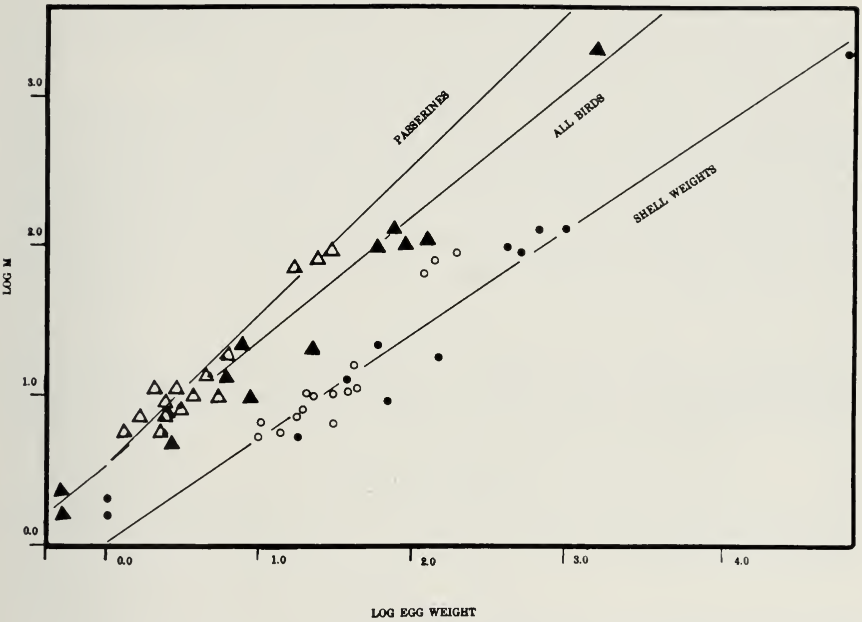


FIG. 1. Standard metabolic rates plotted against egg weights. The open triangles represent passerine eggs, the black triangles non-passerine eggs. The circles are passerine shell weights, the black circles non-passerine. The distribution of egg shell weights is displaced two units to the right (equivalent to increasing the characteristic by two, or multiplying the raw weights by 100), and the true Y-intercept is given in equation (3).

relating energy metabolism to body size in biological organisms (Zeuthen. 1953). The slope for the passerine species is at the upper limit.

The equations allow estimation of the standard rates of metabolism for several rare or extinct forms. The weight of the Ivory-billed Woodpecker's egg was 11.5 g, and of its shell 0.81 g. Equation (2) provides an estimate for standard metabolism of this rare or extinct bird as 28.1 kcal/24 hr, intermediate between the Bobwhite and the small crow *Corvus caurinus.* The predicted metabolic rate based on egg size is probably more accurate than a similar prediction based upon the few records of body weights recorded for this rare woodpecker. For future comparison with a closely related bird, the Pileated Woodpecker's similar weight of the egg (11.56 g, shell 0.80 g) permits estimation of a standard rate of 28.31 kcal/24 hr. The Passenger Pigeon's egg weighs 14.30 g, and its shell 1.36. The estimated standard rate is 33.81 kcal/24 hr.

Thickness of shell depends upon metabolism but also on the amount of yolk and precocial development of the embryo, which must develop sufficiently to crack the shell (Lack, 1968). Most of the birds available for this study were altricial or nearly so. Heavier egg weights of precocial birds as a group would doubtless result in lower constants in the equations.

As the list of birds studied in regard to standard metabolism lengthens and additional egg weights are included, greater reliability can be placed on the values of M. When numerous species within families are studied the new constants obtained probably will permit quite valid predictions of metabolic rates, judging from the very close correspondence of egg size and body weight in the Fringillidae (Amadon, 1943).

SUMMARY

Equations were derived from empirical data relating egg weights for passerines and non-passerines and shell weights for both to published standard metabolic rates. Metabolic rates of two extinct or rare species were estimated.

ACKNOWLEDGMENT

I thank Dr. S. Charles Kendeigh, University of Illinois, for reading over the manuscript and providing information.

LITERATURE CITED

Alexia, M. 1970. Catalog of North American bird eggs and nests in the August J. Schoenebeck Collection. Part 1, Report No. 2, Mus. Nat. Hist. Repts. Fauna and Flora of Wisconsin, p. 1–92.

Amadon, D. 1943. Bird weights and egg weights. Auk, 60:221–234.

Heinroth, O. 1922. Die Beziehungen zwischen Vogelgewicht, Eigewicht, Gelegegewicht und Brutdaur. J. Ornithol., 70:172–285.

Huxley, J. S. 1927. On the relation between egg-weight and body-weight in birds. J. Linnaean Soc., Zool., London, 36:457–466.

Kendeigh, S. C. 1969. Tolerance of cold and Bergmann's Rule. Auk, 86:13–25.

Kendeigh, S. C. 1972. Energy control of size limits in birds. Amer. Nat., 106:79–88.

Lack, D. 1968. Ecological adaptations for breeding in birds. Methuen & Co., London.

Lasiewski, R. C. and W. R. Dawson. 1967. A re-examination of the relation between standard metabolic rate and body weight in birds. Condor, 69:13–23.

Romanoff, A. L. and A. J. Romanoff. 1949. The avian egg. John Wiley and Sons, New York.

Scholander, P. F., R. Hock, V. Walters, and L. Irving. 1950. Adaptation to cold in arctic and tropical mammals and birds in relation to body temperature insulation, and basal metabolic rate. Biol. Bull, 99:259–271.

Steen, J. 1958. Climatic adaptation in some small northern birds. Ecology, 39:625–629.

Zeuthen, E. 1953. Oxygen uptake as related to body size in organisms. Quart. Rev. Biol., 28:1–12.

MUSEUM OF NATURAL HISTORY AND DEPARTMENT OF BIOLOGY, UNIVERSITY OF WISCONSIN, STEVENS POINT, WISCONSIN 54481, 31 MAY 1972.

MOLT OF JUVENILE WHITE-EYED VIREOS

William G. George

The extent of the first prebasic (postjuvenal) molt in White-eyed Vireos (*Vireo griseus*) has been a subject of considerable disagreement among ornithologists. Stone (1896) evidently initiated the controversy, stating, "A young bird in first molt is renewing the tail. . . ." Soon Dwight (1900) concluded that young birds undergo a complete first prebasic molt in the northeastern United States, yet admitted "I am not sure this occurs in all specimens." In contrast, another worker in the northeast, Forbush (1929), flatly maintained that the molt involves only the body plumage and the coverts of the wing and tail, and Bent (1950) was "inclined to think that Forbush is probably right, for I can find no birds renewing wing or tail feathers at the postjuvenal molt in a considerable series that I have examined."

Mengel (1965), however, discussing Kentucky-taken specimens, reported that "Many young birds retain considerable juvenile plumage into September, and both adults and immatures in the series show signs of the complete molt mentioned for the species by Dwight. . . ."

Together these contradictory statements suggest the possibility of individual and/or geographic variation in the first prebasic molt of the species. The present paper aims to demonstrate, first, that young White-eyed Vireos in southern Illinois typically replace most and probably all major flight feathers during juvenile life, and second, that certain specimens or populations in the middlewestern prairie region possibly retain some or all juvenal flight feathers until the second prebasic (first postnuptial) molt.

SPECIMENS

Critical specimens undergoing the first prebasic molt are described as follows (each possessed the juvenile traits of the species—skull "windows," and either brown or gray irises—and all stemmed from Jackson and Union Counties, Illinois; my field catalog numbers appear in parentheses):

Early Stages of Molt

1. 12 August 1971 (2339). General body molt. No sheathed or missing remiges, rectrices or greater upper and lower wing and tail coverts.
2. 8 August 1966 (2187). Molting plumage includes primary nos. 5 and 6, secondary no. 8, all greater upper secondary coverts; carpal remex; middle upper primary coverts; middle upper secondary coverts; upper and under tail coverts, and some feathers in all body tracts.

Late Stages of Molt

3. 26 August 1971 (2337). Molting plumage includes primary nos. 5, 6 and 7, secondary nos. 8 and 9, all rectrices (entire tail is represented by sheaths measuring about 10

mm), upper greater coverts associated with the above-named primaries, all greater upper secondary coverts (almost fully grown in), upper and under tail coverts, and some feathers in all body tracts.

4. 13 September 1970 (2336). Molting plumage includes primary nos. 8, 9, and 10, secondary no. 7, all rectrices (a sheathed "bob" tail measuring 39 mm), and some feathers of chin, throat, breast, flanks and rump.
5. 27 August 1971 (2338). Molting plumage includes primary nos. 7, 8, 9, and 10, secondary no. 2, all rectrices (a sheathed tail measuring 44.5 mm), and a few feathers of neck, crown, chest, flanks, plus the greater under wing coverts.

The lesser wing coverts of most of these birds show signs of molt.

From a consideration of this series as a whole, it appears that the first prebasic molt of the southern Illinois population combines: a) descendant loss and replacement of the primaries with each greater upper primary covert being renewed in concert with the primary existing proximal to it; b) complicated but probably sequential renewal of the secondaries (see Stresemann and Stresemann, 1966, for a general discussion of the complex molting patterns of secondaries); c) synchronous or nearly synchronous loss and replacement of the greater upper secondary coverts (a typical sequence in songbirds); d) synchronous or nearly synchronous loss and replacement of the rectrices (a relatively rare phenomenon in songbirds; described in *Cassidix mexicanus* by Selander, 1958, and known in various other passerines: typical of small owls, as shown by Mayr and Mayr, 1954, and Ligon, 1968); e) gradual renewal of the body plumage and of the minor coverts of wing and tail (a typical songbird sequence).

Doubt nevertheless must linger as to whether all remiges are renewed. None of my specimens exhibits a molt stage involving replacement of primary nos. 1, 2, 3, and 4, or secondary nos. 1, 3, 4, 5, and 6. However, the birds with molting middle and outer primaries exhibit what appear to be fresh inner primaries and corresponding fresh greater upper primary coverts, while the same birds also exhibit apparently fresh inner and middle secondaries.

VARIATION IN THE MOLT

Table 1 compares the minimum and maximum lengths of the closed tail, folded wing (more or less flattened) and individual primaries of juveniles and breeding birds. Measurements of the primaries were obtained from specimens prepared with one wing fully extended. A millimeter rule was used, placing its tip at the inserted feather base on the proximal side of the calamus of all the primaries except the innermost, which was measured from the distal side of the feather.

Only a small sample was available to me but I believe it is sufficient to indicate that juveniles tend to possess markedly smaller primaries than the breeding birds. This tendency particularly is striking in respect to primary

TABLE 1

MINIMUM AND MAXIMUM LENGTHS (MM) OF WING, PRIMARIES, AND TAIL IN BREEDING ADULT AND JUVENILE *VIREO GRISEUS* FROM SOUTHERN ILLINOIS

Length	Adult		Juvenile	
	♂*	♀	♂	♀
	N = 6	N = 6	N = 2	N = 3
Wing	59–64	58–60	59	57–59
Primary 1	42–44	42–43	41–43	39–41
2	43–45	44–45	42–43	42–43
3	44–46	43–45	43–46	43–45
4	45–47	45–46	43–47	43–45
5	48–50	47–48	46–48	46–47
6	49–51	48–50	47–48	46–48
7	47–50	47–48	45–46	44–46
8	47–49	47–48	43–44	42–43
9	39–40	38–40	37	35–37
10	16–18	15–18	16–20	15–20
Tail	46–49	46–48	44–45	44–49

* One specimen with unusually small measurements is not included; see text.

no. 8, which ranges in length from 42 mm to 44 mm in juveniles and from 47 to 49 mm in the other age groups. Accordingly, the specimen that I have set off by itself at the bottom of Table 1 (W.G.G. 2214) merits special comment.

Its measurements overall correspond to those of a small female in unworn juvenal plumage. This bird, however, is a spring male, the flight feathers of which are somewhat more worn than are those of my other spring males. Collected as it sang one mile north of Cobden, Union County, on 12 May 1968 (skull fully ossified; iris, white; testes: L, 4 × 4 mm; R, destroyed by shot), it proved to have not only a small wing and short tail but narrow sharp-pointed middle rectrices, as is characteristic of juveniles. Moreover, the bird is undergoing molt of the throat and breast, although the rest of the body plumage appears adult and no prealternate (prenuptial) molt seems to have been recorded in White-eyed Vireos. This bird possibly was an aberrant individual. But because it combines a series of juvenile traits with what can be interpreted as evidence either of delayed elements in the first prebasic body molt, or of a prealternate molt, the specimen may point either to molt variation in our southern Illinois birds, or to an undescribed molt sequence in birds that breed elsewhere (northward?) in the middlewestern prairie region.

WING LOAD IN JUVENILES

White-eyed Vireos in southern Illinois exhibit one striking variation in wing plumage that, though of theoretical significance to the subject of this paper, has not yet been mentioned directly: that is, the wide difference in the overall size of the spread wing of the juveniles. The total surface area of the complete spread adult wing (as traced on paper and measured with a planimeter, after the manner of Poole, 1938) ranges from about 60 cm^2 (worn) to 65 cm^2 (fresh). Some fresh juvenile wings equal and a few even surpass the lower figure, but the remainder fall considerably below 50 cm^2, with one specimen measuring only 42.1 cm^2. The small-winged examples weigh approximately as much as the longest-winged ones (11.2 g to 12.7 g) and thus wing load in them is comparatively unfavorable. For example, in a juvenile with a total wing surface area of 42.1 cm^2 and weighing 11.2 g, wing load is over 0.52 lbs/ft^2 (= 3.7 cm^2/g), whereas it is only about 0.34 lbs/ft^2 (= 5.6 cm^2/g) in a juvenile with a total wing surface area of 63 cm^2 and weighing 11.2 g. This suggests that perhaps the first prebasic wing molt may be related in part to the desirability of equipping young birds with an adult-sized wing prior to migration.

ACKNOWLEDGMENTS

I thank George Spiegel and David Hayward for their help in securing specimens and Kenneth C. Parkes for critically reviewing the manuscript.

LITERATURE CITED

Bent, A. C. 1950. Life histories of North American wagtails, shrikes, vireos, and their allies. U.S. Natl. Mus. Bull., 197.

Dwight, J. 1900. The sequence of plumage and moults of the passerine birds of New York. Ann. New York Acad. Sci., 13:73–360.

Forbush, E. H. 1929. Birds of Massachusetts and other New England states, part 3. Massachusetts Dept. Agr.

Ligon, J. D. 1968. The biology of the Elf Owl, *Micrathene whitneyi*. Misc. Publ. Mus. Zool., Univ. of Michigan, No. 136.

Mayr, E. and M. Mayr. 1954. Tail molt of small owls. Auk, 71:172–178.

Mengel, R. M. 1965. The birds of Kentucky. Ornithol. Monogr. 3, Amer. Ornithol. Union.

Poole, E. L. 1938. Weights and wing areas in North American birds. Auk, 55:511–517.

Selander, R. K. 1958. Age determination and molt in the Boat-tailed Grackle. Condor, 60:355–376.

Stone, W. 1896. The molting of birds with special reference to the plumages of the smaller land birds of eastern North America. Proc. Phil. Acad. Natl. Sci., 108–172.

Stresemann, E. and V. Stresemann. 1966. Die Mauser der Vogel. J. Ornithol., 107:1–53.

DEPARTMENT OF ZOOLOGY, SOUTHERN ILLINOIS UNIVERSITY, CARBONDALE, ILLINOIS 62901, 10 SEPTEMBER 1972.

GENERAL NOTES

Promiscuous mating behavior in the White Ibis.—The colonial breeding of most ciconiiforms, which concentrates displaying males and subsequent nest sites, leads to many types of interactions among individuals most of which have been little studied. Such information can be obtained only by careful observation of individual birds. The White Ibis (*Eudocimus albus*) is particularly amenable to this because during pair formation birds become variously stained by dirt and blood. Observations of such birds at a White Ibis nesting colony in southern Florida revealed an interaction apparently not previously described in ibises, promiscuous mating behavior. The clearest example was observed on 20 June 1972 between 15:00 and 17:00. Nine nests were located in close proximity to each other on two lateral branches of a red mangrove tree (*Rhizophora mangle*). Nesting in this group ranged from a partially constructed nest without eggs to a nest with two one-week old young. The ibises at five nests were involved in the situation described here. These nests were designated B, G and H (females incubating one egg), J (a male incubating one egg) and C (a male gathering nest material and female building the nest).

While gathering nesting material, male C became involved in a territorial squabble with female B which was incubating at the nest immediately above his. Male J left his nest and joined the conflict against both female B and male C. After male C withdrew, male J continued to peck at the female and then mounted and unsuccessfully attempted to copulate with her. He dismounted, remained nearby for several minutes, mounted her again and was apparently successful in copulating. He then returned to his nest in response to male C who was trying to remove some of the nesting material. Within 5 minutes, male J returned to female B, gave her a few sharp jabs and again successfully copulated with her. This sequence was repeated 5 minutes later. The next time he flew over to female B, he pecked at her but then flew up to nest G and attempted to approach the female incubating there. At first he was soundly driven off, but he remained nearby and was soon standing next to her preening the feathers along her back. Meanwhile pair H with a nest immediately below that of male J completely dismantled male J's nest adding his material to their unfinished nest and in the process knocked male J's single egg into the water. Approximately 10 minutes after they finished, male J returned to his nest site but merely stood nearby for nearly 15 minutes before flying first to a nearby island and then off in the direction of the feeding ground. This example of promiscuous mating behavior is the best documented of several such instances that I have witnessed. In this case male J, who already had a nest with one egg and whose mate was present earlier in the day, copulated repeatedly with another female and showed considerable interest in a third.

Deviation from normal monogamous behavior has been reported in other colonially nesting species. For example although herons (Ardeinae) along with most Ciconiiformes are generally considered to be monogamous (Lack, Ecological adaptations for breeding in birds, London, 1968) and to exhibit strong pair bond stability, there are a number of reports of promiscuity in this group (e.g., Verewey, Zool. Jahrb., 48:1–120, 1930; Meanley, Wilson Bull., 67:84–99, 1955; Allen, Audubon Mag., 57:24–27, 1955; Mountfort, Portrait of a wilderness, London, 1958; Meyerriecks *In*: Palmer (ed.), Handbook of North American birds, Vol. 1, 1962). In fact, the phenomenon seems to be widespread among colonial nesting birds. It has, for example, been reported in the Rook (Yeates, The life of the Rook, London, 1934), European Cormorant (Kortlandt, Arch. Neerl. Zool., 4: 401–402, 1940) and Wandering Albatross (Tickell, *In* Austin (ed.), Antarctic bird studies, 1968). The Laysan Albatross is the only colonial bird in which promiscuity has been thoroughly studied. Fisher (Living Bird, 10:19–78, 1971) showed that in this species promiscuous copulation never resulted in intromission. Although I did not conduct a similar study with the White Ibis, I detected no differences between the behavior and duration of promiscuous copulations compared to those of paired birds. It therefore was my impression that many promiscuous copulations were successful. If this is true, the effect, if any, that such behavior may have on the reproductive success of an individual deserves attention (see Mayr, Animal species and evolution, Cambridge, 1963:199–201). In the case described here, the male lost his nest, which is a highly probable event if nest attentiveness is relaxed during any stage of incubation. This and the predominance of strictly monogamous relationships in the White Ibis suggest that promiscuity would be maladaptive for an individual. However the fact that such behavior is widespread in colonial species of birds and in some cases extremely common within a colony (e.g., Meanley, op cit.) suggests that the existence of promiscuous behavior in typically monogamous, colonial birds may in some cases be of importance within the population and merits further study.—James A. Kushlan, *Department of Biology, University of Miami, Coral Gables, Florida 33124, 23 October 1972.*

Marsh Hawk catches fish.—On 26 October 1972 while scanning a coastal salt marsh in Milford, Connecticut, I saw an immature Marsh Hawk, (*Circus cyaneus*) slowly gliding over the grass and water filled ditches. It reached a pool that had been formed by an exceedingly high tide and began circling. Then it began a wild, bouncy flapping flight back and forth over the pool obviously harrying something in the pool. It did this for a minute or so then swooped up to a point 10 feet or so above the pool, held its wings out in back and plummeted in Osprey fashion with outstretched talons into the water. It remained on the surface for a few seconds then rose with a fairly large, 10 inch or so, fish dangling from its talons. It flew a few hundred feet then settled on a knoll of high ground and began to devour the fish.

Investigation showed the pool to be roughly round in shape with a 50 foot diameter; and the depth averaged two and one half feet. The hawk had taken the fish in roughly two feet of water. There is no doubt that the fish had been caught in this pool during the exceptional high tide of the night before as it was obviously only a temporary pool.

Though fish are listed as part of their diet there are few accounts of their hunting methods dealing with this form of food.—Noble S. Proctor, *Biology Department, Southern Connecticut State College, 501 Crescent Street, New Haven, Connecticut 06515, 1 November 1972.*

Some food preferences and aggressive behavior by Monk Parakeets.—The Monk Parakeet (*Myiopsitta monachus*) is well established in New York, southern New England, and the Middle Atlantic States. A pair found in a suburban section of Pittsburgh, Pennsylvania, in the winter of 1971–72 engaged in one of the first occurrences of attempted breeding west of the Allegheny Mountains or Piedmont Plateau. The birds were almost surely a local introduction, there being no evidence and little possibility that they crossed the Alleghenies from the East Coast. In following the breeding efforts of this pair, several interesting food and behavioral patterns were recorded. They are presented here as they may be of some value in attempting to evaluate the pest status of the species in the Northern Hemisphere.

The Pittsburgh birds were first observed in September 1971, building a bulky nest of thorny sticks in a blue spruce tree 10 feet from the third-story window of a home. Invariably the construction took place by one bird passing twigs to the bill of the other for placement in the nest; apparently one adult was thereby responsible for most, if not all, of the actual construction.

By December 1971, at least three nests were completed. Although this was originally thought to indicate the presence of at least two pairs of parakeets, there has been no evidence to date to prove that more than one pair of birds was responsible for all nests in the area. This was a breeding effort in our winter, which corresponds to summer in the birds' native South America. At least two young were alleged to have been born but apparently perished over the winter. It is quite likely that the other two winter nests were for roosting or decoy purposes only. One of these nests was built on a set of three capacitors on an electric utility company pole, attracting the interests of the utility company and, in such an exposed condition, literally hundreds of ordinary citizens. School children often threw stones at the nest, but no great damage resulted.

By May 1972, at least five bulky nests had been located—all within a quarter-mile-square area covering two rather urbanized ridges and a partially wooded ravine. Two of the nests were on utility poles, three in trees, and all were the apparent work of one pair of parakeets. It was in May that House Sparrows (*Passer domesticus*) became involved in a territorial dispute with the parakeets. For several years, House Sparrows had nested in a space between the three capacitors and a crossarm on the utility pole. This space was now entirely encircled by parakeet nesting material. A lady resident of the home nearest the pole heard a commotion one morning in mid-May, the parakeets' shrill voices being easily recognized every time the birds approached or left a nest or feeding site. The lady observed House Sparrows entering and leaving the entry hole of the parakeets' bulky nest, obviously greatly agitated. Within the nest, at least one parakeet and House Sparrows were heard in raucous dispute. Later, the lady found a freshly dead House Sparrow, sex undetermined, on the street directly beneath the entry hole of the parakeets' nest. Several cuts were evident on the sparrow's body, particularly about the head and neck, and several "patches" of missing feathers were observed. There was no commotion observed at this nest site thereafter.

In mid-summer I was called to the area to see young parakeets on the wing. On 12 August 1972 I observed both adults and one well-fledged young bird. Residents of the area later confirmed the existence of three young of the year, with the unproven possibility of a fourth. All were the apparent result of one breeding pair of adults, and the summer nesting appeared to be an early change of mating habits to our warm months, the winter 1971–72 breeding effort having failed.

Many residents have noted the natural and proffered food preferences of the parakeets. Native fruits make up the majority. One resident noted the parakeets frequently left remains of red and blue berries after feeding the fledgling young. There are many varieties of berries in the area—including forms of huckleberry and poison ivy—but the precise identity of the preferred berries has not yet been determined. Several apple and pear trees exist in the neighborhood, and both are favored food sources of the adults, particularly in late fall and winter. Seeds such as millet and supermarket "wild bird seed" are taken when offered, and bread is well accepted, although the parakeets shy away from traditional feeding trays and take food mainly from beneath the trays or on patio decks, etc. Seed and bread are spurned, however, whenever raw corn is offered. Corn kernels—plucked from the cob by the parakeets' bills—are the most favored food of the Pittsburgh birds, apparently even over available fruits. In South America, of course, where the species is considered a great agricultural pest, the parakeets feed frequently in corn fields and do considerable damage to commercial crops of various grains (U.S. Dept. of Interior, Bureau of Sport Fisheries & Wildlife Leaflet 496, May 1971). As no corn fields exist in the rather urban area of Pittsburgh chosen by these parakeets, the only corn available is in the form of handouts. The parakeets are very much the rulers of the feeding periods when hungry, aggressively intimidating all other birds from approaching the food.

The birds have had wide exposure in area newspapers, company publications and other communications media, but nest disturbance has not visibly deterred the birds from beginning what may well become a small colony similar to those on the Atlantic Seaboard.—David B. Freeland, *336 Earlwood Road, Pittsburgh, Pennsylvania 15235, 29 November 1972.*

Response by a Long-eared Owl to Barred Owl Calls.—On 21 April 1972 I saw an interspecific reaction by a Long-eared Owl (*Asio otus*). I was with one other observer in Massachusetts Audubon's Highlands Farm Sanctuary in Belmont, Massachusetts. At about 22:00 we were passing from a thick pine forest through a stand of young oaks bordering a small clearing, much of which was surrounded by mature spruces. About every fifteen seconds I was hooting the typical eight-hoot call of the Barred Owl (*Strix varia*).

After approximately five owl imitations, an owl flew rapidly across the clearing with quick wingbeats and several sharp turns. On each of two subsequent Barred Owl calls the bird flew directly over our heads, roughly fifteen feet off the ground. Immediately following a third call it flew from a stand of spruces and perched in a young oak twenty feet from us. A flashlight illuminated an adult Long-eared Owl, quickly glancing about and periodically shifting positions on the branch. Several additional hoots caused marked reactions in the bird—it appeared agitated by the calls, turning sharply toward us, staring intently in our direction, and at least twice moving several inches farther out on the branch. Throughout the encounter it remained silent. After approximately three minutes the bird left, apparently flying back into the spruce thickets. Although a pair of Long-eared Owls had been reported nesting in the vicinity, further attempts to call it back, that night and on later nights, failed to attract a bird. Based on its attention to the Barred Owl calls, however, I have no doubt that the owl was attracted and excited by the possible presence of that species.

Instances of interspecific reactions among smaller owls have been documented (Foster, Auk, 82:651–653, 1965), but I have found no indication in the literature of such behavior in any of the larger species. Two possible situations may explain this behavior. First, L. Miller (Condor, 54:89–92, 1952) describes instances in which several birds, including some large hawks, were attracted by his imitations of the Great Horned Owl (*Bubo virginianus*), presumably in response to the presence of a potential predator. The presence of a Barred Owl may pose a threat to fledgling Long-eared Owls, causing this nervous response in the adult. Second, the occurrence of interspecific territoriality between birds with similar ecological requirements continues to receive increasing attention in the literature (e.g. Murray, Ecology, 52:414–423, 1971). The similar nesting habits and food sources of these species suggest that the recognition of a competitive owl species may have caused the bird to seek out the source of the calls. A Barred Owl had recently been seen within the 44-acre sanctuary, and it apparently left the area within several days of the first reported sighting of the Long-eared Owl. Its disappearance may have been related to the arrival and territorial behavior of the latter species. Baumgartner (Auk, 56:274–282, 1939) found that no other large owl species nested or fed within the territories of Great Horned Owls, even in areas where Barred Owls were common. However, the Craigheads (Hawks, owls, and wildlife; Harrisburg, Stackpole Co., 1956) found instances of Long-eared Owls maintaining territories partially or entirely within those of Great Horned Owls. Apparently some interspecific territorial behavior does occur among large owls, but its exact extent is as yet undetermined. The behavior described in this note suggests its possible occurrence between Long-eared and Barred Owls.—John W. Fitzpatrick, *40 Mallard Road, St. Paul, Minnesota 55110, 9 November 1972.*

Use of marked prey to study raptor predation.—The food habits of many raptors have been studied by analysis of pellets (e.g., Errington, Condor, 32:292–296, 1930). In addition, hunting territories and prey preferences could be studied if the home ranges of most prey were known. Southern and Lowe (J. Anim. Ecol., 37:75–97, 1968) marked small mammals with numbered leg bands and then used the bands recovered in pellets to estimate hunting territories and prey selection of Tawny Owls (*Strix aluco*). However, they did not give information on the proportion of tags ingested by the owls. Since many tags could be lost as indicated for Marsh Hawks (*Circus cyaneus*) feeding on cotton rats (*Sigmodon hispidus*) marked with subcutaneous radioactive Cobalt-60 tags (Schnell, J. Wildl. Mgmt., 32:698–711, 1968), comparison of prey selection between different raptors would be biased if tags of marked prey were differentially ingested and regurgitated by the predators.

I examined the proportion of tags recovered in pellets of Barn Owls (*Tyto alba*) and Screech Owls (*Otus asio*) feeding on live old-field mice (*Peromyscus polionotus*). Radioactive tags (see Hirth, et al., Ecology, 50:332–339, 1969 and references therein for use of radioisotopes as markers for vertebrates) were used so that all live mice, loose tags, or tags in pellets were recovered, however, radioactive tags would not be necessary in field studies of prey selection by raptors or other predators.

Old-field mice were tagged with radioactive Tantalum-182 pins (1 × 5 mm) inserted subcutaneously through a hypodermic needle into the dorsal neck region. Mice were released into large mouseproof enclosures (3.6 m wide × 9.0 m long × 3.9 m high) containing either a Barn Owl or Screech Owl (described in Kaufman, Ph.D. disser., Univ. Georgia, 1971). Pins were then relocated in pellets or loose in the pens with a portable beta-gamma survey meter (EP 432) with a NaI-Tl activated crystal (range approximately 7 m).

Barn Owls and Screech Owls killed and ate 21 and 11 tagged mice, respectively. A greater proportion of the ^{182}Ta pins were recovered in Barn Owl pellets (16 in 9 pellets, 5 not in pellets) than in Screech Owl pellets (6 in 5 pellets, 5 not in pellets). Differences in tag recovery in pellets for Barn Owls (76 percent) and Screech Owls (55 percent) was probably due to differences in eating behavior, since Barn Owls often swallowed each mouse whole until several mice had been eaten while Screech Owls nearly always tore each mouse into pieces. If prey were larger, such as cotton rats, Barn Owls would tear up their prey and a greater proportion of tags would be lost as in Marsh Hawks (Schnell, op. cit.).

In summary, the proportion of tags (ear tags, leg bands, or subcutaneous tags) recovered in pellets from different raptors would be dependent on prey size, predator size, and feeding behavior of the raptor, and any differences in the recovery of tags would have to be considered before comparing differential selection of prey species by a raptor or differential predation on a prey species by different raptors.

Research was supported by Contract AT(38-1)-310 between the U.S. Atomic Energy Commission and the University of Georgia.—Donald W. Kaufman, *Savannah River Ecology Laboratory, Aiken, South Carolina 29801 (Present address: Department of Zoology, University of Texas, Austin, Texas 78712). 25 September 1972.*

Food and foraging ecology of the Chestnut-bellied Cuckoo.—On Jamaica the 19 species of endemic land birds are poorly known from the standpoint of feeding and other aspects of niche utilization, competition, and resource partitioning. Therefore, the following information of food and foraging behavior of the Chestnut-bellied Cuckoo (*Hyetornis pluvialis*) should be helpful in the future analyses of this species. To my knowledge the only references to its food habits are that of Gosse (The birds of Jamaica, London, Van Voorst Press, 1847, pp. 277–278) who states that it feeds on insects and of Salmon (Gosse Bird Club, Broadsheet No. 6:19, 1966) who observed this species capturing a praying mantis in flycatcher fashion.

This study was carried out in the Lluidas Vale (Worthy Park) region, St. Catherine Parish, Jamaica during the spring and summer of 1970 and summer of 1971. A description of the study area has been published elsewhere (Cruz, Quart. J. Florida Acad. Sci., 35: 72–80, 1972).

I found the Chestnut-bellied Cuckoo to be a fairly common resident in partially cleared areas, such as forest edges, wooded pastures, and citrus groves, but it was rare in heavily wooded areas. It was usually encountered singly, but sometimes in pairs, hopping from limb to limb or "gliding" from tree to tree. The flight pattern is very distinctive, consisting of a few flaps alternating with a glide. It flies gracefully and slowly, never more than a short distance, and usually lands in shrubbery or concealing arboreal vegetation. Particularly apparent in flight are the long rectrices and rounded wings. The members of a pair do not as a rule stay together either in flight or while foraging through the vegetation,

Table 1

Foraging Behavior of the Chestnut-bellied Cuckoo

Foraging Zones	Gleaning for Invertebrates	Gleaning for Vertebrates	Hawking for Insects	Percentage of Foraging
Proximal half of tall shrubs and small trees[a]	6[b]	2	—	47(8)[c]
Distal half of tall shrubs and small trees	2	—	—	11(2)
Proximal half of medium trees	2	1	—	18(3)
Distal half of medium trees	2	—	1	18(3)
Proximal half of large trees	—	—	—	—
Distal half of large trees	—	—	1	6(1)
Percent of foraging behavior	70(12)[c]	18(3)	12(2)	100(17)

[a] Tall shrubs and small trees (1.5 to 4.5 m), medium trees (4.5 to 10.5 m), and large trees (greater than 10.5 m).

[b] Number of times foraging pattern was recorded in each foraging zone.

[c] Number in parentheses indicates total number of observations.

but straggle along one behind the other, often several trees apart, and often keeping in contact by calling. Its foraging activities were confined mainly to the inner branches of high shrubbery, small to medium trees, and rarely large trees (Table 1). The foraging pattern of the Chestnut-bellied Cuckoo included gleaning from branches, twigs, and leaves; and flycatching or hawking. Gleaning was the more frequent tactic employed and flycatching was the less frequently used (Table 1). As the number of feeding observations was small (17), it may not be truly representative. More extended observations could possibly show that other techniques or other feeding methods are used more frequently.

Of the 17 feedings recorded, 14 (82 percent) were on invertebrates, and 3 (18 percent) were on vertebrates (Table 1). The food items taken included slugs (Stylommatophora), insects (Orthoptera, Coleoptera, Lepidoptera, and other unidentifiable insects), tree frogs (*Eleutherodactylus?*), and lizards (*Anolis*). The most common food items recorded were insects, particularly orthopterans and lepidopterans. The stomach contents of a female Chestnut-bellied Cuckoo collected on 10 May 1970 consisted of one slug (*Vaginalus* sp.), four snails (Xanthonichidae?), six grasshoppers (Acrididae), two hairy caterpillars (Lepidoptera), and lizard egg shell fragments (Gekkonidae). There was no evidence of snail shell fragments in the stomach contents, although the soft parts of the snails were present almost intact. This suggests that the cuckoo extracts the snail from its shell before eating it.

While these observations show the foraging pattern of the Chestnut-bellied Cuckoo to be flexible and diverse, much work still needs to be done to complete our knowledge of its niche utilization pattern.

Support during this investigation came from a National Institutes of Health Grant awarded to T. H. Patton, State Museum of Florida, and a Frank M. Chapman Grant and Ford Foundation Fellowship awarded to the author.—Alexander Cruz, *Department of Zoology, University of Colorado, Boulder, Colorado, 80302, 22 September 1972.*

Interordinal copulation on coastal Venezuela.—The evening of 26 December 1970 between 18:10 and 18:30 Roger F. Pearson, William J. Schaldach, Jr., Allan R. Phillips, and I were driving slowly through a grassy coconut grove at Playa de Guaicamacuto, 7 km east of Puerto Cabello, Carabobo, Venezuela, in search of certain members of the Tyrannidae in which we were interested. Our attention was drawn to a pair of *Myiozetetes* flycatchers calling from electricity wires about 30 m from us. To the left of the nearer flycatcher was perched a pair of Ruddy Ground Doves (*Columbina talpacoti*). All four birds were facing us, each approximately one meter apart, but with the flycatcher farthest from us perched separately on the hind wire, and thus somewhat behind the nearer flycatcher. As we watched the nearer dove departed. The nearer flycatcher (presumed male) flew at once and lit beside the remaining dove (presumed female). The dove lifted its rufous wings, holding them vertically in intimidation display. The flycatcher immediately mounted the dove. It appeared to us that copulation was successful and the flycatcher returned to its original position on the wire.

I am not familiar with the posture and movements used by receptive *Myiozetetes* females but Paul Schwartz, Estación Biológica de Rancho Grande, later informed us that both *M. similis* and *M. cayanensis* occur at Puerto Cabello (and Phillips later collected both near by). The race of the latter from that region shows considerable rufous in the wings and to some extent in the tail. Hence I suspect *M. cayenensis* was the flycatcher involved, in which case the visual signals of color and some appropriate wing movements by the dove may have triggered the aberrant behavior observed. Although there was still sufficient light for us to observe birds, apparently it was dark enough that the flycatcher erred on visual cues, in the presence of the correct acoustical stimuli coming from the presumed female flycatcher somewhat behind it.

Alsop (Wilson Bull., 83:312, 1971) reported a case of interfamilial copulation between a flycatcher and a bluebird. In this case the tyrannid mistook the food-begging immature turdid for a soliciting female. Griffin (Auk, 76:238, 1959) noted a male Brown-headed Cowbird (*Molothrus ater*) giving invitatory display to a male House Sparrow (*Passer domesticus*) which repeatedly mounted and copulated. I believe our Venezuelan observation may represent the first report of interordinal copulation.

I wish to thank Roger Pearson and his parents for making possible my studies in Venezuela and for assisting me in the field in numerous ways and Paul Schwartz for his technical assistance and for critically reviewing the manuscript.—AMADEO M. REA, *Center for Man and Environment, Prescott College, Prescott, Arizona 86301, 14 September 1972.*

House Sparrow dispossesses nesting Eastern Kingbirds.—On the afternoon of 9 June 1972 a pair of Eastern Kingbirds (*Tyrannus tyrannus*) was observed building a nest 21 feet up in a sycamore (*Platanus occidentalis*) at the Brookville Ecological Research Center of Earlham College and Miami University. They were frequently seen chasing a male House Sparrow (*Passer domesticus*) which would fly into the nest while the kingbirds were away gathering nesting material. After being chased from the nest the House Sparrow would perch about three feet away, lift its wings slightly from its body, and apparently call to or scold the kingbirds. The House Sparrow would often attempt to sit in the nest while the kingbirds were present, always being chased away immediately. These activities were continued for two hours. The kingbirds were always seen together, sometimes attacking the House Sparrow simultaneously. Throughout this period of activity a female House Sparrow was seen in the sycamore about 12 feet from the nest, apparently watching the activity at the nest.

On the afternoon of 15 June 1972 a male House Sparrow was observed in the kingbird nest continually for 20 minutes. No kingbirds were in evidence during the period of observation.

Around midday on 19 June a male House Sparrow was seen perched about six inches above the nest. A male Ruby-throated Hummingbird (*Archilochus colubris*) was seen to hover immediately over the nest, at which time the House Sparrow hopped down into the nest, driving the hummingbird away. The House Sparrow was later observed feeding on the ground about 30 yards away from the nest, frequently flying back to or directly above the nest to preen, fluff its wings, and occasionally call. It sometimes flew into the upper parts of the tree some 30 feet above the nest where other House Sparrows were heard calling. At one point a Great Crested Flycatcher (*Myiarchus crinitus*) was seen chasing the House Sparrow, which sought refuge in the kingbird nest.

After the activity on 9 June no female House Sparrows were observed near the nest or the male as he flew about. No activity was observed at the nest after 19 June. On 26 June when the nest was examined it was empty, unlined, and it was not cupped over in the manner of a House Sparrow nest.

On the evening of 28 June an Eastern Kingbird was observed defending a territory which included the sycamore with the nest. This kingbird was then seen to fly about 50 feet away into a large patch of poison hemlock (*Conium maculatum*) for the night. The kingbird was seen in the poison hemlock every evening to 10 July 1972, but no nest was found in this area.

Apparently the male House Sparrow dispossessed the Eastern Kingbirds of a nest under construction.

A literature search has turned up five instances of Eastern Kingbirds losing interspecific battles. Bent (Life histories of N. Amer. flycatchers, larks, swallows, and their allies, Dover Publications, Inc. pp. 21–22, 1963) reports a case of a kingbird losing to a Yellow Warbler (*Dendroica petechia*), and another of a kingbird being chased by a sapsucker (*Sphyrapicus* sp.). Davis (Wilson Bull., 53:157–168, 1941) tells of two instances in which Robins (*Turdus migratorius*) defeated kingbirds, and one case where a Baltimore Oriole (*Icterus galbula*) was the victor in a duel. King (Auk, 72:148–173, 1955) mentions that he observed a nesting Traill's Flycatcher (*Empidonax traillii*) harassing a kingbird.

This paper is based on observations made during the course of a project funded by NSF-URP grant Gy10019.—Michael R. Huber and James B. Cope, *Earlham College, Richmond, Indiana, 47374, 26 October 1972.*

First specimens of certain thrushes and vireos from New Mexico.—The following specimens are in the Delaware Museum of Natural History, except for the first which has been deposited in the United States National Museum of Natural History. I am grateful to Roxie C. Laybourne for taxonomic help, to my wife, Claudia, for preparing the specimens and other aid, and to the many others who have contributed to my studies of the birds of New Mexico.

Gray-cheeked Thrush (*Catharus minimus minimus.*)—An adult female (USNM 564,789) was collected on the Ed Sheets Ranch, about 3 miles southwest of Clayton, Union County, on 13 May 1971. The bird weighed 35 g and had moderate fat deposits and a granular ovary measuring 4 × 6 mm. There are several published sight records of this thrush for eastern New Mexico (Hubbard, 1970. Check-list of the birds of New Mexico, New Mexico Ornithol. Soc. Publ., 3:67), but in view of similarities of this species to certain Swainson's Thrushes (*Catharus ustulatus*), such reports should continue to be regarded with question.

Veery (*Catharus fuscescens salicicola*).—An adult male (DMNH 12,255) was collected on the Sheets Ranch (see above) on 13 May 1971. It weighed 37.5 g and had heavy fat deposits and testes measuring 8 × 6 mm. Four other Veeries were banded by me at the ranch in May 1971 and five in May 1972. There are a few sight records of this thrush from New Mexico, including two questionable summer records obtained early in this century (Hubbard, op. cit.: 67–68).

White-eyed Vireo (*Vireo griseus noveboracensis*).—An adult male (DMNH 25,220) was collected 2 miles west of Hermanas, in southern Luna County, on 24 May 1972. The bird had no fat and had testes measuring 6 × 4 mm. The only other record attributed to New Mexico is a specimen collected by T. C. Henry in the last century, but as he did not mention taking the bird there (Proc. Acad. Nat. Sci. Philadelphia, 7:306–317, 1855; Ibid., 11:104–109, 1859), the validity of the record is questionable.

Yellow-throated Vireo (*Vireo flavifrons*).—An adult female (DMNH 22,097) was taken at the Hermanas locality (see above) on 25 May 1972. The bird weighed 16 g and had no fat, while the ovary was granular and measured 8 × 4 mm. There are only two other reports for the state, both sight records (Hubbard, op cit., 73).—John P. Hubbard, *Delaware Museum of Natural History, Greenville, Delaware, 19807, 13 November 1972.*

Wing-flashing in the Black-and-white Fantail (*Rhipidura leucophrys*).—During observations in Kenya in 1961, I reported (Monroe, Auk, 81:91–92, 1964) wing-flashing in the turdine *Erythropygia zambesiana*; this behavior appeared in all respects identical or closely similar to that of the Mockingbird (*Mimus polyglottos*). I know of no other report of mimid-type wing-flashing in a non-mimid.

While in Australia recently, I observed wing-flashing in the Black-and-white Fantail, or "Willie Wagtail" (*Rhipidura leucophrys*), an Old World flycatcher (Muscicapinae of the Muscicapidae). On 1 August 1972 in a park on the outskirts of Adelaide, South Australia, I watched three individual fantails wing-flashing for about ten minutes. This species feeds primarily on the ground, with foraging accompanied by the exaggerated tail-wagging associated with the species. The wing-flashing in all cases noted (some 35 individual observations among the three birds) appeared identical to that of the Mockingbird. Upon alighting, the individual fantail would immediately execute the wing-flashing behavior; in each instance it was accomplished with a single "hitch," a momentary pause close to the body as the wings were extended. Following the pause, the wings were then rapidly and fully extended in the usual slanting plane of about 45° to 60° with reference to the horizontal. The entire pattern involved about one second and was accomplished with the tail cocked about 30° to 45° to the horizontal; there was no noticeable lateral movement of the tail during flashing, but the individual would often tail-wag vigorously immediately following the flash. The behavior appeared entirely homologous to that of the mimids as well as that I observed in the African *Erythropygia.* Although there is no white in the wings of *R. leucophrys*, the inner webs of the primaries are pale gray, resulting in full sunlight in a noticeable flash as the wings are extended.

On 13 August 1972 I noted another individual fantail wing-flashing in a park in Brisbane, Queensland. This individual, also performing in open sunlight, flashed three times in about one minute of observation, but in this instance no hitch or pause was noted; in other respects, the procedure was closely similar to that of the birds in Adelaide.

During my three weeks in Australia spanning the period of the above observations, I noted more than 250 individuals of this species. The wing-flashing behavior was not otherwise observed, although I watched specifically for it. The behavior does, however, appear to be widespread among the passerine groups of this complex (muscicapid-mimid), geographically as well as taxonomically.—Burt L. Monroe, Jr., *Department of Biology, University of Louisville, Louisville, Kentucky 40208, 30 October 1972.*

The occurrence of unusually small eggs in three species of songbirds.—Unusually small or runt eggs, variously called dwarf, cock, wind, or witch eggs, are extremely rare, occurring in the chicken (*G. gallus*), for example, at a frequency of only 0.05 to 0.09 percent (Romanoff and Romanoff, The avian egg, John Wiley and Sons, New York, 1949:258). Reports on the occurrence of such eggs in nature are very few. I here report the occurrence of unusually small eggs in three species of passerines, along with some data on the frequency of such eggs.

On 1 May 1971, I found a dwarf egg in a Common Grackle (*Quiscalus quiscula*) nest in a colony in Prince Georges Co., Maryland. The nest also contained three nestlings, four to five days old. The egg (Fig. 1) measured 18.75 × 13.70 mm as compared with 28.53 × 20.89 and 25.65 × 20.57 mm given by Bent (Life histories of North American blackbirds, orioles, tanagers and allies, Dover Publications, New York, 1965:378) as the average and smallest measurements, respectively, for this type of grackle. The egg contents were

FIG. 1. Normal and unusually small eggs of three species. The three eggs in the left half of the top row are from the Common Grackle, those in the right half of the top row are from the Red-winged Blackbird and all four eggs in the bottom row are from the Catbird.

completely dried out. Using the standard formulas for volume given by Romanoff and Romanoff (op. cit.:108), this egg is only about 28 percent as large as the average egg cited by Bent. During 1971 I examined, in four colonies, a total of 96 grackle nests containing a minimum of 356 eggs. In 1972 I examined, in seven colonies, 211 nests containing at least 921 eggs (the colonies were in Prince Georges, Anne Arundel and Queen Annes Counties, Maryland). The dwarf egg described above was the only one found, giving a rate of occurrence of one in 1,277 or 0.08 percent. I have also examined the entire collection of approximately 560 Common Grackle eggs in the United States National Museum. Three additional dwarf eggs were found. These measured 15.91 × 13.96, 17.54 × 16.32 and 22.00 × 17.78 mm; the first egg was the only representative of its clutch while the latter two were accompanied by normal sized eggs. The high frequency of dwarf eggs, three in about 560 or 0.54 percent, in the museum series relative to the frequency in the eggs I studied in Maryland is possibly due to a preference oologists may have had for incorporating such oddities into their collections. I was able to detect the dwarf eggs in the museum series with great ease since they were well below the size distribution shown by the other eggs. Perhaps this criterion is a reasonable one for a definition of dwarf eggs, i.e. eggs whose extremely small size results in either a bimodal distribution for all eggs or even a discontinuous frequency distribution as relates to the sizes of all other eggs. This definition has the advantage of removing all arbitrary criteria and stresses the fact that dwarf eggs are a distinct phenomenon.

On 2 July 1971, on Grand Manan, New Brunswick, I found a dwarf egg in a Red-winged Blackbird (*Agelaius phoeniceus*) nest which also contained two young about eight days old. The egg (Fig. 1), which measured 17.39 × 13.74 mm, was partially dried out, and showed no evidence of embryonic development. It did contain yolk though, which is often missing from dwarf chicken eggs (Romanoff and Romanoff, op. cit.:295). Bent (op. cit.:133) gives 24.80 × 17.55 mm as the average egg dimensions for this species and 20.57 × 15.75 mm for the smallest egg in his sample. Since this Redwing nest, the only one I found on Grand Manan, contained an anomaly that is generally exceedingly rare, it is possible that dwarf eggs occur at a relatively high rate among Redwings on Grand Manan. An examination of the approximately 1,100 Redwing eggs at the United States National Museum yielded two additional dwarf eggs, measuring 14.19 × 12.59 and 17.20 × 13.60 mm (the latter egg was with a normal sized egg from the same clutch, the former egg was by itself) for a frequency of 0.18 percent. Like the dwarf Grackle eggs, these Redwing eggs were well below the size range of the other eggs.

The young in the Grackle and Redwing nests described above appeared to be normal so it is likely that the rest of the clutch was typical in size. However, all four eggs laid by a Catbird (*Dumetella carolinensis*) between 13 and 16 June 1967, in New Haven County, Connecticut, were abnormally small, although possibly not small enough to qualify as true dwarfs. The two that I measured (Fig. 1) were 20.47 × 15.15 and 19.55 × 15.18 mm as compared with a mean of 23.3 × 17.5 and minima of 21.3 × 15.8 mm given by Bent (Life histories of North American nuthatches, wrens, thrashers and their allies, Dover Publications, New York, 1964:324). Besides its unusually small eggs this nest had several other possibly interrelated aberrant features (see Rothstein, An experimental investigation of the defenses of the hosts of the parasitic Brown-headed Cowbird (*Molothrus ater*), Unpubl. Ph.D. Thesis, Yale University, 1970). In addition to the above mentioned nests, I have in the past seven years sampled approximately 1500 nests of some 35 songbird species with no other dwarf eggs being found.

A critical evolutionary question concerning any abnormality, especially such a maladaptive one as dwarf eggs, relates to the manner in which the feature is maintained. Dwarf eggs seem to be caused by temporary disturbances, accidents or infections in the oviduct and apparently do not have a genetic basis (Romanoff and Romanoff, op. cit.: 260–261), thus selection does not act against the genotype of the rare individual that lays a dwarf egg and cannot completely exclude the appearance of such anomalies. However, selection has undoubtedly acted upon the genetically determined aspects of egg laying so as to virtually exclude the appearance of dwarf eggs.

I thank Eugene S. Morton for his comments on this paper. The nests cited above were found during the course of field work supported by The Frank M. Chapman Memorial Fund, Sigma Xi, Yale University and the Smithsonian Institution.—Stephen I. Rothstein, *Department of Biological Sciences, University of California, Santa Barbara, California 93106, 11 September 1972.*

Physical combat in the Brown-headed Cowbird.—The Brown-headed Cowbird (*Molothrus ater*) is a highly gregarious species, and, although it is territorial during the breeding season (Friedmann, The cowbirds, C. C. Thomas, Baltimore, 1929), intraspecific aggression is rare, apparently being restricted to brief clashes and chases during "communal courting parties" (Nice, Studies in the life history of the Song Sparrow, Trans. Linnaean Soc. New York, 1937). Battles of any intensity are apparently unknown.

About 13:30 on 18 April 1972 I was walking in Schenley Park in Pittsburgh, Pennsylvania and paused to observe a lone male cowbird about twenty feet above the ground singing from the branch of a sugar maple (*Acer saccharum*). Another male suddenly approached the singing bird and, without pausing, attacked it. The two birds fell to the ground together and proceeded to roll over and over for a period of three minutes and fifteen seconds. They were not separated from each other at any time during this period, although they did occasionally lie still (resting?) for periods of five to ten seconds. When they finally broke apart, one flew to a nearby tree, and was immediately attacked by the other. A chase ensued and the combatants flew out of sight to the south.

The motives which may have caused this altercation are not immediately apparent. The early date and the fact that territorial defence, if present, is restricted to an intimidation display (Friedmann, op. cit.) suggests that the conflict was due to some factor other than territoriality. Competition for nest sites is unlikely, since it is the female of the species that selects the nest in which her eggs are deposited (Bent, Life histories of North American blackbirds, orioles, tanagers and allies, U.S. Natl. Mus. Bull. 211, 1958). However, competition for, or protection of a female is possible, since some cowbirds do have apparent monogamous relationships (Friedmann, op. cit.).

The uncommon tendency towards actual physical fighting is likely due to the fact that the cowbird has evolved a complex series of displays and postures (Laskey, Wilson Bull., 62:157–174, 1950) which would ordinarily serve to fulfill the function of actual combat. Thus, when fighting does occur, it may be because the individual has either not correctly interpreted an opponent's display, or its sexual (aggressive) drives are too strong to be fulfilled by a display. If this is in fact so, then an encounter of the duration and intensity described above becomes all the more unusual.

I wish to thank Dr. Jon C. Barlow for reading the manuscript.—Peter L. McLaren, *Royal Ontario Museum and Department of Zoology, University of Toronto, Toronto, Ontario, 23 October 1972.*

Bronzed Cowbird extends range into the Texas Big Bend country.—The Bronzed Cowbird (*Tangavius aeneus*) has been a local summer resident in Big Bend National Park, Brewster County, Texas, only since 1969 when David Easterla (pers. comm.) observed four males and two females (one male was courting two females) in the Rio Grande Village Campground (1850 ft elev.) on 9 June 1969. I had not recorded the species on weekly visits there since August 1966. No further evidence of breeding was detected and birds were last seen on 4 July.

The Bronzed Cowbird next was recorded in the park, at Rio Grande Village, on 8 June 1970. At least six males and four females frequented the campground area until 3 July. On 12 July I found a Hooded Oriole (*Icterus cucullatus*) nest, hanging on a tamarisk, containing two juvenile Bronzed Cowbirds. One nestling was collected, and on 18 July the nest was empty and a juvenile Bronzed Cowbird was found 55 feet away being fed by both adult Hooded Orioles. And on 28 July I discovered another juvenile Bronzed Cowbird at an Orchard Oriole (*I. spurius*) nest, and watched a juvenile cowbird being fed by an adult female Orchard Oriole there on 30 July. In 1970, Pansy Espy (pers. comm.) recorded the Bronzed Cowbird in the Davis Mountains, Jeff Davis County on 23 June.

In 1971 an adult male Bronzed Cowbird appeared at Panther Junction (3800 ft elev.) on 22 May and remained until 29 May when it was banded and released. I found four male and four female Bronzed Cowbirds at Rio Grande Village Campground on 29 May, and at least a few of these individuals remained through 13 July. Also in 1971, at least one male cowbird was present from 5 June through 10 July at Cottonwood Campground, 80 miles up river from Rio Grande Village. On 27 June I found a juvenile Bronzed Cowbird begging from a female Summer Tanager (*Piranga rubra*), and on 4 August a juvenile cowbird begging from an Orchard Oriole at Rio Grande Village Campground.

These data suggest the Bronzed Cowbird is increasing its range westward in Texas. Wolfe (Check-list of the birds of Texas, 1956) considered it as resident only within the lower Rio Grande Valley, and "rarely north as far as Bexar County." However, Webster (Audubon Field Notes, 16:493, 1962) reported that the Bronzed Cowbird is "now regular in small numbers" in San Antonio, Bexar County.

Webster (Audubon Field Notes, 14:466–467, 1960) also reported that "A Bronzed Cowbird in juvenal plumage, fully grown, was collected by Selander southeast of the Austin city limits (Travis County) in July, climaxing several recent reported observations from that area. This marks a northward range extension of this species in central Texas. Expansion is occurring also in the west. Kincaid, who has observed birds in Uvalde County since 1927 (mostly between 1937 and 1939), saw his first Bronzed Cowbird there on May 17, 1960. They appeared well distributed in Uvalde County, on May 25, and were present at Fort Clark (Kinney County) on June 8 (EBK)."

Francis Williams (pers. comm.) reported that C. C. Wiedenfeld found Bronzed Cowbirds at San Angelo, Tom Green County, Texas in May and June 1972; Wiedenfeld observed a juvenal cowbird being fed by a male Cardinal (*Cardinalis cardinalis*) there on 18 May.—Roland H. Wauer, *Natural Science, National Park Service, Southwest Region, Box 728, Santa Fe, N.M. 87501, 9 October 1972.*

Further notes on Rosy Finches wintering in Utah.—Three kinds of Rosy Finches occur in winter in northern Utah, namely two races of the Gray-crowned Rosy Finch, *Leucosticte tephrocotis tephrocotis* and *L. t. littoralis*, which are distinguishable in the field on the basis of the color of the cheek patch, and the Black Rosy Finch (*L. atrata*). Probably some representatives of the black species are altitudinal migrants since the species breeds in the nearby Wasatch Mountains east of Salt Lake City as well as in the Uinta Mountains of northeastern Utah (French, Condor, 61:18–29, 1959). The Gray-crowned representatives are all migrants from the north or northwest. King and Wales (Condor, 66:24, 1964) state that the three kinds appear to arrive and depart concurrently, most arriving within a span of three weeks in late October and early November and leaving during the last two weeks of March. Their evidence suggested a relatively precise annual regularity of migration, particularly in spring. However, dates of observation of Rosy Finches in Salt Lake Valley extend beyond these intervals. The earliest date on which they have been observed is 20 September while the latest date of occurrence is 20 April.

In the middle of winter, during daytime hours, Rosy Finches commonly frequent areas of sagebrush or scrub oak, on the benchlands and foothills foraging in snow-free sites where ground litter and food items are exposed. Flocks observed by the writer consist either of *L. atrata* exclusively or of *L. tephrocotis*. When the latter is the case, representatives of both races occur side by side. Whether some diurnal flocks are made up of both species and hence all three kinds, has not been ascertained, but all three kinds definitely intermingle at their roosting sites. For these they commonly seek warmer areas sheltered from the wind such as cave entrances, strings of standing railroad cars, sheds, and buildings (French, Auk, 76:173–175, 1959 and U.S. Natl. Mus. Bull., 237, pt. 1:

365–372, 1968 = Bent Series). Killpack (Audubon Field Notes, 12:298, 1958) found a flock of 500 Black Rosy Finches using the full depth of a 50-foot-deep well at Roosevelt in northeastern Utah. He also stated that they utilize Cliff Swallow nests to roost in, a feature reported by several others. The two most significant winter roosting sites in Salt Lake Valley have in years past been the outbuildings of the Hercules Company installation at Bacchus and the resort of Saltair on the southeastern shore of Great Salt Lake.

At these two sites several observations have been made on the relative proportions of the three kinds. Behle (Condor, 46:207–208, 1944) found in a sample of 48 birds captured at Bacchus in 1942–43 that 20 were *L. atrata*, 17 were *L. t. tephrocotis* and 11 were *L. t. littoralis*. French (Auk, 76:174, 1959) found 30 *L. atrata*, 3 *L. t. tephrocotis* and 16 *L. t. littoralis* making up the complement of 49 recaptured birds that he had banded earlier at Saltair. King and Wales (op. cit.:26) on the basis of data collected during nine intervals at Saltair extending from January 20–31 through 21–31 December 1960 and 1–10 February 1961, showed that the proportions of the three taxa vary within a single year as well as from year to year. The changes were particularly evident for the Black Rosy Finch which they therefore concluded was the most mobile constituent of the three kinds. The population changes observed from time to time were correlated with weather conditions. One additional random sample obtained at Saltair during the evening of 1 February 1966, showed seven *L. atrata*, 14 *L. t. tephrocotis*, and five *L. t. littoralis*. Incidentally the resort of Saltair burned to the ground on 12 November 1970. House Finches as well as Rosy Finches used to roost there extensively.

Some additional data on banded birds have now been obtained. A female Black Rosy Finch obtained on 4 February 1966 at Saltair carried a band (No. 291–55489) that had been applied at the same location on 31 December 1960 by James King during the course of his studies on photoperiod regulation and fat deposition of Rosy Finches (see King and Wales, Condor, 66:24–31, 1964 and Physiol. Zool., 38:49–68, 1965). Dr. King wrote me about another banded bird, a specimen of *L. t. littoralis* banded at Saltair on 25 November 1955 by French which was trapped and released on 25 January 1960. French (Auk, 76:174, 1959) cited another case where a banded bird returned to the same roosting site at Saltair but the interval was only 13 months in contrast to almost five years in the other two instances.

A noteworthy specimen is a male taken at Bacchus by Michael Hess during the night of 3 March 1968. It has rough, horny, protruding growths at the bases of both upper and lower bill that are similar in appearance to lesions in doves caused by fowl pox (see Kossack and Hanson, Amer. Vet. Med. Assoc. J., 124:199–201, 1954). Otherwise it seems to be a normal bird. It weighed 22.9 g, had a slight amount of fat and its testes measured 1 × 1 mm.

Another remarkable example of a Rosy Finch, not obtained inadvertently at night as the others were, but rather which was taken from a daytime flock, is a partial albino male taken by Kenneth Myrick, five miles north of Dutch John, Dagget County, northeastern Utah on 16 December 1968. It was in a small flock of 35–40 birds feeding on the ground. A normally pigmented specimen taken from the same flock at the same time is an example of *L. atrata*, so presumably the albino represents the same species. It was Myrick's impression that all the birds in the flock were Black Rosy Finches. The albino specimen weighed 25.7 g. Its testes measured 2 × 1.5 mm. Its bill was yellow which is the normal winter color for the species, but seemingly a brighter yellow than usual. This color has persisted to date in the specimen. The eye color was a normal brown. The feet and legs were slightly tinged with yellow but have since bleached to white. The body plumage is essentially all white but there is a prominent wash of strawberry red on the forehead and crown. A faint tinge of red appears on the throat, with an even lesser amount on the rump and bend of wing areas. The outermost primary on each wing is all white but the next six primaries in sequence show on each wing a narrow, delicate line of pink along their exterior margins.

Our series of wintering Rosy Finches show considerable color variation which is probably a manifestation in large part of geographic variation, since various representatives doubtless came from widely situated breeding areas. Three examples seem worthy of comment. Two males taken by the late Gary Lloyd at Echo Canyon, 6000 feet elevation, Summit County, Utah on 19 March 1964, seemed different from the other wintering example of *L. t. tephrocotis* and so were submitted for identification to Richard E. Johnson, who is revising the group. He reported that they possess characters which are the same as those of the breeding population of *L. t. tephrocotis* from Montana rather than the northern Alaska population which all our others represent. Another example examined by Johnson which was taken on 23 March 1938 at Bacchus is a hybrid between *L. atrata* and *L. tephrocotis*, being slightly closest to *atrata.* French (Condor, 61:18–27, 1959) found two areas where hybridization occurs and as a consequence individuals show mixed characters of *L. atrata* and *L. t. tephrocotis.* These areas are the Bitterroot mountains of the Montana-Idaho border and the Seven Devils Mountains of western Idaho. Presumably this winter example originated in one of these two areas.—William H. Behle, *Department of Biology, University of Utah, Salt Lake City, Utah 84112, 16 October 1972.*

Leaf bathing in three species of emberizines.—During the dry summers of coastal California, when water may be locally scarce, the use for bathing of moisture collected on vegetation may be an important aspect of feather maintenance. Sources of water at these times can be from dew, condensed fog, or water drops from a garden sprinkler. There appear to be few observations on record of this method of bathing. The present note describes my observations on leaf bathing in three species of emberizines.

In Strawberry Canyon, Berkeley, California, at 09:41, on 24 May 1971, I observed a Rufous-crowned Sparrow (*Aimophila ruficeps*) bathing on leaves of a eucalyptus about five feet in height. The leaves of the tree were covered with water droplets from a sprinkler which had been on earlier that morning. The sparrow would bend forward, touching the wet leaves with the breast and belly, and flutter the wings rapidly. It continued this behavior for about three minutes, at which time its body feathers appeared quite soaked. The crown seemed to have remained dry. The bird then flew to the ground beneath the eucalyptus, ruffled its feathers, preened, and scratched its head. The sparrow remained squatting on a sunny spot on the ground with the feet hidden by its feathers which were fluffed in such a way as to make it look dorsoventrally compressed. It stayed in this position for some 13 minutes. The wings during this time were constantly flicking out and in, its head constantly was turning as it continually looked around. All this was interspersed with short bouts of preening. At 09:57 a bus was driven by, scaring the bird away. The sparrow now appeared quite dry. I have often observed captive White-crowned Sparrows (*Zonotrichia leucophrys*) after a bath, resting in a flattened posture similar to that described above for the Rufous-crowned Sparrow. The posture adopted after a bath in water is quite different from that during sun-bathing when the feathers of the back and rump are ruffled so as to expose the apteria. The head does not turn constantly about, but is held quite still. The open bill points skyward at an angle of about 45 degrees while the wings droop and the tail is spread.

At 13:45 on 12 August 1971, two juvenile Oregon Juncos (*Junco oreganus*) with spotted breasts were observed being fed by an adult male (sex by plumage) on a lawn on the campus of the University of California, Berkeley. The grass had recently been watered, so that water drops clung to the blades. I observed the adult feeding one juvenile twice and the other once. Between bouts of being fed by the adult the juveniles were apparently feeding themselves, pecking at the grass and kicking backwards with both feet. In between feeding bouts the two juveniles bathed on the wet foliage, dipping forward and fluttering their wings rapidly.

A White-crowned Sparrow was trapped in a residential area in Berkeley, California, on 1 May 1971. It was banded with a red color band for recognition and given the freedom of my home along with four other captive White-crowns. The sparrows were periodically given Romaine lettuce which I washed under a tap prior to feeding to the birds, so that water droplets often remained on the leaves. On several occasions Red was seen alternating bouts of feeding and of bathing on the lettuce leaves. The last time I observed lettuce-bathing by Red was on 30 October 1971. I continued to offer Romaine lettuce almost daily, and into the month of February, but could not induce further leaf-bathing behavior. On 20 February 1972, I placed a sprig of coyote bush (*Baccharis pilularis*) under a tap so that water droplets collected on the leaflets. With a clothes pin, I attached the plant on the outside of a cage in my birdroom, making it accessible to my free-flying White-crowns. Red approached, pecked at the moist greens several times, flew on to it, and then proceeded to go through bathing movements. On one occasion I saw Red bend forward, twist his head in such a way so as to expose the right side of his cheek and neck to the moist vegetation, then flutter his wings and push forward so as to deliberately anoint the cheek and neck with water. Between bathing movements, Red fluffed and shook his feathers, preened, and waggled his tail. This bout of leaf-bathing continued for about three minutes, after which the sparrow did not appear to be very wet. Miller (Condor, 44:232, 1942) similarly observed an adult Rufous-sided Towhee (*Pipilo erythrophthalmus*) leaf-bathing for approximately a minute after which "it was only slightly wet, but it had apparently satisfied an instinct at least."

Other field-observers have reported that the leaf-bathing activities of one species may attract other forms to do likewise (Officer, Aust. Bird Watcher, 1:236, 1962; Verbeek, Auk, 79:719, 1962). Whenever a pan of water was offered to my captive flock of White-crowns, the bathing activities of one individual would stimulate others to do likewise. This social facilitation would extend to the 50 other assorted fringillid and estrildid finches in my bird room which would then try to bathe in their drinking vessels or bird baths provided for them. Interestingly, I never observed the leaf-bathing activities of Red being imitated by any of the other birds in the room, suggesting that this was a habit peculiar to this one individual.

Dow (Bird-Banding, 39:227–229, 1968) reported leaf-bathing by Cardinals (*Richmondena cardinalis*) and pointed out that, "Foraging behavior usually preceded dew bathing, thus it is possible that contact with wet leaves during foraging stimulated the bathing." My observations on the two Juncos and the White-crowned Sparrow appear to lend support to Dow's conclusion.

These data were gathered incidental to studies on song dialects of the White-crowned Sparrow, supported by a grant from the Chapman Memorial Fund. I thank Ned K. Johnson who read the manuscript and offered helpful suggestions.—LUIS F. BAPTISTA, *Museum of Vertebrate Zoology and Department of Zoology, University of California, Berkeley, California 94720, 5 May 1972.*

Double-scratching and terrestrial locomotion in emberizines: some complications.—Harrison's (Wilson Bull., 79:22–27, 1967) review shows that some species of emberizine sparrows perform a "double-scratch" foraging movement in which the two feet are moved synchronously, and proposes that this behavioral trait is a useful taxonomic characteristic. He suggests that the possession of double-scratching behavior is correlated with hopping locomotion, as opposed to terrestrial locomotion in which the legs are moved separately (e.g., walking and running). In this contribution I add new data and discuss several aspects of Harrison's hypothesis.

Harrison "expected" that certain genera would show the double-scratch/hopping combination, and further contributions stimulated by his paper have already been published. For instance, Taylor (Wilson Bull., 82:465, 1970) reported that the Vesper Sparrow (*Pooecetes gramineus*) double-scratches, as expected by Harrison. However, Enders (Wilson Bull., 82:225, 1970) reported that the Seaside Sparrow (*Ammospiza maritima*) double-scratches, and described its locomotion on land as "walking"—contrary to the hopping expected by Harrison. I here add some further data of my own on double-scratching and locomotory behavior from 15 species of American emberizines. These data show that a strict interpretation of Harrison's hypothesis of correlation is inconsistent with the facts, and also reveal a number of complications about the behavioral patterns and attempts to correlate them.

During the period 1957–58 I made extensive observations on the behavior of emberizines, only some of which were published. In one report (Hailman, Bird-Banding, 29:241–244, 1958) I noted that the Ipswich Sparrow (*Passerculus princeps*) was always seen to run, never to hop. This is a genus that Harrison expected to hop rather than run. I have

Table 1

Double-Scratching and Terrestrial Locomotion Observed in Some American Emberizines

Species	Double-scratch	Locomotion	
		undisturbed movement	hostile chasing
Pipilo erythrophthalmus	X	H	—
Passerculus sandwichensis	X	W,R	R
P. princeps	—	W,R	R
Pooecetes gramineus	—	H/W	—
Amphispiza belli	X	—	—
Junco hyemalis	X	H/S,R	H/R
J. oreganus	—	—	R
Spizella arborea	—	H/R	R
S. passerina	—	H	—
Zonotrichia albicollis	X	H/W,R	H/R
Z. leucrophys	X	H	—
Z. capensis	—	H	—
Passerella iliaca	X	H	—
Melospiza georgiana	X	—	—
M. melodia	X	H/S,W,R	—

Key: H, hop; R, run; S, "skip"; W, walk; X, observed; synchronous leg movements separated from asynchronous ones by a slash (see text).

TABLE 2

DOUBLE-SCRATCHING OF EMBERIZINES REPORTED BY NICE (1937)

Pipilo erythrophthalmus
Passerculus sandwichensis
*Spizella arborea**
Zonotrichia querula
Z. leucophrys
Z. albicollis
Passerella iliaca
Melospiza lincolnii
M. melodia

* Double-scratching apparently absent in the congener *S. pusilla*.

summarized in Table 1 previously unpublished observations from my notebooks, which include not only data from my study in the late 50's, but incidental observations made in the intervening years.

The first data column of Table 1 indicates nine species I have seen double-scratching. Harrison laments that information on emberizine double-scratching is not available in the literature. Yet, in a well-known study not cited by Harrison, Margaret Nice (Trans. Linnaean Soc. New York, 4:42, 1937) reported nine species of American emberizines that double-scratch (see Table 2), adding that the behavior "does not seem to occur in the Field Sparrow" (*Spizella pusilla*). My list (Table 1) is remarkably similar to Nice's (Table 2).

The second data column of Table 1 summarizes notes made on locomotion in undisturbed birds moving over the ground, and includes the South American *Zonotrichia capensis*, observed in Ecuador. Emberizines use at least four discernable means of moving over the ground: *hopping* (denoted H), in which the two legs are moved synchronously; "*skipping*" (S), in which the legs are moved asynchronously, but not truly alternately; *walking* (W), in which the alternation is slow; and *running* (R), in which the alternation is rapid. Some species, such as the Song Sparrow (*Melospiza melodia*) can use any of the four methods. Nice (op. cit.:49) also reports hopping, walking, and running in the Song Sparrow.

The frequency of use of these different modes of terrestrial locomotion is not known quantitatively for any species, nor are the conditions that govern the type of locomotion employed clear. Nice (op. cit.: 49) states that "although adult Song Sparrows progress over the ground chiefly by hopping, they also walk to some extent, especially where the going is rough." On 24 July 1958 I noted that a Song Sparrow hopped on uneven surfaces and ran across even surfaces, which seems to be the opposite of Nice's experiences. On 25 April 1959 I noted that a White-throated Sparrow (*Zonotrichia albicollis*) ended a bout of fast hopping with a few single walking steps. It may thus be that both the substrate and speed of locomotion help to determine the gait employed.

The data in Table 1 on undisturbed locomotion do not bear out Harrison's correlation between double-scratching and hopping. Among the species seen as double-scratchers, four were seen to use the limbs asynchronously during undisturbed locomotion. The Tree Sparrow (*Spizella arborea*) runs, and is cited by Nice (Table 2) and Harrison (op. cit.) as double-scratching. Furthermore, the Vesper Sparrow, reported to double-scratch by

Taylor (op. cit.), walks as well as hops (Table 1). If we also add to this list Ender's (op. cit.) notes quoted above, at least seven species of double-scratchers are known to move over land by some means in which the legs are not moved together.

A point overlooked by Harrison when he described species as having "hopping locomotion" is that in hostile chasing emberizines appear often to run. This behavior was noted in my study of *Passerculus princeps* (Hailman, op. cit.), and previously unpublished observations of other species are shown here in the last column of Table 1. Harrison noted that "*Junco* spp." double-scratch, and this column adds evidence that *J. oreganus* moves its legs alternatively in at least one type of terrestrial locomotion.

There are, then, at least eight known species that do not fit a strict interpretation of Harrison's hypothesis. The hypothesis might be rephrased to state that double-scratchers hop, even if they use other terrestrial locomotory patterns as well. While I have not seen *Passerculus sandwichensis* hopping, Robbins et al. (Birds of North America, p. 308, 1966) state that it "runs and hops, rarely walks." Perhaps then all emberizines that double-scratch also hop as well as run or walk. However, Harrison notes that the Old World emberizines do *not* double-scratch, yet possess hopping *as well as* running and walking. The double-scratchers hop, run and walk and the "non-double-scratchers" also hop, run and walk.

Finally, a few further complications exist. A fifth form of terrestrial locomotion in emberizines is "*side-stepping*," which was described more than a decade ago (Hailman, Auk, 77:349–350, 1960) in a foraging Song Sparrow. I have only one other such observation in my notebooks: a Slate-colored Junco (*Junco hyemalis*) side-stepping along a tree-branch, which is not, of course, truly terrestrial locomotion. Another point to be reckoned with in attempting to correlate scratching and locomotion is raised by my field notes of 11 January 1959, in which the leg movements of a "double-scratching" Song Sparrow were noted as being somewhat asynchronous.

On the basis of this relatively scanty evidence it would be unwise to reject the notion of *any* correlation between scratching and locomotory patterns. We require evidence on more species, more detailed observations on the synchrony of leg movements in scratching of various species, an understanding of what contexts determine locomotory gaits, and special attention to kinds of behavior that *appear* to be lacking in certain species. Furthermore, there may already exist much more published evidence than cited by Harrison, as suggested by publications of Nice and me quoted above. The importance of the subject matter, however, transcends the taxonomic usefulness of these characters. This is an example of functional relationships among physical movements that may help to clarify anatomical substrates of as well as evolutionary processes in behavior, and is thus worthy of continued attention.

I am grateful to Edward H. Burtt, Jr. and my wife, Liz, for comments on the manuscript.—Jack P. Hailman, *Department of Zoology, University of Wisconsin, Madison, Wisconsin 53706, 17 November 1972.*

The Purple Finch nests in central Ohio.—Male Purple Finches (*Carpodacus purpureus*) were seen and heard regularly between early April and the middle of July of 1972 on the Ohio State University Golf Courses in Franklin County, Columbus, Ohio. At least four territories were held throughout the season in groves of scotch pine and spruce, which also contained honey locust, tulip poplar, ash, oak, and maple. The appearance of three young and an attendant female on 8 July and a similar family group on 18 July in two of these territories justify the inference that they nested.

Although the Purple Finch had been reported to nest only in Ohio's northern counties (Trautman and Trautman, Ohio Jour. Sci., 68:303, 1968) it nested at East Liverpool, Columbiana County, Ohio in 1954 (Laitsch, Redstart, 21:66, 1954) and in subsequent years. A review of the Nesting Season Editions of Audubon Field Notes and American Birds indicates that the species has been expanding its nesting range southward in both the Appalachian and the Middlewestern Prairie Regions. They "summered at Indiana, Pa." (Hall, Audubon Field Notes, 18:507, 1964). In 1967 Hall stated, "The Purple Finch continues to expand its summer range to lower elevations. The species was quite common throughout Crawford County, Pa." and "Near Youngstown, Ohio a total of 16 singing males were located during late May and June" (Hall, Audubon Field Notes, 21:567, 1967). In 1968 it was listed at East Liverpool, Ohio, and Indiana, Pennsylvania and "A nest found near Allison Park, Pa. gave Allegheny its first record" (Hall, Audubon Field Notes, 22:609, 1968). In 1970 Hall reported, that "Purple Finches remained all summer and probably nested in Indiana, Pa., a continuation of the southern trend in this species" (Hall, Audubon Field Notes, 24:684, 1970). In 1971 it was stated in American Birds that "Purple Finches were common all summer at Warren and at Indiana, Pa. They nested at P.N.R. (Powermill Nature Reserve), were reported from Fox Chapel in June and at Irvona, Pa." (Hall, Am. Birds, 25:859, 1971).

Similar reports of southward expansion of nesting by the Purple Finch in the Western Great Lakes Region and the Middlewestern Prairie Region which includes Columbus, Ohio, are also given in Audubon Field Notes. In 1964 "The first actual nesting record of the Purple Finch in the Detroit area was the nest found on May 23 in Clyde Township" (Green, Audubon Field Notes, 18:510, 1964). The sighting of a "very late" Purple Finch at Lake St. Marys, Ohio was reported in 1969 (Petersen, Audubon Field Notes, 23:666, 1969) and "Purple Finches lingered long in Mansfield, Richland Co., Ohio" (Petersen, Audubon Field Notes, 24:691, 1970). "A June 6 Purple Finch was the first June (1970) report ever from Berrien County, Michigan" (Soulen, Audubon Field Notes, 24:688, 1970). It was reported in 1971 that, "Purple Finches were more abundant and in a wider distribution than is typical for the N. Ohio area, but there was no definite evidence of nesting." (Kleen and Bush, Amer. Birds, 25:865, 1971).

In view of these reports this record of the Purple Finch nesting in central Ohio represents a substantial extension in the southern movement of its nesting range.—MAURICE L. GILTZ, *Department of Zoology, The Ohio State University, Columbus, Ohio 43210, 27 October 1972.*

THE PRESIDENT'S PAGE

Editor George Hall has suggested reinstitution of "The President's Page," a feature of some of the past volumes of The Wilson Bulletin. John Hubbard, who becomes Editor in 1974, has joined Dr. Hall in inviting me to contribute such a page, and I am happy to accept. The "Page" will not necessarily appear in every issue; its nature will vary, but I visualize it as a sort of "editorial" by the President rather than by the Editor.

There are three principal ornithological societies in North America: the American Ornithologists' Union (A.O.U.), the Wilson Ornithological Society (W.O.S.), and the Cooper Ornithological Society (C.O.S.). Each publishes a journal. The question is sometimes raised as to whether the existence of three journals (or even three organizations) can be justified. This is a valid question, and if there were no essential differences among the societies, there would *not* be any justification for the existence of three. The A.O.U. is unique in that it is the "official" professional society for ornithology in North America; if any "official" voice is needed, the A.O.U. provides it (such as the recently formed committee to advise the National Science Foundation on relative importance of the various bird collections in U.S. museums). The A.O.U.'s journal, The Auk, should reflect *everything* that is going on in ornithology. With a limited number of pages per year, however, The Auk can only be a sampler. I believe the other two journals should continue to publish a broad range of papers, but each should have an "angle" such that an author would think of a manuscript as especially appropriate for The Wilson Bulletin (or The Condor or American Birds or Bird-Banding or a state journal). The C.O.S. is still primarily a western organization, and during most of its history The Condor emphasized western North America, Middle America, and the Pacific. Although still the repository for many papers on this regional basis, The Condor now publishes many more with general or even eastern subject matter.

Although the W.O.S. had its origins in the midwest, only the oldest ornithologists still have any tendency to think of it as a midwestern organization. Its meetings have been held from the Colorado mountains to the coast of Maine, from Ontario to the Gulf coast of Alabama. The emphasis in The Wilson Bulletin, except in its earliest years, has not been regional. In W.O.S. Council discussions in recent years, the prevailing opinion has been that The Wilson Bulletin should emphasize the publication of *field-based* studies. This leaves plenty of scope for variety, but reduces the amount of space available for (although we continue to publish papers on) anatomy, experimental (i.e., lab-based) physiology, some kinds of systematics, synthetic and theoretical ecology based on other people's field work, etc. The W.O.S. has a higher proportion of non-professional ornithologists among its members than is true of the A.O.U. and C.O.S., and the kinds of contributions to ornithology most often made by non-professionals lie primarily in field-based studies. The term "non-professional," incidentally, is used here without any implications concerning relative competence. As editors in particular are aware, there are "non-professionals" among our best and most prolific ornithologists, and there are some real duds among the "professionals."

With respect to the contents of The Wilson Bulletin, George Hall has pointed out to me correctly that the professional or experienced non-professional is quite content if there are one or two good papers per issue that touch on his or her own field, and will generally read at least the abstracts of the rest of the papers. An interesting abstract often "hooks" the reader, stimulating the tackling of the entire paper even if it is in an unfamiliar field. On the other hand, some Wilson Society members, of less experience and less understanding of what a scientific journal is all about, feel cheated of dues money if *all* of the articles are not of immediate interest and comprehensibility. I have consistently maintained in Council discussions that the W.O.S. cannot cater to this group. There is a "Birding" magazine for people who are interested in nothing more than that. The serious amateur should expect to use The Wilson Bulletin as a means of *learning* what is going on in the study of birds outside of his or her own immediate interest. To that end, the Editor and the editorial board are mandated to see to it that all papers published in The Wilson Bulletin are well written and readable without diminishing in any way their scientific merit.

Kenneth C. Parkes

ORNITHOLOGICAL NEWS

The A.O.U. Committee on Classification and Nomenclature has recently published The Thirty-second Supplement to the American Ornithologists' Union Check-list of North American Birds (Auk, 90:411–419, 1973). Beginning with the December issue the names of birds used in papers in *The Bulletin* should conform to this new list.

Members will notice the long list of Resolutions voted at the Annual Meeting. This shows an encouraging awareness on the part of the membership in current conservation problems. As mentioned earlier on this page (85:88, 1973) all too often this opportunity for the Society to take a stand is lost. It is hoped that even more problems will come to the attention of the Committee on Resolutions in 1974.

The frontispiece to this issue shows, and a paper in the "General Notes" section discusses an exotic form which has apparently become established in some parts of the East. It seems likely that most people at inland locations or otherwise distant from the places involved have little idea of the magnitude of the imported bird industry in this country, and of the number of exotic species that, at least temporarily, have established themselves. The December issue will feature a three-part invited symposium on the exotic avifauna of three key areas in the United States.

Olin Sewall Pettingill, Jr. has retired as director of the Cornell Laboratory of Ornithology, being succeeded by Douglas A. Lancaster. Our understanding is that retirement will mean little change in former President Pettingill's active schedule.

A recent study carried out by Joseph J. Hickey, President of the A.O.U. has shown that the membership in the three major American Ornithological Societies has remained constant for a number of years. In the face of increasing population, and increasing interest in nature in general and birds in particular such a result is difficult to understand. At the recent meeting the members of the Executive Council resisted the temptation to raise dues in the face of rising costs, but all agreed that one way out of this dilemma was an increased membership. It would seem reasonable that almost every member of the Society would know at least one person whom he might nominate for membership in the Society, and so it is earnestly hoped that all members will make use of the nomination forms enclosed in the front of this issue of *The Bulletin.*

ORNITHOLOGICAL LITERATURE

The Birds of the Republic of Panamá. By Alexander Wetmore. Smithsonian Institution Press, Washington, D.C., 1965: Part I: Tinamidae (Tinamous) to Rhynchopidae (Skimmers). Smithsonian Misc. Coll. Vol. 150, part 1. 6⅛ × 9¼ in., 483 pp., 1 col. pl., 73 figs. Paperbound $6.00, clothbound $12.50; 1968: Part II: Columbidae (Pigeons) to Picidae (Woodpeckers). Smithsonian Misc. Coll. Vol. 150, part 2. 6⅛ × 9¼ in., 605 pp., 1 col. pl., 75 figs. Clothbound $15.00; 1972: Part III: Dendrocolaptidae (Woodhewers) to Oxyruncidae (Sharpbill). Smithsonian Misc. Coll. Vol. 150, part 3. 6⅛ × 9¼ in., 1 col. pl., 48 figs. Clothbound $15.00.

This large-scale and ambitious publication represents the culmination of Dr. Wetmore's many years of field work in Panama, begun in 1944 and carried out for several months each year from 1946 through the mid-sixties. The first three volumes comprise detailed species accounts, with only perfunctory introductory material and no maps of the country. The contemplated final volume (four) is meant to finish the passerines and to provide a gazetteer, the main discussion of the avifauna, a review of ornithological studies (including Wetmore's field work), a complete bibliography, and, hopefully, one or more maps.

The published volumes dwell largely on taxonomy and distribution, although there is considerable information on natural history as well. For each family there is a brief introduction, generally covering range and number of species in the world and in Panama, something of habits, and other commentary, including taxonomic. For families with several species in Panama there is a key, usually based on specimens in the hand but also applicable in the field to some groups. For each species there is a general heading and discussion; for those which are polytypic in Panama there are additionally individual subspecies headings and discussions. Covered overall in each species account are the scientific, English, and Spanish names, literature citations for the accepted taxonomic names, descriptions, measurements, status in Panama, observational information, and oological data. For subspecies there are statements on comparative characters by which they are distinguished, specific measurements, records, and other data applying to that race. In some cases natural history information is broken down by subspecies within a species. I suppose this is the most accurate way to signal possible differences between populations, but it consumes more space and scatters the information. Additional space is taken up by rather drawn out accountings of specimens, collectors, and other data, a luxury that could have been decreased with some abbreviating and tightening.

Part I treats 202 species and 247 subspecies as definitely occurring in Panama, but of these 19 and 22, respectively, appear not to have been actually collected there. The uncollected species include all three phalaropes, two of three albatrosses, and three of four in the skua-jaeger group. Not included above are four additional hypothetical species and three introduced species (i.e. *Phasianus colchicus*, *Colinus virginianus*, *Numida meleagris*). I fail to discern how the line is drawn between species that are uncollected and those that are hypothetical, and the point is not explained in the volume. For example, *Laterallus jamaicensis* is considered hypothetical, yet it was reportedly seen by several people, its voice taped, and a set of eggs collected in Panama. *Phalacrocorax bougainvillii* is also called hypothetical, although the sight record of it by Robert Cushman Murphy seems no less valid than the evidence for accepting such species as *Diomedea irrorata*, *Pterodroma phaeopygia*, *Oceanites gracilis*, *Larus modestus*, and *Creagus furcatus*. *Ictinia misisippiensis* and *Pardirallus maculatus* are the other hypothetical species in this volume.

The 206 non-introduced species in Part I fall in 10 orders and 35 families, of which the largest of the latter are the Accipitridae (37 species/44 subspecies) and Scolopacidae (24/26). Interestingly, Phoenicopteridae and Burhinidae appear not to have been recorded in Panama.

In Part II, 208 species and 262 subspecies are accepted (and all collected) from Panama. These are assigned to 9 orders and 18 families. Not included in the above total is the unsuccessfully introduced *Streptopelia risoria*, two species recorded in Panama from questionable specimens (*Zenaidura auriculata*, *Forpus passerinus*), and two vaguely ascribed to the country in the literature (*Coccyzus lansbergi*, *Celeus immaculatus*). The largest family in this volume is the Trochilidae (54 species/69 subspecies), followed distantly by Columbidae, Psittacidae, and Picidae with around twenty species each. Interestingly, the Oilbird is known from the country only on the basis of one recently-taken specimen.

In Part III, I count 197 species (not 196 as stated there) and 292 subspecies accepted as occurring in Panama; of these all but *Pyrocephalus rubinus* appear to have been collected there. Another species, *Contopus ochraceus*, is listed as hypothetical, based on a questionable specimen and a possible sight record. The species are assigned to eight suboscine families, the largest of which is the Tyrannidae (88 species/117 subspecies). Included in that family are several genera often considered as members of the Cotingidae (i.e. *Attila*, *Laniocera*, *Lipaugus*, *Rhytipterna*), based on the work of Ames (Peabody Mus. Nat. Hist. Bull. 37, 1971) and S. L. Warter (unpubl.). This is the only volume in which a new form is described, that being the manakin *Schiffornis turdinus acrolophites* (p. 357).

In general Dr. Wetmore is conservative in his taxonomic approach, although as the examples above suggest, he is not close-minded on the subject. In most cases he chooses to keep as species those entities that are morphologically distinct, and this includes *Empidonax alnorum* as separate from *E. traillii.* Many admittedly minor subspecies are also recognized, although in a departure from the A.O.U. Check-list of 1957 he considers *Anas acuta* and *Ceryle alcyon* as monotypic. Another change is the lumping of all Caribbean and Middle American jacanas (except those of northwestern Mexico) into one race, instead of three as accepted in the past. These he calls *Jacana spinosa spinosa*, which he considers distinct from *J. jacana* of South America and adjacent Panama. Besides retaining a broad version of the Apodiformes, Wetmore also continues to recognize some families that have been merged recently by others, including the Cochlearidae, Phalaropodidae, and Stercorariidae, along with a number of sometimes lumped genera, including *Mareca*, *Spatula*, *Squatarola*, *Totanus*, *Erolia*, *Ereunetes*, *Thalasseus*, and *Nuttallornis.* On the other hand, he transfers *Aphriza* and *Arenaria* to the Scolopacidae and merges *Leucophoyx* (but not *Casmerodius*, etc.) into *Egretta*, *Caracara cheriway* into *C. plancus*, *Columbigallina* (but not *Claravis*) into *Columbina*, and *Phloeoceastes* into *Campephilus*, further evidence of a degree of taxonomic openmindedness. Overall, I find Dr. Wetmore's generally consistent approach preferable to wholesale lumping, especially of allopatric taxa, which would be especially questionable in poorly known tropical birds—particularly in view of transgressions that have been committed among better-known temperate zone forms, e.g. *Otus scops*.-*O. flammeolus.*

Each volume is illustrated by a color frontispiece and line drawings by Walter Weber. The plate in Part I is of the endemic wood quail, *Odontophorus dialeucos*; that in Part II, the rare (in Panama) woodpecker *Chrysoptilus punctigula*; and that in Part III the little-known antbird *Xenoris setifrons.* The line drawings show all or parts of just under

200 species of Panamanian birds, or about 30 percent of the here treated avifauna. While realizing that this is not intended as a field guide, it is unfortunate that the drawings were not confined to less familiar species as an aid to identification. Such species as the Pied-billed Grebe, Marsh Hawk, Mourning Dove, Black-billed Cuckoo, and Great Crested Flycatchers are among those illustrated that could have been traded in for more exotic ones. In the Threskiornithidae (Part I) both the White Ibis and the Roseate Spoonbill are figured, whereas *Mesembrinibis cayennensis* and perhaps *Theristicus caudatus* would have been more appropriately shown, in my opinion. In several instances the drawings have been used to full potential, e.g. in Part I to show the three tiger-bitterns and two jacanas, and in Part III to show two distinctive races of the manakin *Corapipo altera.* The quality of the drawings is variable, but most seem satisfactory. There are some flaws, including figure 23 in Part II (p. 156), showing the foot of *Otus clarkii,* that looks quite anisodactyl. The bird in Figure 67, Part I (p. 403), is actually *Tringa solitaria,* not *Actitis macularia.*

I regret the lack of maps in these three volumes, and wish that it would be rectified by the Smithsonian Press. I suggest that a one- or two-page basic map be made available that can be glued to the inside cover of each volume. This would make each more self-contained (as they are now by being individually indexed) and avoid the inconvenience of having to go to Part IV for all mapped information. The maps could be obtainable by writing the publisher, and Part IV could have a complete set issued with it for the first three volumes.

The reader will note that Part I is available paperbound ($6.00) or clothbound ($12.50), while subsequent parts come only in cloth ($15.00 each). The increase in price of the clothbound volumes between 1965 and 1972 is expected, based on inflation, and the differential between paper and cloth covers in Part I can also be appreciated. What is less understandable is the Smithsonian Press's decision not to continue to offer the choice between paper and cloth covers in subsequent volumes—especially in view of the precedent set by Part I. At any rate, because of changes in Smithsonian publication policies (too intricate to go into here), cloth binding is now standard for this work. As a result, part of the market for the book has undoubtedly been reduced, particularly among those who are not keenly interested in the birds of Panama. Based on a guess that Part IV may also cost $15.00, buyers of the entire set in cloth covers stand to spend $57.50 ($63.50 if they repurchased Part I after cloth binding was offered), whereas in paper covers I'd estimate the set would have sold for about $27.60, based on the differential in Part I. While we can all understand the desire for having scientific publications do more to pay their own way, I, for one, lament the possibility that one of Dr. Wetmore's most important works may have become so expensive that its proper dissemination may not be achieved in his lifetime.

Dr. Wetmore has made many contributions to ornithology, and in my opinion the present work is among his best. Any criticisms I might make of the work pale beside its merits, and details such as maps and prices are extraneous to the central issue of this review. This work should serve as the basic compendium on Panamanian birds for some time to come, at least so far as taxonomy and distribution are concerned. Furthermore, the glimpses it gives of natural history should spur further and deeper research, which would be constructive in itself. In the meantime, investigators working in Panama will have for their great benefit this product of the efforts of a truly indefatigable scientist.—JOHN P. HUBBARD.

The Palaearctic-African Bird Migration Systems by R. E. Moreau. Academic Press, London and New York, 1972: 6¼ × 10 in., xvi + 384 pages, 31 photos, figures and tables, 162 species distribution maps. $24.00.

This scholarly work concludes an era of ornithology. Reg Moreau died in May 1970 after virtually completing the text, his swan-song (his own phrase) after a score of years, and more of papers, devoted to problems of migration between Africa and the temperate zone. The era of ornithology is the duration of Moreau's close association with Africa, an appreciation of which belongs more properly to his obituary (See Ibis, 112:549–564, 1970) than to this review. Suffice it to note here that no one else could have undertaken this work; few other ornithologists had such a great number of correspondents to draw upon, and none had the ability so well to integrate information from numerous and diverse sources and disciplines. The synthesis that results is an invaluable contribution to bird biology, and will stimulate the ecologist, energeticist, and physiologist, as well as the ornithologist with no particular academic pretensions.

The book appeared six months after the date that was first intimated by the publishers, a frustrating delay not entirely due to the difficulties of posthumous publication. It was painstakingly edited by Moreau's literary executor, Dr. J. F. Monk, and sections of the proof were made available to several workers in the field of Palaearctic and African bird migration. Notwithstanding, there are many trivial errors, and a few nonsenses such as the inaccurate representation of great circle migratory routes between Asia and Africa in Figure 5; Nairobi marked in Tanzania on the endpaper political map of Africa; and on the dust jacket the space photo of Earth printed on its side—north pole to the left. More seriously, despite a vigorous and voluminous correspondence conducted up to the week of Moreau's death, a lot of germane observations by correspondents in recent years—especially in eastern Africa—have not found a place, while some publications (e.g. Dowsett on *Lanius minor*, Ostrich, 1971) have received no mention.

To emphasize the book's small faults is not my purpose, and anyway criticism is disarmed in the Preface: "I know it is full of imperfections and inadequacies and that readers will find errors from which I cannot be absolved. They will enjoy spotting them but I know too that in not a few places in the book they will find themselves surprised and stimulated." As it closes an era of ornithology—essentially African—it opens another in global context. This is the first work to examine in depth the ecology of intercontinental migration—the circumstances of species on their breeding, passage, and wintering grounds. Of hundreds of books on European birds, this is the first to examine those two thirds of their lives passed elsewhere.

As with Moreau's "The Bird Faunas of Africa and Its Islands" (1966), to which the present work is a companion volume, the bulk of the text is a detailed species account which is unlikely to be of first interest to readers not conversant with the birds themselves. Part III deals in 166 pages with the 187 species of Palaearctic migrants to Africa, each one in respect of wintering range, habitats and season, banding recoveries and the nature of the journey, recurrence, fattening, etc. A 57-page section is appended giving distribution maps for 162 of these migrants, while a further appendix by K. D. Smith deals briefly with each of 73 marine, coastal and vagrant visitors to Africa from the Holarctic. Most readers will refer constantly to the maps, which embody much distributional data. They are visually pleasing, with Asia outlined and African vegetation zones infilled in colour. For African ranges the choice of hatching is unfortunate, and where records are sparse they would have been better given by individual dots than by fragments of hatching.

Indications of *Zugunscheiden* and loop-migration might also usefully have been incorporated.

The remainder of the book in effect uses Palaearctic examples to discuss the biology of migration and can confidently be recommended to the general biologist and all regional ornithologists alike. Some chapter titles, to give an idea of the scope: Part I (Palaearctic)—The Fluctuating Ecology of the Source Areas—The Numbers of Birds Involved; Part II (Africa)—Topography and Climate—The Availability of Food; Part IV (General)—The Maintenance Needs of the Migrants in Africa—Recurrence in Winter Quarters and Itinerancy. Much of the text has an ecological flavor, important considerations being how Africa can accomodate something like five thousand million immigrants, and the distribution of the avian biomass in the various biomes of the northern and southern tropics. A selection of points that emerge: (1) The maintenance needs of Palaearctic birds in Africa average at least 33 percent less than on their breeding grounds. (2) Contrary to expectation, the greatest abundance of wintering Palaearctic passerines is reached in the arid northern savannas and not in the moist equatorial ones. (3) Migrants from Siberia may cross 100° of longitude to central Africa and if they follow a great circle route they start by flying north of west. In autumn the environment that they encounter from Turkestan to Saudi Arabia is mostly desert almost as inhospitable as the Sahara. (4) The insectivorous falcon *Falco amurensis* breeds in far eastern Asia and somehow circumnavigates the Himalayas to India where it fattens (and is reputedly "very good eating") prior to a 3,000 km crossing of the Indian Ocean in November with the monsoon winds; aggregations of 100,000 occur in Rhodesia; the return migration is by a different, as yet unknown, route. (5) Greenland Wheatears (*Oenanthe oenanthe*) have a shorter continuous sea crossing, 2,500 km, but against adverse winds; having arrived in Europe they fatten again for the trans-Saharan passage to Senegal. Wheatears from the Bering Straits area may winter in Africa rather than America. (6) The enormous navigational problems posed are quite unresolved.

The Palaearctic-African Bird Migration Systems is a mine of information and will be indispensible for students of migration and of African and western Palaearctic ornithology. Since three fifths of the 500 references cited were published within the last decade, the book will inevitably need updating in less than a decade's time. Not for a very long time, however, will it be displaced as the definitive treatise on the subject, a fitting tribute to a remarkable man.—C. H. FRY.

NATURAL HISTORY OF THE KING RAIL. By Brooke Meanley. North American Fauna Number 67. U.S. Dept. of the Interior, Bureau of Sport Fisheries and Wildlife, Washington, D.C., 1969: 6 × 9 ins. vii + 108 pp., bl. and wh. photos, 12 tables. $0.60. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

This monograph is chiefly concerned with the ecological relationships of the King Rail toward its breeding habitat and food habits. The adaptability of this bird to the various types of marsh—brackish, delta, prairie, and ricefield—explains its wide distribution over the eastern half of the United States. The description of its breeding biology is the first presented for the species, and is a definite contribution to our scanty knowledge of the marsh-dwelling Rallidae. Perhaps the most interesting subject is Meanley's discovery that King Rails and Clapper Rails hybridize in the brackish marshes where their habitats adjoin or overlap. The book also includes diverse topics ranging from migration to hunting and capture methods to mortality factors.

In general, Brooke Meanley has taken a broad approach to the biology of the King Rail, and while certain aspects may be incomplete, he has delineated the problems. This reviewer was impressed with the breadth of the monograph. Till now, little has been added to our knowledge of marsh rails since the days of Bent, and many of the additions have been anecdotal notes of questionable value, especially in reference to sex identification. This lack of knowledge is not without reason, for rails are shy, though not wary, they lack sexual dimorphism of plumage, and most important, they inhabit marsh vegetation, seldom permitting observation. To gather his data, Meanley has slogged 17 years in the marshes, where data are acquired at an agonizing expense of time and energy. No wonder that most amateur ornithologists are pleased with themselves at the sighting of a rail, and most researchers have shunned the Rallidae.

In view of the scope of the monograph and the special difficulties of working with marsh rallids, I hesitate to criticize any details of Meanley's work. I feel that the descriptions of the displays associated with pair formation and copulation may be incomplete. The close similarity of vocal and territorial behavior between the King Rail and the Virginia Rail, with which I am familiar, leads me to expect that they also have very similar breeding behavior. If this is true, then additional observations must be made, particularly on the earliest displays in pair formation, the presence and role of allopreening and duetting in maintaining the pair bond, precopulatory chases, and postcopulatory displays. I hasten to admit that most of my own data on the Virginia Rail came not from seven years of field work but from one year with color-marked captives. Meanley's descriptions of behavior he observed could have been more complete, for example that of copulation itself: "Copulation is performed with the female assuming a crouch and the male mounting with legs and feet on the female's back." This statement leaves me with a number of questions. Does the female bow forward after the male mounts, as do Soras and Virginia Rails? Does the male balance by holding the nape of the female like a rooster, or arch his wings outward like a Virginia Rail, or rapidly flap his wings like a Sora? Does the male tread on the female's back just prior to the cloacal kiss?

I also object to some of the terms used to label the displays. Such labels should be descriptive of the postures or sounds, such as the grunt-whistle of waterfowl courtship, rather than the use of functional names as "advertising display," "invitational display," "mating call," and "advertising call" given to the King Rail. Functional names present several difficulties. If further investigation proves a display to have a different or additional function, then either the name must be changed or the name is misleading and must always be explained. Functional names also make comparisons of homologous displays of closely related species difficult, especially if a homologous display has different functions. I found the distinction between "prenuptial courtship" and "nuptial courtship" rather hazy, and wondered if they referred to behavior associated with pair formation, maintenance of the pair bond, or the preliminaries to attempts at copulation. In fact, I wondered if this distinction were rather artificial in view of the statement on page 51: "Following pair formation, much of the posturing and calling that characterized the period of prenuptial courtship continues, at least in the earlier phases of nuptial courtship." The adjective "symbolic" used in reference to nest building and courtship feeding has too many implications, such as whether or not a bird is actually thinking that these are symbols of his love. I question whether an observation of one male making initial and incomplete nest building movements is sufficient to justify a separate heading of

"Symbolic Nest Building," and whether or not courtship feeding is a "type of symbolic display," I wonder too why courtship was the only behavior described under the heading of "Display."

For those interested in marsh management, the study's lack of comparison of breeding populations estimated by call counts and by intensive nest searching may be a disappointment. I think an attempt to ascertain the reliability of the call count should have been made in view of its intensive use (pp. 18, 20, 21, 22, 29, and 31), and would not have been too difficult to accomplish after the intensive nest searches in the ricefields.

The wing claw of the day old chick is termed "vestigial" on page 66. I think this is improper because I believe the claw functions in the chick's locomotion. The precocial young of the Sora and the Virginia Rail are rather unstable on their feet and they sit upon their metatarsi and feet; they use their wing claws in scampering during their first few days. The book is nearly free of typographical and editorial errors.

Notwithstanding my criticisms, I would particularly recommend this fine monograph to anyone interested in adding to his library of life histories or books on marshes, marsh management, or the problems of hybridization and speciation.—Gerald W. Kaufmann.

At a Bend in a Mexican River. By George Miksch Sutton. Paul S. Eriksson, Inc., New York, 1972: 8½ × 11 in., 184 pp., 12 col. pls. and 18 half-tone paintings by the author; 17 photographs by Olin Sewall Pettingill, Jr., Robert B. Lea, and William B. Heed. $14.95.

One fall evening nearly thirty years ago I opened a copy of *Audubon Magazine* to the lead article written by Major George Miksch Sutton. Its title duplicated that of the book here under review. The book-length story was introduced by a striking double-page photograph of the Río Sabinas overhung by epiphyte-laden cypress branches; in the background rose a hazy forested mountain. The image of the photograph, and those produced by the author's words, remained in my mind a very long time. Some of them are there to this day.

Shortly after reading that article I met George Sutton and learned first-hand of his boundless enthusiasm for Mexican birds. A few years later *I* was by that stream in southern Tamaulipas, and Sutton's word-pictures assuming reality before me provided an enormously satisfying experience. The clicking butterflies; the colorful, shrieking parrots; the macaws just overhead; a displaying Wedge-tailed Sabrewing; the first, distant, penetrating *ooomp* of a Great Curassow—all are treasured recollections. I never would have been there, and likely would never have undertaken serious study of Mexican birds, had it not been for Sutton. I later learned a vast amount as one of his students but probably nothing eclipsed the impact of his semipopular writing. (And my experience was not unique. Only recently I learned that a mammalogist friend of mine had his interest in Mexico's fauna sparked by the very same Sutton article; doubtless there were numerous other budding naturalists to feel the same influence.) Each of my subsequent visits to the Sabinas, even those of the past two years, brought to mind the *Audubon Magazine* story. I always thought it should be available in book form. Now, with two additional essays about Sutton's other Mexican expeditions, it is.

Once opened this handsome book is difficult to lay aside. Perhaps only those who know well the places and birds discussed can find it truly exciting, but at very least it is genuinely interesting. The full-page color plates add a great deal. Only one, I believe, has been reproduced before: that of the Blue-crowned Motmot appeared as a *Wilson Bulletin* frontispiece in 1946. Reproduction generally is good, although two plates in my copy appear a trifle too pale. Four of the half-tone paintings appear in color in the author's "Mexican Birds: First Impressions." These and the others seem to have been carefully chosen as subjects which would lend themselves well to black-and-white reproduction.

Several of Pettingill's fine photographs have appeared before in various papers (e.g. Birds of the Gómez Farías Region, Southwestern Tamaulipas by Sutton and Pettingill, Auk 59:1–34, 1942), where some were better reproduced than they are in the book. It looks as if the negatives of the Buff-bellied Hummingbird and Social Flycatcher pictures were treated very carelessly by the printer. I was disappointed to find no photograph whatsoever of the Río Sabinas. Such would have been a most appropriate and useful inclusion. Meaningful photographs depicting the tropical thickets and riparian vegetation (and which accompanied the *Audubon Magazine* feature) also are strangely lacking here.

But the writing leaves nothing to be desired. At the book's end one only wishes for more. Some may be quick to criticize Sutton's frequent anthropomorphisms but they should note that he so labels them and justifies his use of such language.

The first essay displays a few minor changes from the material originally published in the 1940s, mostly the names of birds. "Gray Hawk" has replaced "Mexican Goshawk," for example, and several more have been brought into line with current usage. Not all are changed, however. Among others it's refreshing to read once again of Alta Mira (instead of Lichtenstein's) Orioles.

The second and longest narrative deals with a more extensive expedition than either of the others. This material has never been in print before. Most of the third section was published in the November 1972 issue of *Audubon*, there with the scientific names of the birds in the text. These are relegated to a separate list in the book, along with alternate vernaculars.

The book is very personal, for Sutton shares with his readers a vast range of thoughts and happenings including those which most of us would never record in our field notes, much less publish. Years ago Edwin Way Teale wrote, "Read 'Birds in the Wilderness' [Sutton's fourth book] and you have met George Miksch Sutton." The present work provides, perhaps better than his other recent publications, a reacquaintance with the author. To review the book in any detail would be to review Sutton himself. The book *is* Sutton—acutely aware and knowledgeable of his surroundings, viewing and interpreting as both scientist and artist. Surely there are few men who appreciate more fully than he what they see and have seen. Through keenly sensitive eyes he efficiently absorbs and savors even the smallest (and, to many, the most inconsequential or transient) of things, wrings delight therefrom and selectively transmits them to his reader in an utterly charming manner.

This is a book not only about birds but also about the warmth and friendliness of the Mexican people and the small but choice sections of their diverse country which the author knows so intimately. There is no preaching, but his thoughtful "forward" reflects deep concern for the vanishing wild places and their animals. Sutton expresses the belief that the necessary conservation measures will be taken before it is too late. But I wonder. If not already the case, it will not be long before the last macaw flies over the Sabinas and the last Tamaulipan curassow is silenced. If these things can indeed be avoided Sutton's book may well be one of the few effective, available instruments to convince the Mexican officials that an extraordinary resource is rapidly slipping into oblivion.—DALE A. ZIMMERMAN.

An Analysis of the Population Dynamics of Selected Avian Species with Special Reference to Changes During the Modern Pesticide Era. By Charles J. Henny. Wildlife Research Rept. 1, U.S. Dept. of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Washington, D.C. 1972: 7 × 10 in., iv + 99 pp., 7 figs., 62 tables + 3 in appendix, pencil sketches by Janice Chapman, paperbound. $1.00.

The purpose of this paper was to compare the numerical status of 16 selected avian species before and after the era of modern (organic) pesticides began (i.e. before and after 1946 when DDT came on the market). The general conclusion is that birds with long food chains, particularly those eating other birds or fish, have declined since 1946, while birds with short food chains, eating herbivorous animals, have shown no such decline. Henny further proposes that the decline is not due to any change in the survival of post-fledging birds but due to a decline in reproductive rates (due to eggshell thinning and breakage). This is not an original suggestion but the documentation to support this numerical decline is impressive. Henny found evidence for a decrease in fledging rate for Brown Pelican, Osprey, Cooper's Hawk, Red-shouldered Hawk, and Sparrow Hawk. Mortality rates had also decreased in three of these: Brown Pelican, Red-shouldered Hawk, and Sparrow Hawk (attributed to decreased shooting). Great Blue Herons also show evidence of a decreased mortality rate but no evidence of a decreased fledging rate (in spite of a high fish diet). The other species examined included the Great Horned Owl, Black-crowned Night Heron, Barn Swallow, Chimney Swift, Blue Jay, Black-capped Chickadee, Cardinal, Robin, Barn Owl, and Red-tailed Hawk. No significant changes in either mortality rates or reproductive success were found for these species, which are mainly primary carnivores or even lower in trophic level.

The text is in very readable type and free from typographical errors. The sketches of the birds are attractive but not essential to a research paper. Most criticisms are rather trivial. The species were not discussed in the usual taxonomic order, or in any other obvious order. Figure 6 is unorthodox in having the dependent variable plotted on the abscissa rather than on the ordinate. The abstract implies that the mathematical models used were developed in the paper but one has to go to a previous paper (J. Wildl. Mgmt., 34:690 et seq., 1970) to find this development or indeed to gain any real understanding of the methods used. The paper is well organized and well documented so these shortcomings are not serious.

The use of laying date, rather than fledging date, would seem to be more appropriate as the initial date for calculating mortalities, since this is when recruitment to the whole population takes place (in the form of eggs) and also when recruitment to the breeding population takes place, when the females lay those eggs. This also makes it simpler to calculate the pre-breeding mortality, which has given the author some difficulty (because he has chosen fledging date and in some cases January 1 as his initial dates). January 1 has no biological significance and fledging date has all of the disadvantages of egg dates and none of its advantages. The data points for the survival curve of the Black-capped Chickadee in Figure 1 appear to bear no obvious relationship to the data given on pages 66 and 67 in the text dealing with this species. The mortality data in Appendix 1 for this species appear to apply to the 1946–64 period, not the pre-1946 period (compare pp. 66 and 99). I found some other disturbing details when checking the information for this species and for the Robin, the two species of particular interest to me.

However, I believe that the author has made an important contribution to the study of avian population dynamics and the impact of pesticides on bird populations.—J. Murray Speirs.

The Avian Brain. By Ronald Pearson. Academic Press, New York and London, 1972: 6¼ × 9¼ in., xi + 658 pages, 140 figs., 88 tables. $31.00.

Birds are perhaps the most complex of vertebrates evincing stereotyped behavior as a way of life. This fact, their generally efficient visual and auditory organs, and the possession of structures and motor "programs" for flight are more than enough to entice neuroscientists to study the avian nervous system. Making this effort somewhat difficult is the fact that few neuroscientists know anything about birds, let alone about their nervous systems. And, I think this is the correct order.

For the neuroscientist who does know something about birds, Ronald Pearson's volume, "The Avian Brain," will be, with reservation, a fair place to begin one's education. This is a tough and thorough reference work, a dazzling effort to synthesize information on structure with function, biochemistry, endocrinology, and histochemistry. In addition to chapters summarizing the histology and microscopic anatomy of various brain areas, special chapters are also given on ontogenesis, the vascular system, vision and audition, biochemistry, and the electroencephalogram. Peripheral receptors, nerves, nerve-muscle junctions, and the autonomic nervous system are not included.

The book is essentially free of unnecessary comparison of avian with mammalian brain. It is the author's conviction that, given 280 million years of phylogenetic divergence between birds and mammals, homologies of structure and function are risky. It is Pearson's objective that this work shall kindle interest in the use of birds for study of their own neural uniqueness.

As its title alone should sell it—at a time of quickening interest in all phases of neuroscience—more practical aspects of its publication can be considered: Who will use the book; how complete is the information therein; and, as a reference source, could it provide an efficient "lift-off" for a better general understanding or starting a new project with birds?

First, who will use the book? In its 16 chapters, Avian Brain is very technical, unquestionably written for individuals with a mastery of some current field of neuroscience. I do not mean beginning graduate students, naturalists, or necessarily any of the professionals including ornithologists mentioned on the book jacket blurb. The price of admission to Pearson's scholarship is a current working knowledge of at least one of the fields covered.

By working knowledge I mean the reader must supply context, vocabulary, and insight in order to deal with any of Pearson's chapters. For example, in Chapter 3 on biochemistry, you had better be familiar with electron transfer system nomenclature e.g. NADH, NADPH, etc., the significance of phospholipid and cerebroside concentrations in sub-cellular fractions of brain, the ins and outs of glutamate metabolism, and the distribution of various catecholamines. You should know that the opening lines of section VI of this chapter (amino acid metabolism): "In general terms glutamate is the only amino acid which is used at an appreciable rate by vertebrate brain tissue" (p. 55) is a statement of immense theoretical importance, representing a monumental amount of rather recent neurochemical work, actually little substantiated in birds. Here Pearson utilizes information from mammals to fill the gap in data from birds; but the fact that the gap exists is something you must know; it is not mentioned. Without understanding the limitations of histochemical technique, the reader cannot evaluate either the use of this technique in birds or the direction of such work, essentially derived from mammalian findings. You would not know from this chapter that audioradiographic tracers and immunoflourescent techniques add more precision to methodology of neurochemical localization and are now being widely and rapidly used throughout the world. These things you must furnish. Similar levels of background are requisite for handling other chapters intelligently.

Now, about information content. If you are knowledgeable in a field of neuroscience and want to know what has been done with birds, how well does a Pearson chapter hold up? Chapter 8 (The Cerebellum) was chosen for scrutiny. Here trouble emerges. There is no reference, for example, to climbing fibers, or the fact that interneurones of cerebellar cortex are inhibitory in the mammal and frog and probably so in birds, or that the giant Purkinje cell—the output neuron of cerebellar cortex—is also inhibitory in its action. This leads Pearson into further difficulties when he attempts to deal with older literature on the deep cerebellar nuclei and the vestibular system. Whether you are dealing with frogs, birds, or mammals, the activity of the cerebellar neuropil is believed to be roughly comparable, given certain histologic differences. Take away the powerful excitatory climbing fiber input, the interneuron story, and Masai Ito's observation in 1964 that the Purkinje cell output is inhibitory (well established in mammals but not yet confirmed in birds) and you are left with a dated and completely erroneous picture of the cerebellum even if gaps do exist in our knowledge of the avian central nervous system. In addition to these serious omissions and an evident lack of understanding of the significance of material referenced (a text cited covers the missing items in detail), studies which are included can also be faulted, at least from the methodologic point of view of the 1970's. These things being so, the usefulness of this particular chapter collapses. Whether such criticism would hold for some or all other chapters, I cannot say. I did consider that Pearson, in an effort to keep strictly to the text of published avian studies, might have deliberately ignored what he knew to be the case for reptile and mammals. But, as this would serve no one, the notion was dismissed. This negative mark might well be balanced against some chapter where Pearson is obviously stronger as in Chapter 13 which deals forthrightly with the complex matter of forebrain histology and anatomy, and the renowned nomenclatural abyss centered here.

Finally, is the use of such a reference work as Avian Brain a good starting place for background material on a problem of interest? If we are talking either of completeness of information or current material, say in the last five years, the answer is no. This can be illustrated by a recent experiment. In October of 1972, as this review was underway, I asked a national library of medicine, Remote-Access Retrieval Service (Medline) terminal operator to make a search (no charge) of recent publications on the avian visual system. Two code words were given: "Birds" and "Vision." In a few minutes, 105 citations from 38 journals were printed out for a 1968–1972 period, 16 of these (through May) were from 1972. Pearson's Chapter 9, The Avian Eye and Vision contains 81 references, 60 of which were published before 1965 (a comparable four year period viz. 1965–1969, his review was not complete for 1970). In Medline (30 references) vs. Pearson (4 references) the overlapping two years 1968–1969 contain only one reference in common. Medline does not reference well the zoologic literature and Pearson's coverage proved skimpy on visual discrimination, acuity, nystagmus, and electroretinogram studies. But the point remains: this is 1973, and if I were to review background material for a problem, I would start with a Medline or similar retrieval service, supplemented with zoologic abstracts.

It would be churlish to insist that Avian Brain also serve this impossible feat of information i.e. being both complete and up-to-date. But coverage of all bases by Pearson does focus attention on his bibliographic effort which, in turn, uncovers a quite reasonable but unfortunate trade-off of analysis for comprehensiveness. At a stage when there is uneven depth of information available, Pearson chose to live with coverage rather than a hazardous critique. It is an understandable trade-off. The reader by applying his own critique can certainly profit from a Pearson chapter and be in a position to make his own contribution to the literature. The book remains on my shelf for especially this reason, and serves well one of Pearson's goals.—Robert J. Grimm.

The Complete Ecology Fact Book. Edited by Philip Nobile and John Deedy. Doubleday, New York, 1972: 5¾ × 8½ in., xx + 472 pp., maps and charts. $10.00.

It would be much easier to appraise this book dispassionately if it were not for the evangelistic hard sell on the dust cover, e.g. "*You* can save the environment if you know the facts about: Pesticides," etc. The fact is that this book is far from complete (it's hard to imagine what *would* constitute completeness in this field) and it says little or nothing about what to do about our environmental ills.

Obviously the word "ecology" in the title denotes the popular rather than the academic field. Basic (academic) ecology is neatly polished off in the foreword, where Pierre Dansereau's twenty-seven "Laws of Ecology" are quoted without explanation. The degree to which this misses the boat as a layman's guide to ecological understanding can be demonstrated with the observation that of the few professional ecologists who are aware of Dansereu's "Laws," virtually none have a ready recall of their specifics. Such obscure materials illustrate the editors' lack of understanding of ecology better than any other feature.

The book is divided into eight major areas, each represented by a chapter in which pertinent statistical data are presented. The rationale for the topic choices and their organization is obscure. For instance, although one chapter is devoted to Pollution including a subchapter on Rivers, Lakes and Streams, a separate chapter is devoted to detergents. A chapter on energy production is conspicuously absent although the three-page chapter Nonrenewable Mineral Resources (titled "Non-renewable Mineral Wastes" in the Table of Contents) does mention the subject.

Some of the statistics presented seem to be good choices; the inclusion of the Population Reference Bureau's World Population Data Sheet seems appropriate even though it could be had for about twenty-five cents directly from PRB. Excerpts from the *Red Data Book* do come from the best source of information on endangered species, but the inclusion of such groups as marsupials seems to be of questionable value for the average American.

To go on further about this book would be disproportionate to the amount of attention it deserves. Suffice it to say that at ten dollars, a successful attempt at an ecological almanac would be a good value; this attempt is no bargain at all.—Shaun Bennett.

PROCEEDINGS OF THE FIFTY-FOURTH ANNUAL MEETING

James Tate, Jr., Secretary

At the invitation of the University of North Carolina, the Carolina Bird Club, and the Chapel Hill Bird Club, the Fifty-fourth Annual Meeting of the Wilson Ornithological Society was held at Chapel Hill, North Carolina, from Thursday, 17 May, through Monday, 21 May 1973. A reception was held in Parker Dormitory on Thursday evening while the Council engaged in a marathon session in a nearby room. A second reception was held on the lawn of Parker Dormitory on Friday evening. At several times during the meetings, the University Planetarium put on a showing of spring constellations for the Wilson Society. Field trips were held on Friday and Saturday mornings to local areas including localities mentioned by John K. Terres in his book, "From Laurel Hill to Siler's Bog."

The annual banquet, held Saturday evening in the main dining hall of the splendid Carolina Inn was well attended. The presentation of awards was made, followed by the President's address, and the evening was concluded with delightful old-time country music by Jim Watson, Tommy Thompson, and Bill Hicks.

The recipients of Wilson Society prizes announced at the annual meeting were as follows:

Louis Agassiz Fuertes Award: Robert C. Eckhardt, Cornell University—Flycatchers and foliage gleaners as predators.

Margaret M. Nice Award: Richard L. Glinski, Tucson, Arizona—The Gray Hawk in Arizona.

Ernest P. Edwards Prize: First Prize, Ralph W. Schreiber, University of South Florida and Robert W. Risebrough, Bodega Marine Laboratory—Studies of the Brown Pelican; Second Prize, Russell P. Balda, Gary C. Bateman, Northern Arizona University, and Gene F. Foster, Flagstaff, Arizona—Flocking associates of the Pinon Jay.

Alexander Wilson Prize: C. John Ralph, Johns Hopkins University—Disorientation of coastal land bird migrants.

FIRST BUSINESS MEETING

The first business meeting was called to order by President Hofslund at 09:30 Friday in Carroll Hall. The minutes of the business meetings held at Cape May, New Jersey were approved by the membership as published in The Wilson Bulletin (84: 362–372, 1972). The President appointed the following temporary committees:

Resolutions: Robert D. Burns, Chairman.
Alexander Wilson Prize: Elden W. Martin, Chairman.
Auditing: C. Chandler Ross.

The names of the Nominating Committee members were announced as follows: Phillips B. Street, Chairman; John T. Emlen, Jeff Swinebroad.

The Secretary reported on highlights of the Council meeting of the previous evening. Reports of officers of the society which were presented at the Council meeting were summarized, and are reproduced here.

Members of the Executive Council at the Chapel Hill meeting. Front row: A. J. Berger, K. C. Parkes, G. A. Hall, W. A. Klamm, J. Tate. Back row: R. D. Burns, H. I. Fisher, P. B. Street, P. B. Hofslund, and E. W. Martin.

Report of the Treasurer—1972

A formal report was not presented by the Treasurer, William A. Klamm. The Financial Statements given below were presented and discussion followed. It was pointed out that five issues of The Wilson Bulletin were paid for this fiscal period, allowing the Society to return to an up-to-date accounting for four issues per year in the future.

FINANCIAL STATEMENTS

General Fund

Balance as shown by last report 31 December 1971			$ 15,361.10
RECEIPTS			
Membership Dues			
Active for 1972	$ 3,880.00		
Active for 1973	$ 7,163.00		
Total Active		$11,043.00	
Sustaining for 1972	181.00		
Sustaining for 1973	465.00		
Total Sustaining		646.00	
Subscriptions to The Wilson Bulletin			
For 1972	2,254.49		
For 1973	3,371.40		

Total Subscriptions		5,625.89	
Sales of back issues of The Wilson Bulletin		1,317.48	
Interest and dividends on savings and investments		4,116.04	
Royalties from microfilming back issues of The Wilson Bulletin		125.07	
Total Receipts		$22,873.48	

DISBURSEMENTS

The Wilson Bulletin (Printing & Engraving)	$22,378.08		
Less contributions from authors & others	1,900.59		
Printing & Engraving Expense		$20,477.49	
The Wilson Bulletin (Additional mail & service)		833.45	
Editor's Expense		272.50	
Secretary's Expense		113.02	
Treasurer's Expense		558.07	
Foreign discount, bank charges and transfer fees		26.74	
Annual Meeting Expense		265.49	
Committee Expense		60.20	
International Council for Bird Protection		30.00	
Transfer to Research and Grants-in-Aid		273.00	
Review Editor's Expense		24.08	
President's Expense		25.00	
Miscellaneous Expense		2.00	
Total Disbursements		$22,961.04	
Excess of Disbursements over Receipts			$ 87.56

GENERAL CASH FUND

Checking Account	9,627.22
Savings Account	5,646.32
Balance in National City Bank, Cleveland, Ohio, 31 December 1972	$ 15,273.54

Josselyn Van Tyne Memorial Library Fund

Balance as shown by last report 31 December 1971	$ 384.36

RECEIPTS

Sale of duplicates and gifts	220.00
Total Balance and Receipts	604.36

DISBURSEMENTS

Purchase of books	197.16
Balance in National City Bank, Cleveland, Ohio, 31 December 1972	$ 407.20

Louis Agassiz Fuertes Research Fund, Margaret Morse Nice Fund, Edwards and W.O.S. Paper Funds

Balance as shown by last report dated 31 December 1971	$ 20.00

RECEIPTS

Contributions	459.00

Transfer from General Fund		273.00
Total		752.00
DISBURSEMENTS		
Grants-in-Aid		
To Donald E. Kroodsma	200.00	
To Rebecca L. Radcliffe	100.00	
To Frances James	150.00	
To Anthony J. Erskine	50.00	
To W. Jon Richardson	100.00	
Total		600.00
Balance in National City Bank, Cleveland, Ohio, 31 December 1972		$ 152.00

SPECIAL FUND ACCOUNT

Balance as shown by last report 31 December 1971		$ 342.75
RECEIPTS		
Prepaid Student Dues	0.00	
Advanced Renewals	100.00	
Discount Due Agencies	2.50	
Total Receipts		102.50
Total		445.25
DISBURSEMENTS		200.75
Balance in National City Bank, Cleveland, Ohio, 21 December 1972		$ 244.50

ENDOWMENT FUND

Balance in Endowment Savings Account as shown by last report 31 December 1971		$ 10,737.50
RECEIPTS		
Life Membership Payments		4,235.00
Balance in Endowment Savings Account, National City Bank, Cleveland, Ohio, 31 December 1972		$ 14,972.50
Investments held as of 31 December 1972.		
United States Government bonds	$ 4,956.25	
Canadian Provincial bonds	4,425.00	
Corporate bonds	9,000.00	
Convertible corporate bonds	2,875.00	
Convertible preferred stocks	43,122.25	
Common stocks	20,876.87	
Investment trusts	8,970.64	
Cash	12.50	
Total Investments		94.238.51
Total Endowment Fund, 31 December 1972		$109,211.01

Respectfully submitted,
William A. Klamm, *Treasurer*

Report of the Secretary—1972

Immediately following last years Annual Meeting, the Proceedings and the minutes of the Council meeting were prepared. The 1972 Proceedings were published in the September issue of The Wilson Bulletin. During much of the fall, the Secretary was in the field.

The 1973 announcement was prepared from excellent copy provided by Helmut Mueller. All members were sent announcements in early February. The program was prepared from copy provided by Andrew Berger and Helmut Mueller. It was printed at Ithaca and handcarried to the meetings by the secretary. Similarly, the abstracts were prepared at Ithaca from material provided by Dr. Berger, and carried to the meeting.

There has been considerably more correspondence in 1972 for the Secretary than previously.—James Tate, Jr., *Secretary*

Report of the Editor—1972

Volume 84 (1972) consisted of 533 pages, and included 30 papers, 43 Notes, 31 Book Reviews, two Conservation papers, The Annual Meeting report, and the Index. There was one colored plate.

One issue of Volume 85 has appeared and the second issue is being put into page proofs. The two issues will total 256 pages. It is hoped to have a colored plate in each issue of Volume 85.

During the past year, 72 papers and 80 General Notes have been received. Of these 21 papers and 50 notes have been accepted. Eighteen papers and two Notes have been returned to the authors for substantial revision before acceptance; 18 papers and 24 Notes have been rejected; and 15 papers and 4 Notes are still awaiting decision, either by referees or by the editor.

At present the General Notes section for Volume 85 is full and a few Notes will be turned over to the new Editor. The lead paper section is not quite full as far as accepted papers go, but will be very shortly.

The average publication delay of major papers in Volume 84 was 11 months including one paper that had a 17 month delay due to the author's holding it up. For Notes the delay averaged 11 months also.

There has never been a formal written style sheet for the Bulletin, and each Editor has had to dig such matters out for himself. As one of my final duties I have prepared a written style sheet, as well as a sort of "Guidebook" for editorial procedures.

In this, my last report to the Council, I wish to express my thanks to the members of the Council for the support given me over the years, and for the confidence they placed in me. It has been a real pleasure to serve the Society for these years, and it is with very mixed emotions that I retire from the position.—George A. Hall, *Editor*

Reports of several of the committees which reported to the Council Meeting were then summarized. Edited versions of these reports appear here.

Report of the Research Committee—1972

There were 10 completed applications for the Fuertes Award and 11 completed applications for the Nice Award. In addition to these, there were a few inquiries that were not pursued by the inquirers. Unfortunately, one inquiry was sent in a letter on which there was no return address; presumably there was an address on the envelope, but the envelope had been discarded before the difficulty was discovered. The best efforts of the

Research Committee and the secretary of the Society to locate the letter writer on the basis of his name alone were in vain.

The committee had unusual difficulty in recommending a winner for the Fuertes award, and after telephone conversations among its members it decided to present its problem to the Council.—Val Nolan, Jr., *Chairman*

The Council acted on the recommendations of the Research Committee as detailed earlier.

The Trustee's Committee report was given by Phillips Street, Chairman. It detailed the activities of the Trustees as reflected in the Treasurers report of the endowment fund.

Report of the Membership Committee—1972

The annual drive for new members got off to a late start again this year—in part due to procrastination, and in part as a rationalization that between Christmas and income tax time would be a good time to get prospective members to part with the membership fee.

By early February, I had sent each committee member a new supply of materials and an average of five names gleaned from the membership roster of the AOU. Several committee members are apparently turning up many prospects, since some have requested additional brochures and cards.

As of 9 May, I have received the cards of 143 new members from the Treasurer. Of this total, 44 were nominated by Treasurer Klamm, and 43 others were nominated by 28 other WOS members not serving on the membership committee. Thus, the committee has been responsible for the production of 46 new members. These were recruited by 20 different members of the committee. This is a significant increase over last year when the committee produced only 29 new members. Mrs. John Lueshen led the committee with six new members to her credit.

The 143 new members represents an increase of 39 over the new members recruited last year. More importantly, for the first time in several years the number of new members is greater than the number lost through deaths, resignations, and delinquency. A total of 95 have been lost from the membership roll, leaving us with a net gain of 48 members.—Norman L. Ford, *Chairman*

Report of the Student Membership Committee—1972

My committee has continued its canvass of natural history organizations, nature centers, and other science oriented public institutions around the country asking for nominations of promising pre-college students who exhibit a special interest in natural history and bird study. This year the states in the middle of the country were covered, and the responses from this effort are now just beginning to arrive. Next year, the fourth in this endeavor, will include the western states. Then we plan to start over again on the East Coast.

Once again there were only one or two responses to our year-end notice in The Wilson Bulletin asking for student membership nominations from W.O.S. members. Recognizing the continuing existence of this deplorable situation I received permission from the Executive Council last year to compose a form letter requesting nominations each year that would be included with the mailing of the annual dues request. The form letter is attached to this report for consideration by the Council. This matter should be coordinated with the regular Membership Committee of the Society and also would necessitate an annual mailing to Life Members as well as those routinely contacted each year.—Douglas James, *Chairman*

Continuing the summary of the Council meeting, the Secretary reported that further discussions were required for the appointment of the Editor following the retirement of George Hall.

The fifty-fifth annual meeting of the Society will be held at the University of Michigan Biological Station near Pellston, Michigan, from 6–9 June 1974.

The Conservation Committee report was delayed, and was not presented at the meeting. For the Proceedings, it is presented herewith.

Report of the Conservation Committee—1972

After consultation with President Pershing Hofslund and Vice-president Andrew Berger it was decided late in 1971 that the WOS Conservation Committee could render an important service by sponsoring reviews of the bird conservation problems of the central and south Pacific islands which are under American administration, and the Chairman proceeded to persuade appropriate persons to prepare reviews of the islands for which they had information.

The rationale for the decision was that in the Pacific islands, as elsewhere, developments which are destroying bird habitat are proceeding rapidly, and it was urgent that the public be aware of the critical status of some of the birds and their environment. We were fortunate in persuading Andrew Berger to prepare the review of Hawaiian Birds which appeared in the June, 1972 issue of the Bulletin, and that Warren B. King, through arrangements with Secretary S. Dillon Ripley of the Smithsonian Institution, was able to do the same for the large number of central Pacific Islands which had been studied by Smithsonian Institution expeditions in recent years. His fine report appeared in the March, 1973 issue.

For Guam the ornithologist best qualified to summarize the status of its bird life is Gerald S. A. Perez, now Director of Land Management for the government of Guam, and his report, the final one in the series, we hope can be published in the September issue of the Bulletin.

In addition to this major undertaking for the two year period the Chairman of the Conservation Committee has handled a considerable amount of routine correspondence relating to bird conservation which came to the Society.—Gustav A. Swanson, *Chairman*

Similarly, the activities of the Endowment Committee were not available at the time of the meeting, but are reproduced herewith for the Proceedings.

Report of the Endowment Committee—1972

I have, as permitted by an unusually difficult schedule over this particular period, contacted a number of associates who have shown interest in scientific ornithology and have approached each of them with a request to consider the Wilson Society and in several cases the Cooper Society also in the preparation of their wills.

I have also asked a close friend who is a fine attorney to assist the Society by including it in the bequests of interested clients. In all except two of these cases my friends were, as is usual in these areas, noncommittal but told me they would consider my suggestion and did have interest. Two persons agreed to include both Societies in their bequests but did not indicate in what amount and asked that I maintain this information in confidence. I have also furnished the name of the Wilson Society to a stockbroker and estate planner friend who suggests that at times under certain favorable conditions he might be able to direct gifts of stocks to the Society under the provisions allowing deductability of market value without the payment of capital gains on such gifts to educational non-profit organizations.

I will continue to suggest the Society as a possible recipient of bequests, and perhaps the effort may be a rewarding one.—Don Bleitz, *Chairman*

Lists of new members were posted in the meeting hall by the Secretary. There being no further business, the President closed the first business meeting at 09:52.

SECOND BUSINESS MEETING

President Hofslund called the meeting to order at 16:35 on Saturday. The auditor's report was given, and is reproduced here.

Report of the Auditor—1972

I have analyzed the financial affairs of the Wilson Ornithological Society for the past ten years, in which I have served for five years as treasurer and five years as auditor and I find that this year our treasurer's report shows the best results of any of the years with which I have been connected with them. This is particularly commendable when it is noted that the costs of five Wilson Bulletins were included in the 1972 Report. Mr. Klamm is to be congratulated that he is able to turn the books over to his successor in such good condition.—C. Chandler Ross, *Auditor*

Frances James, member of the resolutions committee presented the resolutions prepared in advance. Other resolutions were presented from the floor. Those resolutions which passed are presented here in their final form.

WHEREAS there is a need to provide better overall coordination of efforts to conserve endangered species, and

WHEREAS we see a need for international cooperation in controlling exploitation of the biota, including plants,

THEREFORE BE IT RESOLVED that the Wilson Ornithological Society lends its support to the Endangered Species Conservation Act of 1973, H.R. 4758, which would broaden federal authority to protect and conserve endangered species in cooperation with the various states, and

BE IT FURTHER RESOLVED that we seek early ratification and implementation of the recently-concluded convention on trade in endangered species of wild fauna and flora signed in Washington D.C. on March 3, 1973 and we suggest that the Endangered Species Conservation Act of 1973 now before the Congress be modified to include plants as well as animals, and to otherwise implement the convention. (To be sent to: Lenore Sullivan, Chairperson, Merchant Marine and Fisheries Committee, House of Representatives; Hon. John Dingle, Chairperson, Subcommittee on Wildlife Conservation and the Environment; and to the Chairperson of the Senate Commerce Committee; Secretary of the Interior Morton, Secretary of State Rogers.)

WHEREAS the migration of Whooping Cranes is geographically widespread and temporally unpredictable, and

WHEREAS prohibiting the hunting of Sandhill Cranes only after Whooping Cranes have been sighted in a given province or state may be insufficient protection for the Whooping Cranes, and

WHEREAS the two species are difficult to distinguish in poor light.

THEREFORE BE IT RESOLVED that the Wilson Ornithological Society recommends that the hunting of Sandhill Cranes be prohibited in regions where it endangers Whooping Cranes.

WHEREAS the threat of the imported fire ant in the southeastern states to humans, to domestic and wild animals, and to southern agriculture have been exaggerated, and the benefits of the fire ant as a predator on forest insect pests have been largely ignored, and

WHEREAS the U.S. Department of Agriculture and various state departments of agriculture are engaged in control or eradication programs involving the aerial application of Mirex, a persistent chlorinated hydrocarbon pesticide, and

WHEREAS Mirex kills other arthropods including the food of many species of birds, has been linked to reduced reproductive success in birds, and has been found in concentrations of up to 11 parts per million in tissues of the Red-cockaded Woodpecker, an endangered species found almost exclusively within the range of the imported fire ant,

THEREFORE BE IT RESOLVED that the Wilson Ornithological Society is opposed to the aerial application of Mirex and to the application of Mirex by any means other than mound to mound treatment, and then only in areas of human habitation.

WHEREAS ranchers in Colorado and Wyoming holding privileges to graze cattle on public land have continued to break the law by killing eagles,

THEREFORE BE IT RESOLVED that the Wilson Ornithological Society urges the Secretary of the Interior to enforce the Bald and Golden Eagle Protection Act in accordance with the recent amendment increasing the penalties for this crime.

WHEREAS the establishment of populations of several species of exotic wildlife into the United States has occurred recently as the result of the escape or the deliberate release of animals imported for commercial purposes, and

WHEREAS the number of animals imported into the United States each year has been increasing, making more probable the establishment of additional exotic species, and

WHEREAS the introduction of exotic wildlife into established ecological communities has many potentially harmful effects that cannot often be predicted within reasonable limits, including competition with native species, alteration of native habitats, and introduction of diseases and parasites to native wildlfe, and

WHEREAS introduced species may become serious pests in agricultural areas, introducing disease to domesticated animals, damaging crops or stored agricultural products, and

WHEREAS introduced species may bear diseases harmful to human health or may become pest or nuisance species,

THEREFORE BE IT RESOLVED that the Wilson Ornithological Society urges the United States Department of the Interior and the Bureau of Sport Fisheries and Wildlife to adopt and implement more stringent regulations restricting the importation of exotic species of wildlife into the United States.

WHEREAS the Wilson Ornithological Society has held its fifty-fourth annual meeting at the University of North Carolina in Chapel Hill, from 17 through 20 May, 1973, and

WHEREAS the members have benefited greatly from the efforts of the Committee on Arrangements chaired by Helmut C. Mueller and the gracious facilities and services provided by the University of North Carolina, THEREFORE BE IT RESOLVED that the Wilson Ornithological Society extends its sincere appreciation to the Carolina Bird Club, the Chapel Hill Bird Club, the University of North Carolina, and to the Local Committee on Arrangements for their contributions toward providing this memorable meeting.

WHEREAS George A. Hall has served as editor of the Wilson Bulletin from 1963 to 1973 and

WHEREAS during this time he has given immeasurable personal attention to the job of coordinating and guiding the flow of manuscripts through the editorial procedure, resulting in the maintenance of the high standards and prompt publication of the Wilson Bulletin by Allen Press,

THEREFORE BE IT RESOLVED that the Wilson Ornithological Society expresses its very sincere appreciation and warmest thanks for this outstanding service.

WHEREAS Albert Ganier is the oldest former president of the Wilson Ornithological Society and will celebrate his 90th birthday in September 1973, and

WHEREAS he has contributed greatly to the knowledge of birds in the Middle Southern states and has been instrumental in the establishment of several state ornithological societies,

THEREFORE BE IT RESOLVED that the Wilson Ornithological Society extends to Mr. Ganier its special greetings and best wishes.

The list of new members was accepted and voted into membership as posted.

Phillips Street, Chairman of the Nominations Committee proposed the following slate of officers: For President, Kenneth C. Parkes; First Vice-President, Andrew J. Berger; Second Vice-President, Douglas James; Secretary, James Tate, Jr.; Treasurer, Jerome A. Jackson; Elective Member of Council (three years), George A. Hall. There being no further nominations, the nominations were closed. A unanimous ballot was cast for the proposed slate.

The President closed the second business meeting at 17:15.

At a special meeting of the Council on Saturday Dr. John P. Hubbard, Delaware Museum of Natural History was elected Editor of the Wilson Bulletin.

PAPERS SESSIONS

Symposium: Progress in Rare and Endangered Species Programs

Introductory remarks by Chairman, Andrew J. Berger, University of Hawaii.

Earl B. Baysinger, Office of Endangered Species, Washington, D.C., *The Federal Government's Endangered Species Conservation Program.*

Ray C. Erickson, Assistant Director, Endangered Wildlife Research, Laurel, Maryland, *The Current Status of the Whooping Crane.*

Warren B. King, The International Council for Bird Preservation, Washington, D.C., *The Conservation of the Hawaiian Dark-Rumped Petrel.*

George Archibald, International Crane Research Center, Baraboo, Wisconsin, *Introducing the International Crane Foundation.*

Paul W. Sykes, Patuxent Wildlife Research Center Field Station, Delray Beach, Florida, *Some Ecological Requirements of the Florida Everglade Kite.*

General Papers Session

James A. Kushlan and Marilyn S. Kushlan, University of Miami, *Population Changes of of the White Ibis in Southern Florida.*

Allan R. Phillips, Delaware Museum of Natural History, *Progress Report on the Vulture and Caracara Investigation.*

Paul B. Hamel, Clemson University, and Lester E. Eyer, Alma College, *Population Change in Common Grackles in Central Michigan.*

Oscar T. Owre, University of Miami, *The Exotic Avifauna of Southeastern Florida.*

Charles Hartshorne, Austin, Texas, *Some Problems about W. H. Hudson's Argentine Birds.*

Maurice L. Giltz and Harold E. Burtt, Ohio State University, *The Value of Continuity and Diligence to the Data Gained by Banding and Recovering Red-winged Blackbirds.*

David E. Davis, North Carolina State University, *Emigration of Northern Shrikes (1959–1971).*

C. John Ralph, Johns Hopkins University, *Disorientation of Coastal Land Bird Migrants.*

George Allez, Cedar Grove Ornithological Station, Cedar Grove, Wisconsin, *Age and Sex Differences in the Timing of Sharp-shinned Hawk Migration.*

Robert J. Raikow, University of Pittsburgh, *Adaptive Variation in the Hind Limb and the Foraging Behavior of the Hawaiian Honeycreepers (Drepanididae).*

Alan Feduccia, University of North Carolina, *The Morphology of the Bony Stapes in New and Old World Suboscine Birds: New Evidence for Monophyly.*

Charles R. Blem and David Spittle, Virginia Commonwealth University, *Geographic Variation in Wing-Loading of the House Sparrow.*

Jerome A. Jackson, Mississippi State University, and James Tate, Jr., Cornell University, *The Dynamics of Nest Box Use by Purple Martins, House Sparrows, and Starlings in Eastern North America.*

Frances C. James, University of Arkansas Museum, and H. H. Shugart, Jr., Oak Ridge National Laboratory, *Seasonality Modeling of the Nesting Season of the Robin.*

Douglas James and Doris J. Watt, University of Arkansas, *Comparison of Feeding Niches of Arkansas Paridae.*

James R. Karr, Purdue University, *Seasonal Patterns of Resource Exploitation in Panama Avifauna.*

Charles R. Smith, Cornell University, *Time Budget of the Loggerhead Shrike in Southwest Florida.*

Alan F. Posey, University of Arkansas, *Multivariate Analysis of Breeding Bird Habitats in Ozark Shrubby Old Fields.*

Harold Pomeroy, University of Rhode Island, *Startle Response Times of the Starling.*

Gilbert S. Grant and Thomas L. Quay, North Carolina State University, *Breeding Biology of the Cliff Swallow in the Southeastern States.*

Robert F. Soots, Campbell College, and James F. Parnell, University of North Carolina at Wilmington, *Avian Community Succession on Dredge Islands.*

Daniel D. Berger, Cedar Grove Ornithological Station, *Population Trends in Migratory Raptors.*

ATTENDANCE

One hundred and ninety-four members and guests were registered. Twenty-five states, the District of Columbia, and one Canadian province were represented.

From ALABAMA: 1—*Birmingham*, Thomas A. Imhof.

From ARKANSAS: 6—*Fayetteville*, Mr. and Mrs. Douglas James, Alan E. Posey, Mr. and Mrs. Kimberly Smith, Doris Watt.

From DELAWARE: 3—*Greenville*, Allan R. Philips; *Newark*, Roland R. Roth, James Steinhauer.

From DISTRICT OF COLUMBIA: 3—Richard C. Banks, M. Ralph Browning, Warren B. King.

From FLORIDA: 8—*Coral Gables*, Oscar T. Owre; *Delray Beach*, Paul W. Sykes, Jr.; *Lakeland*, John R. Haldeman; *Miami*, Mr. and Mrs. James Kushlan; D. B. Stott; *Tallahassee*, W. Wilson Baker, Robert L. Crawford.

From GEORGIA: 3—*Atlanta*, Mr. and Mrs. Winthrop N. Davey; *East Point*, Doris Cohrs.

From HAWAII: 1—*Honolulu*, Andrew J. Berger.

From ILLINOIS: 3—*Carbondale*, Mr. and Mrs. Harvey Fisher; *Urbana*, Mrs. C. H. Puterbaugh.

From INDIANA: 2—*Jeffersonville*, Bill J. Forsyth; *West Lafayette*, James R. Karr.

From MARYLAND: 11—*Baltimore*, C. John Ralph; *Chestertown*, Dorothy A. Mendinhall, Margery Plymire; *Columbia*, Earl B. Baysinger; *Gaithersburg*, Jeff Swinebroad; *Huntingtown*, Mr. and Mrs. John H. Fales; *Laurel*, Carol A. Pearson, Jay M. Sheppard; *Silver Spring*, Ray C. Erickson; *Towson*, Mrs. Richard D. Cole.

From MASSACHUSETTS: 2—*Manomet*, Kathleen S. Anderson; *West Newton*, Deborah V. Howard.

From MICHIGAN: 3—*Alma*, Mr. and Mrs. Lester Eyer; *Detroit*, Vivian Anderson.

From MINNESOTA: 3—*Duluth*, P. B. Hofslund; *St. Paul*, Mr. and Mrs. Thomas C. Savage.

From MISSISSIPPI: 2—*Starkville*, Mr. and Mrs. Jerome A. Jackson.

From NEW JERSEY: 5—*Mount Holly*, Katherine G. Price; *Newark*, Helen Wallace; *Princeton*, Charlotte A. Dubois; *Ramsey*, Eleanor E. Dater, Linda Mattson.

From NEW YORK: 6—*Ithaca*, Alice M. Briant, Charles R. Graham, Andrew Grainger, Charles R. Smith, Mr. and Mrs. James Tate, Jr.

From NORTH CAROLINA: 63—*Buies Creek*, Robert F. Soots; *Cary*, Kenneth Knapp; *Chapel Hill*, David R. Barnes, Annie Leigh Broughton, Barbara Christy, Alan Feduccia, Frances W. Fuller, Herman H. Henkle, J. P. Jones, Lynn J. Moseley, Mr. and Mrs. Helmut C. Mueller, James O. Pullman, Barbara Roth, Harold F. Sears, Mildred Sharpe, Mr. and Mrs. Robert Teulings, Mr. and Mrs. Albert C. Walker; *Charlotte*, Mr. and Mrs. Edwin O. Clarkson; *Durham*, Mr. and Mrs. Robin Carter, Mr. and Mrs. Robert S. Ridgely; *High Point*, Mrs. John F. Benson: *Hillsborough*, Charles H. Blake; *Long Beach*, Mr. and Mrs. Samuel R. Tipton; *New Bern*, Thomas A. Sherratt; *North Wilkesboro*, Wendell P. Smith; *Oxford*, Paul A. Stewart; *Raleigh*, Micou M. Browne, David Davis, Dorothy C. Grigg, R. J. Hader, Grace John, Edmund K. LeGrand, Harry E. LeGrand, Chris Marsh, Thomas L. Quay, Karen T. Ross, Irvin Savidge, Mary Showalter, C. David Whitehurst, Mr. and Mrs. E. W. Winkler, Ray L. Winstead; *Roanoke Rapids*, J. Merrill Lynch; *Southern Pines*, J. H. Carter III; *Statesville*, Mrs. John S. King, Jr., Mrs. Allen Knight, Sarah M. Nooe; *Swannanoa*, Robert C. Ruiz; *Whispering Pines*, Mr. and Mrs. Laurence C. Davis; *Wilmington*, Edna Appleberry, James F. Parnell, John T. Williams, Jr.; *Winston-Salem*, Ruth Hill, Ramona Snavely, Mr. and Mrs. Robert Witherington.

From OHIO: 19—*Ashtabula*, Howard E. Blakeslee; *Bowling Green*, Elden W. Martin; *Chagrin Falls*, Mr. and Mrs. David W. Swetland; *Cincinnati*, Mr. and Mrs. Arthur J. Wiseman; *Cleveland*, Lydia M. Tummonds; *Columbus*, Mr. and Mrs. Maurice L. Giltz; *East Liverpool*, Mr. and Mrs. John T. Laitsch; *Gambier*, Robert D. Burns; *Girard*, H. Heimerdinger; *Lakewood*, Mr. and Mrs. William A. Klamm; *Mentor*, Estrilla Daniels, Mildred Daniels; *Solon*, Ethel D. Surman; *Toledo*, John M. McCormick.

From PENNSYLVANIA: 7—*Chester Springs*, Mr. and Mrs. Phillips B. Street, *Indiana*, Richard F. Waechter; *Philadelphia*, C. Chandler Ross; *Pittsburgh*, Mr. and Mrs. Kenneth C. Parkes, Robert J. Raikow.

From SOUTH CAROLINA: 15—*Aiken*, Jeannine Angerman, T. M. Rial; *Charleston*, T. A. Beckett III, William McIntosh, Jr.; *Chester*, Mrs. B. Clyde Carter, Mrs. W. W. Johnston, Catherine T. Moore, Mrs. W. Cornwell Stone, Sr.; *Clemson*, Robert C. Beason, Sidney A. Gauthreaux, Jr.; *Clinton*, Jane P. Holt; *Pawley's Island*, Mr. and Mrs. F. M. Probst; *Seneca*, Paul B. Hamel; *Sumter*, Evelyn Dabbs.

From TENNESSEE: 4—*Knoxville*, Mr. and Mrs. Joseph T. Mengel; *Maryville*, Ralph J. Zaenglein; *Nashville*, Katherine A. Goodpasture.

From TEXAS: 5—*Arlington*, Robert L. Neill; *Austin*, Mr. and Mrs. Charles Hartshorne, Mr. and Mrs. Henry R. Henze.

From VERMONT: 1—*South Londonderry*, Mrs. James R. Downs.

From VIRGINIA: 12—*Alexandria*, Chris Risley; *Manassas*, Roxie C. Laybourne; *Mechanicsville*, Mr. and Mrs. Joseph E. Trahan; *Richmond*, Charles R. Blem; *Scottsville*, Mrs. Frederick S. Whiteside; *Sweet Briar*, Mr. and Mrs. Ernest P. Edwards; *Williamsburg*, Mr. and Mrs. Paul S. Baker, Mitchell A. Byrd, Jerry W. Via.

From WEST VIRGINIA: 2—*Morgantown*, Mr. and Mrs. George A. Hall.

From WISCONSIN: 3—*Baraboo*, George Archibald, *Madison*, George Allez, *Milwaukee*, Daniel D. Berger.

From ONTARIO: 1—*Hamilton*, Eric W. Bastin.

This issue of *The Wilson Bulletin* was published on 28 September 1973.

SUGGESTIONS TO AUTHORS

See Wilson Bulletin, 84:513, 1972 for more detailed "Suggestions to Authors." Manuscripts intended for publication in *The Wilson Bulletin* should be neatly typewritten, double-spaced, with at least one inch margins, and on one side only of good quality white paper. Tables should be typed on separate sheets, and should be designed to fit the normal page width, i.e., narrow and deep rather than wide and shallow. Before preparing these, carefully consider whether the material is best presented in tabular form. Follow the AOU Check-list (Fifth Edition, 1957) insofar as scientific names of United States and Canadian birds are concerned unless a satisfactory explanation is offered for doing otherwise. Use species names (binomials) unless specimens have actually been handled and subsequently identified. Summaries of major papers should be brief but quotable. Where fewer than five papers are cited, the citations may be included in the text. All citations in "General Notes" should be included in the text. Follow carefully the style used in this issue in listing the literature cited; otherwise, follow the "CBE Style Manual" (1972, AIBS). Photographs for illustrations should be sharp, have good contrast, and be on gloss paper. Submit prints unmounted and attach to each a brief but adequate legend. Do not write heavily on the backs of photographs. Diagrams and line drawings should be in black ink and their lettering large enough to permit reduction. Extensive alterations in copy after the type has been set must be charged to the author.

NOTICE OF CHANGE OF ADDRESS

If your address changes, notify the Society immediately. Send your complete new address to the Treasurer, Jerome A. Jackson, Dept. of Zoology, Mississippi State University, Mississippi State, Mississippi 39762. He will notify the printer.

The permanent mailing address of the Wilson Ornithological Society is: c/o The MUSEUM of Zoology, The University of Michigan, Ann Arbor, Michigan 48104. Persons having business with any of the officers may address them at their various addresses given on the back of the front cover, and all matters pertaining to the Bulletin should be sent directly to the Editor.

IMPORTANT NOTICE

All manuscript material for the Wilson Bulletin should be sent to Dr. John P. Hubbard, P.O. Box 3937, Greenville, Delaware 19807. Dr. Hubbard becomes the Editor for Volume 86.

Plan Now to Attend the

FIFTY-FIFTH ANNUAL MEETING

at

THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION
PELLSTON, MICHIGAN

6–9 June 1974

- W

The Wilson Bulletin

PUBLISHED BY THE WILSON ORNITHOLOGICAL SOCIETY
WEST VIRGINIA U. • MORGANTOWN, W. VA.

VOL. 85, NO. 4 DECEMBER 1973 PAGES 379–546

THE WILSON ORNITHOLOGICAL SOCIETY

FOUNDED DECEMBER 3, 1888

Named after ALEXANDER WILSON, the first American Ornithologist.

President—Kenneth C. Parkes, Carnegie Museum, Pittsburgh, Pennsylvania 15213.

First Vice-President—Andrew J. Berger, Dept. of Zoology, University of Hawaii, Honolulu, Hawaii 96822.

Second Vice-President—Douglas A. James, Dept. of Zoology, University of Arkansas, Fayetteville, Ark. 72703.

Secretary—James Tate, Jr., Dept. of Natural Resources, Fernow Hall, Cornell University, Ithaca, New York 14850.

Treasurer—Jerome A. Jackson, Dept. of Zoology, Mississippi State University, Mississippi State, Mississippi 39762.

Elected Council Members—Robert D. Burns (term expires 1974); Harvey I. Fisher (term expires 1975); George A. Hall (term expires 1976).

Membership dues per calendar year are: Active, $8.00; Sustaining, $15.00; Life memberships, $200 (payable in four installments).
THE WILSON BULLETIN is sent to all members not in arrears for dues.

THE JOSSELYN VAN TYNE MEMORIAL LIBRARY

The Josselyn Van Tyne Memorial Library of the Wilson Ornithological Society, housed in the University of Michigan Museum of Zoology, was established in concurrence with the University of Michigan in 1930. Until 1947 the Library was maintained entirely by gifts and bequests of books, reprints, and ornithological magazines from members and friends of the Society. Now two members have generously established a fund for the purchase of new books; members and friends are invited to maintain the fund by regular contribution, thus making available to all Society members the more important new books on ornithology and related subjects. The fund will be administered by the Library Committee, which will be happy to receive suggestions on the choice of new books to be added to the Library. William A. Lunk, University Museums, University of Michigan, is Chairman of the Committee. The Library currently receives 104 periodicals as gifts and in exchange for *The Wilson Bulletin.* With the usual exception of rare books, any item in the Library may be borrowed by members of the Society and will be sent prepaid (by the University of Michigan) to any address in the United States, its possessions, or Canada. Return postage is paid by the borrower. Inquiries and requests by borrowers, as well as gifts of books, pamphlets, reprints, and magazines, should be addressed to "The Josselyn Van Tyne Memorial Library, University of Michigan Museum of Zoology, Ann Arbor, Michigan." Contributions to the New Book Fund should be sent to the Treasurer (small sums in stamps are acceptable). A complete index of the Library's holdings was printed in the September 1952 issue of *The Wilson Bulletin* and newly acquired books are listed periodically.

THE WILSON BULLETIN

The official organ of the Wilson Ornithological Society, published quarterly, in March, June, September, and December, at Morgantown, West Virginia. The subscription price, both in the United States and elsewhere, is $10.00 per year. Single copies, $2.50. Subscriptions, changes of address and claims for undelivered copies should be sent to the Treasurer. Most back issues of the *Bulletin* are available (at $2.50 each) and may be ordered from the Treasurer. Special prices will be quoted for quantity orders.

All articles and communications for publications, books and publications for reviews should be addressed to the Editor. Exchanges should be addressed to The Josselyn Van Tyne Memorial Library, Museum of Zoology, Ann Arbor, Michigan. Known office of publication: Department of Zoology, Mississippi State University, Mississippi State, Mississippi 39762.

Second class postage paid at Mississippi State, Mississippi and at additional mailing office.

PRINTED IN U.S.A. Allen Press, Inc., Lawrence, Kansas 66044

THE WILSON BULLETIN

A QUARTERLY MAGAZINE OF ORNITHOLOGY
Published by The Wilson Ornithological Society

VOL. 85, NO. 4 DECEMBER 1973 PAGES 379–546

CONTENTS

GENERAL NOTES

Downy young of some primitive rails: top—*Himantornis haematopus;* middle—*Canirallus kioloides;* bottom—*Canirallus (Rallicula) forbesi.* Painting by Willam Zimmerman

A CLASSIFICATION OF THE RALLIDAE

STORRS L. OLSON

THE family Rallidae, containing over 150 living or recently extinct species and having one of the widest distributions of any family of terrestrial vertebrates, has, in proportion to its size and interest, received less study than perhaps any other major group of birds. The only two attempts at a classification of all of the recent rallid genera are those of Sharpe (1894) and Peters (1934). Although each of these lists has some merit, neither is satisfactory in reflecting relationships between the genera and both often separate closely related groups. In the past, no attempt has been made to identify the more primitive members of the Rallidae or to illuminate evolutionary trends in the family. Lists almost invariably begin with the genus *Rallus* which is actually one of the most specialized genera of the family and does not represent an ancestral or primitive stock.

One of the difficulties of rallid taxonomy arises from the relative homogeneity of the family, rails for the most part being rather generalized birds with few groups having morphological modifications that clearly define them. As a consequence, particularly well-marked genera have been elevated to subfamily rank on the basis of characters that in more diverse families would not be considered as significant.

Another weakness of former classifications of the family arose from what Mayr (1949:3) referred to as the "instability of the morphology of rails." This "instability of morphology," while seeming to belie what I have just said about homogeneity, refers only to the characteristics associated with flightlessness—a condition that appears with great regularity in island rails and which has evolved many times. I have elsewhere (Olson, 1973) argued that flightlessness in rails is a neotenic condition that is evolved very rapidly, involves little genetic modification, and is without major phylogenetic significance. Flightlessness and its associated morphology can be used as a taxonomic character in the Rallidae only at the specific or subspecific levels. When this is done, the result is the elimination of much fragmenting of genera that had previously obscured the origins and relationships of many species.

Whenever possible in determining relationships I have tried to examine skeletons of each genus, but in many cases anatomical material was not available and often I have had to rely solely on skins. Consequently the classification of certain groups remains tentative. The skeletal material examined for this study is the same as that used in Olson (1973).

Publication of this paper was subsidized in part by a gift from the Smithsonian Institution.

THE SUBFAMILIES OF RALLIDAE

The family Rallidae has traditionally been divided into three subfamilies—the Rallinae, the Gallinulinae, and the Fulicinae (see Brodkorb, 1967, for original citations), but there has been little justification for such a treatment and the assignment of many genera to a particular subfamily was often purely arbitrary. Sharpe (1893*a*:26) pointed out that

> "the popular division of the family into Rails, Gallinules, and Coots was an untenable one, the Coots alone having definite characters for their separation as a subfamily, and that even these characters were approached by those of the Gallinules. It seemed therefore, best to keep the whole of the Rails together as a family, and not recognize minor divisions such as those specified. The gradual transition from typical Rails to Crakes . . . and from Crakes to Gallinules . . . was so marked that it was impossible to say where the Rails ended and the Crakes began, or where the Crakes ended and the Gallinules began."

A similar opinion was voiced by Ridgway and Friedmann (1941:41):

> "Notwithstanding the great dissimilarity between the typical rails . . . and the coots . . . there is so complete a gradation from one extreme to the other in forms of intermediate characters that it is doubtful whether any subfamilies can be satisfactorily defined."

With these opinions I am in full accord. Certainly there can be no realistic separation of "rails" from "gallinules." There are no external or osteological characters that can be used to distinguish the two groups and genera such as *Amaurornis* can scarcely be separated on the one hand from some of the crakes included in the "Rallinae" or on the other from the more typical gallinules of the "Gallinulinae."

A better, but not convincing, case might be made for recognizing the Fulicinae. However, the lobed toes are not confined to *Fulica.* The toes of *Porphyriops* are narrowly but distinctly lobed and those of *Gallinula chloropus* are at least somewhat emarginated. Ridgway and Friedmann (1941:207) state that

> "*Fulica ardesiaca* Tschudi, *F. armillata* Vieillot, and *F. rufifrons* Phillipi and Landbeck agree with one another and differ from all the species of *Fulica* proper in having the lateral membranes of the toes very narrow, with the segments very slightly if at all convex, indeed almost bridging the gap between coots and gallinules."

This statement is correct only as it applies to *rufifrons*, the toes of *ardesiaca* and *armillata* being as well lobed as those of other species of *Fulica.* Nevertheless, *F. rufifrons* and *Porphyriops melanops* do clearly bridge the gap between the coots and the gallinules in this respect and there is no external character of subfamilial importance by which *Fulica* may be distinguished from the "gallinules."

The skeleton of *Fulica* is with few exceptions very similar to that of *Gallinula.* The most marked difference is in the pelvis, which in *Fulica* is narrower and more elongate. This is an adaptation that is correlated with the diving habit (Raikow, 1973). The tarsus of *Fulica* is somewhat more compressed than in *Gallinula* and the cnemial crest of the tibia is better developed, both also correlated with diving locomotion. In all other Rallidae, except the flightless species, the humerus length is about the same as that of the femur, but in *Fulica cristata*, *F. atra*, *F. americana*, *F. ardesiaca*, *F. caribaea*, *F. armillata*, and *F. leucoptera* the humerus averages from 27 percent to 34 percent longer than the femur. However, in *F. rufifrons* the humerus and femur are equal in length as in most other rails (it thus appears that in at least two respects—humerus length and lobing of the toes—*rufifrons* is the least specialized species of *Fulica*, although the pelvis is modified in typical coot fashion). The apparently longer humerus of most species of *Fulica* is probably correlated in part with a high wing loading, such as reported for *F. atra* (Jeikowski, 1971), but may also reflect a shortening of the femur which is another characteristic of diving birds.

Both the adult and juvenal plumages of *Fulica* are similar to *Gallinula*. Clearly, *Fulica* is a derivative of a *Gallinula*-like ancestor and differs from gallinules only in adaptations for diving which parallel those of most diving birds. This is not the sort of profound phylogenetic dichotomy that should characterize a subfamily. *Fulica* is a well-defined genus in a family where generic lines are often difficult to draw. It has, however, diverged only slightly, and along predictable lines, from its quite-evident ancestral stock. I cannot support subfamilial status for the genus.

The most recent assessment of the subgroupings of the Rallidae is that of Verheyen (1957) who divided the family into five subfamilies as follows: Fulicinae (containing two tribes, Fulicini for *Fulica* alone, and Gallinulini for *Gallinula*, *Amaurornis*, *Rougetius*, *Tribonyx*, *Megacrex*, *Gallicrex*, *Habroptila*, *Pareudiastes*, *Porphyriops*, and *Porphyriornis*), Porphyriinae [sic]* (containing *Porphyrio*, *Porphyrula*, and *Notornis*), Sarothrurinae (for *Sarothrura* alone), Himantornithinae (for *Himantornis* alone), and Rallinae (for the remaining genera). Verheyen's inability to provide rational classifications has been well documented (Sibley and Ahlquist, 1972) and I found but little of value in his classification of the Rallidae, many of his characters being inconsistent or insignificant. None of the characters he gives for his Fulicinae serve to differentiate that group from his Rallinae. The same is true of the "Sarothrurinae." *Sarothrura* is very closely related to genera he includes in his Rallinae (see below).

A somewhat better case for subfamilial status could be made for the Porphyrioninae but no stronger than that for the Fulicinae. Most of the characters of the group given by Verheyen are not diagnostic. Those that are, are adaptations for locomotion on floating vegetation (many paralleling those

---

* The correct rendering of the subfamily name should be "Porphyrioninae," a term, according to Gray (1871), first used by Reichenbach in 1850.

seen in the Jacanidae) and for rather specialized feeding methods. I have elsewhere discussed the nature of some of these modifications (Olson, 1973). They constitute a derived state that is of about the same significance as the diving adaptations of *Fulica*. The specializations of the "Porphyrioninae" are unduly conspicuous because of the lack of specialization of most of the rest of the family. It is hardly of value to taxonomy to erect a subfamily for each genus that evolves adaptations for some specialized mode of locomotion.

One subfamily recognized by Verheyen is quite valid, namely, the Himantornithinae, containing the single species *Himantornis haematopus*. Previous to Verheyen, only Gray (1871) had elevated *Himantornis* to subfamily rank—an action that was subsequently ignored by both Sharpe (1894) and Peters (1934) who placed the genus *in medias res*.

Himantornis is a forest-dwelling bird (apparently even nesting in trees, Chapin, 1939:24) confined to western and west-central Africa. The adult is a large rail with very long slender legs, a short decurved bill, and a singularly unrail-like appearance. The natal down is also highly unusual (Chapin, 1939:29). The downy plumage of most rails is black. In some species of *Aramides* it may be uniform brownish or brownish-black and in *Mentocrex kioloides* and *Rallicula* the down is patterned with black and reddish-brown (frontispiece). In *Himantornis*, however, the chick is distinctively patterned with light and dark markings totally unlike any other rail (frontispiece). This presumably cryptic plumage pattern more closely resembles that of precocial chicks of other orders, such as the Galliformes or Anseriformes, than it does the remainder of the Rallidae. The all-black natal down of most rails is a wide departure from that of typical downy precocial chicks while that of *Himantornis* is not. The natal down of *Himantornis* probably represents a relatively primitive state while the black down of typical rails is a specialized, derived condition.

The skeleton of *Himantornis* shows a number of peculiarities. The distinctive appearance of the skull cannot be matched by any rail (Fig. 1). *Himantornis* is the only rail in which the ectethmoid bone projects far outward and abuts firmly against the lacrimal. The very large, heavy lacrimal has a strong descending process with an expanded foot which comes in contact, or near contact, with the jugal. In these respects and in the general appearance of the skull, *Himantornis* is amazingly similar to the trumpeters (Psophiidae) and in fact comes closer to *Psophia* than to other rails (Fig. 1). *Psophia* differs in having the palatines, maxillopalatines, and the head of the lacrimal larger and more expanded and in its almost completely ossified interorbital septum. The greatly expanded orbital rims in *Himantornis* are asymmetrical in the specimen I examined and it appears as if they could very well have had their origins in something comparable to the accessory supraorbital bones found in

FIG. 1. Top to bottom: Skulls of *Psophia leucoptera*, *Himantornis haematopus*, and *Canirallus oculeus*. Note the lacrimal-ectethmoid contact (arrows) in *Psophia* and *Himantornis*, and the tenuous nasal bar in *Canirallus* versus the broad condition in the other two.

Fig. 2. Left to right: Coracoids of *Psophia crepitans*, *Himantornis haematopus*, *Canirallus oculeus*, and *Fulica americana* (ventral view above, dorsal view below). The dotted line on *Psophia* suggests that portion of the procoracoid that need be removed for the coracoid to approximate that of *Himantornis*. Arrows indicate pneumatic foramina.

Psophia. The distribution of nutrient foramina in the orbital rims of *Himantornis* and *Psophia* are similar.

Several elements of the postcranial skeleton of *Himantornis* are distinct from other rails and are closer to *Psophia*. The coracoid has a peculiar shape, with the head rather flat and oriented nearly perpendicular to the shaft, as seen in *Psophia*, and the procoracoid process is long and broad (Fig. 2). The head of the coracoid in typical rails is oriented in a line with the shaft and the procoracoid process is usually smaller and more angular (Fig. 2). The procoracoid process of *Psophia* is extremely broad and expanded, more so than in any other family of birds, and thus exaggerates the condition seen in *Himantornis*. This process abuts against the dorsal portion of the clavicle, but why so much additional bracing is needed in *Psophia* is not known. If part of the procoracoid of *Psophia* were removed (as suggested by the dotted lines in Fig. 2) the result would be a coracoid almost identical to that of *Himantornis*. Of the other genera of rails examined, the coracoid of *Canirallus oculeus* (Fig. 2) comes closest to that of *Himantornis*, the procoracoid also being much expanded, but in a different manner. The sterno-coracoidal impression is very deep and pneumatic in *Psophia* and *Himantornis*. Although this cavity may be greatly excavated in other rails, such as *Canirallus*, in no other rail is the coracoid pneumatic. The shape of the pelvis in *Himantornis*, particularly in the more elongated postacetabular ilium and ischium, is more similar to *Psophia* than to the Rallidae. The very broad, pneumatic ribs of *Himantornis* are also more similar to *Psophia* than to the Rallidae.

The tibia of *Himantornis* is proportionately very long and more slender than in other rails. The medial face of the internal condyle is deeply excavated and the posterior rim of this condyle is a thin expanded flange, differing from other rails but closely resembling *Psophia*. The tarsus is likewise distinctive, being long and slender with a thin rectangular shaft and abruptly flaring articular surfaces. The inner trochlea is in nearly the same plane as the outer. In no other rail is the inner trochlea as low. In this respect also, *Himantornis* resembles *Psophia* (Fig. 3).

At this point the familial allocation of *Himantornis* might be questioned but a number of characters show that it indeed belongs to the Rallidae. It has the typical 2-notched sternum of the Rallidae, whereas the sternum of *Psophia* is long, narrow, entire, and rectangular like that of the Gruidae, Aramidae, and Rhynochetidae. *Psophia* lacks, and *Himantornis* has, the scapular tubercle for the dorsal branch of the tendon of M. expansor secundariorum—a rallid character (Olson, 1973). Vertebrae 19–21 are fused into one bone in *Psophia*, whereas the lumbar vertebrae are not fused in any rail, including *Himantornis*. Rails have either 14 or 15 cervical vertebrae, *Himantornis* has 15, but *Psophia* has 17. The humerus of *Himantornis* is rallid and unlike the peculiar knobby humerus of *Psophia*.

The external appearance, osteology, and natal down of *Himantornis* show it to be the most primitive and distinctive rail. It has no close relatives. The characters it shares with the Psophiidae suggest that it, of all rails, is closest to the stock that gave rise to both the Psophiidae and the Rallidae and it provides a definite link between the two families. No other species or group of living rails presents peculiarities of the magnitude of those of *Himantornis*.

FIG. 3. Left to right: Tarsi of *Aramides cajanea*, *Himantornis haematopus*, and *Psophia crepitans* (reduced for comparison). Note the lower inner trochlea in *Himantornis* and *Psophia*.

I therefore recommend that only two subfamilies of living Rallidae be recognized—the Himantornithinae and the Rallinae.

RELATIONSHIPS WITHIN THE RALLINAE

In attempting to determine relationships within the Rallinae, *Himantornis* at least gives us a few clues as to which species may be primitive. Forest-dwelling forms with long slender tarsi, broad procoracoid processes, and patterned natal down would provide good starting points.

Two other characters emerge as being of possible importance in grouping or separating certain genera. The presence of conspicuous white or buffy bars in the remiges ties in a number of genera that on other grounds as well seem closely related. This barring may be secondarily lost so that its absence in some species does not necessarily prove lack of relationship with bar-winged genera.

The second character of possible utility is the condition of the nasal bar. The nasal bar in the Rallidae may be broad and flat, contributing to a typically "holorhinal" nostril such as in *Himantornis* (Fig. 1), or it may be slender and twisted, forming the so-called "pseudoschizorhinal" nostril such as in

Canirallus (Fig. 1). The slender nasal bar and either schizorhinal or pseudoschizorhinal nostrils are found in most families of Gruiformes, but the broad, flat nasal bar and holorhinal nostril are found in the Psophiidae and the Heliornithidae, the two Gruiform families probably most closely related to the Rallidae. It is difficult to say which condition is primitive and which derived, although at least in some instances the broad condition of the nasal bar appears to have been derived from the tenuous condition by a simple ossification of the area between the nasal bar and the dorsal branch of the nasal bone. Either condition may be found in both long-billed and short-billed species, making a functional correlation difficult. (In a number of species for which there was no skeletal material I was able to determine the condition of the nasal bar by exposing it in skins.)

One of the most primitive groups of the Rallinae is formed by the three "genera" *Canirallus*, *Mentocrex*, and *Rallicula*, containing the species *C. oculeus* of West Africa, *M. kioloides* of Madagascar, and the four species of *Rallicula* in New Guinea. I have seen a skeleton of only *C. oculeus*. This exhibited a very much expanded procoracoid process (Fig. 2) and very slender, square-shafted tarsi with wide articulations as in *Himantornis*. All of these forms are forest dwellers that are united by a combination of the following characters: bill with similar shape (high flat-ridged culmen and large deep nasal fossa); tenuous nasal bar; rich chestnut neck and breast; black or dark brown lower belly, thighs, and crissum narrowly barred with buff; long, fluffy red tail; black remiges and axillars barred with broad bands of white. Furthermore, the natal down of at least *Mentocrex* and *Rallicula* is distinctly patterned (frontispiece), another indication of the primitiveness of the group. The beautiful velvety down of *M. kioloides* is striped above and mottled with brown and black below (Rand, 1936, gives a full description). The chick of *Rallicula forbesi* is entirely mottled with black and brown and lacks the distinctive dorsal pattern of *M. kioloides*. A chick of *Rallicula rubra* (AMNH 338622) is similar to *R. forbesi* but darker, with black predominating over the brown. Bannerman (1931:8) describes the chick of *C. oculeus* as "entirely covered with blackish-brown velvety down" but does not mention any pattern. The patterned natal down in this group is somewhat intermediate between the primitive condition of *Himantornis* and the pure black down of typical rails.

The species *kioloides* was generally placed in *Canirallus*, along with *oculeus*, until Peters (1932*a*) separated it in the genus *Mentocrex* because its imperforate nostrils differed from the perforate condition of *oculeus*. This difference is not generically important, however, as Wetmore (1967) has recently pointed out that two forms of *Neocrex*, previously considered conspecific, differ in this same respect. As *kioloides* otherwise differs from *oculeus* only in its smaller size, white versus gray throat, rufous versus green scapulars, and absence of white barring on the upper coverts, I follow Rand (1936) is not recognizing *Mentocrex.*

Peters (1932*a*) noted a similarity between *C. kioloides* and *Rallicula* but later (1934) separated them widely in his checklist. *Rallicula* differs from *Canirallus* only in its smaller size, sexual dichromatism (probably the result of active speciation on New Guinea), presence of white markings and/or black coloration instead of green in the dorsum, and absence of gray on the head. In its intermediate size and presence of rufous in the dorsum, *kioloides* bridges the gap between *oculeus* and *Rallicula.*

The great similarity in the structure, plumage, and natal down of *Rallicula* and *Canirallus,* in my opinion, outweighs their comparatively minor differences in plumage. It is more realistic and instructive to combine the two genera, maintaining *Rallicula* Schlegel 1871 as a subgenus of *Canirallus* Bonaparte 1856.

This has the zoogeographical effect of tying together West Africa, Madagascar, and New Guinea. The relict nature of much of the Madagascan fauna has long been recognized and this fauna has connections both with Africa and Asia. The forests of West Africa have also acted as a refugium for relict forms, many of which have their closest relatives in the Oriental realm. Although the observant Chapin (1932) was well aware of the relationship between the West African forest fauna and that of Asia, such was not apparent to Moreau (1966:177) who gave it little consideration. A few examples should suffice to establish the link: the African heron *Tigriornis* is apparently closest to *Zonerodius* of New Guinea (Chapin, 1932); the relict Congo eurylaimid *Pseudocalyptomena* has its closest apparent relatives in the Asian genus *Calyptomena* which has its center of species abundance in Borneo; the West African piculet *Verrauxia* is very close to, and probably should be congeneric with *Sasia* of Asia; the Congo Peacock *Afropavo* has its closest affinities with Asian peacocks; the most primitive living swallow, *Pseudochelidon eurystomina* of the Congo, has as its closest relative the recently discovered *Eurochelidon* (= *Pseudochelidon* auct.) *sirintarae* of Thailand; the owl *Phodilus prigoginei,* known from a single specimen taken in 1951 in the mountains northwest of Lake Tanganyika, has its only relative in *Phodilus badius* of Asia; Ripley (1966) has noted that the West African owl *Otus icterorhynchus* and its relict relative, *O. ireneae,* of Kenya, seem to be most similar to *O. balli* of the Andaman Islands. Among mammals, the chevrotains (Tragulidae) are known from West Africa, India, and Malaysia, with fossil forms known in intervening areas and Europe (Anderson and Jones, 1967). The presence of the most primitive living rail, *Himantornis,* in the West African forests lends additional weight to the idea of their being an important refugium. The list could no doubt be profitably expanded to include other groups of organisms. It is clear that many forest-inhabiting taxa were once of much wider distribution and are now confined to disjunct refugia in West Africa and Asia because of the deterioration of the environment in the areas between. The fragmented distribution of *Canirallus* (sensu lato) is further testimony to the antiquity of the group.

Very closely related to *Canirallus* (especially *Rallicula*) is the African genus *Sarothrura* containing nine species of small "crakes" that appear to be a direct offshoot from a *Rallicula* stock (providing another link between Africa and New Guinea). Salvadori (1875) tentatively described *Rallicula leucospila* as a species of *Sarothrura* and the similarity of the two genera was also noted by Chapin (1932). This was not reflected by Peters (1934) who interposed 26 genera between them.

In *Sarothrura*, as in *Rallicula*, the sexes are strongly dichromatic, a condition found elsewhere in the Rallidae only in *Gallicrex cinerea* and *Porzana parva*. The male of *S. pulchra*, with its chestnut head, breast, and upper back, fluffy red tail, black mantle and wings with round white polka-dots, plush loreal feathering and nearly identically shaped bill, is an exact duplicate in miniature of the females of *Rallicula*. The black tail-barring of females of *S. pulchra* and *S. insularis* is found in some plumages of *Rallicula*, and the white streaking of males of *R. leucospila* is very reminiscent of males of the *Sarothrura rufa* group. The white barring on the flight feathers of *Rallicula* is present in *Sarothrura* only as spots on the outer webs of the remiges of *pulchra* and *elegans* and has apparently been lost in the other species of the genus. In *S. pulchra*, at least, the nasal bar is broader than in *Canirallus-Rallicula*.

Not only is *S. pulchra* the most similar in plumage to *Rallicula* but it also has by far the longest and most slender tarsi of the genus (Chapin, 1939), and with the exception of *S. elegans*, is the only truly forest-dwelling member of the genus. These features, as previously noted, appear to be primitive in the Rallidae. In this case, *pulchra* would be the most primitive species of *Sarothrura*, the others having secondarily adapted to more open grassland marshes. This is exactly the reverse of the phylogeny advanced by Keith et al. (1970). In the process of adapting to grassland habitat, *Sarothrura* has progressively lost many of the *Rallicula*-like characters such as the fluffy red tail and the wing-barring, while the tarsi have become shorter, and in the most advanced forms, the bill has become very short and deep.

Two other genera, *Coturnicops* and *Micropygia*, are possible relatives of *Sarothrura*. Both of these taxa consist of small species with very short, deep bills and which inhabit open grassland marshes. *Coturnicops* contains the species *notata* of South America and *exquisita* and *noveboracensis* which form a holarctic superspecies. All three have a large white patch in the secondaries—a character that is found elsewhere only in *Sarothrura ayresi*, a relict species that has at times been placed in *Coturnicops*. As the white secondary patch is found nowhere else in the Rallidae and is shared by species of such similar build and ecological preference, a relationship between *Sarothrura* and *Coturnicops* is strongly implied. Furthermore, the plumage of *Coturnicops* is not unlike that of females of the more advanced grassland species of *Sarothrura. Coturnicops* is possibly a "hen-plumaged" derivative of *Sarothrura* stock that has lost its sexual dichromatism in isolation from related species.

In the South American species *Micropygia schomburgkii*, the ocellated dorsum, rufous crown, short bill, and grassland habits are also suggestive of *Sarothrura*, and in spite of its name it has a rather well-developed tail like *Sarothrura*. Dickerman (1968) has shown that there is a fairly consistent sexual difference in the crown color of *Micropygia*—perhaps a partial retention of the sexual dichromatism seen in *Sarothrura*.

There is nothing in the internal or external morphology of *Sarothrura* that supports the retention of Verheyen's "Sarothrurinae." The genus is obviously closely related to *Rallicula* and possibly to *Coturnicops* and *Micropygia* as well. The white, unmarked eggs of *Sarothrura* were believed by Verheyen (1957) to be distinctive, but unmarked eggs are also found in *Rallina*, and in *Laterallus viridis* and *L. leucopyrrhus* (Schoenwetter, 1961). I have been unable to find any reference to the eggs of *Rallicula*. A domed roosting nest, from which birds of both sexes were taken, has been reported by Mayr and Gilliard (1954) and is suggestive of the domed nests of *Sarothrura*.

Closely related to *Canirallus-Rallicula* are the four species of *Rallina*. They differ in possessing a broad, flat nasal bar and, in contrast to *Rallicula*, are not sexually dichromatic. They agree with *Canirallus-Rallicula* in their generally chestnut coloration, white-barred wings, and slender tarsi. *Rallina canningi*, found in dense forests on the Andaman Islands, is the only species of the genus with a long, fluffy, red tail. This is a definite link with *Canirallus-Rallicula* and *Sarothrura*, the only other genera in the family exhibiting this distinctive character. *Rallina tricolor* has a dark belly narrowly barred with buff as in *Canirallus-Rallicula* but the other three species of *Rallina* have the belly heavily barred with black and white—a pattern that also appears in some species of *Sarothrura*. *R. tricolor* occurs on New Guinea but inhabits swampy jungle and marshes and is thus ecologically isolated from *Rallicula*. *Rallina fasciata* and *R. euryzonoides* occupy both wet forested situations and marshes. *Rallina* appears to be a group that is in transition from the woodland habitat of the more primitive rails, to the wetland habitat usually thought of as typical for the family.

In the New World, the genera *Anurolimnas* and *Laterallus* appear to be derivatives of *Rallina* stock. *Anurolimnas castaneiceps* is a forest rail with very similar structure and coloration to *Rallina* except that it lacks the wing barring and has a very abbreviated tail. Sharpe (1894) included the species *fasciatus* (= *Laterallus hauxwelli* auct.) in *Anurolimnas* but Peters (1934), ignoring its obvious similarity to *A. castaneiceps*, arbitrarily placed it in *Laterallus*. Stresemann and Stresemann (1966) were the only subsequent authors not to follow Peters' lead. They returned *fasciatus* to *Anurolimnas* because its pattern of primary molt was similar to that of *A. castaneiceps* and different from that of *Laterallus*. *A. fasciatus* differs from *castaneiceps* only in its smaller size and black-barred belly—the two are otherwise nearly identical. Another species, *Laterallus viridis*, also seems closer to *Anurolimnas* than to *Laterallus*. It is not as close to *castaneiceps* as *fasciatus* is, and the tail is slightly better developed than in those two species. Nevertheless, all three are larger than *Laterallus* and differ from that group in having proportionately longer tarsi, greenish backs, and bright chestnut crowns, and are best considered congeneric.

With the removal of *fasciatus* and *viridis*, the genus *Laterallus* may prove to be more of a natural group than I was formerly inclined to believe (Olson, 1970). In the skeletons of the species I have examined (*leucopyrrhus*, *albigularis*, *jamaicensis*, and also *A. viridis*) the hindlimb elements are proportionately longer and more slender and the wing elements shorter than in any of the "crakes" in or near *Porzana*. They are more similar to *Rallina*. There are also some striking similarities in plumage between *Laterallus* and *Rallina*. *L. leucopyrrhus*, except for having the center of the throat and breast white instead of rufous and except for its discontinuous ventral barring, shows a marked likeness to *Rallina fasciata*. Both the adult and juvenal plumages of *L. albigularis* are near duplicates of the corresponding plumages of *Rallina euryzonoides*. The barring of the remiges characteristic of *Rallina* is generally lacking in *Laterallus*, however, the remiges of *L. jamaicensis* are spotted with white and those of occasional specimens of *L. albigularis* may be faintly mottled or barred with white. Except for *Sarothrura*, the only rails known to have white, unspotted eggs are *Rallina*, *A. viridis* and *L. leucopyrrhus*. I think it is highly likely that *Anurolimnas* and *Laterallus* were derived from an Old World *Rallina*-like ancestor and are not related to *Porzana*. Thus in Africa and South America there appears to have been a parallel radiation of diminutive "crakes"; one group being derived from a *Rallicula* woodland ancestor and the other from a *Rallina* stock.

Returning to the Old World, we encounter the two species of *Nesoclopeus* (*poeciloptera* of Fiji and *woodfordi* of the Solomons), both originally described as members of *Rallina*. Sharpe (1894) placed them in *Eulabeornis*, a quite unrelated genus, from which Peters (1932*b*) properly removed them, creating the genus *Nesoclopeus* for their reception. Greenway (1958), with no explanation, returned them to *Rallina*, using *Nesoclopeus* as a subgenus. Both species have barred primaries and the broad white bars of *woodfordi* are indeed suggestive of *Rallina*. However, both species have the tenuous nasal bar, unlike *Rallina*, and both have relatively heavier, shorter tarsi. There is a faint but distinct outline of a facial pattern (better developed in *poeciloptera*) that is similar to that of the *philippensis* group of *Gallirallus* (sensu lato, see below) and the brown-barred wings of *poeciloptera* are more suggestive of that group than *Rallina*. Until more of their structure is known, it is preferable to maintain the genus *Nesoclopeus*. The genus may provide an intermediate between *Rallina* and the *Gallirallus* group.

We come next to a group of barred-wing rails the relationships of which have been greatly obfuscated by combining a number of the species with the more specialized species of *Rallus* (sensu stricto) and also by the creation of several unnecessary genera for flightless forms of the group. The species *philippensis*, *owstoni*, *wakensis*, *torquatus*, and *striatus* have either been combined with *Rallus* or segregated as a separate genus *Hypotaenidia*. Peters (1934) recognized *Hypotaenidia* as a subgenus of *Rallus* although he placed *striatus* in the subgenus *Rallus*. I recently revived the use of *Hypotaenidia* (Olson, 1973) but as we shall see below, this name must ultimately give way to *Gallirallus*.

The abovementioned species of "*Hypotaenidia*" differ from *Rallus* in being relatively unspecialized, with stouter bills, wider sterna, and heavier hindlimbs. They differ further in having the primaries barred conspicuously with white or reddish-brown, and most species are rather ornate with a bold pattern of stripes on the face and a chestnut or ochraceous band across the chest.

Within this group may be recognized subgroups, of which, that containing *philippensis* and its derivatives has the widest distribution and has given rise to the most flightless forms. The flightless species *owstoni* on Guam, although larger and longer-billed than *philippensis*, retains the same facial pattern and some individuals still show a faint ochraceous pectoral band and a pronounced reddish color on the nape recalling *philippensis*. Individuals of the small flightless species *wakensis*, of Wake Island, also retain traces of the pectoral band, rusty nape, and facial pattern of *philippensis*.

A confusing situation has existed concerning the *philippensis* derivatives of the Chatham Islands. This group of islands lies about 500 miles east of New Zealand and consists of the large main island of Chatham itself, smaller Pitt Island 14 miles to the southeast, and numerous other islets of which only Mangare, a satellite of Pitt, is of concern here (see map in Fleming, 1939). Two *philippensis* derivatives were described from this group, each of which eventually came to rest in its own genus. Erroneously, both of these species have commonly been regarded as occupying the whole Chatham group

(Rothschild, 1907; Peters, 1934; Greenway, 1958). Their rather complicated history runs as follows.

A single specimen of a distinctive rail was collected by Dieffenbach in 1842 on the main island of Chatham and was named *Rallus dieffenbachii* by Gray. The species is now extinct. A correspondent wrote Buller (1873:180) in 1863 that he knew this bird as a boy and that it disappeared in the third year of Maori occupation of the island.

In 1872 Hutton described a new species, *Rallus modestus*, from the islet of Mangare, which differed considerably in plumage from *dieffenbachii*. For this species Hutton (1874) quickly created a new genus, *Cabalus*, the basis for which lay in skeletal modifications correlated with flightlessness. Buller (1873) considered *modestus* to be merely the juvenal plumage of *dieffenbachii*, as at first did Forbes (1892) and Sharpe (1894—plate 6 shows an example of *modestus* encaptioned "*Cabalus dieffenbachii* juv."). Upon receipt of a series of skins from Mangare containing both young and adults of *modestus*, and upon the testimony of the collector Hawkins who stated that young and adult were alike, Forbes (1893*a*) rescinded his former opinion and maintained *modestus* distinct from *dieffenbachii*. Sharpe (1894:331) inserted an addendum to this effect in his catalogue.

The type of *dieffenbachii* came from Chatham Island. Forbes (1893*b*) reported bones of this species from Chatham. Andrews (1896) also discussed a collection of bones from Chatham that included this species and upon the basis of its better developed sternum, shorter bill, and different plumage, he removed *dieffenbachii* from *Cabalus* (where Sharpe had placed it) and created the genus *Nesolimnas* for it. Fleming (1939:492) mentions an adult of *modestus* in the Canterbury Museum labelled "Pitt Island" and a downy young in the Dominion Museum with the same locality. Apart from these two specimens, all known examples of *modestus* were taken on Mangare. Forbes (1893*b*:533) reported that "bones referable *apparently* [emphasis mine] to this species [*modestus*] have, however, been found among the subfossil remains in Wharekauri [= Chatham]." This single very doubtful statement seems to be the only evidence for the sympatry of *dieffenbachii* and *modestus* which is implied in later works. Andrews (1896) did not mention *modestus* in the extensive collections he examined from Chatham. It is more than likely that Forbes mistook bones of *dieffenbachii* for those of *modestus*. The range of *dieffenbachii* should therefore be restricted to Chatham Island proper and that of *modestus* to Mangare and possibly Pitt. Falla (1960) reported on bones of a small rail from Pitt Island that he tentatively referred to *dieffenbachii* on the basis of size. They were not compared to that species, however, and could easily have been of *modestus* or some other form.

Illustrations of *dieffenbachii* (Buller, 1873; Rothschild, 1907) show a bird that is extremely similar in plumage to *philippensis* except that the black and white ventral barring extends farther up the throat, the pectoral band is wider and barred with black, and the dorsum lacks white spots. All of these characters may be found in the juvenal plumage of *philippensis*. The bill in *dieffenbachii* is longer and more decurved than in *philippensis* and the flying apparatus is reduced. None of these characters is of generic value and the species is obviously a direct *philippensis* derivative as has already been observed by Delacour (in Mayr, 1949).

The plumage of *modestus* is more somber, being a uniform shade of brownish above and entirely barred below with brown and buff. The primaries are barred with buff as in *philippensis.* The bill is longer and more slender and decurved than in *dieffenbachii.* "Dr. Bowdler Sharpe [1893*b*] observed that it was a singular fact that this little Rail [*modestus*] should possess in its adult plumage the exact dress which might have been expected to characterize the young of *C. dieffenbachii.*" He later (1894:331) said that "in this species the fully adult birds resemble the young of the species of *Hypotaenidia.*"

Flightlessness in rails is a result of a retention of juvenile skeletal characters and proportions (Olson, 1973). It is evident that such a neotenic condition is also responsible for the plumage characters of *dieffenbachii* and *modestus.* The more reduced sternum and more somber plumage of *modestus* indicates that the development of these characters was arrested at an earlier stage than in *dieffenbachii,* in which the sternum is better developed and the plumage more nearly like that of adult *philippensis.* Since *dieffenbachii* neatly bridges the differences between *modestus* and *philippensis,* there is no need for separate generic status for either of the Chatham Islands forms.

The large, flightless Weka (*Gallirallus australis*) of New Zealand, at first sight seems to be a strange and distinctive rail. Early classifiers, deceived by the neotenic characters associated with flightlessness, considered it as a peculiar, primitive form without close relatives. However, Mayr (1949:4) commented that "the currently adopted sequence [of rails] frequently separates genera widely that appear related. For instance, it seems to me as if *Gallirallus* were near *Rallus philippensis.*" The plumage similarities are actually quite striking, as noted by Delacour (in Mayr, 1949). The facial pattern is the same—gray superciliary stripe, brown ocular stripe, gray throat. Some individuals show the reddish nape of *philippensis.* The ochraceous pectoral band is present in some birds, while in most the pectoral band is wider and streaked with black as in the juveniles of *philippensis.* The dorsal plumage is like that of juvenile *philippensis.* The flight feathers are strongly barred with rufous and black, again a *philippensis* character. One of the most striking features of the Weka is its large, well-developed tail, quite in contrast to most large, flightless rails, in which the tail is usually almost obliterated. But turning once more to *philippensis* we find that this species, too, has a notably well-developed tail, longer and stronger than in any of the other species of "*Hypotaenidia.*"

In the skeleton the similarities are nearly as great. The skulls of *G. australis* and *philippensis,* apart from the differences in size, are virtually identical. Both have the tenuous nasal bar. The hindlimb elements of *G. australis* are somewhat heavier than in *philippensis* but are otherwise similar and the transition to the large size of *australis* appears to be bridged by the small, extinct species *G. minor* and the still smaller and more slender *G. hartreei*

(Scarlett, 1970), both known from Quaternary deposits in New Zealand. The wings and pectoral girdle of *G. australis* are, of course, considerably different from those of *philippensis* but like the plumage, are simply recently derived neotenic characters. New Zealand must then have been colonized twice by *philippensis* stock. The first invasion gave rise to *Gallirallus australis*, *minor*, and *hartreei* and the second invasion was by *philippensis* itself. As even the species stock from which *australis* was derived is apparent, and since its flightless characters are without phylogenetic significance, I do not feel that generic segregation for the flightless New Zealand forms is warrented. Since *Gallirallus* Lafresnaye 1841 has priority over *Hypotaenidia* Reichenbach 1852, the entire *Hypotaenidia* group and its derivatives must now be placed in *Gallirallus*.

Two other insular rails are possible derivatives of *philippensis* stock. From Tahiti there is a rail known only from the Forsters' illustration and description (both reproduced in Rothschild, 1907). Rothschild lists this species as "*Hypotaenidia? pacifica*" based on *Rallus pacificus* Gmelin 1787, but "*Rallus ecaudata*" J. F. Miller 1783 is used by Peters (1934) and appears to have priority. The bird, as described and depicted, differs from "*Hypotaenidia*" in its black dorsum, unbarred belly, and blood-red bill and iris, but its ferruginous nape, white superciliary stripe, white spotted dorsum, and banded wings, as well as geographical probability, are all suggestive of *philippensis*.

The remaining possible derivative of *philippensis* stock is the species *sylvestris* of Lord Howe Island. This species has usually been placed in the genus *Tricholimnas* along with *lafresnayanus* of New Caledonia. Both species were originally described as members of *Gallirallus*. Sharpe (1893*a*: 28) erected the genus *Tricholimnas* for *lafresnayanus* only and felt that *sylvestris* should be congeneric with "*Cabalus*" of the Chatham Islands. Apparently Mathews (1912) was the first to place *sylvestris* in *Tricholimnas*, doing so merely in a list with no explanation. He later (1928) proposed the subgeneric name *Sylvestrornis* for *sylvestris*, still keeping it in *Tricholimnas*. Peters (1934) listed both species under *Tricholimnas*. Greenway (1958:225) did likewise and spoke of the two species as being "so similar that it is quite possible that they would breed freely if brought together." This is simply not so. The two species are so dissimilar that it may be rightly questioned if they evolved from the same ancestral stock.

In *sylvestris* the plumage is uniform olive-brown above and grayer below with a whitish chin. *Lafresnayanus* is much darker brown above with the plumage much more fluffy and decomposed than in *sylvestris*. The tail of *sylvestris* is better developed than that of *lafresnayanus* while the wings are more reduced. Most conspicuously, the remiges of *sylvestris* are barred with rufous and black as in *Gallirallus* while those of *lafresnayanus* are unpatterned.

Aside from their both being large, brown, flightless rails of some geographical proximity, there is nothing to indicate a relationship between *sylvestris* and *lafresnayanus.* Clearly they have been derived independently and each is more closely related to some volant ancestor than to the other. Whether this ancestor was the same for both species cannot now be discerned. If so, *lafresnayanus* has diverged to the point that any external resemblance to the ancestral stock has been obscured. I consider *lafresnayanus* as the only species of *Tricholimnas* and place the genus provisionally near *Gallirallus.*

Sylvestris has evidently evolved from some *philippensis* stock somewhat along the lines of *Gallirallus australis.* The skull of *sylvestris* is more slender with a longer more decurved bill than in *australis.* The lacrimal is much more tenuous and reduced than that of *australis* but this is not of generic importance (Olson, 1970; 1973). The wing and pectoral girdle are not as reduced as in *australis* and the leg elements are not as robust. The hindlimb elements, in fact, rather resemble those of *G. hartreei* shown in Scarlett (1970). The skeleton of *sylvestris,* except for the skull, has diverged less from its apparent ancestral stock than has *australis,* while the plumage has diverged more. I place it provisionally in *Gallirallus.* If generic distinction were desired, *Sylvestrornis* would apply.

The species *torquatus* and *insignis* form another subgroup within *Gallirallus. G. torquatus* is found throughout the Philippines and on Celebes and its off-lying islands. It inexplicably skips the Moluccas and reappears again in northwesternmost New Guinea on Salawatti and adjacent parts of the Vogelkop, but the species is not found elsewhere on that great island. It has a chestnut pectoral band which is reduced in the populations of the southern Philippines (Parkes, 1971) and lacking altogether in the Celebes and New Guinea populations. The species *insignis,* restricted to the island of New Britain and widely separated geographically from the nearest population of *torquatus,* is a somewhat larger bird with reduced wings, although it apparently is not completely flightless (Coultas, in Mayr, 1949). It is very similar to *torquatus,* being uniform olive-brown above, and black below finely barred with white from chin to abdomen, as in some of the Celebes individuals of *torquatus.* It differs from that species only in having the crown, cheeks, and nape dull reddish, and in lacking the white subocular stripe. Both have the flight feathers barred with white.

Sclater (1880*a*, 1880*b*), Salvadori (1882), Sharpe (1894), and Meyer and Wigglesworth (1898) all considered *insignis* to be a representative of *torquatus.* This obvious relationship was not altered until Stresemann (1932) created a new genus, *Habropteryx,* for *insignis,* based only on the characters associated with the apparent flightlessness of the bird. Peters (1934) recognized *Habropteryx* but Mayr (1949:11) felt it unwise to "camouflage its obvious *Rallus*-nature by segregating it in a separate genus." There is nothing in the structure of *insignis* that merits retention of *Habropteryx*; its affinities are patently with *torquatus*. Just as *philippensis* stock gave rise to a large flightless form in *Gallirallus australis*, so did *torquatus* stock give rise to a large, nearly flightless form in *insignis*.

The only remaining species of *Gallirallus* (sensu lato) is *striatus*, which is the only member of the group found in continental Asia. It is superficially very similar to "*Rallus*" *pectoralis*, a species with a complementary range to the southward. Both have grayish breasts, barred flanks and belly, and a reddish nape and crown. That they are manifestly confusing is indicated by the fact that one form of *pectoralis* (*insulsus*) was originally described as a subspecies of *striatus*, and an aberrant individual of *striatus* was described as a new race (*deignani*) of *pectoralis* (cf. Ripley and Olson, 1973). Hartert (1927:21) even went so far as to say—"It is perhaps daring to treat *R. pectoralis*, *exsul*, and *alberti* [the latter two now considered subspecies of *pectoralis*] as subspecies of *striatus*, but I think it will be accepted. . ." Daring it was—accepted it was not.

Despite their superficial similarities, *striatus* and *pectoralis* are two quite different birds, as Parkes and Amadon (1959:306) have outlined. Although it lacks a breast band and distinct facial pattern, *striatus* agrees with "*Hypotaenidia*" (= *Gallirallus*) in being a larger, heavier bird with a stouter bill and heavier tarsi and toes than *pectoralis*. Also, the remiges are patterned with bold transverse white bars. This barring is reduced in one specimen (AMNH 545053) from Ceylon and is absent in one specimen from Celebes ("*deignani*"). Otherwise, the white-barred remiges are characteristic of *striatus* and serve to ally it with *Gallirallus*. The remiges of *pectoralis* are never barred, although in some specimens there may be vermiculations and irregular splotches of white. The skeletons of the two species are distinct. That of *striatus*, in all elements, is larger and heavier than *pectoralis*. The shafts of the long bones are stouter. The tarsi are markedly different—that of *striatus* while heavier in the shaft, has more constricted articulations and distally, both the inner and outer trochleae are turned toward the middle. The proximal end of the tarsus of *pectoralis* is noticeably more expanded than in *striatus*.

The skeleton of *striatus* is nearest that of other species of *Gallirallus* but the hindlimb, skull and bill, and pelvis are more slender. The sternum is very narrow, like *Rallus*. I interpret *striatus* as being an advanced form of *Gallirallus* that has *paralleled* the evolution of the true *Rallus* group in evolving towards their slender marsh-dwelling build.

The skeleton of *pectoralis* does not agree with true *Rallus* either; the hindlimb is not as elongate and slender, nor are the bill, skull, or pelvis as long and slender as in *Rallus*. Yet it is not as heavy a bird as the species of *Gallirallus*. In contrast to *striatus*, *pectoralis* is a generalized, and in some ways more primitive species, forming part of a pro-*Rallus* stock. The plumage similarities of *striatus* and *pectoralis* are probably due purely to convergence.

From the island of Luzon, Amadon and Parkes (1959) described a new rail, *Rallus mirificus*, allied to *pectoralis* but differing mainly in its shorter bill, lack of dorsal streaking, and duller coloration. Paynter (1963), Ripley (1970), and Mayr (1971) considered *mirificus* as a subspecies of *pectoralis* but Amadon and duPont (1970:4) could not agree with Paynter that *mirificus* represented the termination of a "cline" and preferred "to reserve judgment" on the matter. Amadon and Parkes (1959:306) emphasized that *mirificus* and *striatus* were found "side by side" on Luzon. What was not indicated was that this is the *only* place where *striatus* and a form of *pectoralis* occur sympatrically. I suggest that the distinctive features of *mirificus* may have resulted from character displacement brought about by interaction with *striatus*, and that *mirificus* best be considered a well-marked form of *pectoralis*.

G. striatus appears to be a better adapted, more specialized species than *pectoralis*, that is expanding its range out of continental Asia and has already penetrated into the Australian realm as far as Celebes. If it were replacing *pectoralis* as it expanded, and entered the Philippines from the south *via* Malaya and Borneo, then *mirificus*, in the northern Philippines, might represent a relict population that has not yet been replaced or which has evolved mechanisms allowing it to compete successfully with *striatus*.

As I have indicated, *pectoralis* belongs to what I have designated as a pro-*Rallus* group (Olson, 1973) intermediate between the stocky generalized forms of *Gallirallus* and the slender specialized species of true *Rallus*. Closely related to *pectoralis* is the much larger species *Dryolimnas cuvieri* of Madagascar and the off-lying islands of Aldabra, Assumption, and Astove. The skeleton of *Dryolimnas*, except for the larger size and wider sternum, is virtually identical to that of *pectoralis*. The plumage is similar in that both species have the crown, cheeks, and nape rich rufous. It is a less conspicuous feature of *Dryolimnas* because the breast and belly of this species are also red. However, in *Dryolimnas* the crown and nape are a richer rufous than the red of the lower parts, which is washed with vinaceous. The barely visible line of demarcation between the two shades is at about the same place as the border of the red nape of *pectoralis*. The ancestor of *Dryolimnas* may first have had a red crown and nape like *pectoralis* and then later acquired the reddish underparts.

Another closely related group is the remarkable genus *Atlantisia* with its three flightless species on the remote South Atlantic islands of Inaccessible, St. Helena, and Ascension. *Atlantisia* differs from *pectoralis* and *Dryolimnas* in proportions and several details of the skeleton (Olson, 1973) and also in that in *A. rogersi* and apparently in *A. elpenor* as well, the red is lacking in the nape and crown. Neither *pectoralis* nor *Dryolimnas cuvieri* can properly be placed in *Rallus* and their lack of wing barring and less robust build precludes their assignment to *Gallirallus*. Since they are more closely related to each other than either is to any other species, *pectoralis* may be included in *Dryolimnas*.

The distribution of the pro-*Rallus* group (*Dryolimnas-Atlantisia*) is essentially relictual, with the species being found on islands scattered around both sides of Africa and in Australasia. The pro-*Rallus* line probably split off from some *Gallirallus*-like stock and differentiated somewhat along the lines taken by true *Rallus* later. The pro-*Rallus* stock then spread nearly worldwide, including the South Atlantic islands and the Malagasy region. From it, the specialized true *Rallus* line was derived in the New World. This group then invaded the Old World, replacing pro-*Rallus* in continental Africa and leaving representatives isolated on the islands around Africa. *Gallirallus striatus* may possibly be responsible for the decline of pro-*Rallus* in Asia. It is interesting that the specialized true *Rallus* has not colonized small, remote, oceanic islands whereas the more generalized pro-*Rallus* group has been very successful at doing so. This parallels the situation seen in the specialized genus *Porphyrula* versus the generalized *Gallinula* on small oceanic islands (Olson, 1973).

Four problematical genera are perhaps best considered at this point. The African genus *Crecopsis*, with its single species, *egregia*, has a "crake-like" appearance which, combined with a superficial resemblance to *Porzana albicollis* of South America, has prompted Benson and Winterbottom (1968) to suggest that the two form a superspecies. The plumage differences are rather greater than Benson and Winterbottom allow and since *Crecopsis* has a slender twisted nasal bar and *P. albicollis* has a broad, flat nasal bar as do other species of *Porzana*, I am confident that they are unrelated. Actually *Crecopsis*, although lacking the barred remiges, more closely resembles species in the *Gallirallus* group. Its bill is not much shorter than short-billed examples of *G. philippensis* and it has a white superciliary stripe of the same character and position as *philippensis* which is lacking in *Porzana albicollis*.

The monotypic genus *Crex* also has a very tenuous nasal bar unlike most other "crakes." Its bill and tarsi are proportionately shorter than in *Crecopsis* and its rufous plumage is more similar to species of *Rallus* (e.g. *R. elegans* and *R. limicola*) than to other rails. *Crecopsis* and *Crex* are probably not at all related to other short-billed "crakes" and possibly fit somewhere between *Gallirallus* and *Rallus*.

The large species *Aramidopsis plateni* of Celebes is superficially patterned like the primitive South American genus *Aramides*, but the bill is shaped entirely differently, the tarsi are not as slender, and the white ventral barring is quite unlike any species of *Aramides*. The remiges are unbarred. The bill shape, rufous nape, and the rest of the plumage is somewhat similar to the pro-*Rallus* group, near to which it may be provisionally placed.

Rougetius rougetii, an unpatterned, nondescript species restricted to the highlands of Ethiopia, was placed after *Amaurornis* by Sharpe (1894) and in the "Gallinulini" of Verheyen (1957). However, it has a tenuous nasal bar unlike *Amaurornis* or any of the gallinule line and may therefore possibly belong somewhere in the *Gallirallus-Rallus* lineage. It certainly cannot be placed in *Rallus* as was done in White (1965) and Urban and Brown (1971) and the monotypic genus *Rougetius* should be maintained for it until something more of its relationship is known.

The genus *Rallus* I restrict to the species *longirostris*, *wetmorei*, *elegans*, *semiplumbeus*, *antarcticus*, *limicola*, *aquaticus*, *caerulescens*, and *madagascariensis*. The Neotropical species *maculatus*, *nigricans*, and *sanguinolentus*, although often placed in *Rallus*, are completely unrelated and are treated later. The species of *Rallus* are much more specialized forms than *Gallirallus* and are highly adapted to a semi-aquatic existence in reedy marshes. Compared to the "*Hypotaenidia*" forms of *Gallirallus* the skull of *Rallus* is narrower and the nostril and premaxillary symphysis is longer; the sternum is narrower; the procoracoid process is less expanded, with a smaller foramen; the pelvis is narrower and the preacetabular portion longer; the femur is more slender with a narrower neck, smaller trochanter and straighter shaft; the whole tibia, particularly the shaft, is more slender: the tarsus is more slender, the proximal end more constricted and the intercotylar knob more delicate and more nearly vertical. Structurally, *Rallus* has gone much farther towards being "skinny as a rail" than has *Gallirallus*. The plumage of *Rallus* is much less conspicuously patterned and no species shows any evidence of a pectoral band or of barring in the remiges. With the exception of *caerulescens*, which is uniform above, all the species of *Rallus* look very much alike in dorsal view.

Rallus has its center of species abundance and diversity in the New World. Only three allopatric species are found in the Old World. *R. aquaticus*, which ranges widely through Eurasia, is one of few Palearctic rails that does not migrate to sub-Saharan Africa. There it is replaced by the species *caerulescens* which differs from *aquaticus* only in its longer, reddish-colored bill and uniform dorsum. Isolated on Madagascar is the distinctive species *madagascariensis*, differing from *aquaticus-caerulescens* in its extremely long, slender bill and in having the gray underparts replaced by an exquisite vinaceous color. Its chin, upper throat, cheeks, and postocular areas, however, are a clear gray, harking back to the *aquaticus* stock from which this species, too, was likely derived. The three Old World species of *Rallus* appear to form a single superspecies which probably had its origins in a single invasion of *Rallus* from the New World.

We have traced a lineage from the primitive genus *Canirallus* through to the specialized genus *Rallus*. Included in this assemblage are all the forms with barred remiges and all those known to have a tenuous nasal bar. The genera remaining outside the *Canirallus-Rallus* line are mainly the relatively inornate crakes and gallinules centering around the genus *Amaurornis*.

The species of the Neotropical genus *Aramides* comprise an unspecialized group of forest birds with expanded procoracoid processes and long, slender tarsi. They seem to be primitive but have no apparent ties with the primitive genus *Canirallus*. Most species have the posterior culmen expanded into a rudimentary frontal shield such as seen in much of the *Amaurornis*-gallinule group. It is possible that *Aramides* may be close to the stock that gave rise to the *Amaurornis* assemblage but there is no real clear cut connection between them such as there seems to be between *Canirallus* and its derivatives.

Ripley (1964) has remarked on the similarity between *Aramides* and *Gymnocrex*. *Gymnocrex* consists of two species, *rosenbergii* of Celebes, and *plumbeiventris* ranging from the Moluccas through Papua to New Ireland. *G. plumbeiventris* has a rufous neck, olive dorsum, blue-gray breast, black tail, and white-barred underwing coverts and axillars, and is strikingly reminiscent of *Aramides*, particularly *A. calopterus*. It also has reddish primaries as in most species of *Aramides*. Both species of *Gymnocrex* are long-legged forest birds with expanded procoracoids. They differ from *Aramides* in the peculiarly shaped, sharply tapering bill, bare orbital skin, and much shorter toes. In a body skeleton of *G. rosenbergii* the pelvis was broader than in *Aramides* and had a convex rather than a concave dorsal surface of the posterior synsacrum. These differences are quite sufficient to separate *Gymnocrex* from *Aramides* at the generic level but the two quite possibly were derived from the same stock. Their disjunct distribution is a probable indication of their antiquity.

Another possible derivative of *Aramides* stock is the monotypic Neotropical genus *Amaurolimnas*. This bird, too, is a forest dweller with rufous underparts, brownish-olive dorsum and grayish juvenal plumage suggesting a diminutive *Aramides*. The structure of the bill is identical to that of the smaller species of *Aramides*. It lacks the barred underwing coverts and black venter of *Aramides* and I place it only provisionally near that genus.

One of the most difficult problems in rail taxonomy lies in the proper allocation of the species included in the genera *Porzana* and *Amaurornis*. The four species that Peters (1934) included in *Amaurornis* (*phoenicurus*, *akool*, *olivaceus*, and *isabellina*) form a rather basic stock from which both the *Porzana* assemblage and the gallinules could have arisen. Baker (1929) placed *Porzana fusca* and *P. bicolor* in *Amaurornis*, as did Ali and Ripley (1969). The little known Madagascan species *olivieri* was originally described as a *Porzana* but later was listed under *Amaurornis* by Rand (1936). Benson and Wagstaffe (1972:163) have suggested that *olivieri* forms a superspecies with *Limnocorax flavirostris* of Africa and advocated putting *flavirostris*, *olivieri*, *bicolor*, and *Porzana tabuensis* in the same genus "perhaps most correctly [in] *Porzana*."

Limnocorax on examination proves inseparable from *Amaurornis*. The skeleton is, except for size, virtually identical to that of *A. phoenicurus* and both have a relatively longer and more slender tarsus with the medial face of the hypotarsus more excavated than in the species of *Porzana* available for comparison (*P. carolina*, *fusca*, *pusilla*, *palmeri*, *albicollis*, *tabuensis*). The bill structure and plumage of *Limnocorax* is like that of *Amaurornis* and the grayish juvenal plumage is particularly similar to *A. akool*.

I note from Benson and Wagstaffe (1972) that the tarsus of *olivieri* and *bicolor* is proportionately shorter than in *Limnocorax*. They note as much similarity between *bicolor* and *olivieri* as between *olivieri* and *Limnocorax*. Until better anatomical material becomes available with which a more detailed study can be made, I prefer to place *flavirostris* and *olivieri* in *Amaurornis* and *fusca*, *bicolor*, and *tabuensis* in *Porzana*. I fully realize that *Porzana* may well be polyphyletic but if so it remains to be established what the different lines are and what their relationships are before most of the genus can be successfully divided.

A natural group within *Porzana* is formed by the species *pusilla*, *parva*, *carolina*, *porzana*, and *fluminea*, all of which have gray underparts, olive and black dorsum streaked with white, and a buffy juvenal plumage. The African species *Aenigmatolimnas marginalis*, often included in *Porzana*, basically agrees with these plumage characters but is larger, longer-legged, and has a distinctly broader, almost gallinule-like bill with a very broad, nearly vertical nasal bar and a smaller bony nostril than in any species of *Porzana*. It may prove quite distinct from *Porzana* and its merger with that genus should at least await comparison of skeletons.

I do not recognize the genus *Porzanula* for the species *palmeri* of Laysan but instead consider it a flightless derivative of *Porzana pusilla* (Olson, 1973). Mayr (1943:46) felt that the taxonomic position of the Hawaiian genus *Pennula* would "probably remain doubtful" as it "has lost all distinctive characters." However, in the two specimens I have seen, I note a likeness to *Porzana fusca* and can see no characters that would preclude its being considered a flightless *Porzana* derivative also. *P. fusca*, like *P. pusilla*, has a wide distribution along the western Pacific coast and is migratory in parts of its range. It could have colonized Hawaii just as *P. pusilla* colonized Laysan. The extinct, flightless species *monasa*, in the monotypic genus *Aphanolimnas*, is known from two specimens from Kusaie Island, both of which are now in Leningrad. Mayr (1943) and Baker (1951) considered it related to *Porzana tabuensis* and "*Nesophylax*" *ater*. S. Dillon Ripley (pers. comm.), who has examined the specimens, considers *monasa* to be a *tabuensis* derivative that is referable to the genus *Porzana*. The characters used by Murphy (1924) to establish the genus *Nesophylax*, for the species *ater* of Henderson Island, are those associated with flightlessness and are not sufficient to distinguish it from *Porzana*. It too, is possibly derived from *P. tabuensis*. *Porzanula*, *Pennula*, *Aphanolimnas*, and *Nesophylax* are here considered synonyms of *Porzana*.

The genus *Poliolimnas* I have expanded to include *Porzana flaviventer* (Olson, 1970). I am still convinced that *P. flaviventer* and *Poliolimnas cinereus* are more closely related to each other than either is to any other species. In my previous note I neglected to point out that the white streaking in the dorsum of *flaviventer* is different from that found in the white-streaked species of *Porzana*. In the latter, each streaked feather has one or, more often, two streaks in the *outer* margins. In *flaviventer* each streaked feather has only a single streak down the *center*. The white streaks of *flaviventer*, therefore, must have evolved independently of those of *Porzana*.

In the New World is found another small assemblage consisting of the genera *Cyanolimnas*, *Neocrex*, and *Pardirallus*, that may have had its ancestry in an *Amaurornis*-like stock. *Cyanolimnas cerverai* is a nearly flightless relict species confined to Cuba (and formerly the Isle of Pines, Olson in prep.). *Pardirallus*, including the variegated species *maculatus* and the two uniformly-colored species *sanguinolentus* and *nigricans*, (= *Ortygonax* auct.) are long-billed Neotropical rails often mistakenly placed in *Rallus*. *P. maculatus* differs from the other two species mainly in its strikingly variegated plumage. Dickerman and Parkes (1969) and Dickerman and Haverschmidt (1971) have shown that there exists a dark phase of the juvenal plumage of *maculatus* that is similar to the plumages of *sanguinolentus* and *nigricans*. The plumage pattern of *maculatus* is evidently a recently evolved condition derived from an inornate plumage. As there are no structural differences of consequence between *maculatus* and the other two species, *sanguinolentus* and *nigricans* must be referred to *Pardirallus*. The two species *Neocrex erythrops* and *N. columbianus*, are rather small, short-billed Neotropical "crakes."

The three genera *Cyanolimnas*, *Neocrex*, and *Pardirallus* share a number of similarities. All (except *P. maculatus*) are drab olive-brown above and dark gray below, usually with light throats. All except *nigricans* have a paint-like red spot at the base of the bill. The loss of this spot in *nigricans*

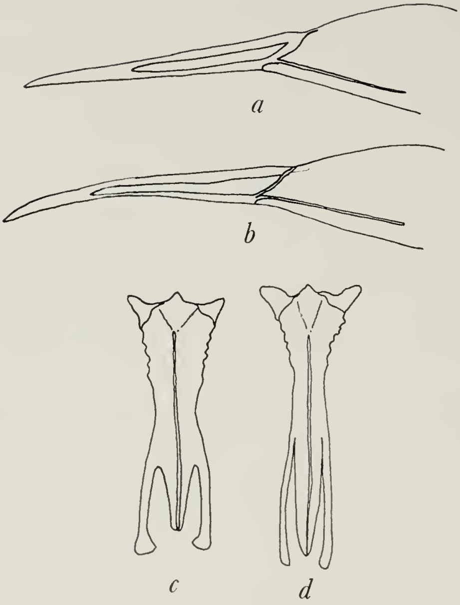


Fig. 4. *Rallus* and *Pardirallus* compared: a. bill of *P. sanguinolentus* b. bill of *R. longirostris* c. sternum of *P. sanguinolentus* d. sternum of *R. longirostris.*

may function in species discrimination, *nigricans* being broadly sympatric with *sanguinolentus.* The same phenomenon may be taking place in *Neocrex,* as the bill of *columbianus* is much less brightly colored than that of *erythrops. Cyanolimnas,* which a number of authors have noted as resembling *P. sanguinolentus* (Barbour and Peters, 1927; Bond, 1940, 1967, 1970; Greenway, 1958), forms a nearly perfect intermediate between that species and *Neocrex.* In fact, it may be closer to *Neocrex* than to *Pardirallus.* In its finely barred flanks and buffy crissum, *Cyanolimnas* combines characteristics of *N. erythrops* and *N. columbianus,* respectively, that are lacking in *Pardirallus.* Furthermore, the bill shape and the narrow, pointed frontal plate of *Cyanolimnas* is like that of *Neocrex* and differs from the broad, rounded frontal plate of *Pardirallus.*

The frontal plate of *Pardirallus* is also quite unlike that of *Rallus.* The skeletons of *Pardirallus* and *Rallus* exhibit a number of marked differences. In *Rallus* (Fig. 4), the nostril is longer; the premaxillary symphysis is shorter, broader, and slightly more decurved; the nasal bar is very slender and twisted; the brace from the jugal attaches on the anterior part of the maxillo-palatine process; and the cranium is narrowed. In *Pardirallus* (Fig. 4), the nostril is considerably more restricted in length and basal depth; the premaxillary symphysis is longer, narrower, and straighter; the nasal bar is broad, flat, uniform in width, and not twisted; the jugal brace attaches nearer the middle of the maxillo-palatine process; and the cranium is broader than in *Rallus.*

In *Rallus*, the whole sternum (Fig. 4) is greatly narrowed throughout its length; the sternal notches extend anteriorly almost half the length of the sternum and terminate anteriorly in very narrow slits; the posterior lateral processes taper very gradually off the sternal plate and are closely adpressed to the xiphial area. In contrast, the sternum of *Pardirallus* (Fig. 4) is broader; the sternal notches extend only a little over a third the length of the sternum and are U-shaped anteriorly; the posterior lateral processes are farther away from the xiphial area and curve strongly into the sternal plate, giving the sternum somewhat of an hourglass shape like that of *Amaurornis* (Fig. 6). The coracoid of *Pardirallus* is heavier with a more expanded sternal end and a larger, more bladelike and recurved procoracoid process than in *Rallus.* The humerus is heavier with the distal end more expanded, the shaft more curved, and the brachial depression deeper than in *Rallus.* In *Rallus* the preacetabular portion of the pelvis is longer and straighter than in *Pardirallus* in which the median dorsal ridge is much more humped. The hindlimb elements of *Pardirallus* are proportionately shorter and stouter than those of *Rallus.*

It is quite evident that *Rallus* and *Pardirallus* are in no way related. I feel that *Cyanolimnas* is probably closest to an ancestral *Amaurornis*-like stock that has given rise both to long-billed species (*Pardirallus*) and to short-billed species (*Neocrex*) which are only convergently similar to *Rallus* and *Porzana.*

Another line apparently derived from *Amaurornis* is found in the three large Australasian species *Habroptila wallacei*, *Megacrex inepta*, and *Eulabeornis castaneoventris. Habroptila* and *Megacrex* are geographical counterparts, the first occuring on Halmahera and the other on New Guinea (Fig. 5). They differ only in plumage and bill color, *Habroptila* being all dark with a red bill and *Megacrex* brownish above, white below, with a yellowish-green bill. In the shape and size of the bill and frontal shield, the very large heavy legs, and abbreviated tails, *Habroptila* and *Megacrex* are so similar that it is difficult to see why they were ever placed in different genera. I can find no character of generic importance that will permit their separation; therefore *Megacrex* D'Albertis and Salvadori 1879 becomes a synonym of *Habroptila* Gray 1860.

Eulabeornis differs from *Habroptila* in having a well-developed tail and less heavy bill and legs, but these differences may possibly be attributable to the fact that *Eulabeornis* is not flightless, whereas both species of *Habroptila* reputedly are. Interestingly, *Eulabeornis* appears to be the exact geographical

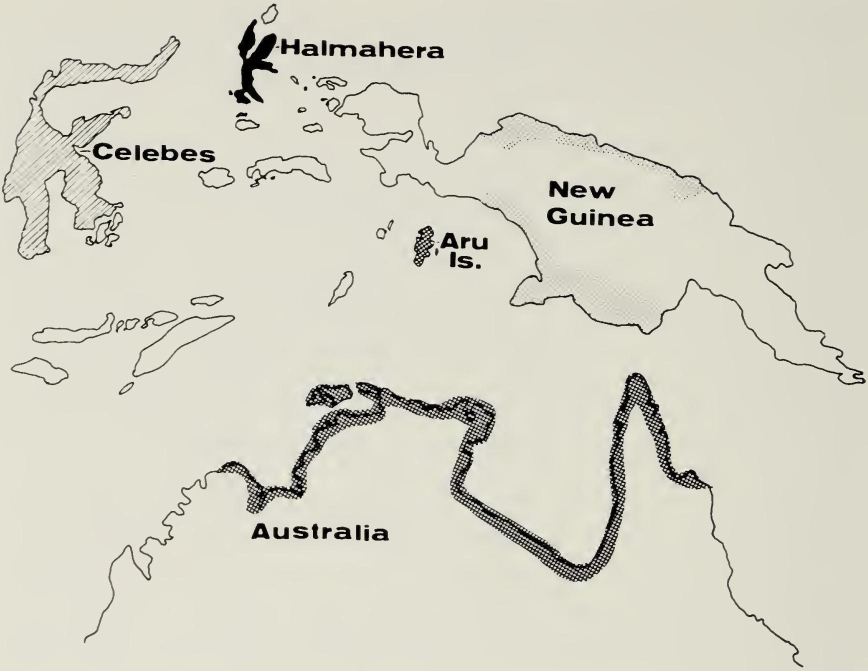


FIG. 5. Allopatric distribution of *Eulabeornis castaneoventris* (dark shading), *Habroptila inepta* (light shading), *H. wallacei* (solid), and *Amaurornis isabellina* (hatched).

counterpart of *Habroptila*, as it occurs in northern Australia and even extends to the Aru Islands, but is not found in New Guinea and is thus nowhere sympatric with *Habroptila* (Fig. 5). *Eulabeornis* inhabits mangroves exclusively; *H. inepta* inhabits mangroves and to a lesser extent lowland forest and bamboo thickets, while *H. wallacei* is apparently more of a forest dweller than either. The similar choice of habitat and rather striking allopatry of *Eulabeornis* and *H. inepta* lends support to their affinity but in view of their external morphological differences it seems best to keep the two genera separate at least until skeletons can be compared. Although *Eulabeornis* and *Habroptila* have been likened to *Aramides*, they lack the barred underwing and the slender tarsi of that genus. They rather appear to be allied to *Amaurornis*, as already suggested by Mayr (1949). Ripley (1964:23) has said of *H. inepta* that it "closely resembles a giant rufous-tailed moorhen [*Amaurornis olivaceus*]." It also bears a resemblance to *Amaurornis isabellina* which is a heavy-legged species found on adjacent Celebes (Fig. 5).

The monotypic genus *Gallicrex* is quite distinctive and *G. cinerea* is one of few rails displaying marked sexual dichromatism. It has a superficial

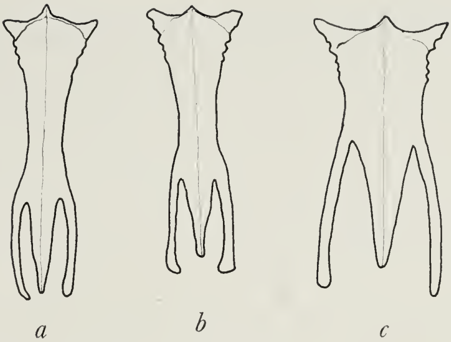


Fig. 6. Ventral view of sternum: a. *Gallicrex cinerea* b. *Amaurornis phoenicurus* c. *Gallinula chloropus*. The wide sternum of *Gallinula* is also characteristic of *Fulica*. The sternum of *Porphyrio* is intermediate between *Amaurornis* and *Gallinula*.

similarity to *Gallinula* and the female and immature plumages are even more reminiscent of the immature plumage of *Porphyrula*. It has some of the same structural modifications of the hindlimb as *Porphyrula* but the peculiar sternum is more similar to *Amaurornis* (Fig. 6). *Gallicrex* cannot be combined with any existing genus but it tends to bridge the differences between *Amaurornis* and the "gallinules."

The purple gallinules *Porphyrula*, *Porphyrio*, and *Notornis*, constitute an obviously monophyletic group and Mayr (1949) has already suggested their merger. *Porphyrula* differs from *Porphyrio* only in its smaller size, less massive bill, and more oval nostril, whereas the two genera share a number of specialized characters, particularly of the hindlimb (Olson, 1973). *Notornis* is but a large, flightless derivative of *Porphyrio*. It bears about the same relationship to *Porphyrio* as *Gallirallus australis* does to *G. philippensis*, and it is no more deserving of separate generic status than is *G. australis*. With the exception of *Porphyrula flavirostris*, the adults of *Porphyrula*, *Porphyrio*, and *Notornis* share a distinctive plumage of blue, green, and purple. *P. flavirostris* does not attain a purple-breasted adult plumage and looks more similar to the immatures of the other species. It is probably the most primitive species of the group. Because the three species of *Porphyrula* are more closely related to each other than to *Porphyrio* a case could be made for maintaining them as a subgenus. Nevertheless, *Porphyrula* and *Notornis* cannot be realistically separated from *Porphyrio* at the generic level and are here combined with that genus.

In the South Pacific are two distinctive gallinules, *Pareudiastes pacificus* of Samoa and *Edithornis silvestris* of the Solomons. The latter was described by Mayr (1933) just 17 days after the cutoff point for Volume 2 of Peters'

Check-list. *E. silvestris*, known only from the unique type, is a singular bird and differs from *P. pacificus* in the greater development of the legs and feet and in the monstrous development of the frontal shield. While recognizing the distinctiveness of *silvestris*, I propose that in view of the similarity of its coloration and the bare spot beneath the eye to that of *Pareudiastes*, it should be placed in that genus, as Mayr (1949) himself has already suggested.

The three very closely related genera *Tribonyx*, *Porphyriops*, and *Gallinula* share a generally dark plumage with a row or rows of prominent white spots down the flanks. Mayr (1949) felt that *Tribonyx* might be synonymized with *Gallinula*. The monotypic genus *Porphyriops* of South America is essentially similar in plumage and shape of the frontal shield to immatures of *Gallinula angulata*. It is intermediate in size between *G. chloropus* and *G. angulata* and there are absolutely no differences in its skeleton that can be construed to be of generic importance when compared to *Gallinula*. The skeleton of *Tribonyx* is equally similar to that of *Gallinula*, its short, heavy bill also being found in *Porphyriops* and *G. angulata*. I propose that both *Tribonyx* and *Porphyriops* be considered part of *Gallinula*, although the two species of *Tribonyx* by virtue of their decidedly shorter, heavier toes, lack of white in the under tail coverts, and longer tails, could be maintained in a separate subgenus. The gallinules of Tristan da Cunha and Gough Islands (*nesiotis* and *comeri*) were derived directly from *Gallinula chloropus* and the name *Porphyriornis* that has been used for them is not considered tenable (Olson, 1973).

As outlined previously, the coots of the genus *Fulica* are derived from a *Gallinula*-like stock that has become adapted for diving. Their center of species abundance and diversity is in South America and it seems likely that the genus may have originated there and later spread to the Old World.

CONCLUSIONS

Mayr (1949:3) lamented that of the 52 genera recognized by Peters (1934), 36 (70 percent) were monotypic and he felt that "such classification fails to recognize the function of the generic name in binomial nomenclature, namely, to indicate relationship." In the classification proposed here, the number of genera is reduced to 35, of which 11 (30 percent) are monotypic. Some of these may also prove untenable. I have perhaps been somewhat conservative in maintaining *Crecopsis* separate from *Crex*, and *Poliolimnas* and *Aenigmatolimnas* separate from *Porzana*. However, we have seen that "crakes" have evolved repeatedly from a number of lines and the possibility of convergence is great. Grouping all the "crakes" together, as Peters did in his arrangement of genera, can only result in an artificial assemblage. Most of the genera distinguished at first on flightless characters alone, have been combined with volant genera. Of those remaining, (*Tricholimnas*, *Atlantisia*, *Cyanolimnas*, and *Habroptila*), only *Tricholimnas* is without obvious close volant relatives.

In Figure 7 I have diagrammed a theoretical phyletic tree of the Rallidae. A glance at this will show the absolute impossibility of listing the genera in a linear manner that reflects without interruption a primitive to derived sequence. Nevertheless, as a linear sequence is a necessary consequence of many methods of presentation, the following list will hopefully make the best of a difficult situation and will present a better understanding of relationships in the family than did the sequence of Peters (1934).

Himantornis, *Canirallus*, *Sarothrura*, *Coturnicops*, *Micropygia*, *Rallina*, *Anurolimnas**, *Laterallus*, *Nesoclopeus*, *Gallirallus*, *Tricholimnas*, *Crecopsis*, *Crex*, *Rougetius*, *Aramidopsis*, *Dryolimnas**, *Atlantisia*, *Rallus*, *Aramides*, *Amaurolimnas*, *Gymnocrex*, *Amaurornis*, *Porzana*, *Poliolimnas*, *Aenigmatolimnas*, *Cyanolimnas*, *Neocrex*, *Pardirallus*, *Eulabeornis*, *Habroptila*, *Gallicrex*, *Porphyrio*, *Pareudiastes*, *Gallinula*, *Fulica*.

The Rallidae, and indeed the whole of the order Gruiformes, are usually thought of as being basically marsh and water birds. However, an aquatic or paludicoline origin for the Rallidae and most other gruiform families would appear to be a false impression.

The most primitive living rail, *Himantornis*, is a forest bird. Other primitive or unspecialized relict genera such as *Canirallus*, *Aramides*, and *Gymnocrex*, are also forest dwellers. On the other hand, the most specialized, derived genera of rails (e.g. *Fulica*, *Rallus*, *Porphyrio*) all contain marsh-dwelling or highly aquatic species. Thus the progression from generalization to specialization in the Rallidae is from forest forms to aquatic forms, rather than the opposite being the case.

A brief review of other families included in the Gruiformes reveals a similar trend. The small, primitive, and largely relict families Rhynochetidae, Eurypygidae, and Psophiidae are all forest birds. The very primitive Mesoenatidae are also inhabitants of forest or brushy areas. The Heliornithidae, although highly aquatic, are found mostly in forest streams and perch and nest in trees and bushes. The Limpkin (Aramidae) is also aquatic but is found mainly in wooded swamps. In the West Indies it normally occurs in forest and brush far from water. The Gruidae are as much inhabitants of dry uplands as of marshes and are probably precluded from strictly forest situations by their large size, although some species, such as *Grus canadensis*, may

---

* Placing *Laterallus viridis* in *Anurolimnas* and *R. pectoralis* in *Dryolimnas* makes the Bonapartian genera *Rufirallus* 1856 (type *Rallus cayanensis* Boddaert = *Rallus viridis* P. L. S. Müller) and *Lewinia* 1856 (type *Rallus brachypus* Swainson = *Rallus pectoralis* Lesson) available. *Rufirallus* has seen some use, even as recently as 1966 (Stresemann and Stresemann), but *Lewinia* has lain unused practically since it was proposed. In the interest of stability and to promote comprehension I have not used either name here.

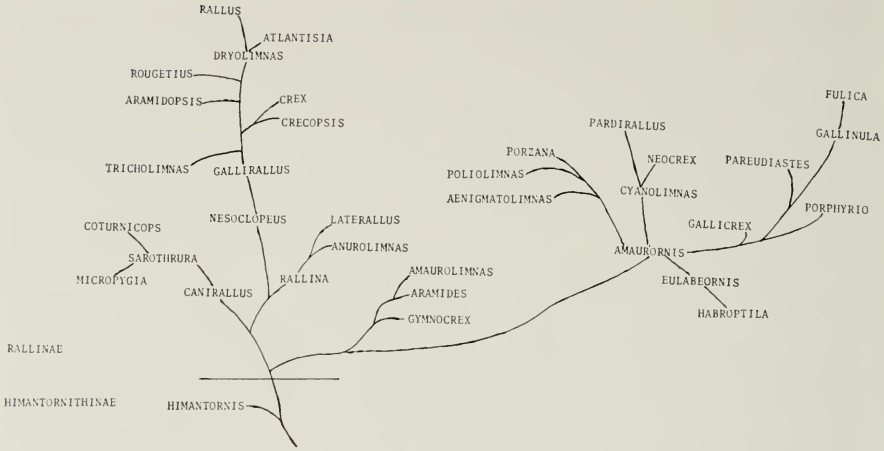


FIG. 7. Diagram of hypothetical phylogeny of the Rallidae. Distances reflect the dictates of space rather than phylogenetic distance. Several genera are placed only very provisionally (see text).

nest in open woodlands. In the Cariamidae, *Chunga* lives and nests in forests, and *Cariama*, although found in open savanna, still nests in trees. The Otididae, Turnicidae, and Pedionomidae are not at all aquatic and are for the most part open-country dwellers, although some turnicids live in forests. It seems likely that the primitive habitat for the whole order Gruiformes, as well as the Rallidae, was forest, and that certain groups have secondarily become adapted to aquatic situations or open grassland.

The geographic origins of the Rallidae have been obscured by the antiquity, cosmopolitan distribution, and inadequate taxonomy of the family. However, with the present and hopefully improved phylogeny, a familiar pattern emerges. The greatest number of species, the greatest number of peculiar genera, and the most primitive members of the Rallidae are found in the Old World tropics. The New World has relatively fewer groups, most of which are derived from Old World stem groups. A few genera appear to have specialized and radiated in the New World, some of which re-invaded the Old World.

SUMMARY

Himantornis is the most primitive and distinctive genus of the Rallidae, showing some characters in common with the Psophiidae. It is placed in a separate subfamily, the Himantornithinae. No subfamilial distinctions can be made among the remaining genera of rails and these are all placed in the Rallinae. A classification of the genera of Rallinae is advanced. The following generic changes have been made: *Mentocrex* and *Rallicula* into *Canirallus*; *Nesolimnas*, *Cabalus*, *Habropteryx*, and the subgenera *Sylvestrornis* and *Hypotaenidia* (including *striatus*) into *Gallirallus*; *Limnocorax* into *Amaurornis*; *Por-*

zanula, *Pennula*, *Aphanolimnas*, and *Nesophylax* into *Porzana*; *Ortygonax* into *Pardirallus*; *Megacrex* into *Habroptila*; *Porphyrula* and *Notornis* into *Porphyrio*; *Edithornis* into *Pareudiastes*; *Porphyriops*, *Porphyriornis*, and *Tribonyx* into *Gallinula*. The limits of the following genera have also been altered: *Sarothrura* to include *Coturnicops ayresi* (after Keith et al., 1970); *Anurolimnas* to include *Laterallus fasciatus* and *L. viridis*; *Tricholimnas* restricted to *lafresnayanus*; *Dryolimnas* to include *Rallus pectoralis*; *Rallus* to exclude *Pardirallus*, *R. pectoralis*, *R. striatus*, and *Hypotaenidia*; *Poliolimnas* to include *Porzana flaviventer*. Flightlessness and the crake-like build have each evolved several times from different parental stocks. The ancestral rails are believed to have been forest dwellers, the family having only secondarily adapted to aquatic environments. The Rallidae probably had its origins in the Old World tropics with secondary radiations in the New World.

ACKNOWLEDGMENTS

An acquaintance with the genera and species of Rallidae was gained by several years of perusal of skins and skeletons in a number of museums, particularly the National Museum of Natural History and the American Museum of Natural History. Dean Amadon, A. R. McEvey, Raymond A. Paynter, Jr., Robert W. Storer, and Melvin A. Traylor loaned me valuable specimens in their care. John Farrand, Jr., Kenneth C. Parkes, S. Dillon Ripley, George E. Watson, and Richard L. Zusi read and commented on various drafts of the manuscript. The photographs are by Victor E. Krantz. I am particularly indebted to my friend Bill Zimmerman for skillfully executing the frontispiece.

LITERATURE CITED

Ali, S. and S. D. Ripley. 1969. Handbook of the birds of India and Pakistan. Volume 2. Oxford Univ. Press, Bombay.

Amadon, D. and J. E. duPont. 1970. Notes on Philippine birds. Nemouria, 1:1–14.

Anderson, S. and J. N. Jones, Jr. 1967. Recent mammals of the world. A synopsis of families. Ronald Press, New York.

Andrews, C. W. 1896. On the extinct birds of the Chatham Islands. Part II.—The osteology of *Palaeolimnas chathamensis* and *Nesolimnas* (Gen. Nov.) *dieffenbachii*. Novitates Zool., 3:260–271.

Baker, E. C. S. 1929. Fauna of British India. Birds. Volume 6. (Second Ed.). Taylor and Francis, London.

Baker, R. H. 1951. The avifauna of Micronesia, its origin, evolution, and distribution. Univ. Kansas Publ. Mus. Nat. Hist., 3:1–359.

Bannerman, D. A. 1931. The birds of tropical West Africa. Volume 2. Crown Agents, London.

Barbour, T. and J. L. Peters. 1927. Two more remarkable new birds from Cuba. Proc. New England Zool. Club, 9:95–97.

Benson, C. W. and R. Wagstaffe. 1972. *Porzana olivieri* and *Limnocorax flavirostris*; a likely affinity. Bull. Brit. Ornithol. Club, 92:160–164.

Benson, C. W. and J. M. Winterbottom. 1968. The relationship of the Striped Crake *Crecopsis egregia* (Peters) and the White-throated Crake *Porzana albicollis* (Vieillot). Ostrich, 39:177–179.

Bond, J. 1940. Check-list of birds of the West Indies. Acad. Nat. Sci., Philadelphia.

Bond, J. 1967. Twelfth supplement to the Check-list of birds of the West Indies (1956). Acad. Nat. Sci., Philadelphia.

Bond, J. 1970. Fifteenth supplement to the Check-list of birds of the West Indies (1956). Acad. Nat. Sci., Philadelphia.

Brodkorb, P. 1967. Catalogue of fossil birds: Part 3 (Ralliformes, Ichthyornithiformes, Charadriiformes). Bull. Florida State Mus., 11:99–220.

Buller, W. L. 1873. A history of the birds of New Zealand. John van Voorst, London.

Chapin, J. P. 1932. The birds of the Belgian Congo. Part 1. Bull. Amer. Mus. Nat. Hist., 65:1–756.

Chapin, J. P. 1939. The birds of the Belgian Congo. Part 2. Bull. Amer. Mus. Nat. Hist., 75:1–632.

Dickerman, R. W. 1968. Notes on the Ocellated Rail (*Micropygia schomburgkii*) with first record from Central America. Bull. Brit. Ornithol. Club, 88:25–30.

Dickerman, R. W. and F. Haverschmidt. 1971. Further notes on the juvenal plumage of the Spotted Rail (*Rallus maculatus*). Wilson Bull., 83:444–446.

Dickerman, R. W. and K. C. Parkes. 1969. Juvenal plumage of the Spotted Rail (*Rallus maculatus*). Wilson Bull., 81:207–209.

Fleming, C. A. 1939. Birds of the Chatham Islands. Emu, 38:380–413; 492–509.

Falla, R. A. 1960. Notes on some bones collected by Dr. Watters and Mr. Lindsay at Chatham Islands. Notornis, 8:226–227.

Forbes, H. O. 1892. [untitled communication]. Bull. Brit. Ornithol. Club, 1:20.

Forbes, H. O. 1893a. [untitled communication]. Bull. Brit. Ornithol. Club, 1:45–46.

Forbes, H. O. 1893b. A list of birds inhabiting the Chatham Islands. Ibis, Ser. 6, 5:521–546.

Gray, G. R. 1871. Hand-list of genera and species of birds. Part 3. British Museum, London.

Greenway, J. C. 1958. Extinct and vanishing birds of the world. Special Publ. 13. Amer. Committee Internatl. Wild Life Protection, New York.

Hartert, E. 1927. Types of birds in the Tring Museum. B. Types in the general collection. VIII Columbae-Struthionidae. Novitates Zool., 34:1–38.

Hutton, F. W. 1872. Notes on some birds from the Chatham Islands collected by H. H. Travers, Esq.; with descriptions of two new species. Ibis, Ser. 3, 2:243–250.

Hutton, F. W. 1874. On a new genus of Rallidae. Trans. and Proc. New Zealand Inst., 6:108–110.

Jeikowski, H. 1971. Die Fluegelbefiederung des Blesshuhns (*Fulica atra* L.). J. Ornithol., 112:164–201.

Keith, S., C. W. Benson, and M. P. S. Irwin. 1970. The genus *Sarothrura* (Aves, Rallidae). Bull. Amer. Mus. Nat. Hist., 143:1–84.

Mathews, G. M. 1912. A list of the birds of the Phillipian [sic] sub-region which do not occur in Australia. Novitates Zool., 18:447–455.

Mathews, G. M. 1928. The birds of Norfolk and Lord Howe Islands. H. F. and G. W. Witherby, London.

Mayr, E. 1933. Birds collected during the Whitney South Sea Expedition. XXII. Three new genera from Polynesia and Melanesia. Amer. Mus. Novitates, 590:1–6.

Mayr, E. 1943. The zoogeographic position of the Hawaiian Islands. Condor, 45:45–48.

Mayr, E. 1949. Notes on the birds of Northern Melanesia. 2. Amer. Mus. Novitates, 1417:1–38.

Mayr, E. 1971. New species of birds described from 1956 to 1965. J. Ornithol., 112: 302–316.

Mayr, E. and E. T. Gilliard. 1954. Birds of central New Guinea. Bull. Amer. Mus. Nat. Hist., 103:317–374.

MEYER, A. B. AND L. W. WIGGLESWORTH. 1898. The birds of Celebes and the neighbouring islands. 2 vols. R. Friedländer and Sohn, Berlin.

MOREAU, R. E. 1966. The bird faunas of Africa and its islands. Academic Press, New York and London.

MURPHY, R. C. 1924. Birds collected during the Whitney South Sea Expedition. II. Amer. Mus. Novitates, 124:1–13.

OLSON, S. L. 1970. The relationships of *Porzana flaviventer*. Auk, 87:805–808.

OLSON, S. L. 1973. Evolution of the rails of the South Atlantic Islands (Aves: Rallidae). Smithsonian Contr. Zool., 152:1–53.

PARKES, K. C. 1971. Taxonomic and distributional notes on Philippine birds. Nemouria, 4:1–67.

PARKES, K. C. AND D. AMADON. 1959. A new species of rail from the Philippine Islands. Wilson Bull., 71:303–306.

PAYNTER, R. A., JR. 1963. Birds from Flores, Lesser Sunda Islands. Breviora, 182:1–5.

PETERS, J. L. 1932*a*. Two new genera and a new subspecies of rails. Proc. New England Zool. Club, 13:63–67.

PETERS, J. L. 1932*b*. A new genus for *Rallus* [sic] *poeciloptera*. Auk, 49:347–348. [The title must be a lapsus as to my knowledge this species has never occurred in the literature under *Rallus*.]

PETERS, J. L. 1934. Check-list of birds of the world. Volume 2. Harvard Univ. Press, Cambridge, Mass.

RAIKOW, R. J. 1970. Evolution of diving adaptations in the stifftail ducks. Univ. California Publ. Zool., 94:1–52.

RAND, A. L. 1936. The distribution and habits of Madagascar birds. Bull. Amer. Mus. Nat. Hist., 72:143–449.

RIDGWAY, R. AND H. FRIEDMANN. 1941. The birds of North and Middle America. Bull. U. S. Natl. Mus., 50:1–254.

RIPLEY, S. D. 1964. A systematic and ecological study of birds of New Guinea. Peabody Mus. Nat. Hist. Yale Univ. Bull., 19:1–85.

RIPLEY, S. D. 1966. A notable owlet from Kenya. Ibis, 108:136–137.

RIPLEY, S. D. 1970. A new form of rail from the Celebes. Nat. Hist. Bull. Siam Soc., 23:367–368.

RIPLEY, S. D. AND S. L. OLSON. 1973. Re-identification of *Rallus pectoralis deignani*. Bull. Brit. Ornithol. Club, 93:115.

ROTHSCHILD, W. 1907. Extinct birds. Hutchinson and Co., London.

SALVADORI, T. 1875. Descrizione di cinquantotto nuove specie di uccelli, ed osservazioni intorno ad altre poco note, della Nuova Guinea e di altre isole Papuane, raccolte dal Dr. Odoardo Beccari e dai cacciatori del Sig. A. A. Bruijn. Ann. Mus. Civ. St. Nat. Genova, 7:1–81.

SALVADORI, T. 1882. Ornitologia della Papuasia e delle Molucche. Volume 3. G. B. Paravia e Comp., Torino.

SCARLETT, R. J. 1970. A small woodhen from New Zealand. Notornis, 17:68–74.

SCHOENWETTER, M. 1961. Handbuch der oologie. Lieferung 5. Akademie-Verlag, Berlin.

SCLATER, P. L. 1880*a*. On a fifth collection of birds made by the Rev. G. Brown, C.M.Z.S., on Duke-of-York Island and its vicinity. Proc. Zool. Soc. London, 1880: 65–67.

SCLATER, P. L. 1880*b*. Note on the *Rallus sulcirostris* of Wallace and its allies. Ibis, Ser. 4, 4:309–312.

Sharpe, R. B. 1893*a*. [untitled communication]. Bull. Brit. Ornithol. Club, 1:26–29.

Sharpe, R. B. 1893*b*. [untitled communication]. Bull. Brit. Ornithol. Club, 1:46.

Sharpe, R. B. 1894. Catalogue of the birds in the British Museum. Volume 23. British Museum, London.

Sibley, C. G. and J. E. Ahlquist. 1972. A comparative study of the egg white proteins of non-passerine birds. Peabody Mus. Nat. Hist. Yale Univ. Bull., 39:1–276.

Stresemann, E. 1932. *Habropteryx* novum genus Rallidarum. Ornithol. Monatsb., 40:122–123.

Stresemann, E., and V. Stresemann. 1966. Die Mauser der Vögel. J. Ornithol., Sonderheft 107:1–447.

Urban, E. K. and L. H. Brown. 1971. A checklist of the birds of Ethiopia. Haile Sellassie I Univ. Press, Addis Ababa.

Verheyen, R. 1957. Contribution au demembrement de l'ordo artificiel des Gruiformes (Peters 1934) 1.—Les Ralliformes. Bull. Inst. Roy. Sci. Nat. Belgique, 33(21):1–44.

Wetmore, A. 1967. Further systematic notes on the avifauna of Panama. Proc. Biol. Soc. Washington, 80:229–242.

White, C. M. N. 1965. A revised check list of African non-passerine birds. Dept. of Game and Fisheries, Lusaka.

NATIONAL MUSEUM OF NATURAL HISTORY, SMITHSONIAN INSTITUTION, WASHINGTON, D. C. 20560. 12 APRIL 1973.

NEW LIFE MEMBER

Frederick S. Schaeffer, of Jamaica, New York, has recently become a Life Member of The Wilson Ornithological Society. Mr. Schaeffer was born in The Netherlands, and was partly educated there. He came to this country with his parents and finished his high school education here. He is currently an employee of Scandinavian Airlines. While serving in the U.S. Army in Germany he became interested in the bird banding work at Vogelwarte Untermain, and since his return to civilian life has been an active and enthusiastic bander in the New York area. He is currently editor of *EBBANews*, and co-editor for the U.S.A. of *The Ring*. Mr. Schaeffer has published a number of papers on the results of his banding studies, in particular studies on Barn and Tree Swallows. He is a member of the A.O.U., The Linnaean Society of New York, The Wildlife Society, and several banding associations.

THE FALL MIGRATION ROUTE OF KIRTLAND'S WARBLER

Mary Heimerdinger Clench

Kirtland's Warbler (*Dendroica kirtlandii*) is an exceedingly rare species with highly specialized habitat requirements for breeding. It has been well studied on the breeding grounds, but is little known as a migrant or on the wintering grounds. From time to time the species has been recorded during spring migration when the males may sing, drawing attention to themselves, but well documented fall migration records are exceptionally rare. In the autumn of 1971 we had the good fortune to band a migrant Kirtland's in southwestern Pennsylvania. This was an exciting event for several reasons: it was the first well documented Pennsylvania record for the species; it was the first fall banding of a migrant outside of Michigan; and the bird was rehandled at our banding station twice after it was banded, allowing us to make a limited analysis of habitat preference, weight change, and correlation of its migratory behavior with weather patterns. Perhaps most important, this Pennsylvania record may throw new light on the little known fall migration route of the species.

THE PENNSYLVANIA RECORD

On 21 September 1971 at 10:15, Robert C. Leberman captured a Kirtland's Warbler in a mist net at Carnegie Museum's Powdermill Nature Reserve, three miles south of Rector, Westmoreland County, southwestern Pennsylvania (40° 10′ N, 79° 16′ W). Realizing that this was an important record and should have verification he telephoned Kenneth C. Parkes and the author at the museum in Pittsburgh. We quickly gathered up study skins representing the various plumages of the species and drove to the Reserve. Upon seeing the bird we confirmed the identification. It was an immature individual, as indicated by the only partly pneumatized skull and heavy streaking on the breast plumage. We could not definitely determine its sex because immature Kirtland's Warblers are not known to be sexually dimorphic (Van Tyne, 1953).

After identification the warbler was measured, weighed, banded, photographed, and released. Its measurements were: unflattened wing chord, 67.5 mm; tail, 55 mm; exposed culmen, 10.7 mm; tarsus, 20 mm. It weighed 14.0 grams and had a trace of visible fat in the furcular region. To document the record color photographs were taken. Several of the pictures are now on file at Carnegie Museum and one in black and white appeared on the cover of the November, 1971, issue of *Carnegie Magazine*.

On 26 September, five days after it had been banded, the warbler was recaptured at Powdermill at 11:50: it weighed 14.9 g and had no visible fat deposits. On 2 October at 17:40 it appeared again, weighing 15.8 g and with a small amount of visible fat (index of 1 on a scale of 0–3).

When the Kirtland's originally was netted it was found in the company of several other parulids in a net lane cut through a dense old field hawthorn (*Crataegus* spp.)—crabapple (*Pyrus coronaria*) thicket. The lane is located slightly above the floor of the Ligonier Valley (elevation approximately 1,350 feet) and extends from the edge of a dirt road through the thicket for approximately 45 meters, then crosses a small open marsh and ends in another but more open old field hawthorn-crabapple thicket. The total length of the net lane is 120 meters. In the same general area of the Reserve 33 additional nets are operated, but in different types of habitat: willow thickets bordering streams and a pond: old fields in different stages of succession: second-growth forest, etc. The 45 meter stretch of the net lane in which the Kirtland's Warbler was originally found is unique within the banding area in terms of density and height of the hawthorn and crabapple trees.

When the bird was captured on 21 September it was carried to a banding office some 250 meters from the net lane: after banding it was released near the office. On the second capture the Kirtland's was transported and released near a different banding office, some 880 meters from the capture lane. Regardless of the release site it returned *both* times to the same 45 meter stretch of the same net lane, and was netted with other warbler species. The repeated appearance of the Kirtland's in the same hawthorn-crabapple thicket would seem to indicate a preference of this individual for this type of habitat. The region in and around Powdermill lacks any habitat similar to the jack pine scrub of the Michigan breeding grounds.

The weather records during the period the Kirtland's was at Powdermill show an interesting correlation of wind direction with the probable migration direction of the bird. According to the U.S. Weather Bureau at the Pittsburgh airport (approximately 56 airmiles WNW of the Reserve) northwest winds developed in the early evening of 20 September: during the two previous days the winds had been from the south. The northwest winds continued until the late afternoon of 21 September, several hours after the warbler had been caught and banded. For the entire eleven-day period the bird stayed at Powdermill the winds did not come from the northwest quarter except for very brief periods. Two days after the warbler was last handled the winds swung around and blew from the northwest, from the evening of 4 October until the morning of 8 October.

The Reserve banding records indicate that although the Kirtland's remained in the area from 21 September at least through 2 October, considerable numbers of migrants were passing through the region during that period.

On 21 September the capture rate at the banding station was 0.91 birds per net hour, with a total of 145 birds of 33 species (including 99 warblers of 16 species). In the following days through 2 October the capture rate remained high (for the Powdermill station): 0.48 birds per net hour, with 1,146 birds banded, or 104 birds per banding day. During the same period, 21 September–2 October, in the previous five years, with more nets open for longer periods (av. 3,062 net hours 1966–70 vs. 2,390 in 1971) the capture rate was lower: 0.29 birds per net hour, or 85.6 birds per banding day. Thus it is clear that a higher than normal amount of migratory activity occurred at Powdermill while the Kirtland's was present.

Yet with all this movement of other species, the warbler remained. It apparently had a habitat preference, and it was gaining weight (1.8 g, an increase of 13 percent over its original capture weight). The layover period was a minimum of eleven days, presumably a long time for a migrant passerine.

The most reasonable explanation for this delay is that although other birds were actively migrating (the winds were out of the northeast quarter for a total of six days, the southeast for one, and the southwest for four), the Kirtland's was waiting for a more favorable wind. It had been banded, apparently as a new arrival, during a period of northwest winds and it remained in the area at least until two days before the next northwest winds began. After that second period of northwest winds the bird was not seen again. The association of this warbler with a particular wind direction, therefore, seems fairly clear and reasonable. Powdermill lies to the southeast of the Michigan breeding grounds, hence a bird migrating from there on a northwest wind might easily come down in southwestern Pennsylvania. A second period of northwest winds would take the warbler toward the southeastern states, where it could then continue south to the wintering grounds in the Bahamas.

Support for our belief that the Powdermill bird was not an "accidental" (an individual well outside the normal migration route) comes from two other southern Pennsylvania records. On 26 September 1972, an "adult male" was watched for over an hour while it fed with other warbler species on insects in "sweet birch" growing on abandoned strip mine spoil on a hill above Wellersburg, Somerset County (McKenzie, 1973; in litt.). Wellersburg is less than 45 airmiles SE of Powdermill. Mr. McKenzie saw the bird at close range and described it well; unfortunately he was alone at the time and did not have a camera with him, but otherwise his is a convincing description of a Kirtland's Warbler. At the time he apparently was unaware of the Powdermill banding record. An earlier sight record from Lewisville, Chester County, in the southeastern corner of Pennsylvania, is similarly well

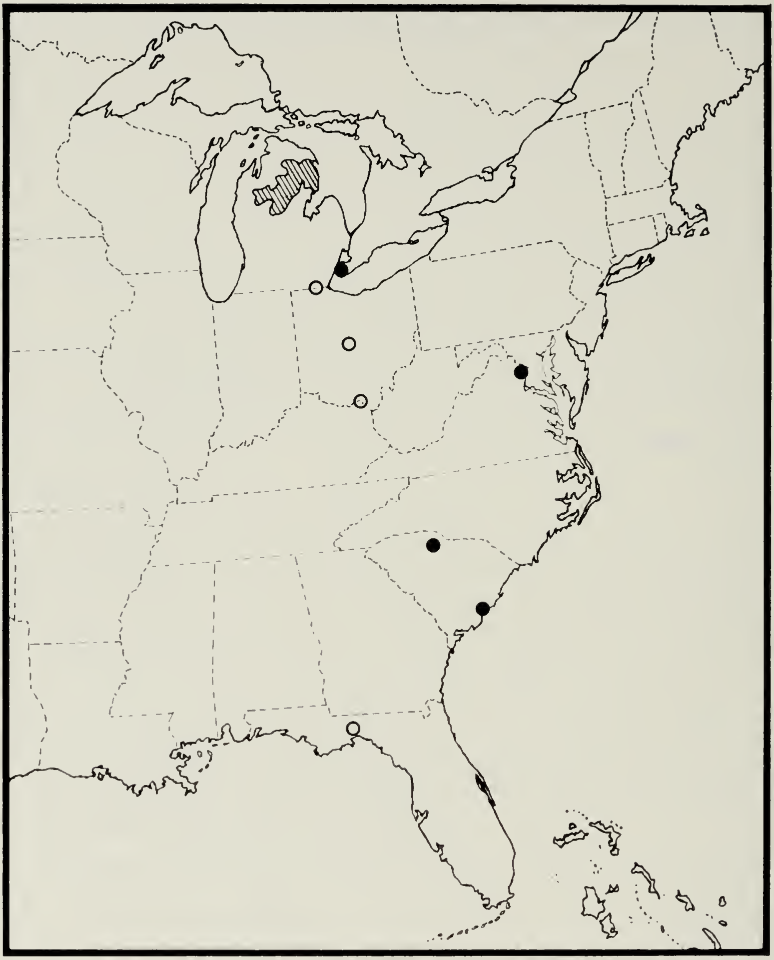


Fig. 1. Fall migration records of Kirtland's Warbler as mapped by Van Tyne. Solid circles represent specimen records; open circles, accepted sight records; hatched area, known breeding grounds. Redrawn from Van Tyne (1951).

described but undocumented. The bird was in "full breeding plumage" and recorded on 27 September 1964, by a single observer who had had previous experience with the species on the breeding grounds (B. Hurlock, D. Cutler, in litt.).

OTHER FALL RECORDS

What little is known about the fall migration route of Kirtland's Warbler was first summarized by Van Tyne (1951). Van Tyne also was almost entirely

TABLE 1

FALL MIGRATION RECORDS OF KIRTLAND'S WARBLER*

Locality	Date	Type	Reference
Ontario			
Point Pelee	2 Oct. 1915	Specimen	Mayfield, 1960
Michigan			
Bloomfield Hills	24 Sept. 1965	Banding	W. P. Nickell, AFN**, 20:52
Ohio			
Bowling Green	28 Sept. 1969	Sight	V. B. Platt, in litt. to Mayfield
Buckeye Lake	Sept. 1928	Sight	M. B. Trautman, in litt. to Clench
Cleveland	14 Oct. 1886	"Specimen"	Davies, 1906
Cleveland (Hudson)	25 Oct. 1969	Sight	J. N. Henderson, in litt. to Mayfield
Columbus (Alum Creek)	11 Sept. 1925	Sight	Thomas, 1926
Ironton	28 Aug. 1902	Sight	Jones, 1903
Toledo	22 Sept. 1929	Sight	Mayfield, 1960
Pennsylvania			
Lewisville	27 Sept. 1964	Sight	B. Hurlock, AFN, 19:24
Rector	21 Sept.–2 Oct. 1971	Banding	This paper
Wellersburg	26 Sept. 1972	Sight	McKenzie, 1973
Virginia			
Fort Meyer (Arlington)	25 Sept., 2 Oct. 1887	Specimen, sight	Smith & Palmer, 1888
North Carolina			
Rocky Mount	2–23 Sept. 1936–41	Sight (3 dates)	Mayfield, 1960
South Carolina			
Chester	11 Oct. 1888	Specimen	Loomis, 1889
Christ Church Parish (nr. Charleston)	4 Oct. 1910	Sight	Wayne, 1911
Mt. Pleasant (nr. Charleston)	29 Oct. 1903	Specimen	Wayne, 1904
Florida			
E. Goose Creek (20 mi. W. St. Marks)	9 Sept. 1919	Sight	Mayfield, 1960
Miami	21 Sept. 1958	Sight	R. L. Cunningham & A. Schaffner, AFN, 13:24
West Palm Beach	2–3 Nov. 1961	Sight	V. I. Carmer, AFN, 16:24
Alabama			
Jacksonville	5 Oct. 1966	Sight	W. J. Calvert, AFN, 22:53

* Accepted by Van Tyne (1951) and in the present paper
** AFN = Audubon Field Notes

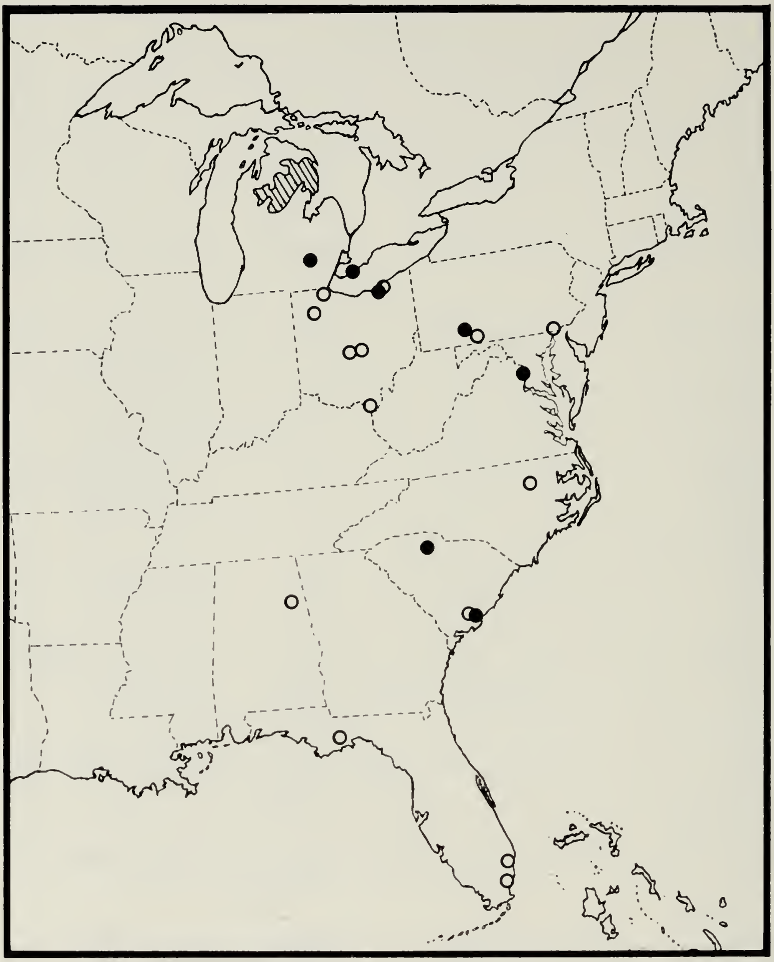


FIG. 2. Accepted fall migration records through 1972. Conventions as in Fig. 1 (banding records also shown as solid circles).

responsible (Mayfield, in litt.) for the section on fall migration records in Mayfield's excellent monograph on the species (1960). In both publications the same map (Fig. 1) was used to illustrate the accepted fall migration records. The later publication also includes a list of localities and dates for each record. In comparing the list of records with the map I found several puzzling discrepancies: four of the listed records are not spotted on the map and three of the map spots are not listed. I then wrote to Dr. Mayfield and he kindly sent me all of his and Van Tyne's notes and correspondence on the fall migration records. In addition to studying this material, I have also searched the literature through 1972 in an effort to gather together all the records, substantiated or otherwise, for analysis.

I found that the Van Tyne map is actually missing only two records that he accepted: one for a specimen from Cleveland, Ohio in 1886, and one for three sight records at Rocky Mount, North Carolina from 1936 through 1941. The third, apparently missing, record was erroneously listed as Oberlin, Ohio but correctly spotted on the map at Ironton on the Ohio River. The fourth, a sight record from the Charleston, South Carolina area, could have been omitted because of the specimen already marked for that locality on the map. The unlisted map spots are both valid records: one a sight record from Columbus (Alum Creek), Ohio in 1925 and the other a specimen taken in interior South Carolina (Chester) in 1888. All these previously accepted records and others made in recent years are detailed in Table 1 and mapped in Figure 2.

The following sight records (listed alphabetically by states) known or suspected to have been rejected by Van Tyne and/or rejected by me have not been included in Table 1. Arkansas: Arkansas County, 23–28 Sept. 1936 (Baerg, 1951); Harrisburg, 11 Sept. 1972 (in litt. to Mayfield). Florida: Fort Pierce, 1 Nov. 1918 (Sprunt, 1954); Chokoloskee, 11 Oct. 1915 (Sprunt, 1954); Pensacola, 26 Nov. 1953 (Sprunt, 1954); Princeton, 25 Oct. 1915 (Sprunt, 1954). Georgia: Savannah, 27 Aug. 1909 (Burleigh, 1958). Kentucky: Bowling Green, 28 Sept. pre-1922 (rejected by Mengel, 1965). Missouri: Weldon Springs, 29 Sept. 1950 (in litt. to Van Tyne). Ohio: Canton, 2 Sept. 1939 and 9 Sept. 1939 (in litt. to Van Tyne); Cleveland, eight dates between 2 Sept. and 7 Oct. 1934–46 (Williams, 1950); Zanesville (Dillon Dam), 3 Sept. 1962 (Hurley, 1963). South Carolina: Eastover, 14 Oct. 1949 and 1 Sept. 1951 (in litt. to Van Tyne). Virginia: Bristol, a specimen supposedly collected sometime in the fall, no date specified (Jones, 1931). A few other records in the Van Tyne correspondence are too inexact or fragmentary to identify. I have listed these rejected records so future workers will know which of the records have already been taken into consideration.

DISCUSSION

In assembling all the known fall migration records for Kirtland's Warbler I have found only two that were, to my mind, completely satisfactory indicators of the route the species is *presently* taking. These two records are the 1971 Powdermill banding and an individual banded by Walter Nickell at Bloomfield Hills, Michigan, in 1965. Most of the others are sight records, and although undoubtedly many are valid they are nevertheless subject to the

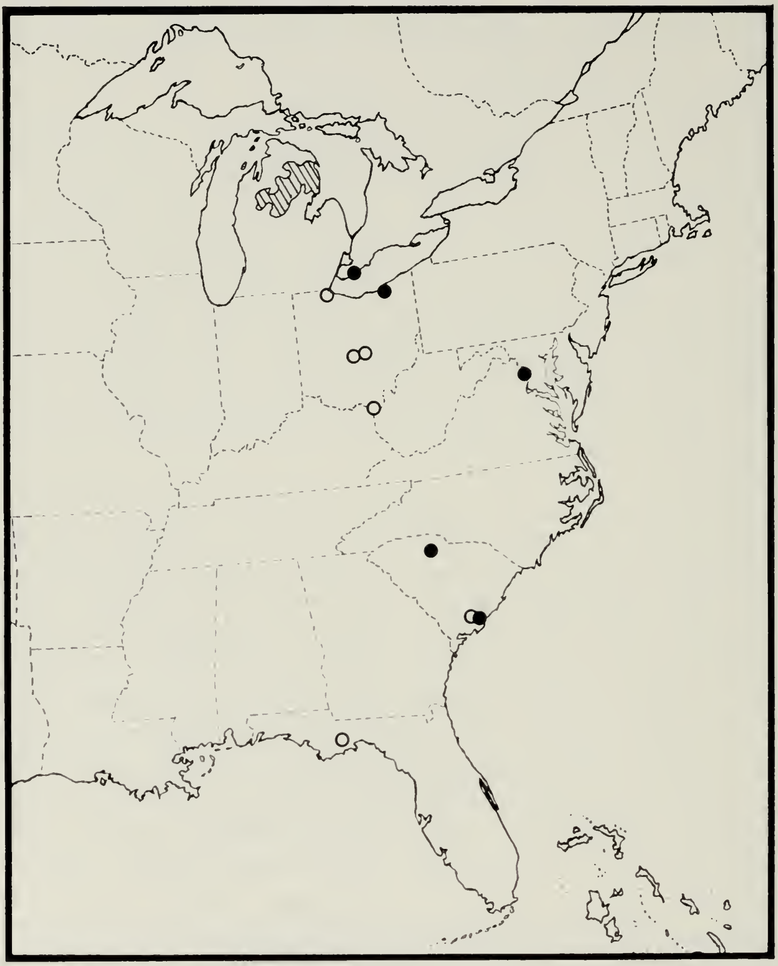


Fig. 3. Accepted fall migration records made before 1935. Conventions as in Fig. 1.

doubts that may be applied to *any* sight record. Specimen records are few, only five, and all over 50 years old: three from 1886 to 1888, one in 1903, and one in 1915. Of course in recent years, because of the species' low populations and official endangered status, it has been unwise or illegal to collect any birds that otherwise might have been secured for unquestioned records.

The greatest problem with the older records is that Kirtland's Warbler apparently has undergone striking changes in population and range size within the last 100 years. It is believed that the species enjoyed an expanded range

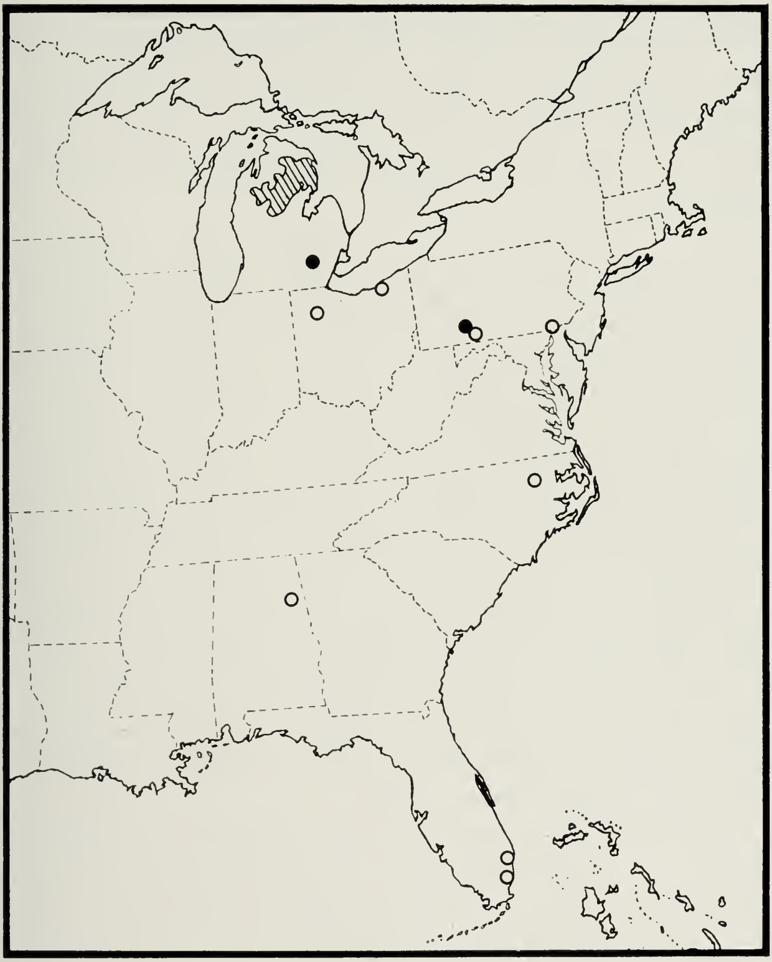


FIG. 4. Accepted fall migration records made after 1935. Conventions as in Fig. 1.

and population between 1885 and 1900. Mayfield (1960:41; legend to Fig. 5 adapted from Van Tyne, 1951) points out some of the spring migration records between 1885 and 1900 that are well "outside the normal migration route . . . when these birds are believed to have been more numerous than before or since." Van Tyne (1951:542) in the legend to the same map states "The dated records, occurring from 1885 to 1900, are those of birds which seem to have been en route to some nesting ground other than that now known." In addition, the population may have suffered a serious decline after about 1934 (Milton Trautman, in litt.; Mayfield, 1960:40) from which it eventually at least partially recovered only to show another marked population loss in the last decade (Mayfield, 1972). All of this means that when considering fall migration records, one must take into account when the records were made and the probable state of the species' population at the time. Certainly the very early records, before 1900, must be considered as coming from a period of relative abundance and possibly representing migration routes that are no longer in use.

To see if any differences were apparent between earlier records and those made in recent years, I mapped the records made before and after 1935 (Figs. 3 and 4). As might be expected, the pre-1935 map is similar to Van Tyne's, and indicates a relatively straight-line, SSE route between the breeding and wintering grounds. The more recent records, however, suggest a more directly eastward route from Michigan, across northern Ohio and southern Pennsylvania (crossing the Appalachians at a relatively low point) and then perhaps following the Piedmont or the inner coastal plain to the southeast coast before the over-water flight to the Bahamas. I doubt that the species reaches the coast north of South Carolina. The evidence for this belief is negative: no Kirtland's Warbler has *even* been seen on the coast north of the Charleston region. With the many hundreds of thousands of fall migrants that have been banded in recent years by coastal stations from New Jersey to Virginia, and with the many bird watchers that frequent the middle Atlantic coast during autumn, if the species did occur there with any regularity, it probably would have been recorded at least once. One might also reasonably suppose that the "Jack Pine Warbler" would find the extensive pinelands of the Piedmont and inner coastal plain attractive habitat.

It is also possible (Fig. 2) that some individuals may travel from Michigan via the western side of the mountains. A few accepted sight records indicate this route, and a number of the rejected records are also from this western area. It is not possible to say which of these unsubstantiated records may actually be valid, but by their very numbers I suspect that at least a few of them may be true sightings.

The direct route, SSE, crossing the Appalachians in Kentucky, Virginia, Tennessee, or the Carolinas, may also be used as suggested by the records in Fig. 3. We have no knowledge of whether mountains such as those in the southern Appalachians are sufficiently high to deflect this species on migration. Perhaps these mountains are not a serious barrier to a migrating warbler, yet *none* of the existing records come from within the southern mountains. The Chester, South Carolina, specimen is not, as it might first appear, from the mountains, but from well within the Piedmont. This specimen was also collected after a heavy gale and the bird might have been blown into the locality from elsewhere. The only montane records of the species, therefore, are both from southwestern Pennsylvania: the 1971 Powdermill banding and the 1972 Wellersburg sight record.

Hopefully field observers and banders from Ohio and Pennsylvania south, and especially those working in the southern mountains and Piedmont, will keep these possible additional migration routes in mind and be on the lookout for the species in the fall. Rare as Kirtland's Warblers now are (only about 200 pairs in the 1971 census) they still *must* pass through the eastern U.S. twice a year and, with luck, can be recorded.

This, then, is the existing evidence on the fall migration route of Kirtland's Warbler: a very sparse record consisting of 21 localities, only seven of which are adequately documented. Of these seven, five are specimens collected between 1886 and 1915, a period when the species is believed to have been more numerous and with a larger breeding range than is now the case; and two are bandings, both within the last decade and the only completely satisfactory modern records. The remainder are sight records which, although apparently valid, are still sight records and thus open to question. Since Van Tyne's compilation, however, nine records have been added to the twelve earlier ones, and the resulting picture is no longer of a straight-line, SSE route leading directly from Michigan to the Bahamas. The evidence is still too sparse to allow a definite statement on the present (or past) fall migration route of the species. It is fairly clear, however, that not all birds now follow the route suggested by the Van Tyne map. It is also probable that several routes are (or have been) used, either by different segments of the population, by different age or sex classes, or in response to varying weather conditions. How or when these various routes may be used cannot be explained by the present data. One might also hazard the (perhaps overly optimistic) guess that Kirtland's Warbler may have breeding grounds in addition to those known in Michigan, and thus in the fall is coming from regions we know nothing about.

ACKNOWLEDGMENTS

I am grateful to the many people who, through correspondence, helped me to find and assess many of the records: Charles H. Blake, David A. Cutler, Frank B. Gill, George A. Hall, Douglas A. James, Paul M. McKenzie, Frederic R. Scott, Milton B. Trautman, and William L. Wylie. I am especially indebted to Harold F. Mayfield who showed warm interest in the study, generously lent me his and Josselyn Van Tyne's files on fall migrants, and routed several recent records to me for inclusion in this paper. I also thank Robert C. Leberman, the resident bander at Powdermill, whose perspicacity and luck initiated the study, and A. C. Lloyd, our devoted weekend volunteer for his continuing contribution to the Reserve banding program. Harry K. Clench and Kenneth C. Parkes read the manuscript and offered several helpful comments; Dr. Parkes also provided stimulating discussion on the problem at several stages in the study. The illustrations were prepared by James Senior.

LITERATURE CITED

Baerg, W. J. 1951. Birds of Arkansas. Univ. Arkansas Agric. Exp. Sta. Bull. 258.

Burleigh, T. D. 1958. Georgia birds. Univ. Oklahoma Press, Norman.

Davies, L. M. 1906. The birds of Cleveland, Ohio, and vicinity. Wilson Bull., 13: 110–120.

Hurley, G. F. 1963. Field notes. The fall season. Redstart, 30:33.

Jones, L. 1903. The birds of Ohio; a revised catalogue. Ohio State Acad. Sci., Special Papers no. 6.

Jones, F. M. 1931. [Editorial notes.] Raven, 2(7):1.

Loomis, L. M. 1889. A rare bird in Chester Co., South Carolina. Auk, 6:74–75.

Mayfield, H. 1960. The Kirtland's Warbler. Cranbrook Inst. Sci., Bull. 40.

Mayfield, H. 1972. Third decennial census of Kirtland's Warbler. Auk, 89:263–268.

McKenzie, P. M. 1973. Kirtland's Warbler sighted in Somerset County. Audubon Soc. Western Penna., Bull., 37(7):10.

Mengel, R. M. 1965. The birds of Kentucky. Am. Ornithol. Union, Ornithol. Monogr: 3.

Smith, H. M., and W. Palmer. 1888. Additions to the avifauna of Washington and vicinity. Auk, 5:147–148.

Sprunt, A. Jr. 1954. Florida bird life. Natl. Audubon Soc., New York.

Thomas, E. S. 1926. Notes on some central Ohio birds observed during 1925. Wilson Bull., 38:118–119.

Van Tyne, J. 1951. The distribution of the Kirtland Warbler (*Dendroica kirtlandii*). Proc. Xth Internatl. Ornithol. Congr., Uppsala: 537–544.

Van Tyne, J. 1953. Kirtland's Warbler. *In* Bent, A. C. Life histories of North American wood warblers. U.S. Natl. Mus. Bull., 203:417–428.

Wayne, A. T. 1904. Kirtland's Warbler (*Dendroica kirtlandi*) on the coast of South Carolina. Auk, 21:83–84.

Wayne, A. T. 1911. A third autumnal record of Kirtland's Warbler (*Dendroica kirtlandi*) for South Carolina. Auk, 28:116.

Williams, A. B. 1950. Birds of the Cleveland region (Kirtland Soc. Bull. no. 2). Cleveland Mus. Nat. Hist., Sci. Pub. 10.

CARNEGIE MUSEUM, PITTSBURGH, PENNSYLVANIA 15213, 8 MAY 1973.

SOME ASPECTS OF THE NESTING REQUIREMENTS OF COMMON LOONS IN ALBERTA

KEES VERMEER

HENDERSON (1924) reported on the preference of Common Loons (*Gavia immer*) for a nesting site on some point or small island in Alberta, while Munro (1945) discussed nest-site location in relation to vegetation cover and access of water. The purpose of this study was to obtain further information on nesting requirements of loons in western Canada. Particular attention was paid to the effects of human disturbance on loons.

A survey of breeding loons was conducted on 19 lakes in east-central Alberta in 1972 (Fig. 1). All lakes surveyed were eutrophic and were located within the boreal mixed woods. Balsam poplar (*Populus balsamifera*) and aspen poplar (*Populus tremuloides*) were found to be the most dominant trees in this lake region, while white spruce (*Picea glauca*), black spruce (*Picea mariana*), jack pine (*Pinus banksiana*) and white birch (*Betula papyrifera*) were also very common.

White-winged Scoters (*Melanitta deglandi*), Lesser Scaup (*Aythya affinis*), Common Goldeneyes (*Bucephala clangula*), Mallards (*Anas platyrhynchos*), and American Widgeon (*Anas americana*) were the most common nesting ducks and the Red-necked Grebe (*Podiceps grisegena*) the most frequently encountered grebe. Lower Therien Lake had nesting colonies of Common Terns (*Sterna hirundo*), California Gulls (*Larus californicus*) and Double-crested Cormorants (*Phalacrocorax auritus*). Common Tern colonies were also observed on Ironwood Lake and Lac Saint Cyr. Great Blue Herons (*Ardea herodias*) nested on treed islands at Lower Mann, Island, and Frenchman lakes.

METHODS

Inasmuch as loons were not observed on 20 sloughs and shallow lakes in the study region, the study was limited to lakes utilized by sport fisherman, as an indication of there being fish present as food for loons. To further facilitate the study, only lakes accessible by road and up to 3000 acres in size were surveyed.

The survey was conducted with a 12 foot long aluminium boat, equipped with a 9½ h.p. outboard engine. Lakes on which no breeding pairs were observed, were checked twice during May and June. Lakes with breeding pairs were checked four to five times during May, June, the first half of July and the last week of August to obtain data on breeding success, which will be reported on later. Shorelines were cruised, with frequent 15-minute stops, for the purpose of detecting loons. The circumference of all islands, smaller than 30 acres, was checked for nests by walking along the shore. Where dense brush and logs made walking difficult, the shoreline was investigated by wading in water

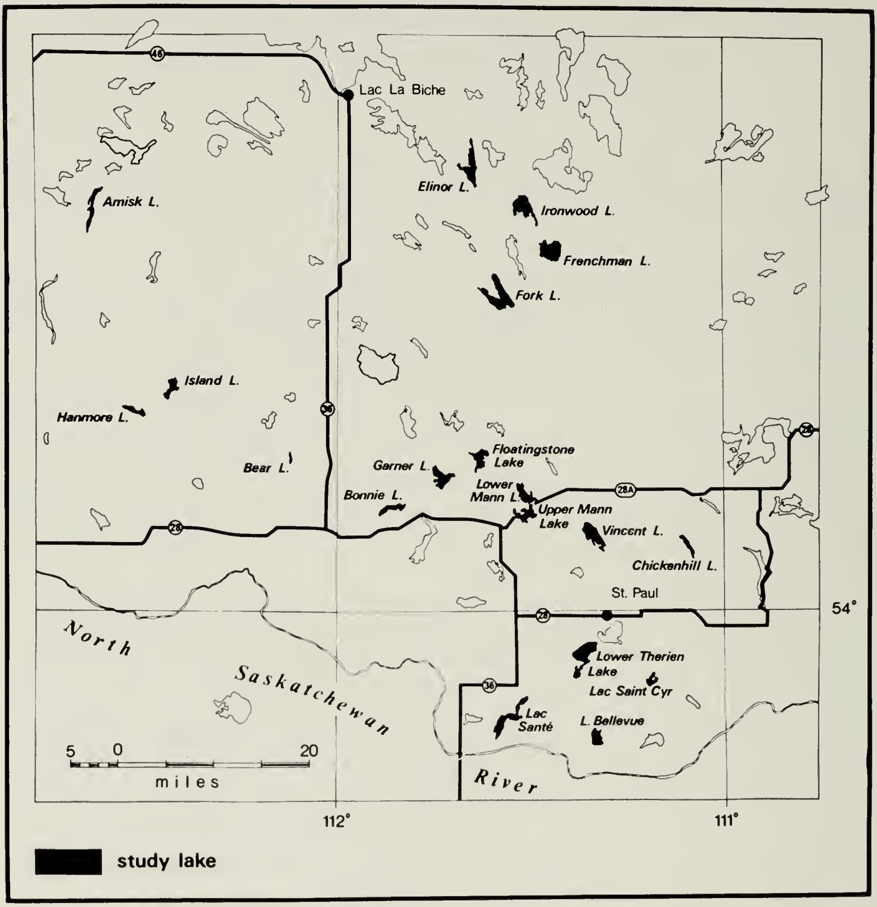


FIG. 1. Location of lakes surveyed for breeding pairs of Common Loons in Alberta.

parallel to the shore. Points and peninsulas along the shore of the mainland and islands, larger than 30 acres, were examined on foot for nests when loons were sighted in the vicinity. The checks in May and June lasted from 2 to 8 hours depending on the number of islands present and the size of the lake investigated. After being familiar with most of the nesting locations, subsequent checks took less time.

Human disturbance occurring at each lake was compared with the number of breeding pairs of loons there. Inasmuch as it was impossible to directly measure the amount of disturbance, an indication of disturbance for each lake was calculated from the number of campsites, resorts and cottages on its shores. Ten disturbance units were given to each government campsite and resort and one disturbance unit for each house and summer cottage bordering a lake. The total number of disturbance units calculated for each lake were divided by the lake acreage to obtain a disturbance ratio (Table 1).

TABLE 1

CALCULATED DISTURBANCE RATIOS OF LAKES SURVEYED FOR BREEDING COMMON LOONS

Name of Lake	Number of government campsites and resorts	Number of homes, summer cottages	Total number of disturbance units	Lake size in acres	Disturbance ratios: Disturbance units/lake size
Amisk Lake	1	11	21	1206	0.0174
Bear Lake	0	0	0	161	0.0000
Bonnie Lake	1	3	13	916	0.0142
Chickenhill Lake	0	3	3	676	0.0044
Elinor Lake	0	2	2	2397	0.0008
Floatingstone Lake	3	20	50	1281	0.0390
Fork Lake	2	7	27	3038	0.0089
Frenchman Lake	0	1	1	2224	0.0004
Garner Lake	2	14	34	1677	0.0203
Hanmore Lake	1	20	30	624	0.0481
Island Lake	0	8	8	1005	0.0080
Ironwood Lake	1	2	12	2027	0.0059
Lac Bellevue	1*	2	3	1107	0.0027
Lac Santé	1	5	15	2478	0.0061
Lac St. Cyr	1	14	24	611	0.0393
Lower Mann Lake	2	15	35	1164	0.0301
Lower Therien Lake	1	0	10	2840	0.0035
St. Vincent Lake	3	68	98	1604	0.0611
Upper Mann Lake	2	10	30	1199	0.0250

* Unused campsite because of flooding.

RESULTS

Nest Sites.—Thirty-three breeding pairs of loons were observed on the surveyed lakes. The nests of 26 pairs were found. Four pairs of those whose nests were not found were seen with broods and three pairs were thought to be breeders because of their occupation of the same localities and their vocalized reaction (yodeling and tremolo calls) each time the boat entered their territories. Twenty-five nests were found on islands and one on the mainland. Twenty-two of the nesting islands were wooded and three were without trees. Common Terns nested on two and California Gulls and Double-crested Cormorants on one of the treeless islands. Ducks and grebes shared many of the nesting islands with the loons.

Most loon nests were situated directly on the water's edge and none was more than four feet away from a lake (Table 2). Of two nests completely surrounded by water half a foot deep, one was situated in a submerged area of sedges (*Carex* sp.) and 60 feet from an island. The other nest was without surrounding vegetation built upon a platform in one foot of water and 15 feet

TABLE 2

NEST LOCATION OF COMMON LOONS IN RELATION TO NEARNESS OF WATER

Distance of nest rim to water, in feet	Number of nests
0	15
0.1–1.0	6
1.1–2.0	2
2.1–3.0	1
3.1–4.0	2

from an insular shore. Four of the 26 nests were situated on muskeg and the other 22 on a firmer substrate of sand, clay and rock boulders. The three most frequent plant species bordering the nests were sedges (15 times), willows (*Salix* spp., six times) and balsam poplars (six times). Twenty nests were sheltered in a bay or by a nearby island and six nests faced a large expanse of water. In 25 cases the nest site was located in such a manner as to afford a good underwater exit for the breeding loon. But at one site, the nesting loon had to swim through half a foot of water for 15 feet, over a lake bottom strewn with boulders, to reach deeper water. Nineteen of the 25 insular nests were situated on islands less than two acres in size (Table 3). However, there was no statistically significant preference of loons to nest on islands smaller than two acres. Amisk Lake, Bear Lake and Lac Bellevue were excluded from the statistical comparison because of one size category of nesting islands at those lakes.

TABLE 3

RELATION BETWEEN SIZE OF NESTING ISLANDS AND THAT OF THE TOTAL NUMBER OF ISLANDS (BETWEEN BRACKETS) ON LAKES WITH NESTING COMMON LOONS

Lakes	Size of nesting islands in acres	
	0–2.0	> 2.0
Amisk Lake		1 (1)
Bear Lake	1 (1)	
Elinor Lake	4 (10)	1 (4)
Fork Lake	2 (6)	2 (7)
Frenchman Lake	2 (3)	0 (2)
Island Lake	5 (25)	1 (5)
Ironwood Lake	2 (4)	0 (1)
Lac Bellevue	1 (2)	
Lower Therien Lake	2 (4)	1 (8)
Total	19 (55)	6 (28)

TABLE 4

COMPARISON OF NUMBER OF BREEDING PAIRS OF COMMON LOONS WITH LAKE SIZE, NUMBER OF LAKE ISLANDS AND DISTURBANCE RATIOS

Name of Lake	Number of breeding pairs	Lake size, in acres	Number of islands	Disturbance ratios
Amisk Lake	2	1206	1	0.0174
Bear Lake	2	161	1	0.0000
Bonnie Lake	1	916	3	0.0142
Chickenhill Lake	0	676	0	0.0044
Elinor Lake	5	2397	14	0.0008
Floatingstone Lake	0	1281	2	0.0390
Fork Lake	5	3038	13	0.0089
Frenchman Lake	3	2224	5	0.0004
Garner Lake	0	1677	0	0.0203
Hanmore Lake	0	624	0	0.0481
Island Lake	7	1005	30	0.0080
Ironwood Lake	2	2027	5	0.0059
Lac Bellevue	3	1107	2	0.0027
Lac Santé	0	2478	3	0.0061
Lac St. Cyr	0	611	2	0.0393
Lower Mann Lake	0	1164	12	0.0301
Lower Therien Lake	3	2840	12	0.0035
St. Vincent Lake	0	1604	0	0.0611
Upper Mann Lake	0	1199	7	0.0250

Breeding Pairs Versus Lake Parameters.—No loons were observed on 20 sloughs and shallow lakes which were checked in the study region. Loons were observed on all of the 19 fishing lakes, but breeding pairs were encountered on only 10 of those lakes. To determine why loons nest at certain lakes and not at others, the number of breeding pairs of loons was compared with size, number of islands and the disturbance ratio of each lake (Table 4). No significant correlation was found between the number of breeding pairs of loons and lake size ($r = 0.36$). There was a positive and significant correlation between numbers of breeding pairs and islands ($r = 0.78$; $p < 0.01$) and a significant inverse correlation between numbers of breeding pairs and disturbance ratios ($r = -0.57$; $p < 0.05$). It appears therefore that loons prefer to nest on lakes with many islands where there is a minimum of human disturbance.

DISCUSSION

Nests of loons in this study were all within four feet from the water while Olson and Marshall (1952) found nests ranging from none to five feet from the water in Minnesota. The proximity of nests to the water edge may be related to the loon's crude locomotion on land. The nearness to water also allows loons a quick escape from man and mammalian predators.

The observation that the large majority of nests were found in a sheltered situation in this study and in Minnesota (41 of 54 nests; Olson and Marshall, 1952) may be related to protection of nests from wave action. That nests of loons are destroyed by waves was evident from a study done in contract for the author at Jan Lake, 54° 55′ N; 102° 55′ W, in Saskatchewan in 1972. Ten of a total of 25 nests were washed out there. The destruction seemed related to a combination of high water levels and waves produced by motor boats (Anweiler, pers. comm.).

Olson and Marshall (1952) reported that of 54 nests of loons located in Minnesota, 50 were on islands and only four on the mainland. The preference of loons for nesting on islands, observed in Minnesota and in this study, may be a mechanism against predation by land mammals.

In Alberta, California Gulls and Canada Geese (*Branta canadensis*) nesting on peninsulas and on islands separated from the mainland by very shallow water channels, have been observed to be subject to extensive predation by coyotes (Vermeer, 1970*a*; 1970*b*).

The mechanism which leads to loons selecting nesting sites on islands may be imprinting of young loons to island sites. Predation may be more extensive for loons nesting on the mainland than on islands. A lower hatching rate for loon clutches on the mainland will leave fewer young to be imprinted to those sites.

Similarly, extensive human disturbance may leave fewer or no young to return to breed on lakes where it takes place. Olson and Marshall (1952) reported that desertion caused the failure of ten nests of Common Loons and that six of those were traceable to human disturbance. Ream (1968) also found that increased use of island campsites by canoeists caused hatching failures of Common Loons in Minnesota. Lehtonen (1970) ascribed the decline of Arctic Loons (*Gavia arctica*) in southwestern Finland to increasing numbers of summer cottages and boating activities at lakes. From the above and from the author's observations it appears that loons are intolerant to human disturbance and for that reason they may serve as indicators of the wilderness quality of fishing lakes.

SUMMARY

A survey on breeding Common Loons was conducted on 19 eutrophic and fishing lakes in east-central Alberta. Loons were only observed on the fishing lakes. The large majority of loons nested on islands; in sheltered situations and within a few feet from the water. Although no correlation was found between the number of breeding pairs of loons and the size of a lake, there was a positive significant correlation between numbers of breeding

pairs and presence of lake islands. In addition there was a significant inverse correlation between number of breeding loons and the amount of human disturbance occurring at lakes. Inasmuch as loons are intolerant of human disturbance they may serve as indicators of the wilderness quality of fishing lakes.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to K. Jaremco for his assistance during the study.

LITERATURE CITED

Henderson, A. D. 1924. The Common Loon in Alberta. Condor, 26:143–145.

Lehtonen, L. 1970. Zur Biologie des Prachttauchers. *Gavia a. arctica* (L.). Ann. Zool. Fennici, 7:25–60.

Munro, J. A. 1945. Observations of the loon in the Caribou Parklands, British Columbia. Auk, 62:38–49.

Olson, S. T., and W. M. Marshall. 1952. The Common Loon in Minnesota. Occ. Papers Minnesota Mus. Nat. Hist., 5:1–77.

Ream, C. H. 1968. Research on loon productivity and pesticide residues. Unpubl. Rept. U.S. Bur. Sport Fish. and Wildl.

Vermeer, K. 1970*a*. Breeding biology of California and Ring-billed Gulls: A study of ecological adaptation to the inland habitat. Canadian Wildl. Serv. Rept. Ser. No. 12.

Vermeer, K. 1970*b*. A study of Canada Geese, (*Branta canadensis*) nesting on islands in south-eastern Alberta. Canadian J. Zool., 48:235–240.

CANADIAN WILDLIFE SERVICE, 515 CENTENNIAL BUILDING, 10015 103 ST., EDMONTON, ALBERTA, 5 DECEMBER 1972.

THE BROOD SIZE OF CRANES

Richard S. Miller

In spite of recent studies of populations of North American cranes, relatively little is known about the breeding biology of the species, especially birds that nest in arctic and sub-arctic regions, and their management has been shown to be based largely on assumptions for which there are few supporting data (Miller et al., 1972). We know, for example, that Whooping Cranes (*Grus americana*) and Sandhill Cranes (*G. canadensis*) normally lay two eggs but seldom raise more than one young (Walkinshaw, 1949; Novakowski, 1966), but we do not know whether this is due to extrinsic factors, such as weather, food, or predation that affect the survival of young, or whether it is due to behavioral events that limit the number of young, regardless of proximate ecological factors. This question has important implications for the protection and management of these species, and is also of biological interest.

OBSERVATIONS

Table 1 shows the clutch sizes of 341 nests from breeding populations of two races of Sandhill Cranes, the Florida Sandhill Crane (*G. c. pratensis*) nesting in Florida and Mississippi, and the Greater Sandhill Crane (*G. c. tabida*) nesting in Oregon and Michigan. Clutches of one and three eggs are uncommon and most clutches contain two eggs. The mean for this sample was 1.9 eggs per clutch.

Walkinshaw (1949) estimated that 27 pairs of Greater Sandhill Cranes in Michigan laid a total of 54 eggs, but were observed to raise only 18 full-grown young, or an average of 0.7 per breeding pair. In another study (Walkinshaw, 1965*a*) observed that a total of 45 pairs raised an average of 0.8 young per year per pair between 1952 and 1958. For no apparent reason, the productivity of this population declined to 0.5 and 0.3 young per pair in 1963 and 1964 respectively (Walkinshaw, 1965*b*). A population of Greater Sandhill Cranes at the Malheur Wildlife refuge in Oregon included 160 pairs of breeding adults that produced between 35 and 45 young, or approximately 0.2 to 0.3 young per pair (Littlefield and Ryder, 1966). The low productivity of Sandhill Cranes is partly due to unsuccessful nesting of breeding pairs, but another important factor seems to be that successful pairs seldom raise more than one young.

Family groups that contain more than one young occur in Japanese Cranes (*G. japonensis*) according to Masatomi (1972), and in populations of Greater Sandhill Cranes in Michigan (Walkinshaw, 1965*a*) and Oregon (Littlefield

TABLE 1
THE CLUTCH SIZE OF SANDHILL CRANES

Locality	Number of Nests	Number of Eggs in Nest 1	2	3	Total eggs	Mean Clutch Size	Authority
Oregon	36	0	35	1	73	2.0	1
Oregon	108	9	99	0	207	1.9	2
Michigan	133	4	121	1	249	1.9	3
Florida	34	6	28	0	62	1.8	1
Mississippi	30	9	21	0	51	1.7	4
	341	28	304	2	642	1.9	

1. Walkinshaw (1949); 2. Littlefield and Ryder (1966); 3. Walkinshaw (1965*b*); 4. Valentine and Noble (1970).

and Ryder, 1966), but this is seldom the case with Lesser Sandhill Cranes (*G. c. canadensis*) and does not appear to be common in any North American cranes. In a census of 623 family groups in a total of over 17,500 Sandhill Cranes at Last Mountain Lake, Saskatchewan in the fall of 1972 (Miller and Hatfield, in press), there was only one instance of two young in a family group, and the difference in size and coloration between the young suggested that one might have been adopted (cf. Masatomi, 1972). These data confirmed several years of previous observations in Saskatchewan and Manitoba that migrating pairs of arctic-nesting Sandhill Cranes are seldom accompanied by more than one young.

Novakowski (1966) observed that Whooping Crane nests at Wood Buffalo Park almost invariably contained two eggs, but that shortly after the first egg hatched, the other egg or its chick disappeared. Between 1954 and 1964 an average population of 14 pairs of Whooping Cranes at Wood Buffalo Park produced a total of 61 young that completed their first fall migration, so that annual recruitment was only 0.4 young per pair. Kuyt (1971) recorded the number of eggs in a total of 31 nests between 1967 and 1970 and found that 28 nests contained two eggs, three contained one egg, and about half of the nesting effort was lost each year.

Lack's (1968) hypothesis is that the clutch size of birds has evolved to correspond to the number of eggs from which, on the average, the most young are raised. In nidicolous species, this limit is presumably set by the amount of food the parents can provide for their nestlings. Selection, of course, operates primarily on the number of offspring that survive to reproduce and perpetuate the parental genotype, rather than on the number of eggs laid or the number of young hatched, even though the latter might represent various degrees of energetic waste which would also be subject to natural selection.

If, for example, brood size can be adjusted quickly to correspond to the proximate factor of food availability, natural selection might not produce a close correspondence between clutch size and survival to reproductive maturity, and a few excess eggs during periods of food scarcity might be a reasonable energetic expense compared with the potential advantage of more offspring when food is abundant. This would appear to be the case among raptors, which may raise all of their young to fledging when food is abundant but allow some chicks to starve when food is scarce (Lack, 1966; Southern, 1970).

Many species of large birds, including cranes, lay small clutches of eggs, have long fledging periods and defer breeding until they are two or more years of age. Sandhill Cranes seldom breed until their fourth year (Walkinshaw, 1949) and Whooping Cranes probably defer breeding until at least this age, or possibly older. It is generally agreed (Ashmole, 1971) that deferred breeding is found in populations in which the breeding adults experience difficulty in finding enough food to successfully raise young. Small clutch sizes and long fledging periods are obvious corollaries of this condition. Asynchronous hatching is also characteristic of birds which have difficulty raising young, and is used in various ways to reduce the brood size during periods of food scarcity. As noted earlier, raptors may raise all of their young to fledging when food is abundant, but when food is scarce some or all of the young starve. The Gray Heron (*Ardea cinerea*) normally has a clutch of two eggs but one chick, usually the first hatched, takes the most advantageous position in the nest and gets the most food, and the second chick usually starves to death (Owen, 1955). This behavior also occurs among the Corvidae (Lockie, 1955). This would seem to be a relatively inefficient method of reducing brood size, in that food is wasted on a chick that will ultimately starve, but a clutch size of two provides insurance against the loss of one egg during incubation and also retains the variability which would allow an evolutionary adjustment to more favorable environmental conditions.

Cranes and a few other species that normally lay a clutch of two eggs may also reduce brood size through sibling rivalry among the young. Doward (1962) examined 598 Brown Booby (*Sula leucogaster*) and 98 White Booby (*S. dactylatra*) nests and found only one instance of two chicks surviving in the same nest—in this case both chicks survived together for 34 days before the smaller one died. He often found a second chick beside or near the nest in a weakened condition, and if the second chick was replaced in the nest, it was accepted by the adult but was later found outside the nest, apparently ejected by the larger (usually the older) chick. Vesy-Fitzgerald (1957) found a similar situation in a breeding colony of the Old World White Pelican (*Pelecanus onocrotalus*) in Tanganyika. White Pelicans lay two eggs several days apart but never seem to raise more than one young, and Vesy-Fitzgerald

(1957) observed many instances "of the older chick bullying the younger to death." This behavior seemed to be quite general and he could find no instance of two chicks surviving in one nest.

In his study of Whooping Cranes on their nesting grounds, Novakowski (1966) found that the parents sometimes left the nest with one young shortly after hatching and "all traces of the other egg (other than fragments) disappeared." In two instances in which the parents left the nest with one chick, there was evidence that another chick had hatched, or nearly hatched, but had been destroyed. Observations of captive Whooping Cranes have not been particularly instructive as eggs have frequently been infertile, or have been deliberately or accidentally destroyed by the parents, and chicks that hatched have in most cases succumbed early to disease or predation. More extensive observations have been made of wild and captive Sandhill Cranes. Walkinshaw (1965*a*) observed that Sandhill Crane chicks are extremely aggressive just after hatching, and that the older chick will attack the younger if the parents allow them to remain together. Hyde (1957) noted "time and time again" in wild Sandhill Cranes that the older chick attacked its sibling soon after the second chick hatched, killing it or driving it from the nest. He also found, when clutches of eggs were artificially incubated, that young cranes could not be kept together until they were almost full-grown. Based on the hatching and rearing of over a hundred Sandhill Cranes at the Patuxent Wildlife Research Center, Ray C. Erickson (pers. comm.) has found that young cranes show pronounced antagonism within two days after hatching and this characteristic becomes even stronger by the fourth or fifth day. Aggression becomes so intense that if young cranes are penned together for a few hours, or even less, it is likely that one will be killed. John J. Lynch (personal communication) also found intense sibling rivalry among artifically reared Sandhill Cranes, and suggested that it was unlikely, from his observations, that more than one young would survive in a brood. Erickson (pers. comm.) observed that aggression subsides after about three months (by the time contour plumage is developed) and does not reappear until the cranes are about two or three years old and are approaching breeding age.

DISCUSSION

Although there have been few direct observations of brood size reduction in natural populations of North American cranes, and especially those that nest in rigorous, northern environments, the data that are available from wild and captive birds, and from possibly analogous behaviors in other species with similar breeding characteristics, suggest the following hypothesis: (1) when the first chick hatches it receives the attention of both parents and the second egg is abandoned or destroyed, or (2) if a second egg hatches sibling rivalry and aggression may lead to the death of one chick. The second chick may die from the attacks of its sibling, or ejection from the nest may cause it to die of exposure to weather, predation or starvation. If this is an innate behavior which is unrelated to the proximate factor of food availability, a second egg may provide insurance against the loss or infertility of one egg, but this reproductive strategy would not permit the species to respond to improved environmental conditions with a corresponding increase in brood size. It would appear, therefore, that natural selection has not eliminated the second egg in clutches of species such as cranes, boobies, and White Pelicans because sibling rivalry is often an efficient method of reducing brood size quickly, and the insurance value of an extra egg is greater than its energetic cost.

SUMMARY

Observations of wild and captive Whooping Cranes and Sandhill Cranes, and apparently analogous behaviors in other species with somewhat similar breeding characteristics, suggest that, although the clutch size of both species is normally two eggs, the brood size is usually reduced to one young because of (1) abandonment of the second egg after the first has hatched, or (2) sibling rivalry which results in the death of the weaker chick. This appears to be an innate behavior which is characteristic of several species, and is unrelated to the proximate availability of food.

ACKNOWLEDGMENTS

I am grateful to R. C. Erickson and J. J. Lynch for the use of their unpublished observations, and to N. P. Ashmole for helpful criticisms and comments.

LITERATURE CITED

Ashmole, N. P. 1971. Sea bird ecology and the marine environment. *In* Avian Biology. D. S. Farner and J. R. King, Eds. Academic Press, New York. 1:223–286.

Doward, E. F. 1962. Comparative biology of the White Booby and Brown Booby *Sula* spp. at Ascension. Ibis, 102b:174–220.

Hyde, P. O. 1957. My Greater Sandhill Cranes. Audubon Mag., 59:265–267.

Kuyt, E. 1971. Whooping Crane management. Canadian Wildlife Service '71. Ottawa, Ontario, p. 30.

Lack, D. 1966. Population studies of birds. Clarendon Press, Oxford.

Lack, D. 1968. Ecological adaptations for breeding in birds. Methuen, London.

Littlefield, C. D., and R. A. Ryder. 1966. Breeding biology of the Greater Sandhill Crane on Malheur National Wildlife Refuge, Oregon. Trans. North Amer. Wildl. Conf., 33:444–454.

Lockie, J. D. 1955. The breeding and feeding of Jackdaws and Rooks with notes on Carrion Crows and other Corvidae. Ibis, 97:341–369.

Masatomi, H. 1972. Communal wintering of a Sandhill Crane with Japanese Cranes in Hokkaido, Japan. Wilson Bull., 84:250–260.

Miller, R. S., G. S. Hochbaum, and D. B. Botkin. 1972. A simulation model for the management of Sandhill Cranes. Yale University: School of Forestry and Environmental Studies, Bull. No. 80.

Miller, R. S. and H. P. Hatfield. in press. Age-ratios of Sandhill Cranes. J. Wildl. Mgmt.

Novakowski, N. S. 1966. Whooping crane population dynamics on the nesting grounds, Wood Buffalo Park, Northwest Territories, Canada. Canadian Wildl. Serv. Rept. Ser. No. 1.

Owen, D. F. 1955. The food of the Heron *Ardea cinerea* in the breeding season. Ibis, 97:276–295.

Southern, H. N. 1970. The natural control of a population of Tawny Owls (*Strix aluco*). J. Zool., 162:197–285.

Valentine, J. M., Jr., and R. E. Noble. 1970. A colony of Sandhill Cranes in Mississippi. J. Wildl. Mgmt., 34:761–768.

Vesy-Fitzgerald, D. 1957. The breeding of the White Pelican *Pelecanus onocrotalus* in the Rukwa Valley, Tanganyika. Bull. Brit. Ornithol. Club, 77:127–129.

Walkinshaw, L. H. 1949. Sandhill Cranes. Cranbrook Inst. Sci., Kingsport Press, Bloomfield Hills, Mich.

Walkinshaw, L. H. 1965*a*. One hundred and thirty-three sandhill crane nests. Jack-Pine Warbler, 43:137–143.

Walkinshaw, L. H. 1965*b*. Why the decrease in young cranes? Jack-Pine Warbler, 43:148.

SCHOOL OF FORESTRY AND ENVIRONMENTAL STUDIES, YALE UNIVERSITY, NEW HAVEN, CONNECTICUT 06511, 3 NOVEMBER 1972.

ANATOMICAL NOMENCLATURE FOR BIRDS

The first plenary session of the "International Committee on Avian Anatomical Nomenclature" was held recently at Creighton University School of Medicine, Omaha, Nebraska. Preliminary lists of anatomical terms for all systems were distributed and discussed for five days. After further revision and committee approval, an illustrated list will be submitted for adoption by the World Association of Veterinary Anatomists and publication as *Nomina Anatomica Avium.*

The avian nomenclature committee consists of 60 members representing a wide spectrum of teachers and investigators around the world. (A list of committee members with their addresses is available from the Secretary upon request.)

The next meeting of the International Committee on Avian Anatomical Nomenclature (ICAAN) will be held in Liverpool, England August 2–8, 1974 and the final list will be presented for adoption July 6–12, 1975 at the meeting of the World Association of Veterinary Anatomists in conjunction with the World Veterinary Congress in Thessaloniki, Greece.

The committee welcomes the participation and suggestions of those interested in anatomical nomenclature and solicits illustrations that can be used in the published list. Address correspondence to Dr. John McLelland, Secretary of ICAAN, Department of Anatomy, Royal School of Veterinary Studies, Edinburgh EH9-1QH, Scotland, U.K. or to one of the Chief Reviewers.

EFFECTS OF DUSTING ON PLUMAGE OF JAPANESE QUAIL

William M. Healy and Jack Ward Thomas

Many authorities have suggested that dust-bathing by birds helps control ectoparasites and promotes cleanliness. However experimental verification of these ideas is meager, and the importance of dusting sites is sometimes questioned by wildlife habitat managers. We noticed that Japanese Quail (*Coturnix c. japonica*) maintained a fairly constant daily level of dusting even when they were free of ectoparasites. This made us wonder if the dusting behavior merited more attention in wildlife habitat studies, and we designed an experiment to determine some of the effects of dusting on plumage condition.

The dusting patterns of Japanese Quail, described by Benson (1965), consist of a series of stereotyped movements that function to place dust particles on the plumage. *Coturnix* appear to perform complete dusting patterns without previous experience. They will dust on solid surfaces, but particulate surfaces elicit more dusting behavior. Visual clues are more important than tactile clues in stimulating dusting, and birds rarely attempt to dust on ½-inch mesh wire screen.

Dusting has been reported for many gallinaceous birds, including Ruffed Grouse (*Bonasa umbellus*) (Bump et al., 1947, Hein, 1970); Bobwhite (*Colinus virginianus*) (Stoddard, 1931); Scaled Quail (*Callipepla squamata*) (Wallmo, 1956); Ring-necked Pheasant (*Phasianus colchicus*) (Ginn 1962); Chukar Partridge, (*Alectoris chukar*) (Bohl, 1957); and Turkey (*Meleagris gallopavo*) (Bailey and Rinell, 1967; Mosby and Handley, 1943; Schorger, 1966; Wheeler, 1948). Ant beds, ashes, and rotted wood were most frequently listed as dusting sites, but animal burrows, road beds, and open places were also mentioned.

Stoddard (1931:315) reported that lice multiplied rapidly on Bobwhite kept in shipping crates and prevented from dusting, but no other documentation of the idea that dusting promoted cleanliness or controlled parasites was found. Schorger (1966:177) in his book on turkeys states, "There is no proof for any of the reasons advanced for dusting. . ."

METHODS

Eighty 6-week-old Japanese quail were obtained from a colony belonging to the West Virginia University Biology Department. Before the experiment, they were kept in cages holding over 100 birds. The room temperature had been held constant at 85°F, and the quail had received 15 hours of light per day.

During the experiment, the birds were kept in individual cages, and the room temper-

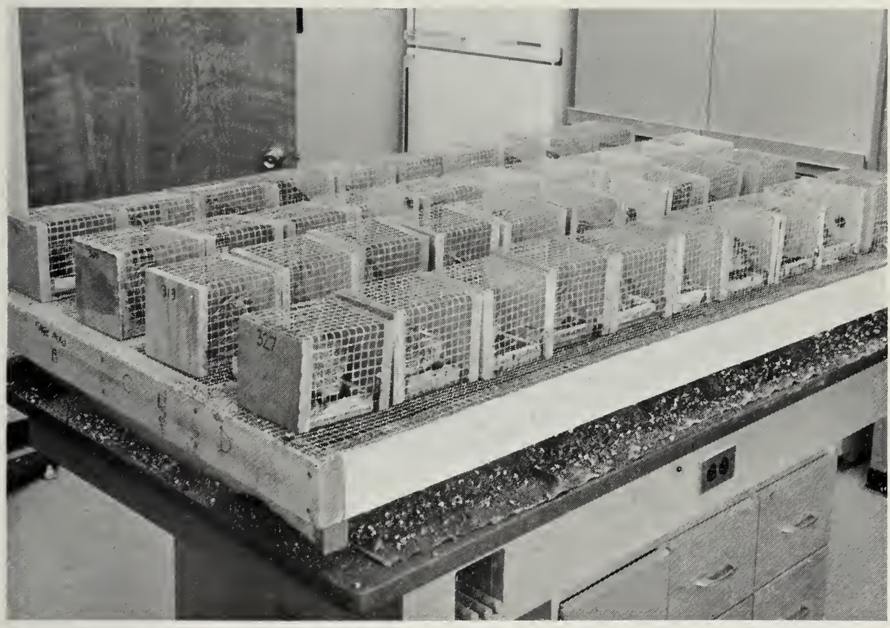


FIG. 1. Arrangement of individual cages on the wire platform.

ature was held at 78°F. The birds were exposed to natural day length, which increased from 12.5 hours (27 March) to 13.8 hours (24 April).

The individual cages had internal dimensions of 5 × 5 × 5 inches. Two sides of the cage were made of boards; the top and other two sides with ½-inch mesh wire screen. The bottom was left open to accommodate a 5 × 5-inch wooden tray which held dusting material. The cages were set in rows on a ½-inch mesh wire screen platform (Fig. 1). This arrangement kept the birds physically isolated, gave them access to food and water, and allowed us to give dusting material to individual birds. Feed and water were supplied ad lib. The feed was turkey starter mash with 1 pound of grit added to each 10 pounds of mash.

The experimental treatment consisted of allowing 40 birds (23 males, 17 females) to dust at will for 17 days. Another 40 birds (15 males, 25 females) were kept as controls, and before and after comparisons were made for sample feathers from both groups.

The birds were put into the experimental cages on 27 March and kept there for a 14-day acclimatization period. At the end of this period (8 April), three feathers were plucked from the right side of each bird (Fig. 2). The feathers were the second primary (wing), a tail feather, and a feather from the center of the ventral tract (breast).

On 9 April, trays filled with dust were placed in half of the cages. The dusting trays were left in the cages continuously for the next 17 days, except for daily cleaning and filling with dust. The dust came from local topsoil, described as a sandy loam of the Monongahela series (Van Eck, 1968), that had been ovendried and sifted through a 0.0787-inch mesh soil sieve.

On 24 April, the dusting trays were removed and a second set of feathers was taken

FIG. 2. Sample feathers from bird 340. Left, feathers taken before dusting. Right, feathers taken after dusting.

from the left side of each bird for comparison with the first set. Sample feathers were examined under a binocular microscope at 13-power magnification and evaluated for two criteria: alignment of barbs and presence of dandruff. Barb alignment is maintained by the overlapping of many hooked barbules which originate from each barb. In a well-groomed feather, the parallel barbs are held together in flat webs, and there are no gaps between individual barbs. The feathers on the left side of Figure 2 show non-alignment of barbs in contrast to the aligned barbs of the feathers on the right side of the figure. Dandruff consisted of particles of feather shaft and bits of skin. Dandruff was visible to the unaided eye, and the particles were easily counted at 13-power magnification. Feather dandruff and barb alignment were judged independently.

The "after" feather was compared to the "before" feather for each bird (wing against wing, breast against breast, tail against tail). Each feather was scored +1 for improvement, 0 for no change, or –1 for a decline. The three scores were then added, so the possible score for each criteria ranged from +3 to –3.

RESULTS

Dusting improved feather barb alignment and reduced dandruff. In the before-and-after comparison, 62 percent of the dusting birds showed better feather barb alignment, compared to 15 percent of the control birds. Reduction of dandruff showed on 85 percent of the dusting birds but on only 8 percent of the controls. Feather condition of most of the control birds remained the same or deteriorated.

There were 10 possible ways in which a bird could show either improvement or decline, and 7 ways a bird could show no change (Table 1). Most of these possible score combinations occurred, but the changes in wing, breast, and tail feathers were not independent. In general, all three sample feathers

TABLE 1

FEATHER BARB ALIGNMENT AND DANDRUFF SCORES FOR WING, BREAST AND TAIL FEATHERS OF JAPANESE QUAIL KEPT ON WIRE OR ALLOWED TO DUST, AND NUMBER OF BIRDS WITH EACH SCORE[1]

				Birds Receiving Each Score			
Sets of Scores Possible for Each Bird				Alignment		Dandruff	
Wing	Breast	Tail	Total	Dust	Wire	Dust	Wire
Net decline scores							
–1	–1	–1	–3	—	1	—	—
–1	–1	0	–2	1	2	—	1
–1	0	–1	–2	1	5	—	—
0	–1	–1	–2	—	2	1	2
–1	0	0	–1	—	7	—	2
0	–1	0	–1	—	1	—	6
0	0	–1	–1	1	—	—	6
+1	–1	–1	–1	—	—	—	—
–1	+1	–1	–1	—	1	—	—
–1	–1	+1	–1	—	1	—	—
				3	20	1	17
No net change scores							
0	0	0	0	4	7	3	20
+1	–1	0	0	—	—	—	—
+1	0	–1	0	—	1	2	—
0	+1	–1	0	2	1	—	—
–1	+1	0	0	3	3	—	—
–1	0	+1	0	2	2	—	—
0	–1	+1	0	1	—	—	—
				12	14	5	20
Net improvement scores							
+1	0	0	+1	1	—	2	—
0	+1	0	+1	4	1	—	1
0	0	+1	+1	4	2	4	1
+1	–1	+1	+1	1	—	—	—
+1	+1	–1	+1	2	—	—	—
–1	+1	+1	+1	2	1	—	—
+1	+1	0	+2	—	1	2	—
+1	0	+1	+2	—	—	4	—
0	+1	+1	+2	9	1	7	—
+1	+1	+1	+3	2	—	15	1
				25	6	34	3

---

[1] All possible sets of scores, wing + breast + tail, are shown in the four left-most columns. The number of quail receiving each score is shown in the columns on the right.

TABLE 2

CHANGES IN THE AMOUNT OF DANDRUFF ON WING, BREAST, AND TAIL FEATHERS OF 40 JAPANESE QUAIL KEPT ON WIRE OR ALLOWED TO DUST

	Number of Sample Feathers					
	With Dust			Without Dust		
Feathers	More	No Change	Less	More	No Change	Less
Wing	0	15	25	3	36	1
Breast	1	15	24	9	29	2
Tail	3	7	30	8	30	2

for each bird changed in the same direction. For example, without dust, 36 birds received a 0 score (no change) for dandruff on the wing feather. Of these 36 birds, 27 also received a 0 score for dandruff on both the breast and tail feathers. Fifteen of the birds allowed to dust had a reduction in dandruff on all three sample feathers.

Considering the three types of feathers independently, dusting decreased dandruff on most feathers (25 wing, 24 breast, and 30 tail feathers from dusting birds had a decrease in dandruff). Most of the feathers from the control birds showed no change in the amount of dandruff (Table 2).

In barb alignment, the three types of feathers did not respond uniformly to dusting. With dusting, breast and tail feathers generally improved in barb alignment (24 and 21 out of 40, respectively) while only 6 out of 40 wing feathers showed any improvement. Without dust, barb alignment of wing feathers definitely deterioriated (23 out of 40) while most of the breast and tail feathers remained unchanged (Table 3).

DISCUSSION

Birds with dusting trays dusted frequently and usually responded immediately when fresh dust was added. Dusting behavior patterns were complete

TABLE 3

CHANGES IN THE CONDITION OF BARB ALIGNMENT FOR WING, BREAST, AND TAIL FEATHERS OF 40 JAPANESE QUAIL KEPT ON WIRE OR ALLOWED TO DUST

	Number of Sample Feathers					
	With Dust			Without Dust		
Feathers	Worse	No Change	Better	Worse	No Change	Better
Wing	9	25	6	23	15	2
Breast	3	13	24	7	24	9
Tail	6	13	21	11	22	7

and typical for *Coturnix.* In a few instances, birds on wire tried to dust. This occurred when several nearby birds with dusting material were dusting.

Mechanical injury in the small cages probably accounted for the decrease in wing barb alignment of non-dusting birds. The improvement in breast and tail feather characteristics of dusting birds was an effect of dusting.

The general appearance of dusting birds was improved. The most noticeable effect of dusting was a reduction in oil or moisture content of the plumage. Down feathers and downy barbs at the base of contour feathers were dry and fluffy, so that down filled the space between the contour feathers and the bird's skin. Birds kept on wire appeared greasy, in comparison to dusting birds. The down was matted and the skin could be seen easily by parting contour feathers.

The common method of cleaning and drying bird skins for taxidermy or museum specimens approximates the effects of dusting by living birds. To clean skins or to dry skins that have been washed, an absorbent powder (borax, corn meal) is heaped on the skin and then shaken through the feathers (Anderson, 1948:98–99). The powder absorbs moisture, blood, and grease as it sifts through the feathers; and the mechanical action of shaking and brushing fluffs and aligns the feathers.

We speculate that dust particles absorb oil and moisture as they are shaken through the feathers. The result appears to be a drying and fluffing action, which helps keep the down from matting and maintains the insulating qualities of the plumage. Thus, dusting does improve plumage condition, and it may also help control ectoparasites. However, because of our incomplete knowledge of the function of dusting, we do not at this time recommend habitat management to provide dusting sites. We think the effects of dusting on plumage oil, and the relationships between dusting and oiling behaviors deserve more study.

Our conclusions agree closely with those of Borchelt, Eyer, and McHenry (1973) concerning dusting behavior of Bobwhite. These authors also noted an oily appearance of Bobwhite that had been deprived of dust, and they hypothesized that dust bathing serves to remove excess lipids from the plumage.

SUMMARY

Forty Japanese quail were kept on ½-inch mesh wire floors, and 40 were supplied with dusting material for 17 days. Sample feathers of dusting birds showed improved barb alignment and a decrease in dandruff. The most noticeable effect of dusting was the drying and fluffing of the down.

ACKNOWLEDGMENTS

Dr. Martin W. Schein, Biology Department, West Virginia University, provided the birds used in the experiment as well as valuable guidance and criticism of the research design and final manuscript.

LITERATURE CITED

ANDERSON, R. M. 1948. Methods of collecting and preserving vertebrate animals. Nat. Mus. Canada Bull., 6.

BAILEY, R. W., AND K. T. RINELL. 1967. Events in the turkey year. *In* The wild turkey and its management: 73–91. Wildl. Soc., Washington, D. C.

BENSON, B. N. 1965. Dust-bathing in Coturnix Quail (*Coturnix coturnix japonica*). Unpubl. M.S. Thesis, Penn State Univ.

BOHL, W. H. 1957. Chukars in New Mexico, 1931–1957. New Mexico Dept. Game and Fish Bull., 6.

BORCHELT, P. L., J. EYER, AND D. S. MCHENRY, JR. 1973. Dust-bathing in Bobwhite Quail (*Colinus virginianus*) as a function of dust deprivation. Behavioral Biology, 8:109–114.

BUMP, G., R. W. DARROW, F. C. EDMINSTER, AND W. F. CRISSEY. 1947. The Ruffed Grouse: Life history, propagation, and management. New York Conserv. Dept., Albany.

GINN, W. E. 1962. The Ringneck Pheasant in Indiana—its history, research, and management. Indiana Dept. Conserv. P-R Bull., 6.

HEIN, D. 1970. Dust-bathing sites selected by Ruffed Grouse. Wilson Bull., 82:310–314.

MOSBY, H. S., AND C. O. HANDLEY. 1943. The Wild Turkey in Virginia: its status, life history and management. Virginia Comm. Game and Inland Fisheries, Richmond.

SCHORGER, A. W. 1966. The wild turkey: its history and domestication. Univ. Oklahoma Press, Norman, Oklahoma.

STODDARD, H. L. 1931. The Bobwhite Quail—its habits, preservation and increase. Charles Scribner's Sons, New York.

VAN ECK, W. A. 1968. Soils and ecology of the arboretum. West Virginia. Univ. Dept. Biol. Arboretum Newsletter, 18(2):1–8.

WALLMO, O. C. 1956. Ecology of Scaled Quail in west Texas. Texas Game and Fish Comm., Austin.

WHEELER, R. J., JR. 1948. The Wild Turkey in Alabama. Alabama Dept. Conserv.

USDA FOREST SERVICE, NORTHEASTERN FOREST EXPERIMENT STATION, 180 CANFIELD STREET, MORGANTOWN, WEST VIRGINIA 26505 AND PACIFIC NORTHWEST FOREST EXPERIMENT STATION, ROUTE 2, BOX 2315, LAGRANDE, OREGON 97850, 2 JANUARY 1973.

COMPETITION BETWEEN AMERICAN COOTS AND FRANKLIN'S GULLS FOR NEST SITES AND EGG PREDATION BY THE COOTS

JOANNA BURGER

FRANKLIN'S Gull (*Larus pipixcan*) is the only gull that nests exclusively in marshes. It is colonial, and often changes colony sites from year to year. Franklin's Gulls build semi-floating nests in the cattail (*Typha* sp.) marshes of the northern prairies of North America. I studied the breeding adaptations of the Franklin's Gull to a marsh habitat from 1968 to 1971 at Agassiz National Wildlife Refuge in northwestern Minnesota. Although there are many other species of birds that regularly nest in the gull colony, Franklin's Gulls selectively defended their nests against the American Coot (*Fulica americana*). In this paper I will describe the interactions between these two species. Descriptions of coot displays are from Gullion (1952), those of Franklin's Gull are from Moynihan (1958).

Coots were attacked by gulls throughout the season. Competition between coots and gulls for nest sites was intense, and frequent battles ensued. Disputed sites usually consisted of a few bent over cattail flags. Franklin's Gulls establish territories by standing on cattails in one area of the marsh and defending it against all other gulls. During this period coots were frequently in the area using some of these same sites as loafing and preening areas. The incumbent gull usually flew before an approaching coot reached its station. The coot swam in the normal posture until it saw the gulls on the site. The coot then swam toward the station in the "patrolling" posture. Usually this was sufficient to cause the gull to fly. However, on some occasions, the coot actually "charged" the gull. After repeated encounters gulls typically abandoned the stations, but in two of 19 cases gulls successfully defended their chosen sites and subsequently built nests there.

I found the first coot nest in the gull colony area on 4 May 1969 (2 eggs) at about the time that the gulls began nest construction. New coot nests were initiated in the colony area until at least 6 July when I stopped searching for nests. Incubating gulls always "gakkered" at coots swimming within 4 meters of their nests. Usually gulls did not nest close to coot nests although they did nest close to nests of ducks (minimum distance of one meter), Black-crowned Night Herons (*Nycticorax nycticorax*) (1.2 meters) and Western Grebes (*Aechmophorus occidentalis*) (2.7 meters).

Ryder (1959) studied the interspecific behavior of the American Coot in Utah and found that they threatened or pursued 16 species of birds, one fish, one reptile, and two mammals. Diving ducks primarily competed for feeding areas, and nesting (and brooding) platforms, while dabbling duck conflicts concerned loafing sites and feeding areas. Ryder believed that the coot's aggressiveness did not have an adverse effect on duck nesting because predators were kept away by the coot. Competition for nesting sites (Sooter, 1945) and the aggressive nature of coots (Gullion, 1953; Fredrickson, 1970) were observed in other studies.

From my blind on 25 May 1971, I watched a coot eat three gull eggs. A gull stood on its nest and gakkered at a coot swimming 4 meters away. The coot assumed a patrol posture until it was 2 meters away and then charged the gull. The gull stood facing the coot and continued to gakker. The gull then attacked the coot on the water by pecking and flapping its wings at the intruder. Both birds were fighting and pecking at each other. The coot maintained its balance but the gull appeared to be pushed under the water several times. The fighting sequence lasted two and a half minutes before the gull flew. The coot walked up on the nest platform, pecked at and ate the contents of all three eggs, and departed while the gull continued to swoop at it from above. A similar observation was made on 6 June over a half mile from the first blind, making it unlikely that the same individual coot was involved. Elsewhere in the colony I located 19 gull nests containing pecked eggs in an area with a coot's nest in the center.

J. T. Lokemoen (pers. comm.) made the following observation on 16 May 1961 near Charlo, Montana. An adult coot was perched on top of cattails nearly one meter above the water surface in a semi-permanent pothole with a cattail fringe. The coot was feeding on the contents of a Red-winged Blackbird's (*Agelaius phoeniceus*) nest while several adult blackbirds attacked the coot. Jerome Stoudt (pers. comm.) reported seeing a coot sitting on a Pied-billed Grebe (*Podilymbus podiceps*) nest pecking at the eggs. Upon closer observation he found all the eggs open and most of the contents gone from one or two of the eggs. This observation was made in 1969 or 1970 in Minnedose, Manitoba.

I was unable to find any reference in the literature to the American Coot eating eggs of other species. Bent (1926) considered the species omnivorous. The European Coot is known to eat the eggs of the Black-headed Gull (Densley, 1966).

SUMMARY

There is competition between Franklin's Gulls and American Coots for nest sites, each species defending its nesting site against the other species. Coots were observed to be aggressive towards Franklin's Gulls throughout the breeding season. On two occasions coots were observed to eat the eggs of Franklin's Gulls and 19 nests in an area centered on a coot's nest contained pecked eggs.

ACKNOWLEDGMENTS

I wish to thank Drs. L. Fredrickson and H. B. Tordoff for help in the preparation of this manuscript. I thank J. T. Lokemoen and J. Stout for permission to use unpublished data. This research was part of a three year study on Franklin's Gull conducted at Agassiz National Wildlife Refuge as a cooperative project with the Fish and Wildlife Service. I gratefully acknowledge financial support from the Frank M. Chapman Memorial Fund of the American Museum of Natural History, The Herz Fellowship of the University of Minnesota, and the Society of the Sigma Xi.

LITERATURE CITED

Bent, A. C. 1926. Life histories of North American marsh birds. U.S. Natl. Mus. Bull., 135.

Densley, M. 1966. Coot eating Black-headed Gull's eggs. Brit. Birds, 59:306.

Fredrickson, L. H. 1970. Breeding biology of American Coot in Iowa. Wilson Bull., 82:445–457.

Gullion, G. W. 1952. The displays and calls of the American Coot. Wilson Bull., 64:83–97.

Gullion, G. W. 1953. Territorial behavior of the American Coot. Condor, 55:169–186.

Moynihan, M. 1958. Notes on the behavior of some North American gulls, II. Non-aerial hostile behavior of adults. Behaviour, 12:95–182.

Ryder, R. A. 1959. Interspecific intolerance of the American Coot in Utah. Auk, 76:424–442.

Sooter, C. A. 1945. Relations of the American Coot with other waterfowl. J. Wildl. Mgmt., 9:96–99.

DEPARTMENT OF ECOLOGY AND BEHAVIORAL BIOLOGY, J. F. BELL MUSEUM OF NATURAL HISTORY, UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA, (PRESENT ADDRESS: DEPARTMENT OF BIOLOGY, LIVINGSTON COLLEGE, RUTGERS UNIVERSITY, NEW BRUNSWICK, NEW JERSEY 08903). 10 APRIL 1973.

NORTH AMERICAN HAWK MIGRATION CONFERENCE

Syracuse, New York, 19–21 April 1974

Valuable research on hawk migration has been done by many individuals and organizations over the past 40 years, but little work has so far been done to correlate these studies. The purpose of the North American Hawk Migration Conference, therefore, is to gather under one roof hawkwatchers from all over eastern North America—from the edge of the Great Plains at longitude 95° east to the Atlantic coast, and from Manitoba to the Gulf of Mexico—to exchange observations on hawk migration, to set standards for record-keeping, and to agree on ways of sharing and collating information on a continuing basis.

The conference will be held at the Holiday Inn north of Syracuse with registration in the evening of Thursday 18 April. Further details about transportation and accommodation can be obtained from the Host Committee Chairman: Dorothy W. Crumb, 3983 Gates Road North, Jamesville, New York 13078.

ANALYSIS OF THE EASTWARD BREEDING EXPANSION OF BREWER'S BLACKBIRD PLUS GENERAL ASPECTS OF AVIAN EXPANSIONS

P. H. R. Stepney and Dennis M. Power

The present paper is part of a continuing study on ecological and evolutionary problems associated with the eastward range expansion of Brewer's Blackbird (*Euphagus cyanocephalus*). This recent expansion from western Minnesota to Sudbury, Ontario, a distance of approximately 700 miles, is believed by us to be due to individuals undergoing relocation from earlier nesting or wintering areas, and upon encountering recently created, favorable habitat east of where the species previously bred, establishing new breeding populations. Previously, Walkinshaw and Zimmerman (1961) reviewed all breeding and non-breeding records of this species east of the Mississippi River. The present study, in addition to updating information on the expansion of the breeding range within the Great Lakes region, analyzes the routes and rates of expansion, with thoughts on the phenomenon of expansion in general.

MATERIALS AND METHODS

The dates and locations of sightings within the expansion zone were obtained from the literature. Much of this information is summarized in one figure (Fig. 1, to be discussed beyond) which indicates year and locality of first known breeding birds or birds classed as summer residents, i.e. birds reported between 1 May and 31 July. The present map shows only those records pertinent to pioneering movements, although working maps showing nearly all records were originally produced. Symbols are used in the figure to indicate either nesting or summer residency. In cases where nesting was reported after an initial summer residency the symbol for nesting is used while the date refers to the earlier report of first residency. Normally only the first sighting per county is given, but in large counties or districts others may be given for clarification. In a few cases where the date of a report was the same as that of a neighboring report, the date is given only once. Where nest location was not specified we have plotted the symbol in the center of the county. References for dates in Figure 1 which are not given in this paper appear in Stepney (1971). The slightly modified boundaries of the potential vegetation shown in Figure 1 are after Küchler (1964). Figure 2, a representation of the routes followed, was constructed by connecting the areas with dates that indicated step-wise occupation. The rates of expansion given in Table 1 were determined by dividing the time between reports of invasion into the straight-line distance between the points of invasion.

PREVIOUS DISTRIBUTION OF BREWER'S BLACKBIRD

Prior to the 1900's, the Red River Valley in western Minnesota was the eastern distributional limit of Brewer's Blackbird (Coues, 1874). The species

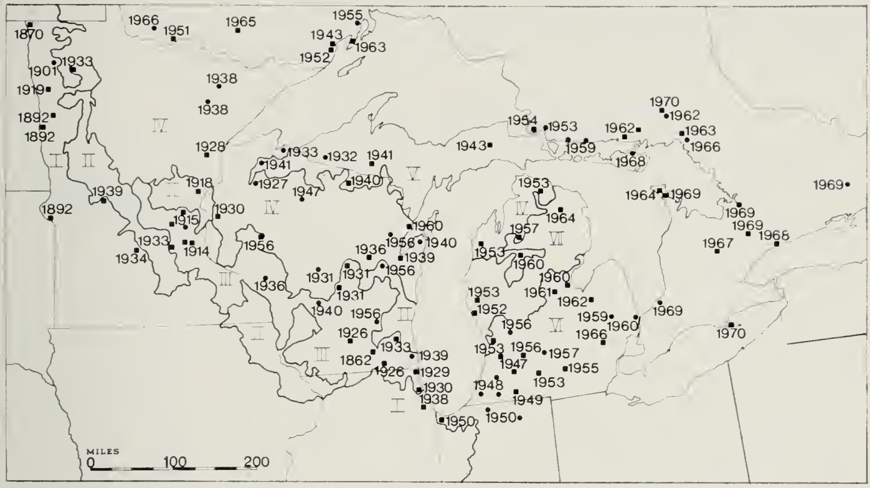


FIG. 1. Dates of sightings of Brewer's Blackbird and major vegetation types within the zone of expansion. Circles—summer resident, squares—known breeding. I—bluestem prairie, II—maple-basswood forest, III—oak-savanna cover, IV—Great Lakes spruce-fir and spruce-pine forest, V—northern hardwood-fir forest, VI—oak-hickory and beech-maple forest, VII—northern pine forest.

was recorded breeding in several western Minnesota counties, namely Kittson, Norman, Polk, and Big Stone Lake (Hatch, 1892). Occurrence farther eastward was probably restricted by the band of maple-basswood forest which paralleled the Red River Valley (Fig. 1) and then extended diagonally southeast across Minnesota and Wisconsin. By 1880 the forest had already been removed from the areas that the species was to later colonize in Minnesota and Wisconsin (Sargent, 1884), but expansion was delayed until the intervening maple-basswood forest barrier was destroyed about the turn of the century. With the removal of the barrier Brewer's Blackbird rapidly colonized the oak-savanna zone (Fig. 1), a vegetation belt the species had been recorded in five times prior to expansion (Kumlien and Hollister, 1903), but in which breeding populations had never become established.

Prior to expansion, numbers of Brewer's Blackbirds increased in the Red River Valley. The species became much more abundant in northeastern North Dakota around 1880 (Williams, 1926), and apparently commenced breeding in Marshall County in northeastern South Dakota sometime between 1870 and 1929 (Youngworth, 1935). There is insufficient information to determine if these changes resulted from an expansion originating farther westward or were just an increased occurrence in response to greater habitat availability resulting from agricultural activity. Youngworth (op. cit.)

supports the latter view. Whatever the cause, the increased density of Brewer's Blackbird probably assisted in launching the expansion into Minnesota.

DYNAMICS OF EXPANSION, ROUTES FOLLOWED

Expansion in Brewer's Blackbird appears to have been accomplished by single birds or small groups of individuals pioneering to what was presumably the nearest suitable area. Only in the Upper Peninsula of Michigan did the initial expansion movement appear to skip over an intervening area that was later colonized (Fig. 1). Although colonization (the first breeding in an area) and invasion (the first appearance in an area) often occurred concurrently, breeding was delayed in some areas. A delay of one to two years appears to have occurred in Walworth County, Wisconsin (Schorger, 1934), Port Arthur, Thunder Bay District, Ontario (Allin and Dear, 1947), Allegan County, Michigan (Walkinshaw and Zimmerman, 1961), Sault Ste. Marie, Algoma District, Ontario (Speirs, 1954) and Sudbury, Sudbury District, Ontario (Devitt, 1964). Unfortunately the ages of the pioneering individuals were not known. If the birds were juveniles, the case in many expanding species (Lack, 1954), then it is logical that breeding was delayed. Williams (1952) suggests that male Brewer's Blackbirds do not breed until their second year and preliminary observation of banded birds suggest the nestlings do not return to, or near, the parental area the following year. Age, however, is not the sole factor governing breeding, as these delays may have been due to poor habitat or too few individuals.

Within the expansion zone local populations have built up particularly around the centers of Minneapolis, Madison, Kalamazoo, Luce County, Michigan, Fort Francis, Port Arthur, Sault Ste. Marie, and Sudbury. These centers of occupation are presumably due to the increase of grassland habitat around centers of human habitation. The main habitat feature apparently necessary to induce settling is the presence of sufficient area offering little vegetational hindrance to movement while foraging (Stepney, 1971). In forest zones, the production and maintenance of suitable foraging areas are dependent upon human activity. Consequently, Brewer's Blackbirds are closely associated with farmlands, towns, highway and railway rights-of-way.

Inspection of dates of first breeding or summer occurrence (Fig. 1) allows determination of the most probable routes of expansion eastward (Fig. 2). (For reasons we will develop beyond, we have considered expansion from one breeding area to the next, rather than from the wintering grounds). The initial expansion into Minnesota was along only one route although several distinct routes ultimately developed within the remaining expansion zone. The initial expansion occurred into central Minnesota where the species was found breeding at Minneapolis in 1914 (Roberts, 1914). From here the

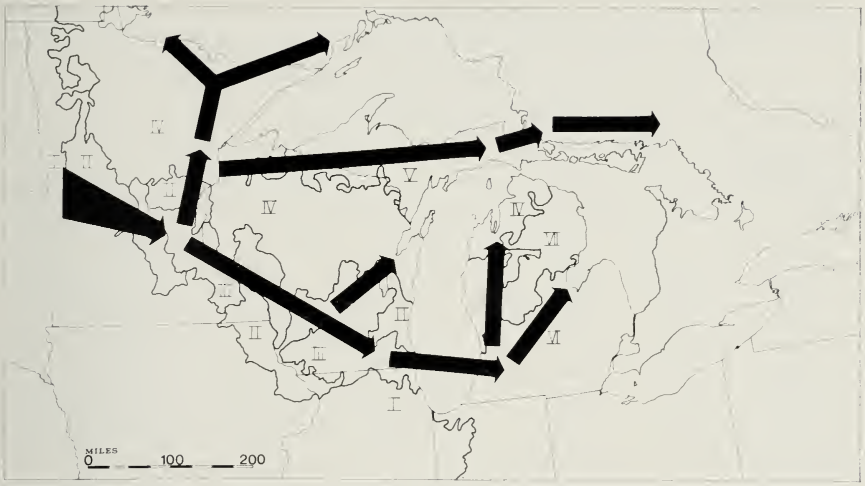


FIG. 2. Inferred expansion routes of Brewer's Blackbird.

blackbird penetrated farther east, reaching Madison, Wisconsin in 1926 (Schorger, 1934). Two northward routes then developed from this initial eastward extension. The more important route was observed in 1928 when the species was found breeding in the less modified areas of the Great Lakes Forest north of Minneapolis (Roberts, 1932). The second northward turning took place near Madison, where the species again invaded the forest but penetrated only as far as the Green Bay, Wisconsin area.

The route north from Minneapolis soon divided; one branch continued northward through Minnesota and the other moved east across the Upper Michigan Peninsula. The route through northern Minnesota again divided, with one terminus reaching Port Arthur, Ontario by 1943 (Allin and Dear, 1947) and the other extending northwest, reaching Fort Francis, Ontario by 1951 (Baillie, 1961). The invasion across the Upper Michigan Peninsula proceeded rapidly reaching Luce County, Michigan by 1943 (Walkinshaw and Zimmerman, 1961). From Luce County the species moved into the Sault Ste. Marie, Ontario area by 1953 (Speirs, 1954), then continued eastward reaching Sudbury, Ontario by 1962 (Devitt, 1964). A minor southward extension developed from the Sudbury route but appears not to have persisted. There has been one report of summer residents on Manitoulin Island (Power, 1971) and two reports of breeding birds in the Bruce Peninsula (Goodwin, 1969) but no subsequent sightings from either area have been reported.

The remaining expansion route was the colonization of Kalamazoo, Michigan from the Madison, Wisconsin area observed in 1947 (Fleugel, 1948).

From Kalamazoo two extensions developed. The first was a southwestward movement into northwestern Indiana by 1950 (Mumford, 1954). The complete sequence of dates from Kalamazoo, Michigan to Gary, Indiana (Fig. 1) and the absence of Brewer's Blackbird from the Chicago area, suggest expansion occurred across rather than around Lake Michigan. The second expansion from Kalamazoo went north along Lake Michigan, the species reaching Benzonia by 1953 (Walkinshaw and Zimmerman, 1961) and Bay City by 1960 (Kenaga, 1961). Another possibility is that parts of northern Lower Michigan, particularly Cheboygan County were colonized via Luce County in Upper Michigan. Owing to the ambiguity of the data we have chosen Kalamazoo as the source region for the Lower Michigan expansions, as it is the least circuitous. To date the distribution of Brewer's Blackbird within the expansion zone is still strongly influenced by these original expansion routes. Overall, the occurrence and numbers of Brewer's Blackbirds tend to decrease moving both north and east in the expansion zone.

Expansion into southeastern Lower Michigan and southern Ontario has not occurred, although a few isolated nestings have been reported (Devitt, 1969; Poitter and Hirt, 1966; Richards and Peck, 1968). The failure of Brewer's Blackbird to establish permanent breeding populations in these areas may be a result of competitive overlap with the Common Grackle (*Quiscalus quiscula*) (Stepney, 1971), an icterid with somewhat similar ecological requirements and one which becomes very abundant in southeastern Lower Michigan and eastward (Zimmerman and Van Tyne, 1959).

The pattern of dates suggests that expansion may have been accomplished primarily by the relocation of surplus individuals to suitable habitat which is nearest to the previously occupied breeding areas. Although occupation of new areas could also have been accomplished through direct movement from the wintering range, this alternative viewpoint seems less attractive, primarily because a number of more northern areas were occupied before southern ones. For example, parts of Upper Michigan were colonized before Lower Michigan, and within Lower Michigan, breeding colonies had become established in the northern section before much of the southern section was colonized.

EFFECTS OF BARRIERS UPON THE RATE OF EXPANSION

Disregarding the initial forest barrier, five major vegetation zones were colonized by Brewer's Blackbird while moving eastward (Fig. 1). On three occasions water barriers of appreciable magnitude were encountered. Expansion across vegetation-zone boundaries or water barriers was at a slower rate than was expansion within a given vegetation zone or before and after overcoming a water barrier (see Table 1). Water barriers hampered expansion more than vegetational barriers but neither exerted more than a temporary

TABLE 1

RATES OF EXPANSION BETWEEN VARIOUS CENTERS AND THE DISTANCES AND TIMES INVOLVED

Pioneering Movements	Distance (miles)	Time (years)	Theoretical Expansion Rate (miles per year)
a. minor			
Minneapolis to Madison	277	12	23.0
Madison to Kalamazoo	77	21	3.6
Minneapolis to western Lake Superior	110	14	7.8
Western Lake Superior to Fort Francis	170	23	7.3
Western Lake Superior to Thunder Bay	236	15	15.3
Western Lake Superior to Luce Co., Michigan	315	16	19.7
Luce Co., Michigan to Sault Ste. Marie	69	10	6.9
Sault Ste. Marie to Sudbury	154	9	17.1
b. major			
Minneapolis to Kalamazoo	354	33	10.1
Minneapolis to Thunder Bay	346	29	11.9
Minneapolis to Fort Francis	280	37	7.5
Minneapolis to Luce Co.	452	30	14.1
Minneapolis to Sudbury	648	49	11.1
c. *general expansion rate*	10.9 miles per year		

restraint. In addition, the suitability and availability of grassland habitat within each vegetational region were likely responsible for variation in expansion rates. The oak-savanna vegetation belt was colonized most rapidly presumably because it was the area physiognomically most similar to the areas west of Minnesota. For example, the stretch of oak-savanna vegetation from Minneapolis, Minnesota to Madison, Wisconsin was colonized at a rate of about 23 miles per year. Conversely, the expansion north through forested areas was at a lower rate, particularly into the Fort Francis area where the availability of suitable habitat was reduced. For this area colonization from western Lake Superior to Thunder Bay, Ontario was at about 15 miles per year and from western Lake Superior to Fort Francis, Ontario was at only 7 miles per year.

Expansion beyond the oak-savanna zone was accomplished three times by crossing a vegetational barrier and once by crossing a water barrier (Figs. 1 and 2). The rates of invading the Great Lakes Forest north of Minneapolis and Madison were reduced to one-third and one-fifth, respectively, of the rate demonstrated while colonizing the oak-savanna region. The bluestem prairie, the habitat type originally occupied in western Minnesota, was reinvaded south of Madison, but at only one-quarter the rate of the oak-savanna expansion. The cause of this anomaly is uncertain. The only water barrier encountered when expanding from the oak-savanna region was Lake Michigan. Expansion across the Lake was slowest of all, presumably due to the magnitude of the barrier.

The route into the forested area north of Minneapolis was the most important of the expansions from the oak-savanna region. After initial slowing while crossing the vegetational boundary (Table 1, Minneapolis to western Lake Superior at 8 miles per year), the rate increased more than two-fold during expansion into Thunder Bay. However, the rate remained about the same while expansion to Fort Francis was underway. Presumably this reflects the differences in the availability of habitat along the two routes, the Fort Francis route having fewer areas where the forest has been disturbed.

A rate increase to 20 miles per year across the Upper Peninsula of Michigan was greater than the increase on the Thunder Bay route. The rate of expansion was presumably enhanced by more extensive habitat modification and the presence of natural treeless regions in the counties of Marinette, Schoolcraft, and Luce (Sargent, 1884). These treeless areas are coincident with the earliest centers of colonization (Fig. 1). From Luce County expansion both east and south of the peninsula was seemingly hampered by water barriers and perhaps poor habitat. Expansion eastward across the Soo Canals slowed to 7 miles per year, one-third the previous rate, and east of the Canals increased again to 17 miles per year, a rate similar to that of expansion across the Upper Michigan Peninsula. The Straits of Mackinac may have stopped expansion from the Upper Michigan Peninsula into Lower Michigan entirely, as discussed previously. However, if Cheboygan County was colonized by movement across the Straits of Mackinac, the rate slowed to 8 miles per year, again reflecting the slowing effect of a water barrier.

The expansion rates along the principal routes reflect the influence that the extent of modification and the number and magnitude of barriers encountered have had upon each local extension. The data suggest that the species is not an innate disperser, that is, tending to make relatively sudden, long-distance expansion movements (Howard, 1960). Rather it is suggested individuals expand only until an area suitable for occupation is located. Environmentally induced dispersal (Howard, op. cit.) by Brewer's Blackbird is also supported by the slowing effect unfavorable habitat or barriers have upon expansion (i.e. the Fort Francis route) in contrast to the innately dispersing Starling and House Sparrow which, upon encountering unfavorable habitat in parts of North America, experienced an increase in the rate of expansion (Wing, 1943).

DISCUSSION

The eastward expansion of Brewer's Blackbird appears to be due to the production of suitable habitat in what was previously a forested area. Although much of this newly created habitat was available approximately 40 years prior to colonization, expansion did not occur until there was a population build-up in western Minnesota, the previous eastern limits of the species distribution. Once expansion started, invasion appeared to be accomplished by the environmental displacement of surplus individuals. With each displacement the individual birds appeared to select the most suitable habitat geographically nearest to the previous breeding center. As the production and maintenance of suitable habitat within the Great Lakes region is dependent upon human activity, the expansion soon divided into three major routes as the birds followed the principal roadways and railroads linking centers of human activity.

During expansion, water and changes in vegetational cover acted as the main barriers to movement. Although both types of barriers proved to be only temporary, bodies of water had a greater retarding effect. The apparent cessation of the overall eastward expansion appears to be due to increasing amounts of competitive overlap with the Common Grackle, particularly where this species increases in density. A study of abundance and distribution of these two species supports this view (Erskine, 1971). These aspects, however, are to be discussed in detail in a paper now in preparation.

In the eastward expansion of the breeding range of Brewer's Blackbird we see a rather orderly progression with moderate expansion rates within a particular vegetation type and lower expansion rates where new vegetation types or geographical barriers are encountered. In fact this has led us to describe the expansion as movement from one nesting locality to another when in reality the species is migratory and could be moving to new breeding sites directly from the wintering grounds, which have also changed in recent years (Stepney, 1971). We have no firm evidence one way or the other on this point, but because of the rather orderly progression eastward we documented expansion from one breeding area to the next whether the birds are behaving exactly in this way or not.

This pattern of a gradual, dendritic movement eastward fits in with the fact that Power (1971) did not find differences in phenetic variability in a new eastern population of Brewer's Blackbird. In Power's study there were no tendencies for variances in skeletal and external characters to be larger or smaller in a population near McKerrow, Ontario, established in 1962 (samples were taken in 1968) when compared to a sample from Winnipeg, Manitoba. An increase in variability would have been expected if expansion had resulted from a sudden population flush, while, on the other hand, a decrease ("founder effect") would have been expected had colonization been due to establishment of nesting colonies by just a few individuals that remained reproductively isolated from populations to the west.

THOUGHTS ON RANGE EXPANSIONS

In the following discussion we have attempted to synthesize a generalized framework for the phenomenon of range expansions.

The distributional limits of a species are probably always in a state of flux. Occasionally relatively rapid changes, which we commonly term "range expansions," take place over a few years or decades and provide the opportunity for study. We define a range expansion as the relatively rapid establishment of a regularly recurring breeding or wintering population beyond some prior distributional limit.

The potential for annual expansion may always exist, coincident with post-breeding season increases in population. The common appearance of individuals beyond their normal breeding range suggests that species frequently occur beyond the edge of their ranges without establishing permanent populations (for example, see Parslow, 1967; 1968). A true range expansion appears dependent upon factors which once excluded a species from an area being removed or altered.

Certain features appear to be common to most range expansions, particularly continental expansions (see Mayr, 1965, for a discussion of expansions by island faunas). The initial invasion, except when eruptions result in short-lived extensions (Cornwallis, 1961), generally involves low numbers of individuals, many of which are juveniles (Lack, 1954). It also appears to us that expansions follow one of three basic patterns. The first pattern involves explosive movement, birds radiating outward in several directions, initially colonizing many isolated points. The gaps between colonizing centers, if suitable, are occupied at a later date.

The second pattern of expansion may be described as dendritic. Species demonstrating this pattern expand in a more step-wise manner along routes which are distinct in at least the early stages of expansion. Colonization centers are generally not far apart but individual routes may extend an appreciable distance outward from the previous distribution. Invasions of this nature appear to be undertaken by a few individuals and breeding occurring concurrently with invasion or within approximately three years.

The third pattern of expansion is the least dynamic. It involves a slow movement along a rather continuous population front, breeding almost always occurring during the year of invasion.

Examples of various range expansions by species in North America and Europe which demonstrate these three basic patterns may be found in Beddall

(1963), Kalela (1949), Keve (1963), Lack (1971), Odum and Burleigh (1946), Odum and Johnston (1951), Rice (1956), and Wing (1943).

These expansion patterns are suggested to be related to two broad groups of factors, grouped according to whether they operate primarily independently of the species' activity or not. Extrinsic, or independent, factors affecting expansion would include climate, predators, parasites, habitat quality and availability, plus the extent to which other members of the avifauna may directly or indirectly interfere with the species. Ordinarily such extrinsic factors would work against expansion resulting in a stable distribution. Intrinsic factors, those associated with the species' life history, would consist of factors such as the type of dispersal, population density and age structure, natural rate of increase, physiological tolerance, nature of inter-individual spacing, and the amount of ecological variability demonstrated by the species. These intrinsic factors normally exert outward pressure upon the limits of distribution. That range expansions occur infrequently is due, presumably, to the total effect of the extrinsic factors normally being greater than the intrinsic factors. The relative importance of the various factors within each category presumably differs between species and to a lesser extent between populations.

Although expansions may result from various combinations of the suggested causal factors, certain factors appear to be rather consistently associated with one particular expansion pattern. Explosive patterns are commonly associated with the species suddenly gaining access to large tracts of suitable habitat either by the recent appearance of the new area of habitat or through the surmounting of a previous barrier, by natural or assisted means. High dispersal rate, an intrinsic factor, also favors an explosive expansion. A dendritic expansion is commonly associated with new areas of habitat occurring only in limited areas and is commonly seen in species which are able to take advantage of areas highly modified by human activity. This is particularly applicable to species requiring an "edge effect" (Odum and Burleigh, 1946). The factors commonly associated with slow, wide-front, expansions are climatic shifts (Udvardy, 1969), ecological succession (Johnston and Odum, 1956) and wide-scale community alterations.

SUMMARY

Within the last 60 years Brewer's Blackbird has expanded its breeding range approximately 700 miles into the Great Lakes region. Its distribution has increased through the creation of suitable habitat resulting from forest removal by man.

Three principal routes were followed eastward through the expansion zone, these routes giving rise to several of lesser magnitude. Expansion originated in western central Minnesota. From there one route went northward and west of Lake Superior, a second went

eastward between Lake Superior and Lake Michigan and a third moved through central and southern Wisconsin across the southern end of Lake Michigan.

The rates of expansion along the routes varied according to the extent of habitat modification and the presence of vegetational and aquatic barriers. Five vegetational and three aquatic barriers were encountered. Although aquatic barriers had a greater effect upon the expansion rate, both types of barriers only slowed expansion temporarily. The average expansion rate through the Great Lakes region has been 11 miles per year.

In general the potential for range expansion is suggested to exist annually, the impetus being derived primarily from post-breeding dispersal activity and other species-dependent activity. However, a host of factors which operate independently of a species' biological activity continually work against expansion. Only with the alteration of one or more of the constraining factors is an expansion possible. Range expansions appear to demonstrate three basic patterns; an explosive pattern, a dendritic pattern, or a slow, even-front pattern. Each pattern is commonly associated with one or two specific constraining factors whose alteration has enabled the species to expand. The difference between expansion patterns is also particularly affected by the type of dispersal activity exhibited by the species.

In Brewer's Blackbird, eastward expansion of the breeding range appears as a continually growing dendritic pattern along recently produced tracts of grassland habitat. The species is not characterized by any particular innate characters which promote sudden increases in numbers and range.

ACKNOWLEDGMENTS

This research was supported by a grant from the National Research Council, No. A-4901, to D. M. Power. We would also like to thank Dr. J. C. Barlow, Curator of Ornithology, Royal Ontario Museum, for reviewing the manuscript.

LITERATURE CITED

Allin, A. E. and L. S. Dear. 1947. Brewer's Blackbird breeding in Ontario. Wilson Bull., 59:175–176.

Baillie, J. L. 1961. More new Ontario breeding birds. Ontario Field Biol., 15:1–9.

Beddall, B. G. 1963. Range expansion of the Cardinal and other birds in the northeastern states. Wilson Bull., 75:140–158.

Cornwallis, R. K. 1961. Four invasions of Waxwings during 1956–60. Brit. Birds, 54:1–30.

Coues, E. 1874. Birds of the northwest: a handbook of the ornithology of the region drained by the Missouri River and its tributaries. U.S.G.S. Terr. Misc. Publ. 3.

Devitt, O. E. 1964. An extension in the breeding range of Brewer's Blackbird in Ontario. Canadian Field-Naturalist, 78:42–46.

Devitt, O. E. 1969. First nesting records of Brewer's Blackbird (*Euphagus cyanocephalus*) for King Township and Simcoe County, Ontario. Ontario Field Biol., 23:41–42.

Erskine, A. J. 1971. Some new perspectives on the breeding ecology of Common Grackles. Wilson Bull., 83:352–370.

Fleugel, J. B. 1948. Brewer's Blackbirds found nesting in Kalamazoo County. Jack-Pine Warbler, 26:63–64.

Goodwin, C. E. 1969. Ontario-Western New York Region. Audubon Field Notes, 23:657.

Hatch, P. L. 1892. Notes on the birds of Minnesota. First Rept. State Zoologist. Geol. and Nat. Hist. Surv. of Minn.

Howard, W. E. 1960. Innate and environmental dispersal of individual vertebrates. Amer. Midland Naturalist, 63:152–161.

Johnston, D. W., and E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecology, 37:50–62.

Kalela, O. 1949. Changes in geographic ranges in the avifauna of northern and central Europe in relation to recent changes in climate. Bird-Banding, 20:77–103.

Kenaga, E. E. 1961. Michigan bird survey, summer, 1960. Jack-Pine Warbler, 39:55–59.

Keve, A. 1963. Peculiarities of range expansion of three European bird species. Proc. XIII Internatl. Ornithol. Congr., p. 1124–1127.

Küchler, A. W. 1964. Potential natural vegetation of the conterminous United States. Amer. Geogr. Soc. Spec. Publ. 36, New York.

Kumlien, L., and N. Hollister. 1903. The birds of Wisconsin. Bull. Wisconsin Nat. Hist. Soc., 3:1–143.

Lack, D. 1954. The natural regulation of animal numbers. Clarendon Press, Oxford.

Lack, D. 1971. Ecological isolation in birds. Blackwell Scientific Publ., Oxford.

Mayr, E. 1965. The nature of colonization in birds. *In* the genetics of colonizing species. Baker, H. G., and G. L. Stebbins, Eds. Academic Press, New York.

Mumford, R. E. 1954. Brewer's Blackbird nesting in Indiana. Wilson Bull., 66:61–63.

Odum, E. P., and T. D. Burleigh. 1946. Southward invasion in Georgia. Auk, 63: 388–401.

Odum, E. P., and D. W. Johnston. 1951. The House Wren breeding in Georgia: an analysis of a range extension. Auk, 68:357–366.

Parslow, J. L. F. 1967. Changes in status among breeding birds in Britain and Ireland. Brit. Birds 60:2–47; 97–123; 177–202; 261–285; 396–404; 493–508.

Parslow, J. L. F. 1968. Changes in status among breeding birds in Britain and Ireland. Brit. Birds, 61:49–64; 241–255.

P̄oitter, R. and J. Hirt. 1966. Brewer's Blackbird nest in Oakland County. Jack-Pine Warbler, 44:168.

Power, D. M. 1971. Range expansion of Brewer's Blackbird: phenetics of a new population. Canadian. J. Zool., 49:175–183.

Rice, D. W. 1956. Dynamics of range expansion of Cattle Egrets in Florida. Auk, 73:259–266.

Richards, J. M., and G. K. Peck. 1968. Nesting of Brewer's Blackbird (*Euphagus cyanocephalus*) in Ontario and Durham Counties. Ontario Field Biol., 22:25–27.

Roberts, T. S. 1914. Brewer's Blackbird (*Euphagus cyanocephalus*) breeding in southeastern Minnesota. Auk, 31:538–540.

Roberts, T. S. 1932. The birds of Minnesota: vol. 2. The Univ. of Minnesota Press, Minneapolis.

Sargent, C. S. 1884. Report on the forests of North America (exclusive of Mexico), 10th census of the U.S. 1880. Census Repts. 9.

Schorger, A. W. 1934. Notes on the distribution of some Wisconsin Birds. II. Brewer's Blackbird (*Euphagus carolinus*). Auk, 51:482–486.

Speirs, J. M. 1954. Brewer's Blackbird nesting at Sault Ste. Marie, Ontario. Fed. Ontario Nat. Bull., 65:29.

Stepney, P. H. R. 1971. Range expansion of Brewer's Blackbird and the ecology of a new population in Ontario. Unpubl. M.S. thesis, Univ. Toronto, Toronto, Ontario.

Udvardy, M. D. F. 1969. Dynamic zoogeography with special reference to land animals. Van Nostrand Reinhold Co.

WALKINSHAW, L. H., AND D. A. ZIMMERMAN. 1961. Range expansion of the Brewer Blackbird in eastern North America. Condor, 63:162–177.

WILLIAMS, H. V. 1926. Birds of the Red River Valley of northeastern North Dakota. Wilson Bull., 33:17–33; 91–110.

WILLIAMS, L. 1952. Breeding behavior of the Brewer Blackbird. Condor, 54:3–47.

WING, L. 1943. The spread of the Starling and the English Sparrow. Auk, 60:74–87.

YOUNGWORTH, W. M. 1935. The birds of Fort Sisseton, South Dakota, a sixty year comparison. Wilson Bull., 47:209–235.

ZIMMERMAN, D. A. AND VAN TYNE, J. 1959. A distributional check-list of the birds of Michigan. Occ. Papers Mus. Zool. Univ. Michigan, 68.

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF TORONTO, TORONTO, ONTARIO AND DEPARTMENT OF ORNITHOLOGY, ROYAL ONTARIO MUSEUM, DEPARTMENT OF ZOOLOGY, UNIVERSITY OF TORONTO, TORONTO, ONTARIO (PRESENT ADDRESS: DMP, MUSEUM OF NATURAL HISTORY, 2559 PUESTA DEL SOL ROAD, SANTA BARBARA, CALIFORNIA 93105, 1 NOVEMBER 1972).

NEW LIFE MEMBER

Dr. Oliver H. Hewitt has recently become a Life Member of The Wilson Society. Dr. Hewitt is Professor Emeritus of Wildlife Science at Cornell University, and is presently a Research Associate at the Mote Marine Laboratory, Sarasota, Florida. He holds degrees from McMaster University and Cornell University. His interests in ornithology are in population measurement, marine birds and waterfowl, and he has over 50 publications in ornithology, as well as serving as editor of the monograph on the Wild Turkey published by The Wildlife Society. He is a member of the AOU, The Littoral Society, American Society of Mammalogists, and The Wildlife Society which he served as a Vice-President and as Editor of *The Journal of Wildlife Management.* Dr. Hewitt lists his hobbies as scuba diving, photography, and boating, and tells us that he has three daughters (all married).

GENERAL NOTES

A new race of *Celeus spectabilis* from eastern Brazil.—Some years ago Mr. Charles O'Brien casually showed me a puzzling specimen of *Celeus* in the Kaempfer collection of the American Museum of Natural History. He had come to the conclusion that the bird resembled *C. spectabilis* more than any other species of that genus. I concurred that its features did indeed resemble those of *C. spectabilis*, and I suggested that he make some careful comparisons with a view of publishing a note about it. Unfortunately the press of other work prevented Mr. O'Brien from further study of the specimen, and upon his retirement in 1972 I undertook a comparative investigation of the bird. The specimen in question represents a distinct population of the rather rare *C. spectabilis*, apparently isolated from previously known populations of that species by some 1500 miles. The single specimen representing this isolate differs mensurally and in coloration from previously described races to a degree prompting me to describe it, despite my reluctance to do so on the basis of but a single specimen.

Celeus spectabilis is known from perhaps two dozen specimens, of which I have seen a dozen. Its range extends from eastern Ecuador sporadically (inferred from its rarity) southward just east of the Andes to Cochabamba, Bolivia (Meyer de Schauensee, The species of birds of South America, p. 221, 1966). The specimen in question was collected 16 August 1926 by E. Kaempfer at Uruçui (Urussuhy) on the Parnahyba River of western Piauhy, Brazil, and thus it represents the first Brazilian record for *C. spectabilis.* The new form is named:

Celeus spectabilis obrieni ssp. nov. (Figs. 1, 2)

Holotype: American Museum of Natural History No. 242687, adult female, collected 16 August 1926 by E. Kaempfer at Iruçui, Piauhy, Brazil, altitude 124 m. Original number 3707.

Diagnosis: Differs from *C. s. spectabilis* Sclater and Salvin and *C. s. exsul* Bond and Meyer de Schauensee, in its smaller size (wings, tail, bill, tarsus), and in several color features, especially the greatly reduced barring dorsally, and reduced markings ventrally. Also whiter above and below; small outer rectrices mainly cinnamon (nearly all black in *exsul* and *spectabilis*); and secondaries paler, more buffy (less chestnut), especially on tertial feathers. The bill appears yellower, less white, compared with both older and more recently collected specimens of other races.

Description: Bill horn-colored, blackish at base. Entire head and crest cinnamon rufous, abruptly becoming pale buffy on sides of neck and hindneck, and black on rear of throat. Upperparts pale buffy, whiter anteriorly and darker, more cinnamon buff on rump; markings restricted to a few chordate spots on some upper back feathers. Primaries blackish brown with rufous bases; secondaries cinnamon-chestnut, paling to buff and even whitish buff on tertials, with tips black; tertials with small irregular black spot-bars, mainly on outer vanes. Wing coverts and scapulars with chordate blackish bars and broad buffy white interspaces and tips. Black patch hindthroat to mid-breast. Rest of underparts very pale cinnamon-buff, barely darker than upperparts, becoming pale cinnamon on under-tail coverts; buff coloring extends over flanks and sides around breast patch to sides of neck; ventral markings restricted to a few bars just posterior to breast patch. Tail unbarred, blackish; small outer rectrices cinnamon-buff, black on outer edge of outer vane, and with an irregular black base and small black mark near tip.

Measurements: Holotype as follows: wing (chord) 136 mm; tail 95 mm (worn); exposed culmen 24.3 mm; and tarsus 21.1 mm. Measurements for a male and a female

FIG. 1. Dorsal view of, from left to right, females of *Celeus spectabilis spectabilis* (from Concepcion, Ecuador), *C. s. exsul* (from Balta, Peru), and *C. s. obrieni* (type). Note small size of *obrieni*, and variation in barring.

C. s. spectabilis respectively are: wing 150, 147 mm; tail 92 (worn), 101 mm; culmen —, 28.3 mm; tarsus 23.4, 23.1 mm. Nine *C. s. exsul* range in measurements as follows: wing 138–153 mm; tail 99–108 mm; culmen 28.7 to 31.2 mm; and tarsus 22.1 to 24.2 mm. Thus, the new form is somewhat smaller than *spectabilis* or *exsul*, with a distinctly shorter bill.

Etymology: I take pleasure in naming this form in honor of Charles O'Brien, who contributed substantially to ornithology during his nearly 50 years of service in the Ornithology Department of the American Museum of Natural History.

Comparative Material: A male and female from Ecuador in the American Museum of Natural History represent *C. s. spectabilis.* An immature female from Kusu, Amazonas, Peru, borrowed from the Louisiana State University Museum of Zoology appears to represent an intergrade of *spectabilis-exsul*, and nine specimens from the same collection taken at Balta, Río Curanja, Loreto, Peru, represent *C. s. exsul*, which extends southward to Todos Santos, Cochabamba, Bolivia (Bond and Meyer de Schauensee, Notula Nat. no. 93, p. 4, 1941).

Range: Known only from the type locality, Uruçui, Piauhy, Brazil, along the Parnahyba River. This is dry forested country, and the form should be widespread in the Piauhy-Maranhão region.

The new form clearly represents a race of *C. spectabilis*, rather than some other species of *Celeus*, by virtue of its fully rufous head, its black, shield-like breast patch, its mainly clear rufous secondaries, and its black, unbanded tail. Its bill, although small, matches *spectabilis* in the slight curvature of the culmen, and in the breadth across the nostrils. In its reduced markings *obrieni* bears the same relation to other races of *C. spectabilis* that *C. torquatus torquatus* does to other races of *C. torquatus*, and that *C. flavescens ochraceus* does to other races of *C. flavescens*. I note that *C. spectabilis* in its color

FIG. 2. Ventral view of, from left to right, females of *Celeus spectabilis spectabilis* (from Concepcion, Ecuador), *C. s. exsul* (from Balta, Peru), and *C. s. obrieni* (type). Note small size, especially of bill, of *obrieni*, and variation in markings of underparts.

patterns and bill shape appears somewhat intermediate between *C. torquatus* and the *Celeus elegans* group, which includes *C. flavescens* (Short, Amer. Mus. Novitates no. 2487, 1972).

The eastern Brazilian occurrence of *C. spectabilis* established by the discovery of *C. s. obrieni* is remarkable, for the species is otherwise confined to the lowlands of eastern Ecuador to Bolivia, although it is likely to be found in Brazil adjacent to Loreto, Peru, and Beni, Bolivia. The extent of the range of *C. s. obrieni* is of course unknown. Generally *Celeus* woodpeckers are inconspicuous, and less common species of the genus occurring at a locality are collected usually after extensive collecting has been undertaken. *Celeus spectabilis* may be widely, but uncommonly distributed in eastern Brazil, but it is doubtful that it will prove to occur throughout the region between Beni and Piauhy. Thus, the distribution of *C. spectabilis* rather suggests a past, more widespread range throughout southern and western Amazonia. One of the unusual features of *C. s. obrieni* is its occurrence in rather dry forest, although *C. s. exsul* occurs in seasonally somewhat dry areas of eastern Peru.—LESTER L. SHORT, *American Museum of Natural History, New York, New York 10024, 10 May 1973.*

Relocation of a Wood Duck clutch from a natural cavity to a nest-box.—During April of 1971, we received a report of a Wood Duck (*Aix sponsa*) nest located in an apple tree in Bedford, Massachusetts. The nest was approximately three meters from a house and the entrance to the nest cavity was less than a meter above the ground. The property owners requested that we move the clutch to prevent brood predation by neighborhood house cats. Because the stage of incubation was unknown, it was necessary to check the clutch for hatching signs several times. The hen submitted to handling without flushing. When the eggs began to hatch, the hen and the entire clutch were removed from the cavity and transplanted to a nest box on the Great Meadows National Wildlife Refuge, 1.5 kilometers northwest of the tree nest. The hen was blocked in with the clutch for an hour and a half during which time the entire clutch hatched. The eleven ducklings were web-tagged according to methods described by Grice and Rogers in The Wood Duck in Massachusetts (Massachusetts Division of Fisheries and Game, Westboro, 1965), and the hen and brood blocked in the box. After a wait of twenty minutes, the entrance was opened. The hen remained in the box until we left the site.

Four of the ducklings were recovered during subsequent fall trapping, indicating a successful relocation.—H. W. HEUSMANN AND JAMES E. CARDOZA, *Massachusetts Division of Fisheries and Game, Westboro, Massachusetts 01581, 14 November 1972.*

An upland nest of the Redhead far from water.—On 30 May 1972 while searching for duck nests in a field of smooth bromegrass (*Bromus inermis*) and alfalfa (*Medicago sativa*) near Roscoe, South Dakota, we flushed a female Redhead (*Aythya americana*) from a nest with 12 eggs. The eggs had been incubated about 8 days and were surrounded by abundant white down. Nest material was dead bromegrass, and the base of the nest was elevated about 4 inches above the ground. The nest was located 872 feet from the nearest wetland with water. No wetland basins that could have held water earlier were nearer to the nest. The surrounding region contained a good complex of 30–40 temporary, seasonal and semipermanent wetlands per square mile. Our next visit to the nest on 22 June revealed it had been destroyed, probably by a raccoon (*Procyon lotor*).

Redheads usually nest in emergent vegetation over or near water. Low (Ecol. Monogr., 15:35–69, 1945) studied 160 Redhead nests in Iowa and found that all were over water. Miller and Collins (California Fish and Game, 40:17–37, 1954) found that 59 of 60 Redhead nests were in emergent vegetation, on muskrat houses, or on islands. The other nest was in nettle (*Urtica californica*). However, in Utah, McKnight (Waterfowl production on a spring-fed salt marsh in Utah. Ph.D. Thesis, Utah State University, Logan, 1969) found 50 of 69 Redhead nests on unwatered sites, and in an Alberta study, Keith (Wildlife Monogr. No. 6, 1961) found 50 percent of the Redhead nests on land. Nests in the Utah study were an average of 7 feet from water; three of these were located 20 feet or more from water. Nests in the Alberta study were an average of 5 feet from water. Hammond and Mann (J. Wildl. Mgmt., 20:345–352, 1956) reported Redheads nesting as far as 50 feet from water on islands but seldom more than 1 foot from water on the mainland.—JOHN T. LOKEMOEN AND HAROLD F. DUEBBERT, *U.S. Bureau of Sport Fisheries and Wildlife, Northern Prairie Wildlife Research Center, Jamestown, North Dakota 58401, 26 February 1973.*

Additional records of non-fish prey taken by Ospreys.—Although the food of the Osprey (*Pandion haliaetus*) is considered to be almost entirely live fish (Fisher, 1893; Bent, 1937; Brown, 1964; Brown and Amadon, 1968) there are numerous accounts of non-fish prey being taken by this species: Mammals—ground squirrels, mice, steppe voles (Dement'ev and Gladkov, 1951), rabbit (Long, 1968), marsh rabbit (John C. Ogden, pers. comm.), rice rat (McCoy, 1966), rat (King, 1972), and an unidentified small mammal (Tait, et al., 1972); Birds—crow, Black-crowned Night Heron (Allen, 1892), storm petrel (Brown and Amadon, 1968), sandpiper (Jourdain, 1939), chicken (Clark-Kennedy, 1874;

Harvie-Brown, 1868; May, 1935; Witherby, et al., 1939), Jackdaws, ducks, Herring Gulls (Dement'ev and Gladkov, 1951), duck, Mallard (Kuser, 1929), Coot (Jourdain, 1939), Cardinal (Sindelar and Schulter, 1968), Lapwing (Swaine, 1947), grebe (Bannerman, 1956); Reptiles—turtles (Bent, 1937), snakes (Macoun and Macoun, 1909), water snake (May, 1935), seasnakes (Grossman and Hamlet, 1964), painted turtle (Postupalsky and Kleiman, 1965), alligator (Ogden, pers. comm.); Amphibians—frogs (Dement'ev and Gladkov, 1951; May, 1935; Witherby, et al., 1939); Invertebrates—crustaceans (Brown and Amadon, 1968), sea snails (Grossman and Hamlet, 1964), beetles (Witherby, et al., 1939). Among the reasons suggested to explain Ospreys taking prey other than live fish are scarcity of fish due to a kill (Tait, et al., 1972); murky water or inclement weather (Dement'ev and Gladkov, 1951); lack of fishing skill due to youth (Brown and Amadon, 1968); or the attraction of easily captured crippled birds (Dement'ev and Gladkov, 1951; Brown and Amadon, 1968), captive birds (ducks, Kuser, 1929; chickens, at least five references), or nearby nesting herons (Allen, 1892). Our observations of a solitary pair of Ospreys nesting near the University of South Florida, Tampa, along the Hillsborough River, Hillsborough County, Florida, indicate that non-fish prey may be more regular in the diet under some circumstances than the literature suggests.

During April to June 1972 we saw this pair capturing or carrying non-fish prey on several occasions. Wiley observed an Osprey capture a cotton rat (*Sigmodon hispidus*) in a marshy pasture adjacent to the river-bottom nest area on three separate mornings. The captures were made as the bird flew low over the open marsh in the direction of a regularly hunted pond. Two of the rats were taken by a direct stoop from flapping flight. In the third case the bird hovered about four seconds before dropping onto the prey. All three cotton rats were carried directly to the nest. In the same area Bruce Barbour (pers. comm.) witnessed one of the Ospreys capture a small mammal with a direct stoop on 5 May 1972.

Between a pond on the west edge of the University of South Florida campus where the pair of Ospreys usually hunted for fish during the breeding season and the nest is a partially cleared live oak (*Quercus virginiana*) woodland with a drainage ditch leading to the pond. Cotton rats were often seen during daylight along this ditch. Wiley observed an unidentified rodent (probably *S. hispidus*) being carried to the nest from this area on 7 April and 17 May 1972. On 7 May 1972 Ed. Carlson (pers. comm.) saw an Osprey, probably one of this pair, north of the campus carrying a rat-sized mammal.

On 14 May 1972 Lohrer saw one of the Ospreys being mobbed by several Mockingbirds (*Mimus polyglottos*) as it perched in a live oak area on campus with a bird in its talons. The prey appeared to be a full-grown Mockingbird or possibly a Loggerhead Shrike (*Lanius ludovicianus*).

In addition to the above observations, remains of three adult cotton rats (consisting of heads, tails, and pellets containing fur), a two-week-old Wood Duck (*Aix sponsa*), and an 8-inch Florida red-bellied turtle (*Pseudemys nelsoni*) were collected at the nest by Wiley. Elsewhere in Florida during 1972, Brian Harrington (pers. comm.) observed an Osprey carrying a large rodent over the St. Johns River marshes, Brevard County, on 9 April, and King (ibid) recorded an Osprey capturing a rat in a field near Oviedo, Seminole County, on 5 April.

During the period of our observations there was little or no rain, local waters were not murky, and the pond at which the Ospreys often fished appeared to contain numerous pan fish, bass, and *Tilapia*. It appears, therefore, that poor hunting conditions or fish scarcity did not account for the relative frequency with which this pair preyed on small mammals. During the spring and summer of 1972 cotton rat populations were unusually high in

Central Florida at the Archbold Biological Station (James N. Layne, pers. comm.) and Merritt Island (Llewellyn M. Ehrhart, pers. comm.). Therefore, we think it is possible that some inland nesting Ospreys might exploit an abundant alternative food source, in this case, cotton rats, since they are presented with more opportunities for non-fish prey, particularly mammals and reptiles, as they fly from the nest to scattered bodies of water than are coastal nesting Ospreys.

LITERATURE CITED

Allen, C. S. 1892. Breeding habits of the fish hawk on Plum Island, New York. Auk, 9:313–321.

Bannerman, D. A. 1956. The birds of the British Isles. vol. 5. Oliver and Boyd Ltd., Edinburgh.

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1. U.S. Natl. Mus. Bull., 167.

Brown, L. 1964. Article "Hawk" in Thomson, A. L. (ed.). New Dictionary of Birds. McGraw-Hill, New York.

Brown, L., and D. Amadon. 1968. Eagles, hawks and falcons of the world. McGraw-Hill, New York.

Clark-Kennedy, A. J. 1874. An Osprey carrying off young chickens. Zoologist, 1874: 3996–3997.

Dement'ev, G. P., and N. A. Gladkov, Editors. 1951. Birds of the Soviet Union. Vol. 1. Sovietskaya Nauka, Moscow.

Fisher, A. K. 1893. The hawks and owls of the United States in their relation to agriculture. U.S. Dept. Agr., Div. Ornithol. and Mammal., Bull. 3.

Grossman, M. L., and J. Hamlet. 1964. Birds of prey of the world. Clarkson N. Potter, Inc., New York.

Harvie-Brown, J. A. 1868. Osprey carrying off chickens. Zoologist, 1868:1484.

Jourdain, F. C. R. 1939. Nährt sich der Fischadler ausschliesslich von Fischen? Beitr. Forpfl.-Biol. Vög., 15:27.

King, B. 1972. Osprey taking food other than fish. Brit. Birds, 65:527–528.

Kuser, C. D. 1929. An Osprey feeds on ducks. Bird Lore, 31:260–261.

Long, D. A. C. 1968. Food of Osprey in Kent. Brit. Birds, 61:172.

Macoun, J., and J. M. Macoun. 1909. Catalogue of Canadian birds. Canada Dept. Mines, No. 973.

McCoy, J. 1966. Unusual prey for Osprey. Chat, 30:108–109.

May, J. B. 1935. The hawks of North America. National Audubon Society, New York.

Postupalsky, S., and J. P. Kleiman. 1965. Osprey preys on turtle. Wilson Bull., 77:401–402.

Sindelar, C., and E. Schluter. 1968. Osprey carrying bird. Wilson Bull., 80:103.

Swaine, C. M. 1947. Osprey taking Lapwing in Carnarvonshire. Brit. Birds, 40:252.

Tait, W. W., H. M. Johnson, and W. D. Courser. 1972. Osprey carrying a mammal. Wilson Bull., 84:341.

Witherby, H. F., F. C. R. Jourdain, N. F. Ticehurst, and B. W. Tucker. 1939. The handbook of British Birds. Vol. III Hawks to ducks. H. F. and G. Witherby, Ltd., London.

James W. Wiley (*Present address: 16341 Skymeadow Drive, Placentia California 92670*) and Fred E. Lohrer (*Present address: Archbold Biological Station, Route 2, Box 380, Lake Placid, Florida 33852*), *Department of Biology. University of South Florida, Tampa, Florida 33620, 8 February 1973.*

Spring use of stock ponds by Lesser Prairie Chickens.—Little is known regarding the water requirements of Lesser Prairie Chickens (*Tympanuchus pallidicinctus*). However, man-made stock ponds have seemingly increased the availability of water for this species in otherwise semi-arid prairie regions. Copelin (Oklahoma Wildl. Dept. Tech. Bull. 6, 1963) and Jones (Auk, 81:65–73, 1964) confirmed that Lesser Prairie Chickens utilized earthen stock ponds for drinking water in late summer and fall. Our study reports the influence of stock ponds on Lesser Prairie Chickens during spring in the western edge of the Texas Panhandle.

The study was conducted from March through May, 1972, in Yoakum County, Texas. The area lacks permanent streams and lakes; stock ponds supplied by windmills are the only permanent water sources. The average annual precipitation measures 15.58 inches, most of which comes from May through October (U.S.D.A. records). Four study areas, two consisting of earthen stock ponds, and two with metal stock tanks, were observed. One of the latter sites consisted of three metal tanks, one of which was buried to ground level; the other site was a single tank above ground. One earthen pond site had a gobbling ground within 100 yards. The other sites had leks from 0.5 to 0.7 miles away. Our data include both direct observations and the incidence of prairie chicken tracks at the water's edge as evidence of watering, although waves and winds undoubtedly obliterated some tracks before they could be recorded. When intact, the tracks were subsequently erased to avoid duplication of counts.

The first observation of springtime use of stock ponds was made on 18 March. A lek occupied by 10 males was located 100 yards from an earthen pond. About one hour after sunrise, a single male flew from the lek to the edge of the pond and drank for 5 minutes and then returned to the lek. Within 10 minutes, all of the males went to the pond. Three males flew directly to the pond's edge and began drinking. Seven other males flew to within 50 feet of the water. At least five of these males walked to the water and also began drinking. All 10 males flew away together after about 5 minutes. Similar observations were made in April. On one occasion, a female was observed drinking 1.5 hours before sunset. Males were also observed watering in the evening. Tracks were found around this pond on several occasions during March and April. Four additional inspections in May disclosed no further use of this pond.

Signs of prairie chicken use were also found at the second earthen pond. Although this pond did not show use in March, direct observation of birds watering and fresh tracks indicated use throughout April. This site was also checked four times in May with no use indicated.

Use of a third site, a metal tank buried to ground level, was observed on only one occasion in late April. This tank was dry throughout March but later collected considerable runoff. Tracks indicated that Lesser Prairie Chickens drank from the buried tank as well as the runoff. No use of this tank was found in May.

The fourth site, containing a metal tank above ground level, was not used at any time during this study. The rim of this tank provided little area for perching and the water level was low throughout the spring.

Male prairie chickens usually came to water after the intensity of morning gobbling dropped off. In the evening, the males watered before gobbling. All watering was observed between one and three hours after sunrise and between one and three hours before sunset. When males came to water in the morning, they normally spent about 5 minutes at the edge of the tank. They spaced themselves 2 to 3 yards apart and no displaying or fighting was observed during the morning drinking period. In the evening, the males spent more time at the edge of the tank and, besides drinking, they preened and rested. No gobbling was observed at the tank in the evening, but males occasionally chased one another at the water's edge.

Drought conditions existed throughout all study areas during March and April. The only measurable precipitation received during these two months was 4 inches of snowfall on 31 March. This snowfall resulted in 0.56 inches of precipitation. The 25 year average for March and April is 0.53 and 0.79 inches, respectively. In early May, there were frequent showers and the vegetation began to "green up"; also there was normally a heavy morning dew. The total precipitation for May was 2.56 inches. The 25 year average is 1.92 inches (U.S.D.A. records). The use of stock ponds by Lesser Prairie Chickens coincides with this period of drought and eased when the drought was relieved.

The differences in water utilization at the various study areas likely reflect the availability of water in the habitat from other sources. For example, diet is undoubtedly of importance in this respect as Lesser Prairie Chickens perhaps do not necessarily require abundant free water in the spring. This species commonly inhabited arid regions prior to settlement and the concurrent development of water resources. However, Lee (J. Wildl. Mgmt., 14:475–477, 1950) reported that populations of Lesser Prairie Chicken decreased during drought years. The reasons for such declines are no doubt complex, but it seems quite probable that the advent of man-made stock ponds may now enhance survival of Lesser Prairie Chickens during periods of spring drought.—JOHN A. CRAWFORD AND ERIC G. BOLEN, *Department of Range and Wildlife Management, Texas Tech University, Lubbock, Texas 79409, 2 February 1973.*

Precocious lek behavior in Sharp-tailed Grouse Chicks.—It is known that juvenile Sharp-tailed Grouse (*Pedioecetes phasianellus*) are able to take part in lek displays as early as their first autumn (Lumsden, Ontario Department Lands and Forests, Rep. No. 6, 1965; R. J. Brown, in prep.), but the earlier development of these displays appears not to have been examined in detail for this species. The precocious occurrence of "dance" displays was reported for young grouse by Ernest Thompson Seton (Trail of an artist naturalist, Scribners, N.Y., 1940) but has not, to my knowledge, been reported elsewhere. Observations that I made, on three occasions, of this phenomenon in 3- and 4-day-old hand-reared chicks, are reported here.

On the first occasion, as my hand containing a chick was moving past another, the latter lowered its head, and with neck outstretched, beak slightly open, wings spread and curved downward, tail up, and feet stamping rapidly, followed my hand across the box. This behavior pattern appeared to be identical to the tail-rattling portion of the lek display (Lumsden, loc. cit.; pers. obs.). This behavior was next observed on two occasions during the following day, when the chicks were four days old. On one of these occasions the behavior pattern was elicited in the same manner as described above, on the other occasion, simply by opening the box in which the chicks were being held. Subsequent dissection showed the gonads to be less than 1 mm in diameter, and not hypertrophied. My observations of this phenomenon agree with Seton's completely, except that the chicks I observed were younger, no crowing occurred and only one of the chicks danced at a time.

By presenting relatively intense stimuli to domestic chicks, Andrew (Anim. Behav., 12:542, 1964) produced various calls similar to those produced in chicks injected with testosterone. More recently, Vidal (Behaviour, 39:20, 1971) has described adult-like sexual responses in domestic cocks as young as 4 days of age. The fact that Sharp-tailed Grouse chicks can exhibit a complex behavior pattern similar to that shown by adult males on the dancing-ground indicates that in this species, one can similarly relate such early behavior to adult sexual behavior, and that the mechanism underlying at least some parts of the complex behavior patterns associated with the courtship ritual are present at, or shortly after, hatching.

As well as sexual components, a considerable number of aggressive components are also present in the courtship display of the Sharp-tailed Grouse (Lumsden, loc. cit.). In one-day-old Red Grouse chicks, Watson and Jenkins (Brit. Birds, 57:137, 1964) describe attempts to "sing" on the ground in characteristic adult posture. The young Red Grouse also exhibited several other adult-like aggressive displays. Reactions towards an imprinting or other object may also contain aggressive components in young domestic chicks (Andrew, loc. cit.; Evans, Anim. Behav., 16:24, 1968). These results raise the possibility that tail-rattling in Sharp-tailed Grouse chicks may also contain elements of aggressive behavior. This hypothesis seems to agree with what has been observed, and perhaps offers a superior alternative to the explanation that these responses represent precocious sexual behavior. Possibly the ultimate interpretation of phenomena such as precocious tail-rattling in Sharp-tailed Grouse involves elements of both hypotheses reviewed here. In either case, it seems likely that the complex and highly competitive mating system of the Sharp-tailed Grouse may have favored the very early development of many of the motor components of the displays associated with reproduction.

This study was conducted as part of a M.Sc. thesis at the Department of Zoology, University of Manitoba. Financial support was received primarily from the Manitoba Department of Mines, Resources, and Environmental Management, the National Research Council, and the Canadian Wildlife Service. Thanks are extended to R. M. Evans for assistance in preparation of this report.—Robert J. Brown, *Box 9, St. Norbert, Manitoba, Canada, 27 April 1973.*

Energetics of a Spotted Sandpiper feeding on brine fly larvae (*Paracoenia*; Diptera; Ephydridae) in a thermal spring community.—The Spotted Sandpiper (*Actitis macularia*) a very adaptable shore bird, is found in both marine and fresh water habitats (Bent, U.S. Natl. Mus. Bull., 146:78–97, 1929). We have observed a Spotted Sandpiper feeding in a habitat which we believe has not been previously reported. Several meadows throughout Yellowstone National Park have flowing hot springs ranging in temperature from 35 to 70 C. Many of these hot spring effluents support blue-green algal mats with large populations of grazing flies. Herbivorous flies complete their entire life cycles in the mat matrix and both larval and adult stages feed upon the blue-green algae. Such thermal communities contain a rich animal food source which we found was exploited by Spotted Sandpipers.

The predominant substrate upon which hot spring algal mats develop is silica; however virtually identical blue-green algal mats grow on artificial substrates such as wooden platforms (Wiegert and Fraleigh, Limnol. Oceanogr., 17:215–228, 1972). The particular sandpiper which we studied fed upon insects found in mat systems throughout the meadow. Most of its feeding, however, occurred upon mats on elevated wooden platforms one meter wide and 24 meters long. Effluent from a hot spring (56 C, pH 6.0) was piped to each of two platforms at 30 liters per minute. The two large algal mats were similar to the several surrounding blue-green algal mats found in the meadow except that the formers' boundaries were clearly defined and effluent inputs and outputs from the boards could be accurately determined. Both algal mats supported a very large population of grazing flies, most of them *Paracoenia turbida* Cresson, Ephydridae. Each summer since 1969 one Spotted Sandpiper has been feeding almost daily from the platforms. This note

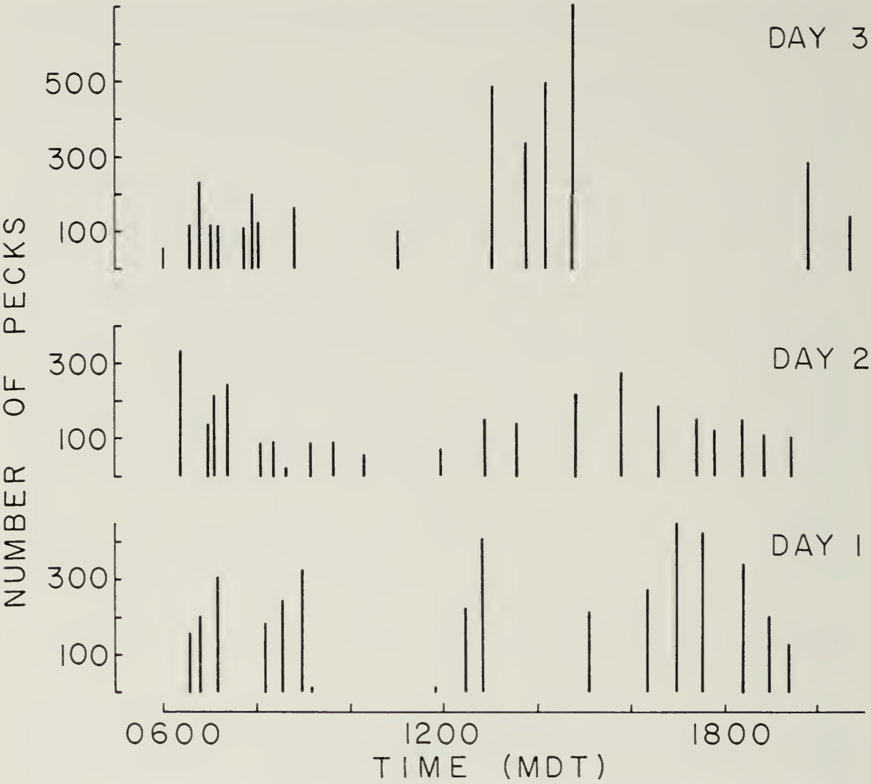


Fig. 1. Diurnal feeding behavior of Spotted Sandpiper. Vertical bars represent onset and number of pecks of each feeding bout.

reports observations (made between 8 July and 20 July 1971) of predation on brine flies by the sandpiper. No other adult sandpiper was seen in the study area.

A diurnal feeding pattern was established by recording the following data each time the bird flew to the algal mat to commence a feeding bout: time of day, number of pecks and duration of feeding bout. When off the algal mats, the bird was observed with a 20-power spotting scope. Feeding bouts were recorded for three days from dawn to dusk. On only two occasions was the bird observed to feed off of the wooden platforms. The bird averaged 18 feeding bouts per day; a greater proportion occurring near the beginning and end of each day (see Fig. 1). The mean number of pecks/bout was 203 ± 37 ($\bar{x} \pm 2$ SE; $n = 54$). The total number of pecks recorded for the three days were 4135, 3067, and 3771 giving a mean number of 3638 pecks/day.

We could not determine from field observation what the sandpiper was eating due to the rapid movements of head and bill. We did note two distinct types of feeding behavior. One, the common type, was a probing, rapid downward peck at the mat while the second (rare) was a very deliberate, slow approach (toward a potential prey?) followed by a quickened pace, forward thrust of the neck and horizontal movement of the bill. Both types of feeding behavior were noted previously in two different species of sandpiper (Drury, Auk, 78:176–219, 1961). The rapid peck was characteristic of the White-rumped Sandpiper (*Calidris fuscicollis*) while the deliberate slower feeding occurred in Baird's Sandpiper (*Calidris bairdii*). Stomach content analyses of the former revealed mostly larvae while Baird's Sandpiper preyed upon adult and flying insects. The present observation of both types of feeding behavior in the same species suggests that the Spotted Sandpiper feeds on both larvae and adult flies.

Direct evidence of prey consumed by the Spotted Sandpiper was obtained from study of feces. A fresh fecal sample was partially dissolved in xylene and insect fragments were identified. The two rounded chitinous caps on the tracheal tubes of *Paracoenia* larvae passed through the bird's digestive tract intact. The number of caps found in the feces (divided by two) gave the number of larvae consumed. The feces contained remains of: 98 larvae, 1 pupa and 2 adults of *P. turbida* plus remains of 1 spider and 1 beetle.

We computed the daily respiratory energy loss of a Spotted Sandpiper using a live weight of 57 g (2 oz.—Palmer, Fieldbook of Natural History, McGraw Hill, X:664, 1949) and the formula relating non-passerine metabolic requirements to body weight: $\text{kcal} \times \text{bird}^{-1} \times \text{day}^{-1} = 78.5 \times \text{body wt (kg)}^{.723}$ (Zar, Condor, 70:278, 1968). These calculations gave a conservative estimated maintenance energy cost of $9.9 \text{ kcal} \times \text{bird}^{-1} \times \text{day}^{-1}$. This is a minimum estimate because a free-ranging bird is not at the thermoneutral temperature and expends some energy in diel activity. However, the Spotted Sandpiper flew seldom, usually from the platforms to a perch some 50 meters distant. Its only sustained activities were walking on the platforms during the feeding bouts and an occasional flight about the study area. Therefore the actual respiratory energy loss could be close to the minimum.

An estimate of maximum ingestion was obtained by assuming every peck resulted in the capture of a prey item. Under this assumption 3529 larvae, 36 pupae and 73 adults of *P. turbida* would be consumed per bird per day (percentages based on proportions in the fecal sample). From the caloric equivalents of these stages (Wiegert, unpubl.) we computed total daily ingestion from the boards as 13 kcal, or corrected for the 10 percent of the daily food obtained off of the boards, $14.3 \text{ kcal} \times \text{bird}^{-1} \times \text{day}^{-1}$. This should be enough to sustain the sandpiper, because the assimilation efficiency for the *P.* larvae is probably rather high because of their lack of a heavily chitinized exoskeleton. Although the larvae are abundant and relatively immobile, the real efficiency of capture is undoubtedly less than 100%. Therefore the sandpiper's estimated total daily ingestion represents a maximum intake, but for reasons stated above the figure should be close to actual caloric consumption.

Total standing crop of the fly population on the platforms averages $11 \text{ kcal} \times \text{m}^{-2}$. There are 58 m^2 in the two board ecosystems. Thus the sandpiper removes a maximum of $0.22 \text{ kcal} \times \text{m}^{-2}$ (13/58) or only 2 percent of the total standing crop per day. Under optimum conditions of temperature the brine fly (*P. turbida*) can produce as much as 25 percent of its standing crop per day (Wiegert, unpubl.), so this level of predation by the Spotted Sandpiper cannot by itself be a controlling factor on the fly population.

Spotted Sandpipers appear to remain in small areas when food is abundant (approximately 3 acres per sandpiper) and usually are sedentary when not feeding. They can tolerate the presence of man within 15 to 20 feet, facilitating direct observation of feeding and they eliminate fecal samples which can be analyzed with relative ease. Accurate, diurnal feeding behavior can be monitored employing minimal equipment: a spotting scope, a stopwatch and a counter. Although this study is preliminary it suggests that the Spotted Sandpiper is an ideal species for studying the energy budget of a wild avian population.

This study was supported by N.S.F. Grant GB-21255 to R. G. Wiegert. We thank Nancy Kuenzel for assistance in the field and laboratory.—WAYNE J. KUENZEL, *Department of Poultry Science, Cornell University, Ithaca, New York 14850,* AND RICHARD G. WIEGERT, *Department of Zoology, University of Georgia, Athens, Georgia 30601, 15 March 1973.*

Electrocution of birds by an electric fence.—In passing the farm of W. J. Whitehead a short distance west of Scotland Neck, North Carolina, on 20 January 1973, I saw a dead Screech Owl (*Otus asio*) hanging, head downward, from the top of a post of an electric fence (Fig. 1). The bird's left tarsus was between the wire and the post, thus grounding the fence wire on the steel post. The tarsus was burned so the foot fell free from it when I removed the dead bird from the fence. Mr. Whitehead advised me that he finds as many as 25 birds killed by his fence at one time when Brown-headed Cowbirds (*Molo-*

FIG. 1. Dead Screech Owl on electric fence.

thrus ater) gather and perch on the wire. He estimated that the fence kills as many as 200 birds of various species in a year.

The wire of the fence was attached to an electric fencer lacking a "chopper," a device providing alternate breaks in the current going to the fence wire. Also, the fencer was not equipped to reduce the voltage delivered to the fence. Thus, being attached to a 110-volt line, 110 volts was delivered to the fence when it was grounded. Mr. Whitehead purchased his fencer about ten years ago, but fencers of the same type are currently (5 February 1973) being sold in the hardware stores at Scotland Neck.

Because of the quick coagulation of muscle protein by electrocution, birds often remain attached to the wire after being electrocuted.—PAUL A. STEWART, *203 Mooreland Drive, Oxford, North Carolina 27565, 20 February 1973.*

Ocular impalement of a Great Horned Owl.—There are a number of features in the structure and function of the owl eye which aid survival. The large tubular-shaped eye of many owls is capable of discerning objects in light which is one-tenth to one-hundredth of the intensity minimal for man (Dice, Amer. Naturalist, 79:385–416, 1945). Maneuverability during nocturnal foraging is further enhanced by the frontally directed position of the eyes. Considering the visual adaptation of the strigiform for its nocturnal predatory behavior, it thus seems surprising that impalement would occur and especially ironic for an incident to involve the eye itself.

At noon, on 24 July 1972, accompanied by Gerald McCarthy, I found a mature Great Horned Owl (*Bubo virginianus*) firmly impaled on the top strand of a double barbed wire arrangement. It was located in a forested area, predominately *Quercus* and *Carya*, approximately 3 miles southwest of St. Elizabeth, Miller Co., Missouri.

The bird was found alive and facing away from the highway, about 10 feet away. Each of the four barbs was enveloped in membranes of the right eye. It was initially hoped that the eye itself was intact. A portion was cut out of the wire strand, freeing the bird but leaving the wire embedded. Upon its removal by the local veterinarian, it was discovered that the eye was destroyed. The bird was found dead two mornings later, prior to its intended release.

Since there appeared to be no other damage and since the bird was alive when found, the chance of it being purposely hung out by someone was eliminated.

It appears that the bird was in flight, towards the highway, when it struck a barb. The momentum of flight no doubt allowed it to swing up and over the fence, impaling it on all the possible barbs. Struggling had occurred and the situation was apparently intensified. The cause of such an accident can only be conjected: poor health, harassment, frenzied predatory behavior or perhaps the limited accommodation present in owl vision. It might be significant that the first substantial rainfall of an otherwise dry summer had occurred during the night.

Cornwell and Hochbaum (Wilson Bull., 83:305–306, 1971) discussed collisions with wires as a definite source of mortality in ducks. Investigation of published reports of owl mortality produced no information on the importance of wire fencing. Fleay (*in* Night watchman of brush and plain: p. 73, 1968) mentioned an Australian Barking Owl (*Ninox connivens*) that had broken its wing following the spiking of its shoulder on a barbed wire fence. No other records of ocular impalement were located.

Although it is likely that this was a freak accident, I am still curious about past unreported occurrences of owl impalements or collisions with wires. In another group of flying animals, the bats, which are also well adapted for nocturnal activities, there is a peculiar species pattern of incidence. There are numerous reports of the hoary bat (*Lasiurus cinereus*) and especially the red bat (*Lasiurus borealis*) being impaled on barbs of usually the top strand of a wire fence. Other than the lasiurine bats, an Indiana bat (*Myotis sodalis*) and a little brown bat (*M. lucifugus*) were reported impaled on barbs of the top strand of wire also. Impalement usually involved the piercing of the wing or interfemoral membranes.

This seems to question the effective detection of these structures by the echolocation system of the lasiurine bats as compared with other bats. Similarly, with future reporting of these occurrences in owls, incidences of species and number should be noted. Possibly, there are also varying degrees of efficiency within different owl species for avoiding wire structures that man utilizes in the environment.

I thank Drs. Millicent Ficken and Charles Weise for reviewing this note.—TIMOTHY MCCARTHY, *Vertebrate Division, Milwaukee Public Museum, Milwaukee, Wisconsin 53233, 23 March 1973.*

Great Horned Owl impaled on barbed wire.—During the summer of 1972 I installed a barbed-wire fence along the south boundary of our 12½ acre property. On my regular morning walk on 20 February 1973 I found a Great Horned Owl (*Bubo virginianus*) impaled by its left wing on the top wire. Close examination indicated that it had caught a barb in the skin and feathers at the base of its left wing. This, apparently, caused the bird to flip over the top wire and become firmly hanged by the four barbs projecting from that point in the wire. The wing bone was broken and the wing was severed, except for a bit of skin. The bird was still alive.

Cornwell and Hochbaum (Wilson Bull., 83:305–306, 1971) reported a large number of birds, particularly waterfowl, striking telephone and power lines, fences, and buildings. Barbed wire fences in the vicinity of marshes seem to be a particular hazard to water-loving birds.

This Horned Owl was a full grown male (testes 10 mm × 14 mm) seemingly in good health.—RALPH M. EDEBURN, *Box 42, R. D. 1, Mercer, Pennsylvania 16137, 23 March 1973.*

An observation of predation by native fire ants on nestling Barn Swallows.—During the period 26 May–4 August 1972 we studied nesting success of Barn Swallows (*Hirundo rustica*) inhabiting culverts in Brazos County, Texas. On 14 July we observed a column of about 5,000 native fire ants (*Solenopsis geminata*) attacking a Barn Swallow nest containing three newly-hatched nestlings and one unpipped egg. The nest was located 1.70 m above the ground and 4.35 m equidistant from the culvert openings.

By stinging and biting away small pieces of tissue, the ants killed the nestlings and carried away their bodies, except for the heads which were left uneaten in the nest. The egg was not attacked. The adult swallows deserted the nest, and the egg, which contained a fully developed, viable embryo, failed to hatch.

We observed more than 25 other swallow nests during this period; however, we saw no further predation by fire ants. The observed attack by ants occurred shortly after the water beneath the nest dried up, whereas the other nests were located over water throughout the study. Apparently, absence of water permitted attack by the fire ants.

Recently, there has been considerable discussion concerning the impact of imported fire ant predation on nestling birds (see Coon and Fleet, Environment, 12(10):28–38, 1971). There are no published records of predation by native fire ants on avian species to date. Because our observation suggests that nestling birds have long been preyed upon by native fire ants, care must be exercised in evaluating fire ant predation reports so that overemphasis on the effects of predation by imported fire ants does not result from confusion with predation by native fire ants.

We thank Drs. D. R. Clark and W. J. Clark for their critical comments on the manuscript. This is contribution No. TA 10383 of the Texas Agricultural Experiment Station.—JAMES C. KROLL, *School of Forestry, Stephen F. Austin State University, Nacogdoches, Texas 75961,* KEITH A. ARNOLD, *Department of Wildlife and Fisheries Science, Texas A&M University, College Station, 77843,* AND ROBERT F. GOTIE, *New York State Department of Environmental Conservation, Watertown, New York 13601, 12 March 1973.*

The Rock Wren in Missouri.—Neither Widmann (A preliminary catalog of the birds of Missouri, Trans. Acad. Sci. St. Louis, 17:1–288, 1907) nor Harris (Birds of the Kansas City Region, Trans. Acad. Sci. St. Louis, 23:213-371, 1919) mention the Rock Wren (*Salpinctes obsoletus*) for Missouri, but Bennitt (Checklist of the birds of Missouri, Univ. Missouri Studies, 7:48, 1932) lists the species as hypothetical. The first record for the state was on 4 November 1950 when the senior author studied for two hours a Rock Wren at Lake of the Ozarks, 10 miles south of Gravois Mills, Morgan County, Missouri. The bird was observed for several weeks around a board pile and a rock foundation of an incompletely constructed cabin in an abandoned field. At that date Easterla (12 years old) did not know the identity of the bird, but was aware that it was new and definitely not in Peterson's Eastern Field Guide. The senior author still has in his notebook a carefully drawn Rock Wren (drawn at that time) with an exact description of the species. It was not until later that the true identity of this bird was learned after a Peterson's Western Field Guide was consulted. Several years later it was learned that a Mrs. Earl M. Johnson, Sedalia, Missouri, had observed and heard calling and/or singing during a two week period a Rock Wren (presumably the same bird) at this same location during November 1950.

On 16 July 1964 John and Julie Hamilton observed for about seven minutes a singing adult Rock Wren near the Missouri River bluffs of northwest St. Joseph, Buchanan County, Missouri. Whether this bird was breeding is unknown, as it could not be found on later dates (pers. comm.). On 23 January 1966, Nathan Fay, Dr. and Mrs. James Key, and Dr. and Mrs. Allen studied a Rock Wren for several hours on a rocky barren slope near the shore of Bull Shoals Lake, near Cedarcreek, Taney County, Missouri (pers. comm.).

During a study of tower fatalities, Ball found a dead Rock Wren on 5 October 1972 at the base of a Radio Tower on the N side of the Northwest Missouri State University campus, Maryville, Nodaway County, Missouri. The bird was fresh and had been killed the previous night. This is the first specimen (juvenile male; testes less than 1 mm; 17.2 gms; little fat) for Missouri. It was preserved as a museum skin (DAE 2691) and is at Northwest Missouri State University.

The Rock Wren should occur sparingly in Missouri during migration, as it is a common transient and summer resident in western Nebraska (rare migrant in the eastern part) and western Kansas (Rapp, Rapp, Baumgarten and Moser, Revised check-list of Nebraska birds, Nebraska Ornithol. Union, No. 5, p. 21, 1958; Johnston, Directory to the bird-life of Kansas, Mus. Nat. Hist., Univ. Kansas, Misc. Publ. 23, p. 43, 1960) and has been recorded once (spring) in Illinois (Smith and Parmalee, A distributional check list of the birds of Illinois, Illinois State Mus., Series 4, p. 44, 1955), twice (spring) in Arkansas

(James and James, The seasonal occurrences of Arkansas birds, Arkansas Acad. Sci. Proc., 18:26, 1964), and several times (summer) in Iowa (Brown, An annotated list of the birds of Iowa, Iowa St. J. Sci., 45:434, 1971).—David A. Easterla, *Department of Biology, Northwest Missouri State University, Maryville, Missouri 64468* and Ronald E. Ball, *804 South Buchanan, Maryville, Missouri 64468, 8 February 1973.*

Starlings stealing worms from Robins.—It is well-known that Starlings (*Sturnus vulgaris*) are adept at stealing worms from Robins (*Turdus migratorius*) and other thrushes Van Tyne, Wilson Bull., 58:185, 1946; Snow, A Study of Blackbirds, 1958). However previous reports have said little about the rate of success enjoyed by Starlings. Here we discuss the results of watching a mixed foraging group of Robins (up to 20) and Starlings (up to 8) attracted to a watered lawn (Rainier Vista) on the University of Washington campus in Seattle on 17, 23, 24, 25, 31 May, 1, 2, and 16 June 1972.

Table 1 shows the species observed attempting to take prey from Robins and the degree to which they were successful. As Van Tyne also noted, Starlings that prey-steal do not usually stand about waiting for a robin to pull a worm from the ground. Instead they walk quickly along probing the lawn frequently in their normal foraging pattern. In the midst of this activity they will suddenly dash over to a robin, sometimes running, sometimes flying. The distance between the two prior to an attempted steal ranged from 15 cm to an estimated 18 m (mean = 3.5 m, N = 32 recorded cases). In one instance a Starling hunting on one side of Rainier Vista suddenly flew across the entire width of the lawn (18 m) to reach a Robin that had just extracted a worm.

In addition, on five occasions Starlings were watched as they cruised in the air over a group of foraging Robins and then suddenly dropped down beside a Robin with a freshly caught worm which they stole.

Most, but not all, attempts to steal a prey occurred when the Robin was in the act of capturing or had just removed a worm (79 of 99 cases in which this information was

Table 1

Birds Stealing Worms from Robins

Species	Attempts	Known Steals		Worm Lost[a]	Outcome Unknown
Starling					
Adult	109	37	(36%)	8 (7%)	6 (5%)
Fledgling	6	4			
Crow[b]	3	3			
Song Sparrow	1[c]	0			
Robin[d]	23	8	(35%)	1 (4%)	6 (26%)

[a] Both the original owner and the attacker lost the worm when it escaped during the attempted steal.

[b] Each time a crow flew at least 15 m from a lamp post or tree at the edge of the Rainier Vista to a Robin with a worm on the lawn, displacing the Robin and taking the worm.

[c] The Song Sparrow (*Melospiza melodia*) attempted to take an adult lepidopteran from a Robin.

[d] Only cases where an adult bird attempted to rob another adult are included because of the difficulty in determining whether juveniles were robbing or being fed by a parent.

TABLE 2
STEALING BY STARLINGS AS A FUNCTION OF THE STAGE OF WORM CAPTURE BY ROBINS

	Attempts	Known Steals	Worm Lost[a]	Not Successful
Robin pulling at worm	16	9 (56%)	5 (31%)	2 (13%)
Robin holding or preparing prey	23	9 (39%)	1 (4%)	13 (57%)

[a] Both the Robin and the Starling lost the worm when it escaped during the attempted steal.
$X^2 = 19.83$, d.f. $= 2$, $P < 0.01$

recorded). Twenty attempts, however, came as the Robin probed the earth or cocked its head prior to striking. None of these proved successful for the Starling; they may sometimes pay off because Starlings are capable of removing a worm by their own efforts and they often carefully examined the area the robin had been inspecting or probing. More importantly perhaps, by starting their rush early they may sometimes arrive just as the Robin is pulling a worm from the ground. As Table 2 shows it is at this moment that the Robin is most likely to drop its catch.

Robins appeared to take no action to avoid searching near Starlings although they would sometimes move ahead if a foraging Starling was moving directly toward them. Frequently the two species hunted within 3 m of one another. Moreover, Robins were surprisingly unresisting when threatened with the loss of a worm. The Robin simply dropped its catch and backed off running or walking away on 47 of 72 complete records of a Starling-Robin interaction (65 percent). On 23 occasions the Robin flew off carrying the worm often with a Starling in pursuit. The outcome of these chases was usually impossible to determine but several times the Robin quickly dropped its catch before disappearing from sight. Only twice (3 percent) did the attacked bird defend its prey by fighting. In contrast Robins vigorously contested with sharp vocalizations and leaps into the air six of 23 attempts to steal by conspecifics (26 percent). In addition, we have three records of Robins pulling large worms from the soil and then charging nearby Robins, aggressively driving them from the area. Such behavior appears to anticipate an attempt at stealing by fellow Robins.

Conceivably the generally passive response of Robins to Starling thievery may be adaptive. Even if they could win an interspecific dispute with this highly aggressive species, it might not be worth it because of the time and energy costs involved. Particularly in areas of high worm density (such as Rainier Vista) the Robin may be a more efficient forager if it simply ignores the Starlings present and cedes a worm or two to a thief rather than trying to keep a large distance between itself and all Starlings, fighting one when attacked, or flying off and being pursued long distances.

The presence of Starlings means that Robins may have to pay a certain price in possible thefts when they choose to search for worms. This may be a characteristic disadvantage associated with the search for and capture of relatively large prey, particularly if the searcher has interspecific competitors for that resource. Large prey may be worth stealing because they are so valuable energetically. Moreover, the fact that they usually demand a good deal of handling time to subdue, prepare, and consume means that large prey are vulnerable to a robber whereas a small prey may be grabbed and swallowed so quickly that there is no time to steal it. This potential cost of hunting for large prey should be taken into account in developing models of foraging for alternate food items (e.g. Schoener, Ann. Rev. Ecol. Syst., 2:369-404, 1971).

These observations were made while the second author was supported by NSF grants GB-28714X, GB-28714X1, and GB-35269.—Joan Bird, *4300 4th Ave. NE, Seattle, Washington 98105,* John Alcock, *Department of Zoology, Arizona State University, Tempe Arizona 85281,* and W. James Erckmann, *Department of Zoology, University of Washington, Seattle, Washington 98195, 12 January 1973.*

Nest records of Cerulean Warbler in Delaware.—The Cerulean Warbler (*Dendroica cerulea*), first described by Wilson from specimens taken along the Schuylkill River in eastern Pennsylvania, remains a rare, but locally fairly common, species in the Atlantic Piedmont region. A nest found near the White Clay Creek in northern Delaware on 13 May 1972 represents the first known state record of a Cerulean Warbler nest; however Rhodes (Auk, 22:194–205, 1905) reported Cerulean Warblers in June 1903 along the Choptank River in Maryland's Eastern Shore and at Seaford, Delaware, approximately 70 miles below the fall-line in the Atlantic Coastal Plain. Because of the Cerulean Warbler's sporadic occurrence and the expressed notion that the breeding status and range might be changing (Bull, Birds of the New York area, Harper and Row, New York, 1964; Fables, Annotated list of New Jersey birds, Urner Ornithol. Club, 1955) the location of some easternmost breeding populations is noteworthy. In northern New Jersey breeding birds have been reported at ten locations along streams in the Appalachian Highlands and the Piedmont Plateau, but not below the fall-line (Stone, Bird studies at Old Cape May, Delaware Valley Ornithol. Club, 1937; Bull, op. cit.; Fables, op. cit.). The White Clay Creek breeding record in northern Delaware is in the lower Piedmont, while in nearby Maryland a breeding colony was reported in the lower Susquehanna River Valley (Stewart and Robbins, Birds of Maryland and D. C., U.S. Fish and Wildlife Serv. N.A. Fauna 62, 1958), and another breeding population has been observed in an arm of the Oak-Chestnut Piedmont section extending below the fall-line: Elk Neck in the upper Chesapeake Bay. A breeding population at Piscataway in southern Maryland (A.O.U. Check-list of North American birds, 1957) is also located slightly below the fall-line; however the Eastern Shore record of Rhodes is the real anomaly. Habitat descriptions of that Eastern Shore area do not fit the streamside mature open forest type of habitat reportedly preferred by Cerulean Warblers (Bent, U.S. Natl. Mus. Bull., 203, 1953). Several other breeding species generally associated with cooler climates occur regularly in the Eastern Shore section, (Stewart and Robbins, op. cit.), but those species, including Tree Swallow (*Iridoprocne bicolor*) and Swamp Sparrow (*Melospiza georgiana*), are Coastal Plain birds.

The rich transitional habitat in the White Clay Creek Valley in northern Delaware numbers such southern species as the Yellow-throated Warbler (*Dendroica dominica*) and Blue Grosbeak (*Guiraca caerulea*) along with such northern species as Least Flycatcher (*Empidonax minimus*) and Veery (*Catharus fuscescens*) among the 90 species listed as breeding along a 6 mile stretch of the creek floodplain (Dyer, Delmarva Ornithologist, 8:24–30, 1973). Two nests, 0.7 miles apart, found near the White Clay Creek in 1972 culminated yearly searches since discovery of Cerulean Warblers there by Frederick Lesser in late May of 1963. The first nest, 40 feet high in a small crotch in a white ash (*Fraxinus americana*) was approximately 200 yards away from where the birds were normally seen and heard in tall sycamores overhanging the stream. The nest habitat, an old field overgrown with sumac, blackberry and black gum, and the location, away from the stream, appear atypical. The second nest, while close to the stream (approximately 20 yards away), varied from most nest site descriptions in being only 17 feet high (equal to the lowest of 12 nests listed in Bent) and overhanging a busy road and parking area.

Neither white ash nor osage (*Maclura pomifera*), the trees supporting the two Cerulean Warbler nests, are listed among the several trees in the Cerulean Warbler breeding habitats in Bent (op. cit.). Four species of vireos and three species of *Empidonax* flycatchers evidently nested within 170 yards of the second Cerulean Warbler nest. Within that 170 yard radius, nests of Acadian Flycatcher (*Empidonax virescens*), Willow Flycatcher (*E. traillii*), Yellow-throated Vireo (*Vireo flavifrons*) Red-eyed Vireo (*V. olivaceus*), and Warbling Vireo (*V. gilvus*) were found, while Least Flycatcher and White-eyed Vireo (*Vireo griseus*) were located by territories. The Least Flycatchers were part of the only known breeding population in Delaware, and the Willow Flycatcher nest is the first one of that species recorded in the state. The nest was destroyed by high water from Hurricane Agnes on 19 June 1972, a few days after it was completed.

A female Cerulean Warbler's excited chatter over a cowbird investigating the nest site on 13 May led to my discovery of the first nest. On 12 June fledging started when, following a feeding, one of the two nestlings hopped to a branch a foot away. A territorial dispute drew my attention to the second nest site on 14 July, and on the following day the nest was spotted by Charles Conway (Scott and Cutler, Amer. Birds, 26:844, 1972) when the female fed three young. The nestlings fledged on 19 or 20 July.

My thanks to Chandler S. Robbins, Migratory Bird Research Laboratory, BSFW, for data and comments.—John T. Linehan, *Bureau of Sport Fisheries and Wildlife, PWRC Fld. Sta., Agricultural Hall, University of Delaware, Newark, Delaware 19711, 4 January 1973.*

House Sparrows feeding young at night.—Night foraging by House Sparrows (*Passer domesticus*) has been reported by Broun (Auk, 88:924–925, 1971) and Brooke (Auk, 90:206, 1973). Both point to the unusual nature of this activity. Broun believed the birds he saw were feeding young but did not actually observe this. On several occasions in May 1966, I observed two pairs of House Sparrows feeding their young at times varying from 22:00 to 24:30. Their nests were in recessed light fixtures under the overhanging roof of a building on the campus of Tarkio College, Tarkio, Missouri. The adults captured insects attracted to the lights and were not seen to leave the lighted area.—Carl D. Marti, *Department of Zoology, Weber State College, Ogden, Utah 84403, 12 March 1973.*

Red-winged Blackbird feeding on horseshoe crab eggs.—On 15 July 1972, I observed a Red-winged Blackbird (*Agelaius phoeniceus*) digging in a sand beach about one meter from the water's edge of the Choptank River near Oxford, Talbot County, Maryland. When I arrived, the bird was scraping and kicking simultaneously with both feet and had created a depression about 8 cm wide and 5 cm deep. After each kick the blackbird used its bill to remove some minute food matter from the scrape. I flushed the bird and searched the depression to find a cache of horseshoe crab (*Limulus polyphemus*) eggs buried at the bottom of the hole. When viewed with a microscope the eggs proved to be in an advanced stage of development, but not hatching. It is not known exactly how the blackbird discovered the eggs since the sand beach was unmarred by tidal action, animal or human activity. Presumably the bird saw neither the eggs being buried or fertilized, the young invertebrates escaping from the sand nor eggs exposed by sand disruption.—Jan G. Reese, *St. Michaels, Maryland 21663, 26 January 1973.*

Notes on the Hoary Redpoll on its central Canadian Arctic breeding grounds.— G. Ron Austing and I made the following observations of the Hoary Redpoll (*Acanthis hornemanni*) during the period of 30 June to 15 July 1972 while photographing birds around Bathurst Inlet Lodge at the mouth of the Burnside River on Bathurst Inlet (66° 50′ N., 108° 02′ W.), Northwest Territories, Canada. The site is approximately 40 miles north of the Arctic Circle. Both redpoll species are reported in the lodge log as occurring at the camp, but the Hoary Redpoll was the only one of these species we identified in the field with certainty.

Redpolls were often seen feeding in small groups on willow catkins. On 4 July I observed one male, with face and underparts stained yellow with willow pollen, to cease its active feeding and fly toward a nearby female. She responded to the approaching male with rapid twittering and wing-fluttering. The male's flight carried him to within a foot of the perched, displaying female whereupon he swung on rapidly beating wings and with constant vocalizations in several short hovering arcs, the apices of which brought him from a position in front of and slightly above the female's face to slightly above and behind her back. At the end of the third or fourth arc the male balanced with beating wings on the female's back and copulated with her. The arced flight was immediately resumed with a second copulatory attempt after which the male flew some 15 feet from the still perched female, preened, and shortly returned to his feeding.

A nest with two newly hatched young and two eggs was located on 29 June and a second nest with four eggs was found the following day. Both nests, constructed in willows, were lined with white ptarmigan feathers and almost constantly attended by the brooding and incubating female redpolls. Soon after the young in the second nest had hatched we erected a blind at the site and began to photograph the feeding activity as the male would bring food to its brooding mate. The distant approach of the food-bearing male was easily detected by its constant emission of rather loud flight notes given as it flew from its feeding ground to the nest. Normally the male would land 15 to 30 feet beyond the nest on the side opposite the blind and work its way through the willows to its rim. At this time the brooding female became excited and reacted during the male's approach with constant vocalizations and rapid wing-fluttering as reported by Baldwin and Reed (J. Colorado Acad. Sci., 4(6):62–63, 1955, quoted in A. C. Bent, 1968. U.S. Natl. Mus. Bull. 237, original not seen). Food was transferred to the still wing-fluttering female who passed it to the young as the male departed. She then removed a fecal sac from the nest site, and shortly returned to her brooding. After watching several repetitions of the above feeding procedure it suddenly became evident that this female was being fed on the nest by *more than one* male.

While Ron was in the blind a food-bearing male in a plumage not much brighter than that of the brooding female returned to the nest some 20 minutes after the previous feeding. As the male fed the female other redpolls were heard. After the transfer of food the male flew to a willow about 20 feet away and in clear view from the blind. Almost immediately a second male in similar plumage to the first came to the nest and fed the female. Both males were observed simultaneously from the blind and the first was still perched while the second was feeding at the nest. Later Ron observed a third highly colored male, which was clearly not one of the previously observed birds, nervously approach the nest and spend 15 to 20 seconds approximately six feet from it before flying off without feeding the excited wing-fluttering female.

Later in the day I was watching one of the drab-plumaged males feed the female. The highly colored male arrived with food as the first male was leaving the nest site through the willows and upon detecting it the second male chased the first several hundred yards from the vicinity of the nest before returning and feeding the female. In every instance the female greeted each approaching male with the same excited response.

Upon relating our observations to several lodge guests who had been photographing the other redpoll nest, previously noted, we learned that they had observed two males feeding that brooding female.

Active feeding was carried on by the Hoary Redpolls 20 to 22 hours in each 24 hour period of the continuous Arctic summer daylight. Surely there must be added survival value to the species through the expression of a behavior which results in an increased food supply to the young by birds which remain somewhat gregarious throughout the nesting season.

The period of fledging was 9 days in both nests as was reported by Walkinshaw (Condor, 50:64–70, 1948 quoted in Bent [op. cit.], original not seen) contrasted to 12 to 14 days as reported by Baldwin and Reed (loc. cit.).—FRED J. ALSOP, III, *Biology Dept., East Tennessee State University, Kingsport University Center, P.O. Box 9, Kingsport, Tennessee 37660, 15 December 1972.*

NEW LIFE MEMBER

We welcome Dr. Robert F. Vane, an oral surgeon of Cedar Rapids, Iowa as a new Life Member of The Wilson Ornithological Society. Dr. Vane, a graduate of The State University of Iowa has been seriously interested in birds for many years, and has been a regular contributor to *Iowa Bird Life.* He is a past-President of The Iowa Ornithologists' Union, and a member of The National Audubon Society, American Birding Association, Saskatchewan Natural History Society, and Minnesota Ornithologists' Union. His special interests in birds include the study of winter birdlife and cine photography of birds, and among his other interests he lists the collecting of an ornithological library. Dr. Vane is married and has two children and one grandchild.

THE GEORGE MIKSCH SUTTON COLORPLATE FUND

George Sutton, twice president of the Wilson Ornithological Society and an illustrious editor of *The Wilson Bulletin*, has had an abiding interest in the Society which has been manifested in many ways. While his contributions of counsel, encouragement, and advice to young ornithologists, artists and writers and his unbounded enthusiasm are well known, only a handful of Wilson members have been aware of the immensity of his financial assistance, so modestly proffered over the years.

When the Louis Agassiz Fuertes Research Grants were established, it was George Sutton who was the anonymous donor who made the awards possible. When *The Wilson Bulletin* had the opportunity but not the wherewithal to publish a meaningful colorplate, it was George who quietly underwrote the cost. That the *Bulletin* has had such an excellent series of colorplates in recent years is almost entirely due to his generosity and his determination that the *Bulletin* be the outstanding ornithological journal of its kind. That the current volume, our outgoing editor's last after ten outstanding years, contains a colorplate in each issue, is again true only because George Sutton has made it possible.

This spring Dr. Sutton enthusiastically suggested that an endowment be established, with the goal of an income large enough to assure a colorplate in *every* issue. He envisages not only the use of outstanding bird art but good color photographs as illustrative material for important papers. He writes, for example: "That fine colored photo of the Steller's × Blue Jay was, to paraphrase Bonaparte and many others, 'worth a thousand words.' It added greatly to the value of the paper and of the issue and of the volume."

When it was decided to name this fund the George Miksch Sutton Colorplate Fund, to be a permanent reminder of Sutton's many contributions to the Society and the *Bulletin*, George said he should raise it all himself! Through his generosity and his fund raising efforts, the fund is well on its way towards the immediate goal. With reproduction costs continually climbing, however, there is no assurance that self-sufficiency today will still be self-sufficiency tomorrow. The Society would welcome, therefore, contributions to the Colorplate Fund. It is hoped that many members, and especially those who have personally experienced the Sutton charisma, will participate with him in his endeavor to make *The Wilson Bulletin* an ornithological journal second to none in excellence of illustration.—*The Council.*

THE PRESIDENT'S PAGE

Resolutions committees of the Wilson Society and similar organizations are usually appointed at the annual meeting on an *ad hoc* basis. Their chief duty is to prepare the traditional resolution of appreciation addressed to the local committee and sponsoring organizations. Additional resolutions are sometimes prepared from information supplied to the committee at the meeting; the subjects vary, but usually concern current conservation issues. The chairman normally reads these resolutions at the second business meeting, the presiding officer asks for a vote, and the resolutions are approved by the members present. The Secretary receives the written report, and sends out copies of resolutions as appropriate.

Readers who were present at the 1973 meeting will recall that several resolutions were offered from the floor after the committee's report had been read. Some of these were carefully prepared, whereas others were merely suggested in a letter read aloud; the members were asked, in effect, to approve subject matter upon which the *ad hoc* resolutions committee would then have to draft resolutions that would become a part of the written record without any mechanism for final approval by the membership. These resolutions were, quite properly in my opinion, voted down—*not* because of lack of merit in the positions represented, but simply because the members that were being asked for approval (thus placing the Society on record as favoring a particular position) were not fully informed about all facts in these issues, some of which are controversial. A similar incident at the 1972 meeting of the Canadian Nature Federation led the Directors of the Federation to abolish resolutions completely.

I believe it appropriate for the membership of the Wilson Ornithological Society to address opinions to individuals and agencies through the mechanism of resolutions, but this action should clearly be taken only after careful consideration of the issues. I am therefore changing the Resolutions Committee from an annual *ad hoc* to a standing committee. Any member who wishes the Society to take a position as expressed by a resolution should send a summary of the facts in the case to a member of the Committee. Before the next annual meeting, the Chairman will send the Secretary a written report, which will be presented to the Council for approval. The report (possibly amended by Council) will be posted during the meeting, and read aloud at the second business session, and approval by the membership asked. No resolutions from the floor will be accepted. During the annual meeting, the Committee will presumably prepare and add to the report the usual resolution addressed to the local groups.

Resolutions to be considered at the 1974 meeting should be sent by 15 April (to allow time for study and circulation among the Committee) to any of the following: Dr. Robert D. Burns (Chairman) (*Department of Biology, Kenyon College, Gambier, Ohio 43022*); Dr. Sally Spofford (*Aguila Rancho, Portal, Arizona 85632*); Dr. Sidney A. Gauthreaux, Jr. (*Department of Zoology, Clemson University, Clemson, South Carolina 29631*).—Kenneth C. Parkes

ORNITHOLOGICAL NEWS

By votes of the Councils of both organizations it is now final that our annual meeting in 1975 will be a joint meeting with the Cooper Society in mid-June at The Montana State University, Bozeman, Montana.

The feature attraction of the 1974 meeting will be a symposium on Kirtland's Warbler, to be organized by Lawrence Walkinshaw, and chaired by Harold Mayfield. The location of the meeting at Douglas Lake, Michigan, makes this an appropriate topic, and without doubt a field trip to the Kirtland's breeding ground will be on the docket also.

On 27 October The Cornell Laboratory of Ornithology awarded the seventh annual Arthur A. Allen Award to Oliver L. Austin, Jr. and Elizabeth S. Austin.

In 1973 Lawrence V. Compton and S. Charles Kendeigh joined the unofficial organization of 50-year members of the Wilson Society.

During 1973 Andrew J. Meyerriecks and Kenneth C. Parkes resigned from the Editorial Board of *The Bulletin*, and the Editor and the Society wish to thank them for their service. Dr. Parkes had been a member of the Board since its inception in 1956.

It has been called to our attention that in these times of budget crunch many university libraries are cancelling their subscriptions to journals that they feel are not important. All members of the Society connected with colleges and universities can serve the Society in an important way communicating to their librarians information about the importance of The Bulletin.

FROM THE A.O.U.

At the annual meeting of the A.O.U. at Provincetown, Massachusetts on 8 October the following officers were elected.

President: Donald S. Farner
First Vice-President: H. B. Tordoff
Second Vice-President: Charles G. Sibley
Secretary: George E. Watson III
Treasurer: John A. Wiens
Editor: Oliver L. Austin, Jr.

The Brewster Award went to the late R. A. Philippi, A. W. Johnston, and J. D. Goodall for their work on Chilean birds. The Coues award went to John T. Emlen for his outstanding work (and that of his students) in many fields of avian biology.

In the final number of each volume of a journal such as this the Editor has the pleasant duty of expressing his thanks and appreciation to the many people who have helped in the production of that volume, the authors of papers, the referees of those papers, the people who prepared special features, and to many others, and this issue is no exception. I do express my thanks to all these people, who must remained unnamed, but this issue is something more (to me at least) than the final number of a volume. After ten years on the job this is the final issue that I will "put to bed." Ten years! That's a whole decade! Put that way it seems almost in the same category as forever. Surely this is the time to say more than just "thanks." But how does one sum up the thoughts that rush through his head after all this time in this job. Simply to list the people—the whole gamut from the invaluable people at The Allen Press to the unsung and unofficial assistant editor (who happens to be my roommate)—would take several pages of precious space, and indeed would serve no useful purpose. It goes without saying that these people have my deepest gratitude.

I choose to remark on only one thing. In a ten-year span one can see and measure progress, even if this comes with glacial slowness, and so it is heartening to know that ornithology is still a dynamic science, even in these days when it stands low on the pecking order of biology. Even more heartening has been the opportunity to watch the development of the new crop of young and vigorous workers. I have had the pleasure of following several instances of persons who first submitted papers while they were undergraduates, and who now are in their turn directing students in worthwhile and stimulating research. To a teacher this chain of events can be one of life's great joys.

It's been a wonderful ten years for me and I have enjoyed every minute of it. The Wilson Society with its peculiarly harmonious bifurcation of membership between professionals and amateurs has been an organization that I have been proud to serve. I couldn't begin to list the friends I have made. Oh, no doubt since it is an editor's duty to criticize, and since some people resent criticism—particularly of their "deathless" prose—I have no doubt made some enemies, but hopefully these are few. But perhaps I and my successors in this job can take some comfort in the following remark quoted from *The Capital Chemist*, "If you ever see an editor who pleases everybody, he will be neither sitting nor standing—there will be a lot of flowers around him." And with that the time has come to say, "So Long."—George A. Hall.

GRANTS-IN-AID AND PRIZES OFFERED BY THE WILSON ORNITHOLOGICAL SOCIETY

At its meeting in Chapel Hill in May 1973, the Council of the Wilson Ornithological Society decided to publish in the Wilson Bulletin a recapitulation of the various awards offered by the Society, together with details of eligibility, deadlines for application, etc.

The Society has two annual grants-in-aid, intended to support original ornithological research. These are administered by the Research Committee, of which the Chairman is Dr. Frank B. Gill, Academy of Natural Sciences, 19th and The Parkway, Philadelphia, Pennsylvania 19103. These grants are as follows:

Louis Agassiz Fuertes Grant-in-Aid, $200. Although there are no restrictions on eligibility, applications from "non-professionals" (including students) are preferred.

Margaret Morse Nice Grant-in-Aid, $100. Restricted to applicants not associated with a college or university; these grants are intended to encourage the independent researcher without access to funds and facilities generally available at the colleges. High school students are eligible.

Applications for either of these grants, including a one or two page summary of the proposed project, should be sent to Dr. Gill no later than 1 April 1974.

Prizes awarded by the Wilson Society are as follows:

Alexander Wilson Prize, $100. Awarded through an *ad hoc* committee appointed by the President for the best paper presented at an annual meeting by a student speaker who has not attained a doctorate. Not eligible for this prize are papers by invited participants in symposia, or papers coauthored by a holder of a doctorate even if presented by a student.

Ernest P. Edwards Prizes, $200 and $100. Awarded through a committee, currently chaired by Dr. Helmut C. Mueller, of which the editor of the Wilson Bulletin is always a member. Given for the best and next-best papers published in the preceding year's volume of the Bulletin. Originality, importance, and clarity of presentation are among the factors considered. Winners are announced at the annual meeting.

Through a generous gift from Mrs. Aaron M. Bagg in memory of her late husband, a former President of the Wilson Ornithological Society, a number of student memberships in the Society will be made available. Details of the Aaron Moore Bagg Student Membership Awards will be published in the March 1974 issue of the Wilson Bulletin.

CONSERVATION SECTION

A CONSIDERATION OF THE EXOTIC AVIFAUNA OF SOUTHEASTERN FLORIDA

OSCAR T. OWRE

Walking catfish, poison toads and giant, garden-devouring snails—which have given Florida a surprising new dimension in publicity—are but part of a large and diversified exotic fauna now in accelerating recruitment. Birds form a conspicuous part of this fauna. Invasion by exotic animals is not, of course, unique to Florida. Surprise and misunderstanding exist, however, as to why these exotics have appeared so suddenly and in such numbers. Confusion and indecision prevail as to what, if anything, can or should be done about the situation.

To appreciate this exotic avifauna, one should examine aspects of the ecology and demography of southeastern Florida, particularly as these relate to the *Atlantic Coastal Ridge*, a narrow, somewhat elevated strip of land which extends from north of Palm Beach to south of Homestead. The ridge forms the eastern rim of the Everglades basin; on its seaward margin lie the mangrove swamps and beaches bordering the Atlantic. In 1930 the ridge was still in considerable part covered with pseudoclimax pineland and climax tropical hammock. Drainage of the Everglades was being accelerated and dredging and filling had been begun in the mangroves. The three counties which straddle the ridge (Palm Beach, Broward, and Dade) plus Monroe County which includes the Florida Keys to the south, contained in 1930 (Bur. Census, 1932) but 228,000 human inhabitants. Forty years later (Bur. Census, 1971) this population had grown to 2,289,000! The natural plant communities had all but been replaced by an urban-suburban sprawl which now covers the ridge along most of its more than 100 mile length. The ecology of the ridge—to express it mildly—had become a "disturbed" one. It is, of course, well recognized that disturbed ecological situations are more easily invaded by at least some types of exotic organisms. A number of factors contributing to this disturbed ecology are of particular significance with respect to invasion by an exotic avifauna.

Zeal displayed by those who would bring exotic animals to their lands appears to have been far outmatched by those engrossed with plant introductions. In Florida the introduction of exotic plants has been no haphazard affair. Within the U.S. Department of Agriculture's plant introduction centers, one of which was established in southern Dade County, David Fairchild (1943:viii) noted that "thousands of species and varieties of tropical trees and plants are growing." Fairchild (and others) undertook far-ranging expeditions to search for tropical plants "to be distributed to plant lovers through these introduction gardens." He referred (1947:56) to millions of Australian cajeput trees (*Melaleuca leucodendron*) being grown near Ft. Lauderdale for landscape gardners. Appropriately enough, Fairchild (1947) entitled a book of reminiscences about his collecting activities "The World Grows Round My Door" (his residence being Coconut Grove, a suburb of Miami).

In development of the vast suburban areas of southeastern Florida, it has been general practice to scarify the land; eventual landscaping has been almost exclusively with exotic plants. (Nurseries seldom stock species of native trees and shrubs.) Exotic plants, usually species popular for their showy flowers and ornamental or edible fruit, have largely replaced the native flora of the *Atlantic Coastal Ridge*. Even the native shade trees have been ignored and, among other kinds of trees affording much shade, numerous species of exotic *Ficus* (in place of two native species of *Ficus*) now line endless miles of suburbia's roadsides. Over wide expanses of southeastern Florida native plants are almost entirely lacking.

Some successful invaders have been described as "preadapted" to a new environment (Allee et al., 1949). Southeastern Florida, one might well say, has been "preconditioned" to a surprising extent for exotic invasion. Thus Carleton (1971) found the Red-whiskered Bulbul (*Pycnonotus jocosus*), introduced from India, roosting in exotic trees native to India, feeding to some extent upon the same fruit the species is known to consume in India and even building nests with plant materials the species has been reported to construct nests with in India.

It should be stressed that the flora of southeastern Florida now contains elements of the world's tropics. Virtually any exotic tropical bird will find aspects of the landscape which are "familiar" to it. Moreover, any former seasonality in flowering and fruiting imparted by the native flora has been much modified, some plants from somewhere now furnishing fruits, seeds, and nectar at every season.

The development of commercial aviation took place as the human population of the *Atlantic Coastal Ridge* exploded. Birds are popular pets. Most Northern Hemisphere countries of the Temperate Zone no longer allow commercialization of their avifaunas. Many of the world's tropical countries do. Tropical birds attract the imagination. Cargo flights originating in the tropics now could transport caged animals with rapidity and therefore minimal mortality to almost any point on the planet. What was more logical than to bring flights destined for North America to southeastern Florida where, in a tropical milieu, the animals could be held until wholesaled and redistributed? Importers established themselves in and about Miami. Some enterprising dealers transformed their holding areas into show places for tourists, thus earning additional return on their investments. The area rapidly became an important center for the traffic in exotic tropical vertebrates. In 1971 more than half a million cage birds (excluding canaries and parrots), more than one million reptiles, and approximately 30 million fish were passed through the Miami Port of Entry (U.S. Dept. Interior, 1972)!

Southern Florida's salubrious climate merits stressing at this point in discussion. The climate entices citizens out-of-doors and encourages outside activities. Zoos, tourist attractions, establishments of some animal importers, the back yard aviaries which dot suburbia, and the bird cages which swing in a myriad of patios—these have but open sky above them.

Thus, the ecological "stage" came to be set for the airborne faunal lift which began moving to southern Florida with accelerating tempo: plane-loads of monkeys and mynas, toucans and hornbills, ocelots and kinkajous, parrots from South America, Africa and southern Asia, tropical fish by the millions, caymans and chameleons, lizards and tortoises. "Tell us what you want and we'll get it for you" was a stock phrase of the animal importer.

Now the "how" of the exotics escaping into the landscape. However small the percentage may be, *some* fraction of any number of imported animals, particularly of volant species, would seem bound to find freedom in some manner or other. Consider the Canary-winged Parakeet (*Brotogeris versicolurus*). Between 1968 and 1970, 123,721 of these were imported into the United States (Clapp and Banks, 1973). To anyone who has kept parrots in captivity, their escape is an ever present possibility. And escape they do. Is it unrealistic to consider such a small percentage as one-half of one percent as likely to be freed by accident and/or by the deliberate intent of persons tired of caring for their charges or even desiring to see them free? The fraction itself is a small one. Such a fraction of

123,721 birds is large enough—more than six hundred—to account for the fact that the birds are free-flying in many areas of the United States where they have been widely sold. Of course, this entire caged population was not imported through Miami—but large numbers were. Pet shops and department stores found the bird a popular item throughout the Miami area. (One store clerk made the comment that some of his previous customers came back for replacements of Canary-wings which had escaped [C. R. Robins, pers. comm., 1973]). That captive birds have indeed escaped is attested to by the fact that of Canary-wings which we at the University of Miami have live-trapped, some, by their behavior, attested to an obvious history of captivity.

There are those who persist unconvinced as to the manner by which the exotic species now establishing themselves in Florida have arrived. To assume that species which are traditionally non-migratory have, at the same time as a wide spectrum of other species, migrated from tropical areas of the world on vectors to an ocean-surrounded peninsula in the north Caribbean is hardly credulous. True, the Cattle Egret (*Bubulcus ibis*) and the Fulvous Tree Duck (*Dendrocygna bicolor*) have invaded the peninsula "on their own." But these species represent taxa known for peregrinations or migratory habits. In the case of the majority of the exotic species now loose in Florida, one has but to inspect existing data on importations (e.g., Clapp and Banks, 1973). In almost every case the species are those which have been commercially trafficked. But let us move on to inventory of this exotic avifauna.

The Carolina Parakeet is gone from Florida's skies. Parrots, however, are represented as never before. Almost 300,000 psittacids were imported into the United States in the years 1968–1970 (Clapp and Banks, 1973). Figures are lacking for the proportion of these which came through south Florida's ports of entry. The numbers, however, have not been inconsiderable. Additional birds have been raised locally in captivity. Parrots are favorite birds for public exhibits as well as for home and garden. Free in the landscape of year-round summer the birds apparently experience little difficulty in finding adequate fruits, seeds and greens as well as provender from multitudes of feeding stations which are kept constantly supplied.[1]

The abundant Canary-winged Parakeet has been previously mentioned. Free-flying birds were noted in the late 1960's, 50 being counted in a roost in South Miami in 1969 (Ogden, 1969:652). The birds were then reported from Upper Matecumbe Key and from the western side of the Everglades (Stevenson, 1971:570). A few were seen in Ft. Lauderdale in 1970 (George, 1971); flocks of 40 to 50 were being seen there during the spring of 1973 (C. E. Timmer, pers. comm.). The species is currently under study by Ms. Crystal Shroads, graduate student of the University of Miami. In December 1972 a winter roost of the birds in Coconut Grove contained very nearly 700 individuals (Shroads, pers. comm.). Birds in immature plumage were evident in this assemblage. Of the 15 or so nests in Miami now (May of 1973) being monitored, it is noteworthy that all of them are in exotic species of palms, burrowed into the frass of decaying leaf stalks which surrounds the trunks. The large, noisy flocks of the birds and their depredations of mangos and

---

[1] The significance of feeding stations in establishment of exotic species can hardly be underestimated. The abundance of the stations in suburbia and the constancy of food supplies they afford have no doubt contributed materially to successful invasions by some species. Carleton (1971:31) writing of the Red-whiskered Bulbul, discussed what might well be described as symbiotic *mutualism*. Humans attracted the bulbuls with all manner of carefully prepared foods—cake, bread soaked in sugar solutions and "mushes, polentas and purees," as well as various fruits, etc. The feeding station operators benefited by: the notoriety and distinction of having attracted crowds of bird watchers, some from remote and interesting places; and aesthetic satisfaction.

other fruits grown in suburbia have occasioned much local comment as well as some consternation.

The Red-crowned Parrot (*Amazona viridigenalis*), native to Mexico, is the most abundant of the amazons now present in southeastern Florida. These have been reported from the Florida Keys (Robertson, 1972:54) and are commonly seen throughout metropolitan Miami and in Ft. Lauderdale. In November 1972 the author counted 32 in a flock feeding in casuarina trees (exotic to Florida) on the University of Miami campus and he is at present (May 1973) observing a nest with two eggs, this within a hollow casuarina tree on the same campus.

The Rose-ringed Parakeet (*Psittacula krameri*), native to southern Asia, is establishing itself in suburban north Dade County (Ogden, 1972:848). Adults, often with accompanying immatures, frequent feeding stations. According to Mrs. J. Hunsinger (pers. comm.), who has numbers of the birds coming to her feeding shelves, there is reason to believe that the population has been present in this area for a considerable time, possibly more than 10 years. University of Miami collections contain skins of two immature birds of this population, one just past fledging. Field observations indicate that the subspecies *P. k. manillensis*, the race of peninsular India, is representative of the local birds.

Monk Parakeets (*Myiopsitta monachus*) have been breeding in the Miami area since at least 1969 (Mrs. M. Jacobs, pers. comm.). The birds are now being seen throughout a wide area (Ogden, 1972:848). Individual birds are frequently seen accompanying the flocks of Canary-winged Parakeets, even visiting feeding stations with them. Two lodges (nests) were constructed on the Miami campus during the fall of 1972 (Both were eventually destroyed, one by rock-throwing youngsters, the other from unknown factors).

Budgerigars (*Melopsittacus undulatus*), as would be predicted, are widespread in southern Florida. One should read of the deliberate manner in which a prosperous colony, the individuals of which have spread throughout a wide area, was established near St. Petersburg (Anonymous, 1963). The freed birds were regarded as a *tourist attraction*!

This is far from a complete list of parrots enjoying freedom in Florida. Among those species presently evident in Dade County but not yet known to be breeding successfully are the following.

The Orange-fronted Parakeet (*Aratinga canicularis*), of Central America, is reported from throughout the Miami area and from northward along the *Atlantic Coastal Ridge* (Ogden, 1972:848). A male killed by an automobile (South Miami, 11 March 1973), was reported to have been one of a pair; this bird (UMRC #7319) was found to have considerably enlarged testes, those of a breeding or near-breeding bird.

The Brown-throated Parakeet (*Aratinga pertinax*), Neotropical in distribution, is reported to have bred at Key West (Robertson, 1971:47) and there are increasing reports of the species in the Miami area.

The Orange-chinned Parakeet (*Brotogeris jugularis*), another Neotropical species, is in increasing evidence about Miami; seven were reported from the 1970 Dade County Christmas Bird Count (Bizet, 1971:282).

Orange-winged Amazons (*Amazona amazonica*) have been seen by the author on several recent occasions and there are continued reports of yellow-headed amazons of unknown species—one flock of eight such was seen by the author in Coral Gables in November 1972. That the White-fronted Amazon (*A. albifrons*) is now present in the area and may be breeding is attested by reports from John Ogden (pers. comm.) and Durban Tabb (pers. comm.).

Pigeons and doves are among the more popular birds of the aviarist. Certain species, in addition to the locally abundant Rock Dove (*Columba livia*) have gained footholds in southern Florida. The Inca Dove (*Scardafella inca*) is known to have bred at Key West (Cunningham, 1966:414). The Ringed Turtle Dove (*Streptopelia* sp.) is apparently established at several localities, including Winter Park in Orange County (central Florida) (Robertson, 1972:54). Fisk's report (1968) of the establishment of the White-winged Dove (*Zenaida asiatica*) in Dade County merits recounting. Privately imported, in part from Venezuela, in part from Mexico, these birds were bred in captivity from 1954 to 1959 when 25 were released near Homestead. In 1968 no fewer than 200 were coming to the releaser's feeding station and the species was being seen throughout an area more than 40 square miles in extent (Ogden, 1970:674).

Other non-passerines may be in process of establishing themselves in southern Florida. The Black-bellied Tree Duck (*Dendrocygna autumnalis*), a native of southwestern United States and Central America, is nesting on Virginia Key, not far from Miami's Crandon Park Zoo which has maintained a large collection of anseriforms, this species included. In 1969 an adult and 12 downy young were seen (Ogden, 1969:652) and M. Heath (pers. comm.) observed four downy young in the same locality in November 1972. Meantime, observations of West Indian Tree Ducks (*Dendrocygna arborea*), which have also been kept at the Crandon Park Zoo, continue to be made in the Virginia Key area.

The Red-whiskered Bulbul, previously mentioned, introduces a new passeriform family (Pycnonotidae) to this Hemisphere. This species, which as a caged bird had already been carried to Australia where it is now feral, found freedom from Miami's Rare Bird Farm in 1960. Carleton (1971) studied the species in its Dade County environment. She estimated that during the first ten years of the bird's establishment in Dade County, there was an annual 30–40 percent increment to the total population! Primarily dependent upon small drupaceous fruits, berries, and sycons, the species also frequents blossoms for nectar and devours some insects. At present, of more than ordinary importance in the bulbul's diet is the drupaceous fruit of an introduced South American shrub or small tree, the Brazilian holly or Brazilian pepper (*Schinus terebinthifolius*), a plant which has spread explosively along roadsides, canal banks, and into suburban and old-field situations. In the winter of 1969–70 Carleton (op. cit.) estimated the population at slightly less than 250 and restricted to a suburban area of approximately 3.2 square miles. Slow spread of the population she attributed to the birds' apparent traditional attachment to communal roosting sites which are resorted to in winter. Indications in 1973 are that the population has continued to grow and is occupying a larger area.

The Hill Myna (*Gracula religiosa*) is another popular, widely-trafficked cage-bird. Pet shops throughout southeastern Florida stock the species. It is not surprising that free birds are being reported locally from Palm Beach County southward through Dade County (Kale, 1972:752), nesting likewise being reported at numerous locations within this area. One of a pair nesting on the University of Miami Campus (in May 1973) wolf-calls and whistles in a manner surely indicative of its having been in captivity. Little is known of the diet in southern Florida, but its diet in India emphasizes fruits and berries, particularly fruits of *Ficus* (Ali and Ripley, 1972:192). It has, interestingly, appeared in the Miami area at approximately the same time as another exotic sturnid, the European Starling (*Sturnis vulgaris*), which has only just begun breeding over much of southeastern Florida's suburbia.

The Spotted-breasted Oriole (*Icterus pectoralis*) from Central America was one of the earliest introductions (1949) into suburban Miami, where the species had been sold as a cage-bird. Conspicuous by song and plumage, spread of the bird has been well noted. By 1956 the orioles were active within an area some 26 miles in north-south extent (Brookfield and Griswold, 1956). In May 1961 the bird had reached Hypoloxo Island in Broward

County (Stevenson, 1961:405). By 1962 it had spread to West Palm Beach (Stevenson, 1962:25). In 1968 sightings were made from Pine Island in Everglades National Park some 40 miles south of Miami (Robertson, 1968). In 1969 two were observed at Lake Wales, some 150 miles north of Miami (Walkinshaw and Walkinshaw, 1970:247). This species is deserving of careful study. It is now appearing, if irregularly, somewhat north of the Tropical Zone of Florida. In large part a fruit and nectar feeder, the bird presumably exploits a spectrum of fruiting and flowering plants, tropical and subtropical, which are now under suburban cultivation far northward along the peninsula. In any considerable range extension northward it may well anticipate others of the exotic species now extending their ranges. Whatever factors of the environment might be important to any further, or indeed lack of any further, range extension of the Spotted-breasted Oriole are deserving of appreciation.

The Blue-gray Tanager (*Thraupis virens*) was discovered in Hollywood (Broward County) in 1960 (Arnold, 1961). Here it was noted attracted to fruit of a large sapodilla tree (*Achras sapote*), the tree like the tanager an exotic species in Florida. Nesting was recorded in the Hollywood area in 1961 and 1962 (Paulson and Stevenson, 1962:403). A singing male was taken on the University of Miami Campus in 1964 (UMRC #4973). Ogden (1972:848), suggesting that the species was increasing, noted its continued breeding in northern sections of Dade County. In the South Miami area wild birds, three or four at a time, have been attracted to an outdoor aviary containing captives of the species (C. R. Robins, pers. comm., 1972). Insectivorous only in part, the berry-eating habits of *T. virens*, should serve the species well in its new milieu.

The Java Sparrow (*Padua oryzivora*), a favorite cage-bird in the Miami area for many years, was, according to my records, reported at feeding stations in the northern portion of Coral Gables as early as 1960. The birds are often attracted to communal roosting assemblages of the House Sparrow (*Passer domesticus*) and I first noted them at such situations in 1966. From 1968 to 1969, the numbers of the birds at one roost increased from approximately 50 to 150 (Ogden, 1969:652). No study has been made of this population which is now distributed over an area of several square miles and breeding in both residential and downtown areas. V. Brach (pers. comm., 1972) found a nest with young on a large theater building on a busy street in the center of Coral Gables. Any similarities of the niche this species occupies to that of the House Sparrow seem not to have materially impeded it in its initial stages of establishment.

The Brazilian Cardinal (*Paroaria coronata*) may well be breeding in Dade and Broward Counties. The author first noted free-flying individuals on the grounds of Crandon Zoo (Biscayne Key) in 1965. Since that time there have been scattered reports of the birds from Coconut Grove and elsewhere in Dade County. This spring the birds were reported from Ft. Lauderdale (C. E. Timmer, pers. comm., 1973).

The majority of the species just discussed have been described as "establishing themselves" or as "established": they are species which give every indication at this time of being successful invaders. Caution should be used, however, in so describing them. First, there are many unknown factors with respect to animal invasion. Phillips (1928) commented on the number of introduced species which have demonstrated an initial local success, then, after a few years have declined in numbers and disappeared. It must also be held in mind that Florida's tropical area is small, terminating northward at about the latitude of Lake Okeechobee. North of this ecological conditions become progressively more temperate. Successful invaders of southern Florida are not gaining a foothold into a biome of continental breadth. Their ranges may well remain restricted to an area of no great geographical extent. Indeed, they may find themselves in much the same, if not a comparable situation as species invading insular areas. The ecological precariousness of insular restriction is well recognized. It is, then, important to temper any premature confidence that these representatives of at least three great biological realms of the world have met ultimate success in adapting to the Florida's much restricted Tropical Zone.

Certain generalizations can be made from examination of habits of the exotic species breeding and extending their ranges in southeastern Florida.

Post-breeding assemblages (in most pronounced form, communal winter roosting) are characteristic of many of the exotic species. Adults and young move into these assemblages during the summer and fall. From various social interactions inherent in such assemblages one may postulate advantage to the species. Just a pronounced tendency to flock would seem to be significant to at least some types of species "pioneering" individuals of which are in initial stages of colonizing vast new areas. Colonial habits assumedly confer increased safety from predation. Young bulbuls in the fall accompany the adults to the communal roosting sites—sites which in some cases remain the same in successive seasons. During daily activities, birds of the year outflight from the roost in company with birds already experienced in exploiting ripening food crops which become available seasonally. Opportunity for synchronization of breeding probably also occurs, bulbul roosts, for example, only breaking up at the onset of courtship. All of these factors, and probably additional ones connected with colonial habits, accrue to longevity which is important to the rapid population growth so characteristic of successful invaders. In addition to the Red-whiskered Bulbul and the various psittacids, these habits are patently characteristic of the European Starling and the House Sparrow. In the Miami area Java Sparrows are known to roost in neighboring and/or the same trees as House Sparrows.

Social habits are evidenced by others of the exotics although in lesser degree. In India the Hill Myna characteristically searches for food in groups of 5 or 6, roosting in pairs or family parties (Ali and Ripley, 1972). Haverschmidt (1968) noted that the Blue-gray Tanager is "often in flocks"; I can find no comments regarding roosting by the species. Skutch (1954:274) observed that the Spotted-breasted Oriole moved about in "small flocks" during winter—this is characteristic of these birds in Florida too. During several weeks of one winter 4 and often 5 of these orioles (possibly a family group) roosted nightly in foliage of a coconut palm in my backyard.

Among Florida's exotics there are no obligate feeders on any single category of food substances—there are, for example, no entirely insectivorous species. Psittacids feed upon a wide variety of fruit, grain, and other plant materials. Bulbuls take fruit, nectar, and insects. The Blue-gray Tanager is both frugivorous and insectivorous. The Spotted-breasted Oriole is to a large extent both a fruit and nectar feeder. The sturnids take a wide variety of food substances. The ploceids take insects in addition to granivorous materials.

With additional study of successful exotic species, numerous characteristics should become apparent which could prove useful in evaluating the potential of species as successful invaders of the various biomes.

This far from concludes the list of exotic birds which have been found free in southern Florida. The Egyptian Geese, the caracaras, lapwings, and the Spectacled Owls from South America, the Indian irenids, assorted estrildids, fringillids, and a host of additional species observed by amazed south Floridians over the past few years have lingered for varying periods of time and then have disappeared. Many may not have been adapted to the environment. Others, which might have been so adapted, were not released in numbers adequate to ensure species survival and breeding. But the supply of these exotics, it would seem, is being constantly replenished. And some from these constantly freed exotic species, as some of those released over the past few years, *will be* released in adequate numbers and may indeed "strike it rich" in the ecological sense.

Two questions pose themselves. What, if anything, should be recommended to avert further introductions into Thomas Barbour's "Vanishing Eden"? And, what of the many species which now seem to be successful invaders—should anything at all be done about them? Let us discuss the second question first.

There are those who are enthusiastic at the parrots, the bulbuls, and the mynas in our midst.[2] They have a point. The numbers of native species which have adapted to suburbia are limited. The native avifauna is a depauperate one to begin with (Crook, 1969). We have, in a sense, simply speeded up colonization of the area by tropical species. In so doing we are building a tropical urban-suburban avifauna which, if nothing else, is colorful and unique.

To those living outside of suburbia, to those concerned with agricultural areas and to those who have concern for the remaining areas of natural ecological communities—is there not cause for apprehension? To what extent these exotic species, once their populations have become large, may move out into the exurban areas cannot be predicted. The Starlings and the House Sparrow, for example, have very different patterns of distribution in North America. Certainly we can take some heed from habits of our exotic species within their native environments. Ali and Ripley (1969:169) described the Indian Rose-ringed Parakeet as "one of the most destructive pests of agriculture and horticulture." Bump (1971:3) described the Monk Parakeet as "one of the worst pests of agricultural crops in Argentina." Southern Florida is a major producer of winter agricultural produce for the United States. Central Florida is a major citrus production area. These parrots and other birds of our exotic menage may well prove to be "time bombs" in our midst.

May not questions be raised concerning competition exotics might afford our native species? Carleton (1971) found considerable similarity in feeding habits of the Red-whiskered Bulbul and the Mockingbird. She also called attention to the fact that the bulbul roams in flocks through the winter territories of the Mockingbird, which, as single birds, reside each upon a piece of the environment, depending upon the supply of food it contains. Tree cavities in suburban or exurban areas are obviously in limited number. What of the many hole-nesting psittacids, the two exotic sturnids and the exotic tree duck now multiplying in southern Florida? There can be no prescient answers to questions of this sort. But may it not be precarious to await the answers?

One final comment regarding arguments in defense of exotic species. Scientists are often accused of being coldly practical and of ignoring aesthetic values. Charles Elton (1958), student of animal introduction and an outstanding biologist presented argument along aesthetic lines against introductions. Must we reduce the world's biological realms, which are the planet's heritage of evolution, to a dreary sameness? Must we be denied the anticipation of first meeting the Oriental fauna in India, the Neotropical fauna in Brazil!

A second question posed itself which invited suggestion regarding regulation of the traffic in exotics. A logical expansion of this consideration involves the owning of exotics

---

[2] The introduction of the Scarlet Ibis (*Eudocimus ruber*) into southern Florida is a case in point of the above philosophy. Zahl (1967) described the originator of the introduction as a "dedicated student of nature" who wanted to "start a colony of these dazzling scarlet birds in Florida." The original birds having inbred with the native White Ibises (*Eudocimus albus*) and the scarlet-plumaged individuals now largely gone, it has been proposed (Zahl, op. cit.) to introduce the species once more in order "to give our land a new and enduring touch of tropical beauty."

and their housing. These problems, if they are to be regarded as such, are, upon contemplation, so multivarious that they would appear to allow but broad approaches.

Obvious in our thinking should be concern for ecosystems beyond our immediate political borders. Ecosystems of the world are being plundered to supply the animal importers' trade. Should we condone in Neotropical countries—in the interests of a non-vital commerce and of insensitive consumers—what we have long ago become too civilized to condone in Nearctica?

It has been suggested that the only trade in exotics which should be allowed is that with birds which can be shown to have been raised in captivity. But this is not always easy to prove. And while it may stop destruction of foreign ecosystems, it will not prevent pollution of ours. Many measures have been suggested which might, in some part, alleviate invasion. Bonds could be required of those with exotic birds in their possession and fines levied for those who allow escapes. But all such measures burden bureaucracy and are but fingers in a leaky dyke.

The problem, it should be stressed, involves more than birds. Exotic plants clog our waterways. Exotic fishes are spreading along southern Florida's canals and throughout the Everglades ecosystem. The fish alone have the potential to bring great change to the aquatic communities (Lachner et al., 1970) birds obviously included. On land, invertebrates without end, amphibians, reptiles, and even mammals are producing change which is ramifying into the food webs and affecting the niches of vast numbers of organisms.

Perhaps what we need to do is take a very hard, selfish look at our native ecosystems—before what remains of them is reduced to something we cannot predict, something subverted to that we would decry. Perhaps the philosophy we need to proscribe should read: "You may not introduce or harbor within the .... ecosystem of .... any species of plant or animal which, in the opinion of the knowledgeable authorities might, if released, compromise the ecosystem."

LITERATURE CITED

ALI, S. AND S. D. RIPLEY. 1969. Handbook of birds of India and Pakistan. Vol. 3, Oxford Univ. Press, Bombay.

ALI, S. AND S. D. RIPLEY. 1972. Handbook of birds of India and Pakistan. Vol. 5, Oxford Univ. Press, Bombay.

ALLEE, W. C., A. E. EMERSON, O. PARK, T. PARK, AND K. SCHMIDT. 1949. Principles of animal ecology. W. B. Saunders Co., Philadelphia.

ANONYMOUS. 1963. Parakeet city—a tourist attraction. Florida Naturalist, 36:1B.

ARNOLD, I. V. 1961. Florida Naturalist, 34:44–45.

BIZET, F. 1971. The seventy-first Christmas bird count—Dade County, Fla. report. Amer. Birds, 25:281–282.

BROOKFIELD, C. AND O. GRISWOLD. 1956. An exotic new oriole settles in Florida. Natl. Geogr., 109:260–264.

BUMP, G. 1971. The South American Monk, Quaker or Grayheaded Parakeet. U.S. Dept. Int., Fish and Wildlife Service, Bur. Sport Fish. & Wildlife. Wildlife Leaflet 946., Washington, D.C.

BUREAU OF THE CENSUS 1932. Fifteenth census of the United States: 1930 population, Vol. 3, Pt. 1, U.S. Dept. Commerce, Govt. Printing Office, Washington, D.C.

BUREAU OF THE CENSUS 1971. 1970 census of population, general population characteristics—Florida. U.S. Dept. Commerce, Govt. Printing Office, Washington, D.C.

CARLETON, A. R. 1971. Studies on a population of the Red-whiskered Bulbul, *Pycnonotus* *jocosus* (Linnaeus) in Dade County, Florida. Unpubl. M.S. thesis, Univ. of Miami, Coral Gables, Florida.

Clapp, R. B. and R. C. Banks. 1973. Birds imported into the United States in 1970. U.S. Dept. Int., Fish & Wildlife Service, Bur. Sport Fish. & Wildlife. Spec. Sci. Report—Wildlife no. 164, Washington, D.C.

Crook, R. E. 1969. Variation in species density of North American birds. Syst. Zool., 18:63–84.

Cunningham, R. L. 1966. Florida region. Audubon Field Notes, 20:412–416.

Elton, C. S. 1958. The ecology of invasions by animals and plants. Methuen & Co., Ltd., New York and London.

Fairchild, D. 1943. Garden islands of the great East. Charles Scribner's Sons, New York.

Fairchild, D. 1947. The world grows round my door. Charles Scribner's Sons, New York.

Fisk, E. J. 1968. White-winged Doves breeding in Florida. Florida Naturalist, 41:126.

George, W. 1971. Canary-winged Parakeets. Florida Naturalist, 44:25.

Haverschmidt, F. 1968. Birds of Surinam. Oliver and Boyd, Edinburgh.

Kale, H. W., II. 1970. Florida region. Audubon Field Notes, 24:591–595.

Kale, H. W., II. 1972. Florida region. Audubon Field Notes, 25:751–754.

Lachner, E. A., C. R. Robins, and W. R. Courtnay, Jr. 1970. Exotic fishes and other aquatic organisms introduced into North America. Smithsonian Contrib. Zool., 59:1–29.

Ogden, J. 1969. Florida region. Audubon Field Notes, 23:651–654.

Ogden, J. 1970. Florida region. Amer. Birds, 24:673–677.

Ogden, J. 1972. Florida region. Amer. Birds, 26:847–852.

Paulson, D. R. and H. M. Stevenson. 1962. Florida region. Audubon Field Notes, 16:398–404.

Phillips, J. C. 1928. Wild birds introduced or transplanted into North America. U.S. Dept. Agric. Tech. Bull., 61:1–63.

Robertson, W. B., Jr. 1968. Florida region. Audubon Field Notes, 22:516–520.

Robertson, W. B., Jr. 1971. Florida region. Amer. Birds, 25:44–49.

Robertson, W. B., Jr. 1972. Florida region. Amer. Birds, 26:50–54.

Skutch. 1954. Life histories of Central American Birds. Pacific Coast Avifauna 31, Cooper Ornithol. Soc.

Stevenson, H. M. 1961. Florida region. Audubon Field Notes, 15:402–405.

Stevenson, H. M. 1962. Florida region. Audubon Field Notes, 16:21–25.

Stevenson, H. M. 1971. Florida region. Amer. Birds, 25:567–570.

United States Dept. of the Interior. 1972. Wildlife imported into the United States in 1971. Bur. Sport Fish. & Wildlife, WL-498., Washington, D.C.

Walkinshaw, C. and L. Walkinshaw. 1970. The seventieth Christmas bird count—Lake Wales, Fla. report. Amer. Birds, 24:246–247.

Zahl, P. A. 1967. New scarlet bird in Florida skies. Natl. Geogr., 132:874–882.

DEPARTMENT OF BIOLOGY, UNIVERSITY OF MIAMI, CORAL GABLES, FLORIDA 33124.

EXOTIC BIRDS IN THE NEW YORK CITY AREA

JOHN BULL

PART I

In addition to the Ring-necked Pheasant (*Phasianus colchicus*), Rock Dove (*Columba livia*), Common Starling (*Sturnus vulgaris*), and the House Sparrow (*Passer domesticus*), which were initially introduced into North America in the New York City region during the latter half of the nineteenth century, the Mute Swan (*Cygnus olor*) was also first imported here, though not until much later, in the second decade of this century. Unlike those widespread species, it is essentially restricted to the northeastern states, mainly within 100 miles of New York City.

Within the past decade, waterfowl (11 species), parrots (11 species), and finches (sensu lato), i.e., Ploceidae, Estrildidae, and Fringillidae (12 species), lead the list of foreign introduced species that have managed to escape from time to time, but nearly all have failed to establish themselves. Of all the exotic, introduced species it is the family Psittacidae (parrots) which have made the headlines in recent years. Certain members of this well-known tropical group have been commonly imported and have escaped into the greater New York area, and one species appears to have become established.

Within the past dozen years or so, members of the parrot family have been imported into the United States in tremendous numbers from many parts of the world. This has been made possible through the development of specific antibiotics in the treatment of psittacosis or "parrot fever"—more properly ornithosis or "bird fever," as chickens, pigeons, and other kinds of birds are as much carriers of this contagious disease as are parrots. With the elimination of this threat, the ban on importing psittacine birds (parrots, parakeets, macaws, cockatoos, lories, and others) was lifted resulting in a veritable flood of these popular birds into this country. However, as of July 1972 all psittacines were banned from importation into the United States without special permit because they are potential carriers of Newcastle's disease, sometimes fatal to domestic poultry.

It is outside the scope of this article to mention all of the diverse kinds of parrots imported. Only the following 11 species reported as seen in the "wild" are treated here. These attractive and colorful birds have always been favorites of aviculturists, and their proverbial tameness, plus ability to "talk," as well as possession of other human attributes, has made them highly desirable as pets.

Suffice it to state that at least 11 species of the parrot family have become very popular as cage birds and have escaped from time to time. Of these 11, two have been found as escapes in the wild in large numbers, one of these even found breeding in the northeastern portions of the United States—the Monk Parakeet (*Myiopsitta monachus*).

The Monk Parakeet is the only species of the 11 that is gray-breasted—one of its vernacular names. It is also gray on the forehead. The pet trade knows this species as the Quaker Parakeet. That the Monk Parakeet has survived four northern winters is very likely due to its being a constant visitor to the numerous well-stocked feeding stations, partaking of mixed wild bird seed, sunflowers, meat scraps, various fruits, bread, cake, and other tidbits. It comes from the temperate zone of southern South America which has a climate not unlike ours, though theirs is somewhat milder and drier.

Much has been written about the Monk Parakeet in recent years as to its status in the wild in and around New York City. Newspaper articles and requests for information about this bird have become increasingly frequent. What with numerous individuals escaping from air shipments, and both accidental and deliberate releases from aviaries, pet shops, and private homes, Monk Parakeets have become adapted to our climate, and have settled down to propagate and have extended their domain far into the suburbs and even to outlying sections. There is hardly a day that passes without one or more telephone calls and letters to the writer asking for information about the "strange green birds"—almost always recognized as parrots.

A comparison of the 11 species is given so that one may be able to identify the various forms when seen. Total length in inches, from bill tip to tail tip, is approximate. The sexes are either alike or very similar.

(1) Monk Parakeet (*Myiopsitta monachus*).—southern South America; 11 inches; long pointed tail; mostly green with much of head and breast gray, wings blue. Perches freely on rooftops, telephone wires, in bushes and trees, and if nesting, will usually be found in the vicinity of the large domed stick nests which are placed in trees, on buildings, utility poles, and various other structures. Highly gregarious, up to six pairs per nest.

(2) Canary-winged Parakeet (*Brotogeris versicolurus*).—called "Bee-bee" in the pet trade; tropical South America; eight inches; tail long and pointed; mostly all green with long yellow and white wing patch. This species is considerably smaller than the Monk Parakeet and, with the bright yellow and white wing patch, is very conspicuous, especially when in flight. It is here in large numbers and flocks of up to 50 birds have been reported on two occasions as descending on feeding stations, once on eastern Long Island, and once in eastern Connecticut. Despite their tropical origin, Canary-winged Parakeets have managed to survive at least one northern winter—thanks to feeders and fruiting trees and shrubs.

(3) Orange-chinned Parakeet (*Brotogeris jugularis*).—called "Tovi Parakeet" in the trade; tropical zone from southern Mexico to northern South America; still smaller, seven inches; *short* pointed tail; mostly greenish with orange chin; wing-coverts brown. Although imported in considerable numbers, relatively few of these birds have escaped.

(4) Orange-fronted Parakeet (*Aratinga canicularis*).—called "Half-moon" in the trade; tropical Middle America from Mexico to Costa Rica; ten inches; long pointed tail; all green with a narrow reddish-orange crescent-shaped band on forehead; wings and tail dark blue. Imported in very large numbers, but relatively few have been reported hereabouts.

(5) Yellow-headed Parrot or Amazon (*Amazona ochrocephala*).—called "Double Yellow-head" in the trade; tropical America; a large parrot. 16 inches in length, with a *short* blunt tail; green, and depending on the subspecies, varying amounts of yellow on the head—from an all yellow head to yellow restricted on crown, forehead, or nape; wings blue with red patches—one at base of primaries, the other at bend of wing. A few have escaped and two even survived the northern winter by feeding on crabapples!

(6) Black-hooded Parakeet (*Nandayus nenday*).—called "Nenday" in the trade; southern South America; 13 inches, with long pointed tail, mostly green with a conspicuous *black* head and bill; primaries bluish-black. Has escaped into portions of northern New Jersey where it has been reported as "attempting to nest"!!

(7) Budgerigar (*Melopsittacus undulatus*).—called "Budgie," "Shell Parakeet," or "Lovebird" in the trade; most of Australia; as the familiar "Budgie" is known to almost everyone a detailed description is scarcely needed; seven inches; long pointed tail; colors may be green (wild population), blue, or yellow; barred black and white on head and upper back. Frequently escapes from captivity, but rarely, if ever, survives

our harsh winters. Not known to visit feeders—at least regularly—which may be the reason it does not survive.

(8) Masked Lovebird (*Agapornis personata*).—tropical East Africa; not imported in large numbers, but reported now and then in city parks. Very small, only five inches; *short*, squarish tail; bill bright red; head blackish with conspicuous yellow eye-ring; neck and breast yellow; rest of plumage green.

(9) Rose-ringed Parakeet (*Psittacula krameri*).—called "Ring-necked Parakeet" in the trade, but several species of this genus possess neck rings; tropical and subtropical Africa and southern Asia; 15 inches; long pointed tail; heavy red bill; mainly greenish, with throat and fore-collar black; hind-collar pinkish. Imported in small numbers, but has been reported in this vicinity as having escaped on a number of occasions.

(10) Blossom-headed Parakeet (*Psittacula cyanocephala*).—"Blossom-head" in the trade; tropical southeast Asia west to India and Ceylon; 15 inches; long pointed tail, blue with white tips; head red with purple bloom; narrow black collar; throat black; otherwise generally greenish with small chestnut patch on bend of wing. A very beautiful species. Reported in small numbers in the "wild," although not infrequent in captivity.

(11) Cockatiel (*Nymphicus hollandicus*).—most of Australia; 13 inches; *crested*; tail long and pointed—white; generally *gray* with long white wing patch; face yellow with orange cheek patch; female similar, but duller. This is the only species of the 11 enumerated here with a conspicuous crest. Although a common species in captivity, very few have escaped. It is very dubious if they would survive for long.

PART II. MONK PARAKEET

Within the past few years in the greater New York metropolitan region, numerous reports of green parrot-like birds have come into the American Museum's bird department. Investigation has shown that the great majority of these reports were Monk Parakeets from South America where thousands are exported yearly. They have since become established locally in the northeastern United States, have nested here, and even raised young.

The Monk Parakeet (*Myiopsitta monachus*) occurs in the subtropical and temperate zones of South America from the southern portions of Bolivia and Brazil, Paraguay and Uruguay, to central Argentina, in the last-named country south at least to Rio Negro province to approximately 40 degrees south latitude. The species is virtually sedentary. It is the sole representative of its genus.

The principal habitats of these birds in their native land are areas of low rainfall in light open forest, savanna, palm groves, thorn scrub, croplands, and fruit orchards. The species is hardy and cold-adapted—minimum temperature records in the central Argentine being as low as 20 degrees Fahrenheit, but usually from 50 to 90 degrees. These birds are found chiefly in the lowlands, rarely up to 3000 feet in the Andean foothills.

The sexes are alike in the Monk Parakeet. It is a stocky bird with thick-set head, broad, hooked bill, and long pointed tail. The overall length is about eleven inches. In color it is chiefly bright grass green. The forehead, cheeks, throat, and breast are light gray. The wings, especially the primaries, are dark blue. The tail is bluish-green, the bill pinkish-cinnamon, the small eyes black, and the legs and feet gray.

This species has various harsh and raucous chattering notes. It can imitate whistles, but generally is a poor talker with little repertoire. It is "friendly and intelligent" in captivity, and can be taught to feed from the hand if raised from the nest; thus it is a tame and confiding pet, and attractive as well.

Monk Parakeets are generally gregarious, occurring in loose flocks of up to a dozen or more. These birds are very fast flyers, moving at no great distance above ground, usually in a direct line of flight from nest to the feeding area and back again. Although relatively tame around the nest, these birds are ordinarily wild and shy at other times.

The Monk Parakeet is unique among the more than 330 parrot species, in being the only stick-nesting member of the family, and one of the few communal breeders in this widespread group. All others are hole or cavity nesters. In their native lands Monk Parakeets build huge stick nests in trees, occasionally on telephone poles. These stick nests are domed, sometimes as much as eight feet in diameter—enough to fill several bushel baskets. Twigs or sticks one-half inch or more in diameter and a foot long are often used, sometimes covered with thorns. Up to a dozen pairs breed in each nest, although two (once as many as six) pairs seem to be the maximum here. Entrance holes are at the side or bottom and each pair has a separate entrance, as well as a separate chamber within the huge structure. These nests are used for both roosting and breeding and are continually under repair throughout the year.

These parrots lay from five to eight glossy white eggs which are relatively small for the size of the bird. The eggs are laid in the chambers some distance from the entrance holes. In some of the largest nests in South America, other animals have been found, such as tree-ducks (*Dendrocygna*) and arboreal opossums, occasionally storks.

Monk Parakeets have a very varied and highly omnivorous diet: fruits—both wild and cultivated—nuts, grass seeds, grains, legumes such as acacia and mimosa pods, insects and, when available at northern feeding stations, meats and suet. I have also seen these birds cracking open pine cones to get at the seeds, as well as stripping foxtail grass seeds off the heads.

During 1968 alone nearly 12,000 Monk Parakeets were imported into the United States, according to government sources. With few or no restrictions on psittacine birds, thousands more came into American ports within the past three years (since 1970). As the species is abundant, the sales price is low. These birds are sold for as little as eight dollars apiece retail in pet shops and department stores. The pet trade and aviculturists know this species by the name of Quaker or Gray-breasted Parakeet. "Monk" and "Quaker" are obvious references to the bird's gray hood-like dress. Multiple releases by design and by accident have resulted in a sizable resident population in southeastern New York, and the adjacent portions of Connecticut and New Jersey. These releases, that is escaped birds, came from broken crates at Kennedy Airport, accidental escapes from pet shops, aviaries, and private owners, as well as intentional releases by persons tired of caring for these parrots. They survived at least two cold and snowy winters by visiting well-stocked feeding stations and have constructed their now-familiar bulky stick nests in a number of localities.

These ubiquitous birds have attached nests to various man-made structures, in addition to the more usual natural vegetation as found in their native South American home.

Regarding the latter category nests have been placed in various broad-leaved deciduous trees, in a cavity-like opening in the broken-off top of a Paulownia tree, and only seven feet above ground in a tangle of pussy willow and rose bush.

There are also at least two nests in evergreens—one in a small pine tree, the other in an ornamental spruce.

In the "man-made" category these adaptable birds have shown an amazing versatility of nest sites. Nests have been attached to both wooden and brick buildings, usually under the eaves; on unused window ledges; between walls and rain gutters; in one instance, under the peak of a house roof atop an air-conditioner fronting on a small dormer window;

on a school fire-escape landing; and finally between a house window and a broken screen left ajar. Transformer boxes on telephone and light poles are favored also.

Some rather odd locations have been: on a steel beam of the club house at the south end of the grandstand at Aqueduct race track in Queens, Long Island; in a smashed glass globe of a floodlight used to illuminate Cleopatra's Needle behind the Metropolitan Museum of Art in New York City's Central Park; on an abandoned metal crane on Riker's Island in the East River between the Bronx and Queens; and last but not least—nearly 100 feet up on the steel platform of a United States Coast Guard microwave tower at Fort Tilden, Rockaway Beach, Long Island!

The Monk Parakeet has bred also in the outdoor enclosures of the Bronx, London, and Paris zoos, and in the wild in the city parks of Amsterdam, Holland.

Actual *successful* breeding in North America in the wild (fledged young) has been reported on very few occasions—including one young offspring in captivity in the writer's house—especially tame and confiding towards the writer's wife, feeding from her hand, and also a record of a young bird from Staten Island.

This attractive species, unlike the drab Starling and House Sparrow, makes a good pet, but unfortunately like them, may also become a pest. The Monk Parakeet is reported to be a serious menace to agricultural crops in the Argentine, especially to corn, millet, rice, and sorghum, and to citrus fruits. Despite bounties being paid out, control of the birds has been unsuccessful.

Although damage to fruit and grain crops in the north might be only moderate or even minimal, it would likely be another story in parts of the south or southwest where these birds would be sure to thrive. Be that as it may, it appears to be fairly well established in portions of the northeast, if only very local.

Monk Parakeets have proved hardy birds, as they survived two consecutive very cold winters, snowbound in some areas; usually more severe here than in a similar latitude south of the equator. As long as a ready-made food supply is at hand, these adaptable birds are able to thrive. Many feeding station operators, including bored housewives, see to it that their "favorites" come through with bountiful handouts—proof that food, not temperature is the main survival factor.

To date, I have heard of no protests about depredations from landowners, gardeners, farmers, or fruit growers. The next few years may tell a different story, but in the meantime these interesting birds are here to stay and for the time appear to be prospering.

It would be desirable to continue the ban on further importations of these and other parrots, with the exception of stock for accredited zoos and aviaries under import license. At the same time it would alleviate pressure on other species which are rare and in great need of protection.

Since writing the above, this ban was removed.

DEPARTMENT OF ORNITHOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK, NEW YORK 10024.

FERAL EXOTIC BIRDS IN SOUTHERN CALIFORNIA

JOHN WILLIAM HARDY

Southern California from the Pacific Ocean coastline to the base of the major mountain ranges, northward to Santa Barbara, southward to San Diego, and eastward to the Salton Sea near the western edge of the Colorado Desert has a year-round mild climate and an abundant exotic arboreal flora. There is also a large human population. These factors encourage aviculture; exotic birds of tropical origin are imported by the thousands annually; zoos are plentiful, pet shops possibly as common as anywhere in the world, and private aviculture, especially among members of the large leisure class, an elaborate avocation. The climate allows tropical species to live in outdoor situations throughout the year. The exotic trees include many fruiting forms that together with native species sustain feral, especially frugivorous, birds when they escape or are accidentally released.

This summary report considers species which have not reached California by natural immigration, thus excluding the House Sparrow (*Passer domesticus*) and the Starling (*Sturnus vulgaris*) and those which have been introduced as game birds, thus excluding the Chukar Partridge (*Alectoris chukar*) and the Ring-necked Pheasant (*Phasianus colchicus*). The paper also excludes comment on numerous scattered reports of individuals of many species and of occasional observations of two individuals together not observed more than once. The report mainly concerns present status of the species in question, but where reasonably good evidence exists a brief account is made of the history of certain species.

THE PROBLEM OF EXOTIC BIRDS IN SOUTHERN CALIFORNIA

The major problems potential in introduced species of birds in this area are common to all areas where escapees can survive and thrive: the birds may prove to be agricultural pests, they may carry disease transmissible to human beings or to other avian species, and they may prove harmfully competitive to native forms either as regards food or nesting space. Fortunately at this time, no exotic feral species appears to be operating seriously in any of the above ways in southern California. The epidemic of Newcastle Disease in poultry could conceivably have been brought about through feral exotic birds as the vector, but the evidence for this is still limited. The Riverside Newcastle Disease Headquarters unpublished report of 2 February 1973 gives the following positive Newcastle isolations from pet trade birds in California: Budgerigar (*Melopsittacus undulatus*) 6; Cockateils (*Nymphicus hollandicus*) 5; Orange-fronted Parakeet (*Aratinga canicularis*) 1; Canary-winged Parakeet (*Brotogeris versicolurus*) 1; and Finsch's Parakeet (*Aratinga finschi*) 1. In wild birds, one House Sparrow, out of a sample of 1800, and one Common Crow (*Corvus brachyrhynchos*) have been positive. No careful studies have been conducted on any exotic bird species in southern California; hence the limited nature of this report. Such in-depth studies are highly desirable, and it is hoped that in the near future they will be conducted.

The evolutionist and ecologist both could find rich problems for study here, since the firmly established exotics constitute populations isolated from the parental ones under peculiar environmental circumstances. The Chinese Spotted Dove (*Streptopelia chinensis*) and the Cardinal (*Cardinalis cardinalis*) might prove especially worthwhile subjects for such study.

SPECIES ACCOUNT

Common Peafowl (*Pavo cristatus*).—This species, native to India, is widely kept as a decorative bird in botanic gardens, zoos, and on private estates. In the area of Palos Verdes Estates, Rolling Hills, and Portuguese Bend there is a feral population of an estimated 20 to 30 adults (Richard Bradley, pers. comm.) plus an undetermined number of sub-adult birds. These have apparently wandered from or were released from captive flocks that were introduced in the 1920's (Wells, pers. comm.). There is no documentation of how long ago this may have occurred. No nests have been reported, but young recently out of the nest have been observed (Wells, pers. comm.). The above two observers report the birds to be thoroughly wild and completely independent of man for food. Wells has noted that they roost in pines.

Rock Dove (*Columba livia*).—Principal reference works dealing specifically with California ornithology (Grinnell, 1915; Willett, 1933; Grinnell and Miller, 1944) have unaccountably ignored this species. It has long been widely distributed and very common in southern California, especially around city buildings but also in suburban and rural situations. Occasionally it nests on cliffs (e.g. earthern coastal bluffs at Santa Monica), but otherwise on man-made structures. It breeds in all seasons. The population seems stable.

Chinese Spotted Dove (*Streptopelia c. chinensis*).—Common to abundant resident in coastal southern California, this species was apparently intentionally introduced, although exact documentation is lacking. According to Willett (1933), this species was first recorded in Los Angeles in 1917 and was common in much of the Los Angeles basin by 1923. By 1933 it had reached suburban areas (Santa Monica, Pasadena, Alhambra). At present its population and range appear stable and the species is known from as far north as Santa Barbara, as far south as San Diego, and inland to the Salton Sea (fide, Robert Copper, pers. observ.). Eastward its occurrence seems restricted by the deserts and the species' requirement of large trees, especially eucalyptus. In its optimal suburban habitat it seems to outnumber the Mourning Dove (*Zenaidura macroura*). There is no evidence that it competes with the latter species. Reproduction begins in early spring (February) as evidenced by increased singing and courtship. Breeding activity is prevalent from March at least through May. Willett (1933) mentions two May breeding dates—a full-grown young on 9 May and two eggs on 1 May.

Ringed Turtle Dove (*Streptopelia risoria*).—This species is common as a reproducing resident population in parks of the urban center of Los Angeles since the late 1920's (Willett, 1933) (e.g. Pershing Square, grounds of the Central Library, and trees along Olvera Street). The population, which may number several hundred birds, is apparently stable, although no careful censuses have been conducted. There are frequent observations of pairs or individuals of this dove in surrounding suburban areas and even in rural localities where birds occasionally come to feeding stations. These birds could be stragglers from the central Los Angeles population but may just as easily represent escaped or released birds from pet shops or private aviaries in which the dove is common. The reproductive season is protracted over spring and summer months, possibly at other times.

Black-hooded Parakeet (*Nandayus nenday*).—This South American species has been observed for several years in Loma Linda, San Bernardino County. State Department of Agriculture Biologist Lewis Davis confirmed their identity and found four individuals, as stated in his unpublished report dated 19 January 1973 which he has graciously allowed me to cite. Local residents reported to him that two adult birds had been released in

1968 and that they had subsequently been seen with one and then four additional birds thought to be their offspring. No further evidence of breeding of this species exists.

Canary-winged Parakeet (*Brotogeris versicolurus*).—This species is common locally and at this time confined to the Palos Verdes Peninsula and its vicinity. Several observers, including Grace Nixon and Shirley Wells (pers. comm.) have reported a flock of perhaps 30 individuals of this small South American parrot inhabiting the area of Point Fermin, on the coast in San Pedro, California. Averill Park area there is the center of another flock's known activities and Wells (pers. comm.) has indirect evidence that a gardener pruning dead fronds of a palm tree, uncovered a young bird from a nest of this species. The birds have been reported to me (Lewis R. Davis, pers. comm.) to be feeding on the fruit of the exotic trees, Avocado (*Persea americana*), Primrose Tree (*Laguneria pattersoni*) and Rusty-leaf Fig (*Ficus rubiginosus*) as well as the buds of orange trees (*Citrus*). A total of 41 was counted on the Audubon Society Christmas Census, 18 December 1972. Another flock of *B. versicolorus* numbering 10–12 birds was reported by Mrs. R. J. Seaquist from Pedley, Riverside County, California, in 1971 (Lewis Davis, pers. comm.). Seemingly this group of birds has been nearly or quite extirpated through largely unknown causes. State agricultural agents found only two birds from 10 to 12 January 1972. Both birds were shot for examination with regard to Newcastle Disease, for which they proved negative. There is no evidence of breeding at this time but the flock at Point Fermin apparently has been of stable numbers for two to three years. This species is common in pet shops in the area.

Yellow-headed Parrot (*Amazona ochrocephala*).—Locally fairly common at all seasons, this widespread neotropical parrot is found in flocks of from two or three to an estimated 30 individuals. It is clear that these birds are wide-ranging, merely from observations of individuals flying at great heights completely out of sight of an observer. Yet, it is also clear that groups of these birds can be found consistently in given areas over periods of several years. A flock varying in size from 2 to about 20 birds has for about a decade regularly inhabited the area on either side of Orange Grove Boulevard within a few square miles of the intersection of that thoroughfare with El Molino Avenue in Pasadena, California. I have personally observed some of these birds as recently as May, 1972 (flock of four). Mr. Lee Arbold noted approximately 30 Yellow-heads in fall, 1970, in Alhambra as reported by David Larsen in the *Los Angeles Times* newspaper for 6 December 1970. Larsen quotes another observer as having been aware of the parrots there for four years. According to Larsen, Mr. Arbold further observed that the birds are attracted to nut trees (sp.?). The presence of many exotic species of fruit bearing trees in the area undoubtedly is a major factor in the survival of this parrot in the Los Angeles basin. Thomas Weber (pers. comm.) notes that a flock of four regularly fed on walnuts (*Juglans regia*) in suburban Glendale in 1970 and 1971. Dr. Kenneth Stager (Larsen, op. cit.) of the Los Angeles County Museum, notes the fondness of the birds for tangerines (*Citrus*) in his backyard trees. James Johnson (pers. comm.) reports that these parrots have been noted eating oranges (*Citrus*), also, wasting the fruit to get at the seeds. They have also been seen chewing on the bark of Camphor trees (*Cinnamomum camphorum*).

There is to my knowledge no hard evidence of Yellow-headed Parrots breeding in southern California. No nest has been found. A number of persons have made observations of apparently young (green-headed) individuals in flocks, suggesting breeding. My observations indicate that crevices in the dead frond accumulations on palm trees so widely planted around the city are likely nest sites. Two adult and one subadult Yellow-head that I observed several times in spring, 1962, near Pepperdine College, south Los Angeles, climbed about on these dead frond structures and went in and out of natural crevices in these accumulations. My studies of nesting of parrots (*Aratinga canicularis*) in captivity and in the wild (Hardy, 1963) lead me to predict that more than circumstantial evidence of the Yellow-headed Parrot breeding in California will be difficult to obtain without concerted search. Cavity nesting parrots of this and related genera (*Brotogeris* and *Aratinga*) are seemingly not only secretive but very inactive around the nest. They feed young by regurgitation a few times a day, spend long hours away from the nest cavity and in it, and the young finally emerge from the nest in practically fully plumaged condition, strongly resembling adults in general appearance (although not color in *A. ochrocephala*). Since the feeding (by regurgitation) of one bird by another is not restricted to adults feeding young, such behavior cannot be used as evidence of breeding. Only the discovery of an adult incubating fertile eggs or caring for young in the nest will suffice.

Areas of what seem to be concentrations of the birds could merely reflect presence of observers who have reported them. However, these areas are: north Pasadena (along Orange-Grove Boulevard), Alhambra, Westwood, west Los Angeles, Lomita, and San Bernardino. Other observations come from Brentwood, Glendale, Altadena, Glendora, Ontario, and Pomona.

The source of these parrots is undoubtedly only accidental escape or intentional release. The Bel-Air district fire of 1961 may have caused the accidental release of parrots that now compose the west Los Angeles group. The fire certainly ravaged many residences where elaborate avicultural activities were a common avocation. Mr. Don Bleitz (pers. comm.) recalls that Mr. Ray Thomas, now deceased, a resident of that district at the time of the fire who maintained large aviaries, informed him of a neighboring aviculturist who opened all his cages about an hour before his home was destroyed by the blaze, releasing large numbers of birds, including many psittacids. A few days later, Bleitz and Thomas observed a flock of Yellow-heads flying about the area where none had been observed prior to the fire. In fact, Bleitz told me (24 January 1973) that he succeeded in trapping one of the birds. Almost all pet shops that sell birds have one to several Yellow-heads. Among the larger psittacids it is by far the commonest species available. Further, it is a rather unpleasant pet, loud-voiced and destructive of woodwork, ill-tempered, and even dangerous to handle. These factors probably promote its release and escape to feral existence. These comments, of course, apply in varying degree to all *Amazona* parrots considered below.

Red-crowned Parrot (*Amazona viridigenalis*).—Very rare, and very local. Consistent observations of two adults of this species (although not definitely the same two each time) in north Pasadena near Orange Grove Boulevard, were made in 1963. I observed two adults near Orange Grove Boulevard and El Molino Avenue in autumn, 1963. These birds were associated with a flock of six *A. ochrocephala* but in flight kept a slight distance as a pair from the aggregation of the other species. Red-crowned Parrots are easily identified by their characteristic vocalization—a combination of upwardly inflected whistles and crow-like cawing.

There is no evidence of breeding of this species in the Los Angeles area and no evidence that more than a few birds are involved in the sightings. However, the species is fairly common in pet shops and has a potential for colonization in the area equal to that of *A. ochrocephala* (see).

Yellow-cheeked Parrot (*Amazona autumnalis*).—Native to tropical eastern Mexico south into the Caribbean lowlands of Central America, this species is known in southern California only from observations over a period of four to five years in downtown San Bernardino, California. Two of this species along with four *A. ochrocephala* form a flock that currently (January, 1973) can be found there. James Johnson (pers. comm.) took photographs which confirm the specific identification of these birds. The species is not common in pet shops locally or in aviculture, but these sources remain the most likely for the feral birds.

Rose-ringed Parakeet (*Psittacula krameri*).—A small group of this species formerly inhabited and probably bred in the Highland Park community of Los Angeles but are now thought to be extirpated through unknown causes. A full account of the history of this bird in the feral state was published by me in the Condor (Hardy, 1964).

Budgerigar (*Melopsittacus undulatus*).—This Australian species is widely held in captivity and infrequently escaped individuals are noted. Don Bleitz (pers. comm.) assures me that a noisy active colony of these birds existed for a period of several years in lower Topanga Canyon about one mile inland from the Pacific Ocean beach at Malibu, California. According to his personal observation the birds were inhabiting natural cavities in Sycamore trees (*Platanus racemosa*) along the arroyo. No evidence of breeding is available, and I have not ascertained whether or not the colony still exists.[1]

Red-whiskered Bulbul (*Pyncnonotus jocosus*).—This Indo-Malaysian species, though widely held in captivity locally, and noted frequently as an escapee, has not become widely established, as yet. I have been privileged by James Johnson to use the following information on bulbuls from his unpublished MS on exotic birds. There is an active program to collect feral individuals to preclude such establishment. As of 20 January 1972, 47 specimens had been taken in southern California by the Los Angeles County Department of Agriculture. A small population of bulbuls has attained a tentative foothold in the Los Angeles County Arboretum (Arcadia) and in the Huntington Garden. According to Johnson, juvenile birds have been taken at the Arboretum and are now in the Los Angeles County Museum. The birds seem to concentrate around natural ponds or swimming pools (southern California is superb habitat in this regard!) when there is dense vegetation nearby. A nest thought to be of this species was found 25 feet up in an oak tree (*Quercus* sp.) overhanging an artificial fish pond in San Marino (near Huntington Gardens). Another suspected nest of the bulbul was collected nearby from 4 feet up in a "juniper" tree, species unknown, 10 ft. from a swimming pool. An observer had noted bulbuls hovering over the pool and entering the "juniper." I emphasize that neither of these nests has been positively identified as belonging to bulbuls and there exists no less circumstantial evidence than these and the juvenile birds for the breeding of the species in southern California. Bulbuls at the Arboretum were noted by Robert Copper, an employee there, to feed on the fruit of the Paperbark Mulberry (*Broussonetia papyrifera*) (Robert Copper, pers. comm.)

Orange-cheeked Waxbill (*Estrilda melpoda*).—Native to central and west Africa, the species is rare and local in southern California, where it is known only from Averill Park and (occasionally) nearby Peck Park in San Pedro. A loose flock of 15–20 has been consistently observed. Mrs. Shirley Wells (pers. comm.) first noted the birds in 1965 and has made observations yearly into 1972. In April, 1968, she reports that Mr. and Mrs. Harold Baxter of Arcadia, California made the only discovery of any active nests (adults with young), but in October, 1968, Mrs. Wells observed adults feeding a grown juvenile. A marked reduction in the population has occurred in the last two

---

[1] While this report was in press, Robert and Elizabeth Copper reported to me that in their recent intensive investigation of exotic birds in southern California, supported by the California Department of Agriculture, they found and excavated a nest of *Brotogeris versicolurus* with four young at Pt. Fermin and gathered reliable reports that the Monk Parakeet (*Myiopsitta monachus*) has been found nesting in the San Fernando Valley.

years, possibly correlated with removal of much vegetation in Averill Park. In the eight months prior to January, 1973, there were only two reports (Wells, pers. comm.) without details of these birds.

Many species of waxbills are so popular in aviculture that it is surprising that they are not more often seen as escaped birds. There are a few sightings including uncorroborated reports of occasional nestings by other species. Existence of appropriate predators and competition with native seedeaters may provide too much pressure for survival of waxbills in the feral state.

Cardinal (*Cardinalis cardinalis*).—Common, as a small breeding population in riparian thicket on both sides of the San Gabriel River in the Whittier Narrows area (including especially the Nature Preserve of the County of Los Angeles), near South El Monte, California. According to Grinnell and Miller (1944) Cardinals of various races have been repeatedly introduced into southern California beginning in 1880. The present self-sustaining population was first reported by Henderson (1925) and its probably mixed racial origin discussed by Michener and Michener (1938). A brief study of the birds was undertaken by Koay-Chee Lee, a student at Occidental College in spring, 1972. From Lee's studies, the estimated population of breeding birds seemed no more than 20 pairs in a total area comprising approximately 200 acres. The population seems to be stable in recent years. Some movements in and out of the breeding zone have been reported by several observers, but apparent movements may represent varying degrees of secretiveness and vocalization by the birds. Nesting activity begins in April and all nests with eggs have been found in May. The nesting habitat and the habits of the birds bear a strong resemblance to those of the species in the midwestern United States, according to my observations.

Observations of individual Cardinals are annually made elsewhere in the Los Angeles basin, especially in suburban areas adjacent to those occupied by the breeders, suggesting that these sightings represent stragglers from the established population. Cardinals of neotropical races are, however, fairly common in aviculture locally and these may contribute local feral birds to the observations.

ACKNOWLEDGMENTS

I am grateful to the following persons in California for allowing me to use information in their possession: James L. Johnson, Biologist in charge of Exclusion and Detection, Division of Plant Industry, California Department of Agriculture, Carpinteria; Lewis R. Davis, Biologist with the same agency, Riverside; Shirley Wells and Grace Nixon, Palos Verdes; Richard Bradley, Palos Verdes Estates; Thomas Weber, Glendale; Robert Copper, Azusa; and Don Bleitz, Hollywood. Many other persons have donated observations of exotic birds to my files collected over the past decade. These persons are too numerous to mention individually, but their contribution collectively is considerable, and much appreciated.

LITERATURE CITED

Grinnell, J. 1915. A distributional list of the birds of California. Pacific Coast Avifauna, 11:1–217.

Grinnell, J., and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna, 27:1–608.

Hardy, J. W. 1963. Epigamic and reproductive behavior of the Orange-fronted Parakeet. Condor, 65:169–199.

Hardy, J. W. 1964. Ringed Parakeets nesting in Los Angeles, California. Condor, 66: 445–447.

Henderson, H. N. 1925. The Cardinal in southern California. Condor, 27:211.

Michener, H., and J. R. Michener. 1938. Rare birds at a Pasadena banding station. Condor, 40:38–40.

Willett, G. 1933. A revised list of the birds of southwestern California. Pacific Coast Avifauna, 21:1–204.

MOORE LABORATORY OF ZOOLOGY, OCCIDENTAL COLLEGE, LOS ANGELES, CALIFORNIA. (PRESENT ADDRESS, FLORIDA STATE MUSEUM, UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA 32601.)

SMITHSONIAN INSTITUTION-PEACE CORPS ENVIRONMENTAL PROGRAM

During the past two years, since the inception of the Smithsonian Institution-Peace Corps Environmental Program, there has been a significant increase in the number of Peace Corps Volunteers requested by developing countries for assignment to projects dealing with environmental problems. A large share of this increase has occurred in the fields of natural resource conservation and ecological research.

To date there are several hundred Peace Corps Volunteers assigned to environmental projects in over forty countries, and many of those hold Masters or Ph.D. degrees. The skills represented by these Volunteers include biology, botany, ecology, conservation education, sanitary engineering, soil science, geology, hydrology, range management, silviculture, entomology, limnology, marine biology, wildlife biology, as well as other related disciplines. In these individual assignments, Volunteers are working directly with a host government program or are attached to a scientific or conservation organization assisting the host country. Most of the assignments provide opportunities for field work while others are mainly teaching or administrative positions.

Mr. Robert K. Poole and Dr. James A. Sherburne of The Office of Ecology at the Smithsonian Institution, Washington, D.C., 20560 are coordinating the Smithsonian Institution-Peace Corps Environmental Program.

The emphasis of the Smithsonian Institution-Peace Corps Environmental Program has been directed toward assisting overseas countries in the development of environmentally related projects. The selection and placement of qualified Volunteers for assignments to these projects is an equally important aspect of the program. To do this, the Smithsonian program staff members work directly with host-country institutions, scientific or conservation organizations, and with Peace Corps staff overseas. Problem areas are identified and determinations of the requisite skills for individual assignments are made. The descriptions of assignments are then circulated to universities, scientific organizations, and appropriate publications in the U.S. Applicants responding to these distributions are evaluated and matched with appropriate assignments by the program staff, and are processed by the U.S. Peace Corps. Background information for each applicant is circulated overseas to assist the host countries in their requests for individuals.

ORNITHOLOGICAL LITERATURE

The Behavior of Spotted Antbirds. By Edwin O. Willis. Ornithological Monographs, No. 10, American Ornithologists' Union, 1972: 6¾ × 10 in., vi + 162 pp., 3 col. pl., 27 text figs., paper cover. $6.00.

Interspecific flocking by birds within tropical forests takes a number of different forms. Characteristic of tropical forests are the flocks that follow raids of army ants. Other flocks, composed of different species, wander through the forest without obvious association with local concentrations of food. Willis's studies over the last decade and a half have generated most of our current knowledge of the Neotropical ant-following species. In the present monograph he gives us a thorough account, based on a 12-year study on Barro Colorado Island, of a species that joins both kinds of flocks.

This report includes detailed descriptions of the Spotted Antbird's behavior patterns, breeding biology, and foraging techniques and, at the end of each chapter, point by point discussion of selection pressures that might bear on their evolution.

In comparison with the Bicolored Antbird (*Gymnopithys bicolor*) (Willis, Univ. California Publ. Zool., 79:1–132, 1967), the smaller Spotted Antbird (*Hylophylax naevioides*) is more distinctly territorial and more facultative in its ant-following. It forages only about 50 percent of the time in association with army-ant raids. The species also associates regularly, but evidently not commonly, with the small mixed-species flocks that form around White-flanked Antwrens (*Myrmotherula axillaris*) in the middle and lower layers of the forest. The greater sexual dimorphism and the more pronounced territoriality among Spotted Antbirds, in comparison with the Bicolored Antbird, are related to this lesser dependence on ant raids for food.

Territories in this species, much as Willis has described earlier for the Bicolored Antbird (Willis, op. cit.), emerge as areas of dominance. Away from their territories, birds become subordinate in encounters with birds still on their territories. Spotted Antbirds differ from the larger species in directing their aggression primarily toward members of the same sex, a difference related to this species' obvious sexual dichromatism. Unless her mate is nearby, a resident female, even well within her mate's territory, usually cannot dominate an intruding male. Spotted Antbirds, again in comparison with Bicolors, leave their territories less often in order to locate ant raids and more successfully expel intruders. The present report, however, actually makes little advance over Willis' 1967 monograph in quantitative description of a resident's movements or changes in dominance relations across territorial boundaries.

Changes in foraging behavior owing to interspecific aggression in mixed flocks have received Willis's attention earlier (notably Ecology, 47:667–672, 1966), and he presents some data along these lines for the Spotted Antbird as well. This species, considerably smaller than either the Bicolored Antbird or the rarer Streak-chested Antpitta (*Grallaria perspicillata*), is expelled from the prime sites at the head of the column of raiding ants and must accept higher or more remote perches on the average. Especially telling are measurements of the intervals between prey capture attempts. For birds foraging over ant raids in the absence of competing larger birds, the average interval approximates 30 seconds (evidently somewhat shorter over swarms of *Labidus praedator* than over *Eciton burchelli*, although the statistical significance of this difference is not tested). Birds foraging away from ant swarms average about 110 seconds between prey capture attempts. The considerable advantage to foraging over army ants is evidently reduced when competitors are present, but Willis does not present measurements for this crucial case. Throughout the discussions of foraging behavior I would have liked more thorough evaluations of his sampling techniques.

Those mixed-species flocks not associated with army ants receive extended treatment, although the Spotted Antbird is not a major constituent of these flocks. Willis restricts his discussion to the small flocks of insectivorous birds within the forest, of which he recognizes two types on Barro Colorado Island: those formed around antwrens in the middle levels of the forest; and those formed around greenlets (*Hylophilus*) in the canopy. Willis makes two contributions by systematizing possible selection pressures acting on the flocking habit and by clarifying the involved nomenclature used to classify the roles that different species play in mixed-species flocks. Although no quantitative measurements of behavior were attempted, Willis concludes that other species are attracted to small family groups of White-flanked Antwrens. He proposes that, in other cases as well, conspecific groups might form the basis for interspecific flocks.

The detailed descriptions and itemized discussions often make it difficult to persevere in reading this monograph, and they hinder an integrated view of the antbird's ecology and behavior. The insights are there, however, for those who do persevere.—R. HAVEN WILEY.

THE SWANS. By Peter Scott and The Wildfowl Trust. Michael Joseph, London, 1972: 8¼ × 10¼ in., x + 242 pp., col. frontis. by Scott, many drawings and photos. £4.20. Obtainable from Southern Booksellers and Publishing Co., 35 Woodland Vale Road, St. Leonards-on-Sea, Sussex, Great Britain.

Man's interest in swans is very ancient. It is therefore surprising that very little factual information has been generally available about these conspicuous birds. If an information gap once existed, it does no longer. Peter Scott and a galaxy of specialists have filled the void—admirably—with "The Swans."

Peter Scott infects readers with his own enthusiasm for swans in the very first chapter. Perceptive remarks on every species flow from his rich, worldwide collection of experiences. His account of identifying individual Bewick's Swans from "billprints" is particularly fascinating. The first wild Bewick's Swan visited the Wildfowl Trust sanctuary at Slimbridge, England in the winter of 1948. By the early 1960's about 20 were coming regularly. In 1964 Peter Scott and his associates realized that these birds could be recognized individually by the variations of the yellow and black bill patterns "like finger-prints but much more obvious," which enabled them to identify and name each bird. Wintering Bewick's Swans—and the capability of identifying them—continued to increase rapidly at Slimbridge during the next few years. Sketches and photographs of bill pattern, information on social and family background, and dates of arrival and departure were combined in hundreds of dossiers covering the total wintering population. By 1968–69 only Mary Evans and Peter Scott's daughter, Dafila, could recognize all individuals. By 1970–71, the eighth year of the study, an astonishing 1,315 individuals had been named! Thus it was that the world's only wild swan genealogical research project was built out of exploited opportunity. Durable pair-bonds and long lives make such records especially valuable to students of population structure and behavior.

The rest of the book maintains the high level of reporting set by the introductory chapter. Hugh Boyd provides a lively and informative discussion of nomenclature and classification of the world's eight species of swans. There follows a succinct chapter by M. A. Ogilvie on distribution, numbers, and migration; Ogilvie not only lays broad foundations for each species, but adds much interesting and important historical information.

Myrfyn Owen and Janet Kear in the third chapter discuss food and feeding habits, bringing out similarities and differences among the species of swans for the first time. Comments and suggestions on keeping swans in captivity, helpful to budding swan-keepers, conclude this broad-brush account.

Twenty-two interrelated topics are treated in Janet Kear's account of reproduction and family life of swans, the longest and most explicit chapter in the book. Comparative information on such topics as pairing, territorial traits, breeding, and cygnets is presented. Genetic charting of sex-linked color inheritance in Mute Swan cygnets is especially interesting, clearing up a point that has long puzzled me.

J. V. Beer and M. A. Ogilvie present a chapter on causes of mortality in swans, explaining that the principal cause of death in some species (in the absence of shooting) is accidents. For example, of 1050 Mute Swans found dead in Britain over a period of years, 65 percent were involved in collisions, two-thirds with overhead wires. One wonders whether or not natural selection will in time tend to eliminate stocks with such poor forward vision and/or capability for reacting.

No book on swans would be complete without a treatise on the role of swans in mythology and art. Mary Evans and Andrew Dawnay provide a poignant review of the meaning of swans to mankind. Viewed against this account of man's appreciation for things spiritual, Dawnay's next chapter on exploitation of swans and G. V. T. Matthews' following account on conservation tarnish man with a somewhat shabby record. One learns, for example, that in spite of their contribution to the cultural life of mankind, swans still suffer from slaughter, accidental killing, denial of food resources, and usurpation of living space. In New Zealand, where Black Swans have been introduced, vast numbers of eggs are collected and used for feeding race horses, of all things. In the United States, Whistling Swans are legally shot each year for sport.

Summaries at the end of the book should be of great interest to specialists. Much technical information of value to waterfowl biologists is neatly capsuled in nine Appendices. A bibliography of 350 titles is of particular worth to readers who wish to pursue specific interests. Lastly, as one has come to expect from Peter Scott and The Wildfowl Trust, the book is delightfully illustrated with over 200 sketches and photographs.

This attractive and informative volume should be in every ornithologist's library, be it for technical or pleasurable reasons. It is a "must" for lovers of waterfowl.—WINSTON BANKO.

PHYSIOLOGY AND BIOCHEMISTRY OF THE DOMESTIC FOWL. Edited by D. J. Bell and B. M. Freeman. Academic Press, New York, 1972: 6¼ × 9¼ in., in three volumes. Vol. 1, xxii + 1–602 pp. + cxlv index, $33.00. Vol. 2, xxii + 603–1152 pp. + cxlv index, $33.00. Vol. 3, xiv + 1153–1488 pp. + cxlv index, $23.50. Many photos, drawings, and charts.

In the first textbook on avian physiology, written by Paul Sturkie in 1953, the author expressed his hope that publication of such a compilation would stimulate investigations on avian species by experimental physiologists, and serve as reference material for ecologists and ornithologists as well. This new work edited by Bell and Freeman attests to the interest in avian physiology and biochemistry that has grown within just one nation, because it is evident from the writings that most of the contributors possess first-hand knowledge of the subject about which they have written.

These three volumes represent the combined efforts of more than fifty scientists within the United Kingdom (with one exception) to bring together existing knowledge on diverse areas of biological features of the domestic fowl. Their findings, arranged in 62 chapters, make an interesting and readable compendium. This project was no easy task in view of the multiplicity of biological journals in which avian biology articles are published.

The domestic fowl is often ignored by ornithologists, being considered an entity unto itself. The physiology and biochemistry of the fowl, however, are not unique among birds, and they provide a fascinating insight into the functioning of nondomesticated species. Investigators of the physiology and biochemistry of the fowl know that the reverse is also true—nondomestic species give insight into the functioning of the fowl—and this fact is reflected in the writings in this book.

Although these volumes are termed physiology and biochemistry, some of the strongest sections, and a considerable portion of most sections, detail the anatomical structure of the gland, organ, or system under consideration. This is to their credit because a strong understanding of anatomy is imperative for comprehending the physiology. Outstanding coverage of anatomy is displayed, for example, in the chapters on the respiratory system by A. S. King and V. Molony, the kidney by W. G. Siller, the cardiovascular system by A. R. Akester, and the lymphoid system by L. N. Payne. Several of these authors have used electronmicrographs to illustrate ultrastructural features; these photographs are printed with excellent clarity.

The three volumes are divided into categories, although not so indicated. Digestion, respiration, excretion, and metabolism together with nonreproductive endocrinology are discussed in Volume 1. Volume 2 covers the cardiovascular system and blood in considerable detail, and to a lesser extent the integument, nervous system, skeleton, special senses, the liver, and thermoregulation. Volume 3 is entirely devoted to male and female reproduction.

The work is intended for students and investigators of ornithology, comparative physiology or anatomy, and nutritional biochemistry. Considerable background and comprehension of these disciplines are required in order to grasp much of the significance of the scientific data that have been selected and presented.

The authors, almost without exception, call on mammalian literature and in some cases lower vertebrate data to support or contrast the present avian knowledge; therefore these chapters embody truly comparative physiology and biochemistry. For example: "In mammals it seems probable that the pineal may affect oestrus, on the other hand, it apparently does not participate in the 'Zeitgeber' for ovulation in the rat, nor is it required for the photocontrol of egg laying in the fowl."

In Volume 1, the authors go beyond the average textbook and cover such subjects as the pineal gland in considerable detail, rather than in the customary two or three lines. The chapter on prostaglandins calls upon the mammalian literature for the most part but includes present knowledge of avian pharmacological actions of these intriguing substances on the central nervous system, cardiovascular system, and smooth muscle of the intestinal tract. The discussion of the ultimobranchial gland, together with calcitonin secretion, is a welcome feature. The chapter by A. H. Sykes on the formation and composition of urine is outstanding.

The second volume adequately covers the integument, skeleton, nervous system, and muscles. The skeleton and muscles are described from histological, biochemical, and physiological aspects rather than comparative nomenclature. The cardiovascular system, together with blood and its constituents, is commendably presented with many references. The chapter on the general aspects of circulation is, perhaps, too general as compared with the other coverage of the vascular system, where the same information is given with more acceptable avian nomenclature. Extensive coverage (140 pages) is given to blood, its cellular and biochemical components, groups, and coagulation, including immunological and pathological actions. These chapters often point out the differences in biochemical components between whole blood and plasma. Volume Two also has a chapter on special senses, in which vision and hearing are treated adequately, but smell and taste are slighted in details of anatomy and physiology. The treatise on the lymphoid system documents fully yet concisely the anatomical and immunological data on the bursa of Fabricius, thymus, spleen, and other lymphoid tissue. In so doing, the author has performed a considerable task since, as he states, the fowl is often used by immunologists as an experimental animal and model.

Much of the volume on reproduction is devoted to specialized follicular hierarchy and ovulatory and laying cycles which are characteristic of the fowl and vital to its understanding as a domesticated species. Most of the volume, however, will be of interest to ornithologists and other avian biologists. The anatomy of the oviducts, ovaries, and the male reproductive system, and the endocrinology of reproduction and egg biosynthesis possess common features in many avian species.

A few cases of conflicting statements by different authors have slipped past the editors. For example, on page 937 the author states that the half-life of thyroxine in the fowl is 22.5 hours, whereas on page 464 another author indicates the half-life to be 8.3 hours. Errors or contradictions such as this are almost certain to occur, as are a few editorial errors, but they must be seen in perspective as a minor consideration when such a vast amount of technical data is compiled by many authors.

Each volume contains an author index, subject index, and a list of abbreviations for all three volumes. This repetition is of some convenience to readers, but adds 145 pages at the end of each volume. It must be questioned whether or not the entire text could have been combined into two volumes had this procedure been omitted. This, of course, would have eliminated the nice package of all reproduction being in one book. For those teaching courses in reproductive physiology, it is convenient to be able to purchase the third volume alone as a textbook.

This reviewer considers the pooling of previously known facts with pertinent up-to-date information and postulated ideas, together with pointing out areas of research still needing investigation, as constituting an invaluable service. Anyone involved in teaching or research in any aspect of avian biology, whether a veteran or neophyte, should have access to all three of these volumes.—ROBERT K. RINGER.

BORN TO SING. AN INTERPRETATION AND WORLD SURVEY OF BIRD SONG. By Charles Hartshorne. Indiana Univ. Press, Bloomington, Ind., 1973: 6½ × 9½ in., xvi + 304 pp., 10 text figures, 5 pp. of musical scores, and 13 sound spectrograms. $10.00.

The author's objective in this book is to present evidence (from various features of bird song) bearing on the question of whether or not birds express an aesthetic sense in their songs. Bird song is treated globally, for some 5000 species that might be said to "sing," and the author draws upon his experiences and observations in many parts of the world, on recordings, and on the literature. His primary concern is with "songbirds" (Oscines), but he has something to say about the vocalizations of other birds, as well as insects, frogs, and some mammals (particularly gibbons and whales).

The author points out the following features of bird song that bear upon his basic question: (a) bird songs resemble human music acoustically, (b) there is a correlation between the biological need for singing and the degree of musical skill, (c) there is a great deal of singing by birds, especially by the better singers, when there is no immediate or pressing need for it, (d) birds with highly developed songs sing more of the time, (e) birds tend to limit the monotony of their singing, and (f) birds with elaborate songs are imitative.

Much of the book consists of the presentation of facts (and some conjectures) about bird songs that have a bearing on these points: bird song is compared with human music; criteria are proposed for evaluating or rating the singing ability of a bird; relationships are pointed out between singing skill and the amount of singing to certain features of the bird's biology (habitat, territorialism, feeding habits, mating habits, and the like); data are presented to support the author's concept of the monotony-threshold in bird song; and ratings are given (and discussed) for a great many species and groups of birds.

The author's system for rating singing ability in a bird is admittedly subjective, but he believes it is better than none at all. Values from 1 to 9 are given for each of six parameters of song: (1) loudness (apparently entirely subjective, as there is no suggestion about determining decibel values), (2) scope or complexity, (3) continuity (the relation between song length and the length of the silent interval between songs, but it is not clear just how this relationship is converted to a number from 1 to 9), (4) tone (the musical quality of the sounds in the song), (5) organization (aspects of song pattern), and (6) imitativeness (the ability of the bird to reproduce sounds heard—possibly a measure of the role of learning in song acquisition). These ratings are based on territorial song—not on subsong, whisper song, or other types of song. Individual ratings thus consist of six digits (one for each parameter) and a total; for example, the Short-billed Marsh Wren is given the rating 676.362:30 (p. 237), and the Dickcissel 622.121:14 (p. 238).

Many readers (including this reviewer) will disagree with some of the author's ratings of individual species, and they may be somewhat skeptical of them when they find many species given different ratings in different places in the book (e.g., the Mockingbird is rated 899.767:46 on p. 116, 899.677:46 on p. 192, and 999.668:47 on p. 235; and the Wood Thrush is rated 978.994:46 on p. 116, 978.995:47 on p. 194, and 967.995:45 on p. 235). The families given the highest ratings are the Mimidae, Troglodytidae, and Turdidae. The families given low ratings include the Hirundinidae, Corvidae, Paridae, Certhiidae, Sittidae, Bombycillidae, Vireonidae, and Parulidae; one might argue about some of these, especially the Paridae, Vireonidae, and Parulidae. The ratings given a few North American species may be of interest (two numbers indicate different ratings in different places in the book): Hermit Thrush 47–48, Mockingbird 46–47, Wood Thrush 45–47, Western Meadowlark 45, Carolina Wren 44–46, Bachman's Sparrow 45, Cardinal 43, Tufted Titmouse 31, Yellowthroat 29, Parula Warbler 17, Sharp-tailed Sparrow 13, and Henslow's Sparrow 8.

The text figures are principally musical scores and diagrams of songs (most of them using Saunders' system of notation): some additional musical scores are given in one of the appendices, and a few sonagrams (mostly reproduced in black and white) in another. The author admits (p. xi) a deficiency in knowledge of music, and is apparently (to judge from comments on pp. 78–79) not very enthusiastic about sonagrams; the few sonagrams he shows add little to the book. There is a short glossary, two lists of references (one of books and articles, and one of sound recordings), and three indexes (to birds, persons, and topics).

The author is a Professor of Philosophy at the University of Texas, but has studied bird song and bird behavior for over fifty years and is a very capable ornithologist. He does not inject too much of his personal philosophy into this book, but one statement (p. 227) suggests some of his philosophy: "It is a stupendous fact about nature that the territorial disputes of thousands of species are something like artistic contests—song duels. The struggle is mainly musical (counter-singing), not pugilistic. If only human beings could do so well."

This is a very interesting book, and of considerable value to professional and amateur ornithologists because of the information on bird song that it contains. The reader may not agree with some of the author's ratings of birds' singing skill, or with some statments in the book—but he will be impressed by the data presented to support the author's contention: that bird song is a type of music, and that birds may express an aesthetic sense in their songs..—DONALD J. BORROR.

SELECTED AMERICAN GAME BIRDS. By David Hagerbaumer and Sam Lehman. The Caxton Printers, Ltd., Caldwell, Idaho, 1972: 11½ × 10¼ in. xiv (unnumbered) + 26 colorplates, each with preliminary pencil sketch. $30.00.

This elegant collection of colorplates of North American game birds, each accompanied by a page of text, calls to mind an illuminated work from some remote mediaeval monastery, for every word of it—aside from the signature of David A. Maas, whose brief biography of Hagerbaumer appears in the fore part of the book—was hand-lettered by Lehman. The paper is heavy throughout and of a quality needed for good reproduction of the fine watercolor drawings and calligraphic text.

The colorplates are, of course, the book's *raison d'etre.* They convincingly stress habitat—notably those depicting the Ruffed Grouse (Plate 1), Common Snipe (Plate 4), Turkey (Plate 19), Clapper Rail (Plate 20), and American Woodcock (Plate 26). Some come close to being landscapes in which bird figures are incidental. Some are strikingly original in concept, especially that of the Mallards (Plate 22) with its boldly handled, dark, grassy hummock and beautifully delineated trees; the two species of goldeneye (Plate 3) hurtling down through a snow flurry; and the Band-tailed Pigeons (Plate 16) flying above "a burned-over ridge, headed perhaps for some mineral spring or favored feeding area."

Without exception, the pictures are well composed. That of White-fronted Geese (Plate 17) evinces close observation on the part of the artist: most of the geese are coasting in on set wings, but the two in the lead have put on the brakes and are flapping down for a landing. The Green-winged Teal picture (Plate 21) disturbs me a little for the branches from which the leaves are blowing seem to be purely decorative rather than part of a tree. In color the plates are satisfying on the whole, only one of them—that of Eastern Mourning Doves (Plate 25)—having background tints of pink, yellow, and blue that do not look quite natural.

The small bird figures are well drawn, but in most of them there is too much detail. Especially is this true of the widespread wings in the California Quail (Plate 10), the lowest and uppermost of the Black Ducks (Plate 24), and the Blue Grouse at the left (Plate 23). In the Wood Ducks (Plate 2) too much pattern shows. A bird artist is forever plagued by a desire to show all of what he knows to be a bird's beauty. He is unwilling to sacrifice any part of this beauty in the interest of keeping his bird moving. He wants every viewer to know that he, the artist, is familiar with a given species' characters—e.g., the white speculum and rufous lesser coverts of a drake Gadwall's wing or the over-all paleness of a hen Mallard's spread tail—and he forgets that as ducks rush past it is often their shape and behavior, rather than details of color-pattern, that declare which species they are. Hagerbaumer's American Woodcock (Plate 26) suffers badly from over-detail. Carefully inspected, the outermost primaries are not quite as narrow as they should be and the poor bird looks decidedly one-legged. Had it been sketched swiftly in, blurred primaries, short legs and all, the viewer's eye would not have expected, nor looked for, minute detail.

Hagerbaumer's "tricks" fascinate me. Having worked with watercolor since my early teens, I know how he achieved the cloud effect in the upper part of his American Brant picture (Plate 12), but not for the life of me can I say how he "got" the truly exciting *blotchiness* of foliage in the deciduous tree in the foreground of his Blue-winged Teal (Plate 18). The picture looks as if the artist had completely finished the vague background, let that become completely dry—sky, trees, and all—than added the ducks and the tree to the left, daubing the branches with dark brown and spreading these daubs, while still wet, with his fingertips. I am no Sherlock Holmes. I can't find the "incriminating" fingerprints, but something tells me they are there!

The text, which obviously was written for sportsmen, is factual rather than literary. Lehman's hand-lettering is exquisite. The decorative touches at the left of each species account, though sometimes repeated (see Plates 22 and 24), vary enough to look as if they had been hand-colored. Some sentences have been so shortened as to change the intended meaning. Some statements, in themselves correct, follow one another in such a way as to mislead. Thus, under American Widgeon (Plate 11), we find: "A new world duck, they are found throughout the United States. North America is their only breeding place." Readers might surmise from this that *Mareca americana* breeds throughout the United States—and perhaps only in the United States. The "fir" from which the two "heavy-bodied grouse" (Plate 23) have burst must have been outside the picture, for the tree they seem to have left is not a fir but a pine.

For me the least satisfactory species account is that accompanying Plate 9. Here the Blue Goose is called "a color phase" of the Snow Goose and the writeup as a whole makes clear that Lehman has read widely, yet his use of the two scientific names contradicts his statement concerning conspecificity. Advice from a seasoned taxonomist might have helped both author and publisher.

Incidentally, as one who has long been deeply interested in the "blue-snow complex"—and loathe to agree that the two forms may actually be one—I suggest that the common name for *Chen (Anser) caerulescens* from now on be Blue Goose rather than Snow Goose, whether or not the white phase be considered more common or more widespread than the blue. This is partly because the name *caerulescens* connotes blueness and has priority, but it is also because it is unscientific to think of the blue as being a phase of the white when no one can say which phase came first or which will eventually win out. Would it not be interesting—in view of all the argument that has continued, now, literally for decades—if the whites and the blues eventually proved to be separate "species," or if the blues eliminated the whites in the west, leaving only blues there and only the Greater Snow (which has never, so far as known, had a blue phase) in the east? This is not unthinkable. If, as Lehman states, the blues are "steadily increasing in proportion of blues to snows," then perhaps the Lesser Snow Goose of current nomenclature is slowly *becoming* the Blue Goose—i.e., a form blue in color as well as in name.

"Selected American Game Birds" is a handsome, well made book. It will find its way into many a sportsman's library—and heart.—George Miksch Sutton.

WORDS FOR BIRDS: A LEXICON OF NORTH AMERICAN BIRDS WITH BIOGRAPHICAL NOTES. By Edward S. Gruson. Quadrangle Books, New York, 1972: 6½ × 9½ in., 305 pp., many bl. and wh. drawings. $8.95.

The author of this little book, an enthusiastic amateur bird student, has set out to provide for all the birds of North America, including Hawaii, a translation of the scientific name and some sort of explanation of the common name. Brief biographical sketches of the eponyms are given. Something of this sort, competently done, would indeed fill a gap in the ornithological literature. With the decline in instruction in classical languages most amateurs and most professionals are hard put to understand the meanings of the technical names, and the meanings of English bird nouns, such as thrush, are lost in antiquity. The long out-of-print booklet "Introduction to Ornithological Nomenclature" by Mary F. Coble filled a part of this gap, but it dealt mainly with western birds and the nomenclature was out of date. However, the reader should be warned that the present book is not the answer, and indeed I cannot recommend it at all. The author makes passing grades in his Latin and Greek scholarship, but flunks history and knowledge of science in general and ornithology in particular.

The translations of the technical names seem to be pretty well done, although in some cases the scientific name of a bird comes from a derived meaning of a classical word and not its original meaning. Thus *Zosterops* is more likely to have been intended to mean "girdled eye" (a descriptive term) rather than "girdled appearance" given by Gruson.

I am not qualified to judge the derivations of the familial and generic English names, but the etymologies given seem reasonable. I did note one faulty one, however; the "pie" in Magpie clearly refers to the "pied" appearance rather than the call note.

Unfortunately the common names and the biographical sketches are another matter entirely, and the reader should be warned that these are often inaccurate, distorted, or indeed completely misunderstood. In preparing this review I collected a long list of mistakes but will mention only the most glaring here.

The author has little understanding of birds, bird students, ornithology or the development of science in general. In common with many other half-informed persons he seems to feel that the common names (and also the technical names) of birds should form a consistent well-organized system, and they should be useful in aiding the beginning student in identification. Such an idea implies that the people who gave the names should have been both omniscient and prescient in anticipating all discoveries that came after them, or else that the whole system should have been adopted after all knowledge was available. Neither case bears much relation to reality.

Gruson constantly remarks as to whether or not names are accurate or useful (to whom is not clear), but unfortunately he is often mistaken in his judgments. Most ornithologists would agree that the name "Red-tailed Hawk" is often of use in identification, although Gruson says that it is not. On the other hand, who would agree with the author's remarks that the name "Long-billed Marsh Wren" is said to allude to the bill, "which is almost as long as the *rest of the bird*" (italics mine)?

The attitude that nomenclature should represent an elegant and orderly system comes only from lack of knowledge of how the knowledge of birds developed. For example, when Lafresnaye named the Gray-cheeked Thrush *Turdus minimus* it was indeed a small bird for that genus and the name was appropriate for the time. Later transfer to the genus *Catharus*, of course, renders the name inappropriate but Gruson somehow feels that the name is "wrong."

The worst errors and distortions come in the biographical sketches, for while the bare bones of these are correct, the author belongs to the "New Journalism" school of writing history. One of the characteristics of this style is that historical accuracy comes second to telling an engaging story. Thus the outstanding historical "howler" in the book finds William Gambel (of Gambel's Quail) crossing the western prairies in 1848 in a wagon train guided by Daniel Boone. Poor Dan'l would have been 114 years old at this time. Other inaccuracies (e.g. the fate of the Franklin expedition) are less interesting, but all go to undermine our confidence that the author knows what he is talking about.

Another characteristic of this school of writing is the tendency to encapsulate people into brief, partially correct descriptions, such as Audubon being a "neurotic," Xantus being "a fantast," and several people being "mysterious" (since Gruson failed to find out anything about them). Incidentally, Gruson proposes a new theory of Audubon's ancestry based on his complete misunderstanding of what the word "Creole" means.

Finally, this school of historical writing tends to judge the events and actions of the past by the standards and mores of today. Thus we read such ex post facto nonsense as "Montezuma became one of the first leaders of The Third World to be felled by Imperialism," a statement that demonstrates an almost complete lack of understanding of history.

The margins of the pages are illustrated by line cuts from the paintings of Alexander Wilson; these are nowhere identified or acknowledged in the text, although the fact is mentioned on the dust jacket.—George A. Hall.

Waterfowl Habitat Trends in the Aspen Parkland of Manitoba. By William H. Kiel, Jr., Arthur S. Hawkins, and Nolan G. Perret. Canadian Wildlife Service, Report Series No. 18, Ottawa, 1972: 8½ × 11 in., 63 pp., maps, graphs, photos, paperbound. $1.25. Available from Information Canada, Ottawa, Canada.

An area of 4100 square miles in the aspen parklands of western Canada, known as the Minnedosa pothole region, is considered "the finest unit of waterfowl production in Manitoba and one of the best in Canada." This area had the potential during the period 1949–54 "to contribute at least 1 million ducks to the fall migration annually." Moreover, in the early 1950's "approximately 10 percent of all canvasbacks in North America nested in this district." With the Canvasback presently at an all time low and waterfowl generally short of demand, this publication has special significance.

The report offers an historical-ecological perspective of waterfowl habitat across 200,000 square miles of parkland and prairie in Alberta, Saskatchewan, and Manitoba, though the famous Minnedosa district is the main concern. Natural and man-made changes and their effects on duck habitat, from Indians and buffaloes to grain farmers and raccoons, are discussed along with weather, soils and vegetation. Limited data are given for waterfowl populations, density and trends. The authors were involved in the study area from 1946 "after the depression, drought and war had slowed progress" to 1966, a period including some of the wettest and driest years on record. A picture emerges of an everchanging habitat with wide ranges of variation and a complex relationship to waterfowl use and productivity. Conservation of these small water bodies, which appear to be essential to maintaining present waterfowl populations, is of concern to both U.S. and Canadian waterfowl managers.

According to this report, drainage and filling of potholes are still taking place, along with burning of adjacent upland habitat and clearing of trees and brush on pond margins. "The economy of the Minnedosa region in Manitoba is largely dependent on cereal grain production. What is a pothole worth to a farmer in comparison to the grain he can produce in its drained basin for the ever-expanding world food market?"

Efforts to preserve wetlands in the whole prairie and parkland region of the Prairie Provinces include a $50 million 10-year program begun by the Canadian Wildlife Service in 1967. Under this scheme landowners are paid to not drain or fill potholes or to burn marginal vegetation. "The landowners receive an income for allowing their wetlands to be used to produce waterfowl and other wildlife for public benefit." The authors note that this program has since been modified and broadened, but it is not made clear whether this program has been successful. In particular, nothing is said about the effect of the program in the Minnedosa district. One would have liked to have seen more recent information included on this important aspect. A brief statement of U.S. expenditures for wetland acquisition is made (it should be noted that both Kiel and Hawkins are employed in the U.S.).

Ornithologists will be quick to note a few errors in a list of common names in an appendix. Though reference is made to the A.O.U. Check-list, six incorrect or incomplete names appear (e.g., "Baldpate" and "Ringneck"). Although containing 63 numbered pages (including inside covers) the text is limited to approximately 27 pages, the remainder consisting of 35 illustrations, five tables and seven figures. Five full pages of aerial photos, including a colored cover, amply portray the rich and varied landscape of the pothole country.

The large format, lavish use of photographs and open layout characteristic of this series of publications makes this report appealing to the eye, though some may find the uncluttered pages an unnecessary extravagance (see, for example, the review of No. 14 in this series, Wilson Bull., 84:223–224). Another reviewer (No. 12 in this series, Wilson Bull., 84:227–228) applauds the style and design of these Canadian Wildlife Service publications. An exciting presentation that is easy to read is useful and necessary in reaching resource administrators, wildlife managers and lay public. Hopefully, landowners in the Minnedosa district and elsewhere will have opportunity to see this publication. After all, according to the authors: "The future of the parkland and prairie potholes and their wildlife rests ultimately with the landowner. His stewardship of the land and its productive potential will be his legacy to future generations. Coming generations may judge us as much for the natural environment we have preserved as for the bushels of grain we have produced."—Robert W. Nero.

THE FOWLES OF HEAUEN OR HISTORY OF BIRDES. By Edward Topsell. Edited by Thomas P. Harrison and F. David Hoeniger. The University of Texas Press, Austin, 1972: 10¼ × 6¾ in., xxxvi + 332 pp., 61 col. illustrs., 3 facsimiles of original MS. $15.00.

Until now ornithologists wishing for a first hand view of the state of ornithology in the late sixteenth century could get it only from the great books of that time, such as Conrad Gesner's "Historia Animalium" (ornithology 1555), Pierre Belon's "l'Histoire naturelle des oyseaux" (1555), and the three-volume "Ornithologiae" (1599–1603) of Ulysse Aldrovandi. Required at least have been access to the rare book rooms of some great library and minimal facility with Renaissance Latin or French.

The publication, after nearly 500 years, of Topsell's "The Fowles of Heauen" is accomplished in the present handsomely produced volume and now provides such a view.

Edward Topsell (1572–?1625), an English curate and scribe addicted to natural history lore, is known by "The Historie of Four-footed Beasts" (1607) and "The Historie of

Serpents" (1608), which are chiefly abridged translations from Gesner. His companion work on birds, completed in 1614, has heretofore been known mainly from a brief article on the manuscript in the Huntington Library, San Marino, California (Bayard Christy, Auk: 50:275–283, 1933). Topsell prepared the MS for Sir Thomas Egerton, Baron Ellesmere, in the vain hope that he would sponsor its publication.

The Fowles of Heauen is essentially a translation, far from complete (treated are birds from A through C) and somewhat rearranged—this time from Aldrovandi, who in his own turn leaned heavily on Gesner and Belon as well as the classical underpinnings common to all. The illustrations of the MS, the better of which are here much reduced, are handmade, hand-colored copies, more or less rearranged, of the immense crude woodcuts from Aldrovandi. Topsell has added just a bit to his authority, notably fanciful matter on African birds from the obscure Luis de Uretta in a work of 1610, and a few brief comments on some birds from Virginia based on lost drawings of the noted explorer-artist John White (see Christy, op. cit.) and other matter.

Besides a careful reproduction of Topsell's unaltered Elizabethan text, minus only a section on domestic fowl, the editors provide a 36-page survey of Renaissance ornithology, perhaps the best to date in comparable compass; extensive literary and ornithological notes—the latter seemingly adequate enough; assorted appendices; and a thorough bibliography of primary and secondary sources. They are not only capable scholars but assess their author well: "Topsell adds little of value to Aldrovandi's volumes on birds. . . . Had The Fowles of Heauen been published, it would have popularized the subject through the pious eyes of the translator but affected the serious study of birds very little."

This volume is addressed, therefore, not to researchers in present-day ornithology but to Renaissance scholars and historians of science and literature. Ornithologists, nevertheless, may be pleased by this convenient opportunity to ponder with Aldrovandi such controversial perplexities as the proper affinities of "the bat," the spontaneous generation of the barnacle goose, and the missing feet of birds of paradise, not to mention enjoying a contemporary sample of opinion on the kinds, proclivities, and uses of birds around 1600.—ROBERT M. MENGEL.

AT THE TURN OF THE TIDE. By Richard Perry. Taplinger Publ. Co., New York, 1972: 5¾ × 8½ in., 256 pp., drawings by Nancy Lou Gahan. $7.50.

This is an early work by a professional nature writer, in the same vein as well-written natural history articles that have appeared in *The Countryman* and some other British publications. Now it is issued in the U.S.A., having originally appeared in Britain before the end of World War II. The chapters concern birds of coastal wetlands—"saltings"—and other places near the sea. The author was familiar with the then-current ornithological literature and his writing was a product of interaction between such sources and his own experience afield. There is some interesting, but not well documented, material on a nesting female Common Tern (*Sterna hirundo*) mated to a male Roseate (*S. dougallii*) in four years, then to a male Common. An appendix includes a "new theory" of "eclipse" in drakes—in which Perry arrived at the correct explanation ("ancestral" condition) via a mixture of right and wrong reasons; nor was he the first to understand this matter. The illustrations were done without understanding of bird anatomy, especially of feet.—R. S. PALMER.

THE WILSON ORNITHOLOGICAL SOCIETY

INDEX TO VOLUME 85, 1973

By Emma J. Messerly, John F. Messerly and Mary M. McClellan

This index includes in addition to the names of genera, species, and authors, references to the following topics: abnormalities, aggression, anatomy, banding, behavior, brood size, care of young, clutch size, communication, conservation, courtship, density, display, distribution, ecology, eggs, food and food habits, growth and development, habitat, hatching, incubation, locomotion, measurements, metabolism, migration, molts and plumages, morphology, mortality, nest building, nest sites, nesting, nesting failure, nesting success, nests, parasitism, pesticides, physiology, populations, predation, roosting, taxonomy, territory, voice and vocalizations, weather, and weights. Also included are references of biological significance to reptiles and mammals. Forms described as new in this volume are given in **boldface.**

This issue of *The Wilson Bulletin* was published on 31 December 1973.

SUGGESTIONS TO AUTHORS

See Wilson Bulletin, 84:513, 1972 for more detailed "Suggestions to Authors." Manuscripts intended for publication in *The Wilson Bulletin* should be neatly typewritten, double-spaced, with at least one inch margins, and on one side only of good quality white paper. Tables should be typed on separate sheets, and should be designed to fit the normal page width, i.e., narrow and deep rather than wide and shallow. Before preparing these, carefully consider whether the material is best presented in tabular form. Follow the AOU Check-list (Fifth Edition, 1957) insofar as scientific names of United States and Canadian birds are concerned unless a satisfactory explanation is offered for doing otherwise. Use species names (binomials) unless specimens have actually been handled and subsequently identified. Summaries of major papers should be brief but quotable. Where fewer than five papers are cited, the citations may be included in the text. All citations in "General Notes" should be included in the text. Follow carefully the style used in this issue in listing the literature cited; otherwise, follow the "CBE Style Manual" (1972, AIBS). Photographs for illustrations should be sharp, have good contrast, and be on gloss paper. Submit prints unmounted and attach to each a brief but adequate legend. Do not write heavily on the backs of photographs. Diagrams and line drawings should be in black ink and their lettering large enough to permit reduction. Extensive alterations in copy after the type has been set must be charged to the author.

NOTICE OF CHANGE OF ADDRESS

If your address changes, notify the Society immediately. Send your complete new address to the Treasurer, Jerome A. Jackson, Dept. of Zoology, Mississippi State University, Mississippi State, Mississippi 39762. He will notify the printer.

The permanent mailing address of the Wilson Ornithological Society is: c/o The MUSEUM of Zoology, The University of Michigan, Ann Arbor, Michigan 48104. Persons having business with any of the officers may address them at their various addresses given on the back of the front cover, and all matters pertaining to the Bulletin should be sent directly to the Editor.

IMPORTANT NOTICE

All manuscript material for the Wilson Bulletin should be sent to Dr. John P. Hubbard, P.O. Box 3937, Greenville, Delaware 19807. Dr. Hubbard becomes the Editor for Volume 86.

LOUIS AGASSIZ FUERTES AND MARGARET MORSE NICE AWARDS

Fuertes Awards are devoted to the encouragement and stimulation of young ornithologists. One particular desire is the development of research interests among amateur ornithologists and students. Any kind of ornithological research may be aided. Recipients of grants need not be associated with academic institutions. Each proposal is considered primarily on the basis of possible contribution to ornithological knowledge. Although grantees are not required to publish their studies in The Wilson Bulletin, it is hoped that they will submit their manuscripts to the editor of The Wilson Bulletin for consideration.

Most of the statements applicable to the Fuertes Awards are also applicable to the Nice Award. However, the Nice Award is limited to applicants not associated with a college or university. It is intended to encourage the independent researcher without access to funds and facilities generally available at the colleges. High school students are eligible.

In some years two Fuertes Awards have been made, in some years, one. Amounts have been between $200 and $100. One Nice Award is made annually, in the amount of $100.

Interested persons may write to Frank B. Gill, Academy of Natural Sciences, 19th and the Parkway, Philadelphia, Pennsylvania 19103. Completed applications must be received by 1 April 1974. Final decisions will be made by the Council at the annual meeting of the Society, 6–9 June 1974.