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THE NATURAL HISTORY SECRETARY.

"It will flourish, if naturalists, chemists, antiquaries, philologers, and men of science in different parts of *Asia*, will commit their observations to writing, and send them to the Asiatic Society at Calcutta. It will languish, if such communications shall be long intermitted; and it will die away, if they shall entirely cease." SIR WM. JONES.

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JOURNAL

OF THE

ASIATIC SOCIETY OF BENGAL.

Part II.—PHYSICAL SCIENCE.

No. I.—1878.

I.—*Description of* Ruticilla schisticeps, *Hodgs.—By* W. T. Blanford, F. R. S.

(Received October 11th, 1876;—Read March 7th, 1877.)

(With Plate I.)

Since the original description of the male of this bird was published in the appendix to the first 'Catalogue of the specimens and drawings of Mammalia and Birds of Nepal and Thibet' presented by Mr. Hodgson to the British Museum, I am not aware that anything has been added to its history. It does not appear to have been seen by Blyth or Jerdon, there is no specimen in the Society's old collection, nor to the best of my belief has there hitherto been one in the Indian Museum, and the bird has not yet, so far as I know, been found in the western Himalayas or in Turkestan. Unless Colonel Prejevalski has obtained it in Mongolia, I do not think it has hitherto been procured elsewhere than in the Tibetan region north of Sikkim and Nepal. The female, so far as I can learn, has not been described, although there appears to be a figure of it amongst Mr. Hodgson's drawings.

I have just received a pair of this rare bird from Mr. Mandelli, and the following is a description of both sexes.

Male. Crown of head and nape, greyish blue, paler in front, becoming rather darker on the nape. A narrow band on the forehead, lores, sides of head and neck, chin and sides of throat, and back glossy black. Scapularies black at the base, but with a broad tip of ferruginous or rich chestnut, lower rump and upper tail coverts the same. Quills black; a broad white band, formed by the whole of the median coverts, and the basal portions of the greater coverts, together with the outer edges of the last 3 or 4 secondaries (tertiaries of some writers), traverses the wing longitudinally. Tail black. Beneath, there is a white spot in the middle of the throat, in contact with the rich ferruginous tint of the breast, abdomen and lower tail coverts, which are the same colour as the rump; axillaries white, under wing coverts black and white mixed, inner margins of quills dusky grey. Wing, 3·5; tail, 2·95; tarsus, 0·93; culmen, 0·62; bill from front, 0·4.

Female. Olive brown above, forehead, lores and sides of head paler and more rufous; rump, upper tail coverts and basal portion of all the tail feathers, except the middle pair, ferruginous; central rectrices and terminal portion of all the others black, rather browner than in the male however; quills brownish black with paler brown edges, and a white bar over the wing as in the male. Chin, throat, breast, sides of abdomen and flanks rufescent brown with an olive tinge; a white spot, as in the male, in the centre of the throat; middle of the abdomen paler, lower tail coverts pale rufous. Wing 3·2, tail 2·8.

Of course I have no means of ascertaining certainly that the female is correctly identified, as the birds were obtained by Mr. Mandelli's collectors, but the white breast-spot leaves very little doubt on this head. As regards the locality, the only information Mr. Mandelli can give me is that these birds were obtained in Tibet in the month of November 1875.

II.—*Aberrant Dentition of* Felis Tigris.—*By* R. Lydekker, B. A.

(Read 6th February, 1878.)

(With Plate II.)

In the accompanying plate (No. II), there is represented the right ramus of a mandible of an individual of *Felis tigris* which was killed in British Burma; this jaw is remarkable in that it carries an additional premolar. The normal number of lower molar teeth in the genus *Felis* is three, namely, two premolars, which are respectively the penultimate and ultimate of that series, and one true molar, which is the first of the latter series, and which is often known as the "carnassial tooth."

In the figured specimen, there is between the canine tooth and the penultimate premolar, a small and simple tooth, which is the ante-penultimate tooth of the premolar series, and which, as we have seen, does not occur in the normal dentition of the genus *Felis;* on the left side of the figured jaw this additional premolar is absent.

The interest that attaches to the presence of this additional premolar in our specimen, is that in an extinct genus of *Felidæ,* the normal number of the lower premolars was three in place of two, as in *Felis.* This extinct genus was named by M. Gervais *Pseudælurus,** and the one species (*P. quadridentatus*) on which it was determined, was obtained from the miocene formation of Sansan in France; the species was previously named by De Blainville in his "Osteographie," *Felis quadridentatus* and *F. tetraodon.* Subsequently Professor Leidy† described a second species of the genus, under the name of *P. intrepidus,* from the Pliocene of Nebraska. Still later, I myself‡ described the lower jaw of a third species, *P. sivalensis,* from the Siwaliks of this country.

It is well known that the small number of the molar series which exists in the living *Felidæ* is a highly specialized character, which is not found in the oldest carnivora, nor in many of those which are still living. The existence of an additional lower premolar in the Miocene and Pliocene genus *Pseudælurus* shows that that genus is less specialized than *Felis,* and indicates that the former was probably the line through which the latter was described from some primitive carnivore in which the whole four of the typical premolar series were developed. The occasional occurrence of the ante-penultimate lower premolar in *Felis* must be regarded as an instance of "reversion" towards the genus *Pseudælurus.*

* "Zoologie et Paléontologie Françaises", Vol. I, p. 127.

† "Extinct Mammalia of Dakota and Nebraska," p. 52.

‡ "Records of Geological Survey of India," Vol. X., p. 83.

III.—*Record of the Occurrence of Earthquakes in Assam*
C. S. I., V. C.,

Date.	District.	Time of Occurrence.
15th February.	Darrang, Mangaldai.	10·45 A. M.
Do.	Kámrúp, Gauháti.	11 A. M.
No reports reached from Goálpára, Nowgong, Lakhimpur,		
23rd do.	Kámrúp, Barpetá.	11·50 P. M.
Do.	Goálpára, Goálpára.	12·8 P. M.
No reports reached from Gauháti, Darrang, Nowgong, Sibságar,		
28th do.	Goálpára, Goálpára.	10 P. M.
Do.	Gáro Hills, Túrá.	11·40 P. M.
No reports reached from Kámrúp, Darrang, Nowgong,		
March		
15th March.	Khási Hills, Shillong.	3·33 P. M.
No reports reached from Goálpára, Kámrúp, Darrang, Nowgong,		
20th do.	Khási Hills, Shillong.	5 A. M.
No reports reached from Goálpára, Kámrúp, Darrang, Nowgong,		
April		
29th April.	Khási Hills, Shillong.	10 P. M.
No reports received from Goálpára, Kámrúp, Darrang, Nowgong,		
May		
11th May.	Kámrúp, Gauháti.	9 P. M.
Do.	Khási Hills, Shillong.	9·10 P. M.
Do.	Darrang, Tezpur.	9·15 P. M.
Do.	Nowgong, Nowgong.	9·30 P. M.
No reports received from Goálpára, Sibságar, Lakhimpur,		
17th May.	Khási Hills, Shillong.	10·10 P. M.
Do.	Darrang, Tezpur.	10·35 P. M.

during 1877. *Communicated by* Col. R. H. Keatinge, *Chief Commissioner.*

Duration.	Extent of damage if any, and general remarks.
20 to 25 seconds.	No damage, two distinct shocks and preceded by loud rumbling noise.
A second.	No damage.
Sibságar, Sylhet, Cachár, Nága Hills, Gáro and Khási Hills.	
4 seconds.	No damage.
7 seconds.	Do.
Lakhimpur, Sylhet, Cachár, Nága Hills, Gáro and Khási Hills.	
3 seconds.	No damage. Slight shock.
30 seconds.	Do. do.
Sibságar, Lakhimpur, Sylhet, Cachár, Nága and Khási Hills.	
1877.	
10 seconds.	No damage.
Sibságar, Lakhimpur, Sylhet, Cachár, Nága Hills, and Gáro Hills.	
5 seconds.	No damage.
Sibságar, Lakhimpur, Sylhet, Cachár, Nága and Gáro Hills.	
1877.	
3 seconds.	No damage.
Sibságar, Lakhimpur, Sylhet, Cachár, Nága Hills and Gáro Hills.	
1877.	
12 seconds.	No damage.
45 seconds.	No damage.
10 to 12 seconds.	Two distinct shocks. Severe and very marked. No damage. Declared by Deputy Commissioner to be the severest felt since the great one in September 1875. The shocks were not preceded by the usual rumbling noise and were not quick and jerky, but long and undulating.
5 seconds.	No damage. One sharp shock.
Sylhet, Cachár, Nága Hills and Gáro Hills.	
30 seconds.	No damage.
6 to 8 seconds.	No damage. Two clear distinct shocks at intervals of 3 to 4 seconds between the two shocks. Very marked, but not severe; not preceded by the usual rumbling noise.

Date.	District.	Time of Occurrence.
No reports received from Goálpára, Kámrúp, Nowgong, Sibságar,		
June		
4th June.	Nága Hills, Sámagúting.	3·30 P. M.
No reports received from Goálpára, Kámrúp, Darrang, Nowgong,		
7th do.	Khási Hills, Shillong.	12·24 P. M.
Do.	Goálpára, Goálpára.	12·25 P. M.
Do.	Kámrúp, Barpetá.	12·25·5 s. P. M.
Do.	Kámrúp, Gauháti.	12·30 P. M.
Ascertained that the shock was not felt in Darrang, Nowgong,		
July		
9th July.	Khási Hills, Shillong.	1·15 A. M.
		Ascertained that the shock was
10th July.	Kámrúp, Gauháti.	1 A. M.
		Ascertained that the shock was
August		
3rd August.	Darrang, Tezpur.	12·30 P. M.
Do.	Nowgong, Nowgong.	2 P. M.
No reports received from Goálpára, Kámrúp, Sibságar,		
August		
6th August.	Khási Hills, Shillong.	9·30 P. M.
Do.	Nowgong, Nowgong.	9·30 P. M.
Do.	Darrang, Tezpur.	10·30 P. M.
Ascertained that the shock was not felt in Goálpára, Kámrúp,		
17th do.	Khási Hills, Shillong.	1 A. M.
Do.	Darrang, Tezpur.	1·30 A. M.
Ascertained that the shock was not felt in Goálpára, Kámrúp,		
21st do.	Goálpára, Dhúbri.	5·50 P. M.
Do.	Gáro Hills, Túrá.	5·37 P. M.
No reports received from Kámrúp, Darrang, Nowgong, Sibságar,		
22nd do.	Khási Hills.	4 P. M.
		No reports received
25th do.	Nowgong.	9 P. M.
Do.	Khási Hills, Shillong.	9·30 P. M.
Do.	Darrang, Tezpur.	9·40 P. M.

Duration.	Extent of damage if any, and general remarks.
Lakhimpur, Sylhet, Cachár, Nága Hills and Gáro Hills.	
1877.	
Very short.	Slight and unaccompanied by noise.
Sibságar, Lakhimpur, Sylhet, Cachár, Gáro Hills and Khási Hills.	
5 seconds.	No damage.
1½ minutes.	Slight shock. No damage.
5 seconds.	No damage.
5 seconds.	Smart shock no damage.
Sibságar, Lakhimpur, Sylhet, Cachár, Nága and Gáro Hills.	
1877.	
3 seconds.	No damage.
not felt in any other district.	
Very short.	Slight. No damage.
not felt in any other district.	
1877.	
6 to 8 seconds.	Slight, no damage, preceded by usual rumbling noise.
2 seconds.	Slight. No damage.
Lakhimpur, Sylhet, Cachár, Nága, Gáro and Khási Hills.	
1877,—(continued).	
5 seconds.	No damage.
2 seconds.	No damage.
A few seconds.	Distinct shock. No. damage.
Sibságar, Lakhimpur, Sylhet, Cachár, Nága and Gáro Hills.	
5 seconds.	No damage.
A few seconds.	Slight. No damage.
Nowgong, Sibságar, Lakhimpur, Sylhet, Cachár, Nága and Gáro Hills.	
4 seconds.	Slight. No damage.
2 seconds.	Slight. No damage.
Lakhimpur, Sylhet, Cachár, Nága and Khási Hills.	
2 seconds.	No damage.
from other districts.	
2 seconds.	Slight. No damage.
3 seconds.	No damage.
8 to 10 seconds.	No damage. Shock, clear, distinct and marked.

Date.	District.	Time of Occurrence.

No reports received from Goálpára, Kámrúp, Sibságar,

Date.	District.	Time of Occurrence.
30th August	Sibságar, Jorhát.	3·30 A. M.

No reports received from Goálpára, Kámrúp, Darrang, Nowgong,

September

Date.	District.	Time of Occurrence.
1st September.	Khási Hills, Shillong.	5 30 A. M.
Do.	Cachár.	5·45 A. M.
10th do.	Kámrúp, Gauháti.	11 P. M.
Do.	Nowgong.	11 A. M.
Do.	Darrang, Tezpur.	11·15 A. M.
16th do.	Sibságar, Jorhát.	7 A. M.
Do.	Sibságar, Sibságar.	7 A. M.
18th do.	Nowgong, Nowgong.	10 A. M.
Do.	Darrang, Tezpur.	10·30 A. M.

Ascertained that the shocks were not felt at Goálpára, Lakhimpur,

October

Date.	District.	Time of Occurrence.
7th October.	Khási Hills, Shillong.	5·30 A. M.
13th do.	Do.	6·45 A. M.
30th do.	Darrang, Tezpur.	11·30 P. M.

November

Nil.

December

Date.	District.	Time of Occurrence.
1st December.	Darrang, Tezpur.	6·10 A M.

Ascertained that this shock was

Date.	District.	Time of Occurrence.
7th do.	Sibságar Jorhát.	12 P. M.
Do.	Goálpára, Goálpára.	1·25 A. M.
Do.	Nowgong, Nowgong.	1 30 A. M.
Do.	Darrang, Tezpur.	1·30 A. M.
Do.	Sibságar, Sibságar.	About 2 A. M.
Do.	Gauháti, (Kámrúp).	Do.

Duration.	Extent of damage if any, and general remarks.

Nowgong, Lakhimpur, Sylhet, Cachár, Nágá and Gáro Hills.

About 5 seconds.	No damage. Slight trembling shock.

Lakhimpur, Sylhet, Cachár, Nágá, Khási and Gáro Hills.

1877.

5 seconds.	No damage.
7 seconds.	Slight shock.
1 min. 10 sec.	No damage.
2 seconds.	Very slight shock. No damage.
8 to 10 seconds.	Sudden and distinct shock not preceded by usual rumbling noise. No damage.
2 seconds.	No damage. The sensation was as of one shock upwards.
Less than a sec.	Nil.
10 seconds.	No damage. One sharp shock preceded by a heavy rumbling noise.
8 to 12 seconds.	Slight shock, but the usual rumbling noise was loud and long.

Sylhet, Nágá and Gáro Hills on the 10th, 16th and 18th.

1877.

10 seconds.	No damage.
15 seconds.	No damage.
20 to 25 seconds.	No damage. Sharp shock.

1877.

1877.

A few secs. only.	Two distinct but slight shocks. No damage.

not felt in any other district.

(?)	No damage.
5 seconds.	Slight shock.
4 seconds.	Do. No damage done.
A full 20 seconds.	Very severe, about half a dozen distinct shocks, the second one very strong and caused much damage. South wall of kutcherry cracked and broken down. Northern walls cracked. Treasury walls cracked in several places. Circuit bungalow walls much cracked. Jail uninjured. Deputy Commissioner's bungalow on the hill suffered most, chimney fell in, causing loss of valuable property.
Less than a sec.	Nil.
5 seconds.	A slight shock accompanied by the usual rumbling noise. No damage.

Date.	District.	Time of Occurrence.
7th December.	Barpetá, (Kámrúp).	2·10 A. M.
Do.	Khási Hills, Shillong.	2 A. M.
Do.	N. Lakhimpur.	2·35 A. M.

Ascertained that this shock was not felt in Cachár,

9th December.	Darrang, Tezpur.	12·30 P. M. 3 P. M. 8·50 P. M.
Do.	Khási Hills, Shillong.	1·45 A. M.

Ascertained that this shock was not felt at Goálpára, Kámrúp,

11th December.	Darrang, Tezpur.	11·30 P. M.
Do.	Nowgong, Nowgong.	1 A. M.

Ascertained that the shock was not felt in Goálpára, Kámrúp,

18th December.	Kámrúp, Gauháti.	3·35 P. M.
Do.	Darrang, Tezpur.	3·45 P. M. 4·20 P. M. 5·15 P. M.
Do.	Khási Hills, Shillong.	3·47 P. M.
Do.	Nowgong, Nowgong.	3·50 P. M.

Ascertained that the shock was not felt in Goálpára, Sibságar,

22nd December.	Darrang, Tezpur.	4 A. M.
Do.	Khási Hills, Shillong.	10·30 P. M.

Ascertained that the shock was not felt in Goálpára, Kámrúp, Nowgong,

29th December.	Khási Hills, Shillong.	9 P. M.
Do.	Cachár, Silchár.	10 P. M.
Do.	Goálpára, Goálpára.	11 P. M.

Ascertained that the shock was not felt in Kámrúp, Darrang,

Duration.	Extent of damage, if any, and general remarks.
Not stated.	Nil.
10 seconds.	No damage done.
2 seconds.	Treasury room cracked in several places. No serious damage.
Sylhet, Gáro and Nágá Hills and Head Quarters Lakhimpur.	
8 to 10 seconds.	The first two shocks very distinct. No damage. The third shock was very smart, and the rumble and shock came almost together. No damage.
A few seconds.	
8 seconds.	
5 seconds.	No damage.
Nowgong, Sibságar, Lakhimpur, Sylhet, Cachár, Nágá and Gáro Hills.	
10 seconds.	Smart shock. No damage.
3 seconds.	Very slight. No damage.
Sibságar, Lakhimpur, Sylhet, Cachár, Nágá, Gáro and Khási Hills.	
5 seconds.	Slight. No damage.
10 seconds.	1st, very distinct with loud rumbling. No damage.
A few seconds.	2nd, slight rumbling, distinct, but no shock.
15 to 20 seconds.	3rd, loud continued rumbling, no shock.
5 seconds.	No damage.
2 seconds.	Sharp shock, no damage.
Lakhimpur, Sylhet, Cachár, Nágá and Gáro Hills.	
8 to 10 seconds.	Distinct shock with loud rumbling. No damage.
5 seconds.	No damage.
Sibságar, Lakhimpur, Sylhet, Cachár, Nágá and Gáro Hills.	
5 seconds.	No damage.
2 seconds.	Very slight.
5 seconds.	Slight shock.
Nowgong, Sibságar, Lakhimpur, Sylhet, Nágá and Gáro Hills.	

IV.—*Sixth List of Birds from the Hill Ranges of the North-East Frontier of India.*—*By* Lieut.-Colonel H. H. Godwin-Austen, *F. Z. S. &c., &c., late Deputy Superintendent Topographical Survey of India.*

(Received 16th March; read 3rd April.)

[With Plates X and XI.]

This list is the result of two seasons' Survey exploration in the Eastern Nágá Hills (Mr. A. W. Chennell) and of the low hills near Sadiya and the neighbourhood of the Bráhmakhúnd (Mr. M. T. Ogle). I have again to acknowledge the kind services of the above gentlemen, to whom I owe so much, and who have added considerably to the value of the collection by taking careful measurements in the flesh and recording the colour of the soft parts. The collection is a large one and contains, as will be seen, besides a large number of species already recorded, many interesting birds. Together with the birds included in my paper on the Dafla Hills and Darrang Terai, which I have now introduced and marked with an asterisk, it brings up the total number of species collected during the progress of No. 6 Topographical Survey to 585.

Having now left the service, I much fear that this will be my last contribution in these pages to the avi-fauna of the Eastern Districts. The assistants who have been associated with me hitherto on this pleasant work are being gradually reduced in number; and have either been transferred to other parties, or have proceeded on well merited leave of absence to a distance, so that it is difficult to arrange for collecting with success, and a certain amount of aid is requisite, which only individuals in the country can obtain. When this paper was almost completed, the arrival of Mr. Chennell in England, with another collection of some 800 skins from the North Khási Hills, has enabled me to add a few more species to the list, and there are still some I have not yet identified.

70. Urrua coromanda, Latham.

North Khási Hills, (collected by Mr. Chennell).

*71. Huhua nipalensis, Hodgson.

73. Ketupa flavipes, Hodgson, var. *magnifica*, Swinhoe.

North Khási Hills. The specimen in Mr. Chennell's collection has the tarsus covered with a white down, buffy above, extending to within 1·3 inch of the base of the toes, as recorded by Mr. Swinhoe in his description of *K. magnifica* from Ningpo, (Ibis, 1873, p. 127).

On Mr. Chennell's label I find the following notes:

L. 21 inches, W. 16·5, T. 6·0, t. 3·0, Bf. 1·8. Bill greenish horny, irides golden yellow. Legs and feet dusky grey. The mid toe is 1·75, its claw 1·1, hind toe 1·0, claw 1·25.

These dimensions and the coloration of the feet and legs are much nearer to those of Mr. Swinhoe's bird than to those given by either Sharpe or Jerdon for *flavipes.* In neither of the latter is any mention made of the down covered tarsus, a character so striking that it could hardly have escaped their notice, and one which, besides the vermiculated breast and lower parts, distinguishes the species from *Ceylonensis.*

Swinhoe concludes with the remark that the fine down of the tarsus appears to wear off, but the specimen now recorded is an adult, and though this down may disappear to a certain extent, I do not think the tarsus and the joint above would ever become bare as in *Ceylonensis* and *flavipes.*

*94. Chelidon nipalensis, Hodgson.

106. Batrachostomus javensis, Horsfield, ♀ ?

This specimen belongs to the Indian Museum, Calcutta, where I found it among some skins that had been sent down by the late lamented Captain John Butler from the Nágá Hills, and I was by the kind permission of the Trustees allowed to bring it to England. It is a most interesting specimen in the rufous phase of plumage, but unfortunately the sex is not marked. It agrees with a specimen of *B. Javensis* ♀ in the collection of Lord Tweeddale, and the description of the species as given in P. Z. S. 1877, p. 435, and the dimensions do not differ materially. I give a description of the Nágá Hill bird, interesting as being found so far to the northward.

Entire plumage rich chestnut brown, a few white feathers at the base of the upper mandible tipped rufous and barred with black. White on chin and throat, some of the feathers on the latter crossed by a V-shaped dark line, but they only extend to the upper breast, this being covered by feathers having large, rounded white centres, bounded on the terminal margin by a narrow dark line and fringed with chestnut; towards the abdomen and flanks the white marks become narrow and lengthened. The wing is unspotted, but conspicuous white feathers margined with black are mingled with the scapulars, and there is a well-marked nuchal collar, each feather crossed by a narrow black line edged terminally by another. There is a slight mottling of dull black on the primaries and secondaries and lower back. The tail is similarly mottled and crossed by 7 pale clear rufous bands, the outer penultimate tail feather has 5 distinct white bars on the outer web, the very short outermost feather has a terminal whitish spot.

W. 5·25 inches, T. 5·5, t. 0·6, Bf. 0·6. Breadth at gape, 1·05, mid-toe and claw 0·75. The long frontal plumes are black, rufous at the base.

This bird is, I think, nearest to *B. Javensis*, *B. affinis* apparently not having any white in front of the eye.

On my submitting this paper and the specimen to Lord Tweeddale he thus wrote to me,—" This Nágá Hill example of the genus, *Batrachostomus* " without doubt belongs to the *B. Javensis* (Horsf. ex Java). I have criti- " cally compared the two and cannot detect any difference. It may turn " out to be Mr. Hume's *B. castaneus*, in which case *B. Hodgsoni* will be- " come a synonym of *B. Javensis*. It is a large form of *B. affinis*, but the " white on the throat seems to extend higher up, as it does in the Javan " species and in *B. cornutus* of Sumatra and Borneo." Lord Tweeddale does not concur with me regarding the white mark in front of the eye, and says, " it is just as strongly marked in my examples of *B. affinis*."

130. Halcyon pileata, Bodd.

H. atricapillus, Gmel.—Jerdon, Birds of India, Vol. I, p. 226.

♂ L. about 10·3, W. 4·9, T. 4·0, t. 0·58, Bf. 2·3, Bill from nostril 2·15.

The dimensions of the length and wing are much smaller than those given by Dr. Jerdon.

133. Ceyx tridactyla, Pallas.

Dr. Jerdon informed me that he saw this species in a small stream close under the village of Cherra Púnji, but as I never got it myself, I did not record it. Mr. A. W. Chennell has two specimens he shot on the Umthunna River, N. Khási Hills.

*135*a*. Alcedo grandis, Blyth.

Also got on the Buri Dihing.

*137. Ceryle guttata, Vigors.

Tenga Páni and Buri Dihing.

147. Palæornis eupatrius, Lin.

L. 21, W. 8·1, T. 13·5, t. 0·8, Bf. 1·5, Bg. 1·2.

Bill deep red. Legs and feet orange yellow.

N. Khási Hills, December, (Chennell).

*152*a*. Palæornis melanorhynchus, Wagler.

*171. Gecinus striolatus, Blyth.

210. Surniculus dicruroides, Hodgson.

Mr. Chennell has two specimens from the N. Khási Hills of this curiously plumaged bird, so like the king-crow.

Length 10·0, W. 5·5, T. 5·75, t. 0·7, Bf. 0·8.

*245. Certhia discolor, Blyth.

*303. Cyornis unicolor, Blyth.

313. Nitidula hodgsoni, Moore.

A single male specimen was collected for me by Mr. A. Chennell in the Nágá Hills; this is of a richer chestnut below than a specimen from Darjiling. A female was obtained by Mr. Ogle at Sadiya. I give a description of the latter, that in Jerdon being taken from the male.

♀. Above, olivaceous brown, wings and tail dark umber-brown, beneath, all pale rufous buff. Under tail coverts white.

W. 1·75, t. 0·65. The wing is rather shorter than in the male which has it 1·90.

320. Siphia leucomelanura, Hodgson.

I now possess two males and three females from Sadiya, two males from the Munipur Hills, and one male from Sibságar, Assam. Dr. Jerdon only describes the male, the female apparently was unknown to him. I therefore give one of a specimen sent me from Darjiling by Mr. L. Mandelli.

♀. Above, brown with an olive cast, darkest on the head, ochraceous on the rump. Wing and tail ruddy brown, ferruginous at the base of the tail feathers and on the wing coverts. Beneath, dingy sordid white, purer on the centre of the abdomen, ochraceous on the flanks. Hind claw well curved. W. 2·3, T. 2·05, t. 0.72, Bf. 0·36.

♂. Sadiya, W. 2·4, T. 2·15, t. 0·85, Bf. 0·30 to 0·35.

Legs, sepia-brown ; irides deep brown.

377. Chleuasicus ruficeps, Blyth, var. *atrosuperciliaris*, Godwin-Austen. P. A. S. B., June 1877, p. 147.

♂. Rusty chestnut on the head, same colour, but paler, on the nape and ear coverts: back and wings pale olive-brown, quills tinged rufous, tail brown. A narrow black streak over the eye, beneath dull white with an earthy tinge.

Legs dark plumbeous.

L. about 6, W. 2·85, T. 3·3, t. 0·90, Bf. 0·43.

Maubum Tila, near Sadiya.

Larger than typical *C. ruficeps* and not so white below.

*378*b*. Suthora daflaensis, Godwin-Austen.

*382. Grammatoptila striata, Vigors.

390*c*. Turdinus Nagaensis, Godwin-Austen, [A. M. N. H., Dec. 1877.]

"Above, rich umber-brown throughout with no streaking on the feathers of the head. Beneath, the same tint, much paler, with slight rusty shading into and adjacent to the dull whitish centre of the breast, chin also whitish.

"Irides dark brown, legs and feet light sienna-grey.

"Length about 5·70, wing 2·2, tail 2·2, t. 0·90, Bf. 0·50, hind toe, 0·35, claw 0·3. This species is very distinct from *T. Garoensis* in its deeper umber coloration and smaller size. Particularly is this the case in the legs, feet and hind claw.

"It was obtained by Mr. A. W. Chennell, of the Survey, in the Eastern Nágá Hills."

390*d*. Turdinus striatus, Walden.

I have compared a specimen from Sadiya of the bird hitherto considered as *T. brevicaudatus* with the type in the Calcutta Museum, obtained by Col. Tickell in Tenasserim, and find that they are, after all, distinct. The Tenasserim form is very strong rufous on the breast, belly and under tail-coverts, the spots on the secondaries are small and triangular, whereas in that from Sadiya they are large and tip the feather. The throat is also grayer in this last. In the "Ibis" for 1876, p. 354, Lord Tweeddale remarks on the highly colored drawing by Tickell of *T. brevicaudatus*, and Mr. Gould has very probably figured an Assam bird, which should stand properly under the title of *T. striatus*, Walden, described in Ann. Mag. Nat. Hist., (4), vii., p. 241, and which Jerdon had very probably compared with true *brevicaudatus* from the Burmah side and considered distinct. This bird is the one I refer to under the title of *T. Williamsoni* in J. A. S. B., Pt. II., 1877, p. 44. I have four specimens from Sadiya (Gáro Hills and Munipur), in all of which the spots on the secondaries are rufous, while in a specimen from the Mulé-it range, Tenasserim, obtained by Mr. Limborg, they are white, thus agreeing with Col. Tickell's drawing of true *brevicaudatus* from the same locality. This specimen is again not so rufous as the type in the Indian Museum, but this is a very variable character in this group, (as may be seen in *Pnoe. squamata*, of which specimens white beneath are often met with,) and probably depends on age. After all *striatus* is only a variety of *brevicaudatus*.

399*b*. Pellorneum Mandellii, W. Blanford, [J. A. S. B., vol. XLI, Pt. II, p. 165, pl. VII., (1872).]

Var. *pectoralis*.

I described this variety of the Darjiling form in the J. A. S. B. vol. XLVI, Pt. II, 1877, pp. 41-42, as it differs a good deal in its markings from *P. Mandellii* described by W. Blanford from Darjiling, and is the form which extends to the Gáro, Khási and North Cachár Hills, *P. ruficeps* of my First List, [J. A. S. B., Vol. XXXIX, p. 103, (1870).]

Jerdon, when noticing a new species from the Khási Hills, in Vol. II., Birds of India, had *Pel. palustre* in mind.

*401. Pomatorhinus ferruginosus, Blyth.

405*c*. Pomatorhinus stenorhynchus, G.-A.

The original description appeared in this Journal, Pt. II., Vol. XLVI. p. 43, (1877), and I have only to add that its nearest ally is *P. ochraceiceps*, Walden, from Burmah; but the above species is larger and has the lower parts pale ferruginous, whilst in *ochraceiceps* they are of the purest white, and it is not so rufous on the head and nape. The legs of *stenorhynchus* are horny grey; in the figure of *ochraceiceps* lately published in the Ibis for 1877, Pl. XIII, the legs appear to be much too blue; should this coloring however be correct, it will mark another point of difference.

Mr. Ogle shot this species on Manbúm Tila, at an elevation of 8,000 feet, not far from Sadiya.

407*a*. Garrulax nuchalis, Godwin-Austen. Plate X.

The second specimen of this bird was obtained again by Mr. Ogle, on the Kamlangpáni, at 500 ft. I described the first example, obtained also by Mr. Ogle, in the Annals and Magazine of Natural History for November 1876, and I here repeat the original description and remarks upon it. It is figured on the accompanying plate.

" Above, top of head to nape dark slaty grey, succeeded by a broad rich ferruginous collar an inch in breadth, which fades into the olive-green of the back. Wings and tail of a rather darker tint of olive, the latter tipped black; the first four primaries are tipped hoary-grey; the shoulder of wing has a rusty tinge. A narrow frontal band; the lores, with a narrow line over and below the eye, black; this is continued in a streak of dark rusty brown over the ear-coverts; a few white feathers border the black frontal band above. Chin black, extending a short way down the middle of throat; breast pale ashy, with a slight vinous tinge. Cheeks and ear-coverts pure white. Flanks and under tail-coverts dull olive-green. Bill black. Irides purple-lake. Legs fleshy-grey.

" Length 10 inches, wing 4·25, tail 4·6, tarsus 1·7, bill at front 0·9.

" This beautiful species was among a batch of birds lately received from and collected by Mr. M. T. Ogle, of the Topographical Survey, in the Lhota-Nágá hills. It is the representative there of *G. chinensis*, but differs in possessing the broad ferruginous nape, and the neutral grey of the head is of a darker hue. In other respects it is identical, save in some minor points, such as :—the black of the throat does not extend so far down on to the upper breast ; the lower breast is paler than in *chinensis*, and has a vinous tinge ; the under tail-coverts are pure olivaceous with no ochraceous tint ; and, lastly, the white of the check and ear-coverts extends in this new form further down the side of the neck."

*427*b*. Actinura daflaensis, Godwin-Austen. [Pl. IV, J. A. S. B., 1876.]

497*d*. Actinura Oglei, Godwin-Austen. Plate XI.

This beautiful new form, discovered by Mr. M. T. Ogle, was described in J. A. S. B., Vol. XLVI, Pt. II, 1877, p. 42, from Manbúm Tila on the Tengapáni River, near Sadiya. It is now figured.

*430. Sibia picaoides, Hodgson.

*432. Malacocercus terricolor, Hodgson.

*498. Ruticilla Hodgsoni, Moore.

*534. Prinia socialis, Sykes, small variety.

*535. Prinia Stewarti, Blyth.

562*a*. Phylloscopus fuliginiventer, Hodgson, sp.

Horornis fuliginiventer, Jerdon. [Birds of India, Vol. II, p. 162, No. 525.]

A dull but well marked ring round the eyes, an indistinct supercilium of same colour as the breast. All above very dusky bistre-brown with an olive tinge. Beneath dingy oil-green, paler on chin; under tail-coverts rather lengthened. Irides dull brown, legs ochraceous green. Obtained at Sadiya.

L. 4·25, W. 2·15, T. 2·0, t. 0·87, Bf. 0·34.

564. Reguloides trochiloides, Sundeval.

♂ from Noa Dihing, March 6th. Compared with specimens in British Museum.

Lord Tweeddale writes—" Has your specimen got white margins to the outer tail feathers ? If it has so, it will be true *P. viridipennis*, and which is probably nothing but *P. presbytes* of S. Müller. Seebohm thinks that *P. trochiloides*, *viridipennis*, and *presbytes* are one and the same."*

576. Abrornis affinis, Hodgson.

This bird I have only received from the Nága Hills; it has a bright yellow ring round the eye.

* Compare Stray Feathers, V, 1877, pp. 330, 504.—Ed.

572. Abrornis flavigularis, n sp.

Description : Above ash grey, purer grey on rump, rather darker on the head. Wings pale umber-brown. Tail ash-brown, the two outer feathers white on the inner web, the next with a narrow edging of white. Lores white, ear-coverts white and grey. Chin pure yellow fading on throat; breast, nape, flank and thighs greyish white, whitish on the breast; a very faint yellow tinge on the abdomen; under tail-coverts white. A small patch of yellow on inner shoulder of the wing,

Bill dark above, buff below.

W. 1·84, T. 1·8, t. 0·67, Bf. 0·3.

Hab.—Sadiya. (Mr. Ogle.)

Having failed to identify this bird with any species I have examined, I have now described it more fully; it is the specimen I noted as probably new under the above title in the J. A. S. B., Vol. XLVI, Pt. II, p. 44, (1877).

It is nearest to *A. xanthoschistus*, having the same coloured head and form of bill, but its entire ashy upper surface distinguishes it well from all the species I am acquainted with.

*586. Henicurus schistaceus, Hodgson.

*587. Henicurus scouleri, Vigors.

*588. Henicurus sinensis, Gould.

*590*a*. Motacilla hodgsoni, G. K. Gray.

*592. Calobates melanope, Pallas.

594. Budytes citreola, Pallas.

♀. Pengapáni, W. Sadiya. April 24th.

The black band on the nape is hardly developed at all.

594*a*. Budytes citreoloides, Hodgson.

♀. Brahmaputra. April 5th.

The white of the wing has a slight wash of yellow on it.

*612. Cutia nipalensis, Hodgson.

*621. Proparus chrysæus, Hodgson.

625*a*. Staphidea plumbeiceps, Godwin-Austen.

Ann. Mag. Nat. Hist., Dec. 1877.

Original Description : "Head (sub-crested) ash-grey, purer behind; feathers narrowly edged paler. Back pale olive-brown, a few feathers pale-shafted. Wings umber-brown. Tail darker, the four outer feathers tipped with white, increasing outwards diagonally. Lores pale grey. The ear-coverts only to just beneath the eye chesnut, the feathers white-shafted. Chin, throat, and all the lower parts white. Flanks pale sepia-grey; under tail-coverts the same, tipped white.

"Irides reddish brown. Legs umber.

"Length 4·6 inches, wing 2·3, tail 9·05, tarsus 0·7, bill at front 0·3.—Obtained near Sadiya and Brahmakhúnd."

A near ally is *Staphidea castaneiceps*, Moore, very common in the Khási and Nágá Hills, while another very distinct species is *Staphidea torqueola*, Swin.; but in this last the chestnut commences at the base of the lower mandible, passes under the eye and round the nape in a broad band of chestnut-brown, and the last three tertiaries are margined white on the inner web. This is absent in the Assam species.

In my note-book I find that I obtained one example in the Dikrang valley, Dafla hills, which I shot at camp No. 9; but this was subsequently lost somehow or other, and therefore I did not insert it in the List of Birds from the Dafla Hills, published in the Society's Journal.

Can this be *Ixulus striatus*, Blyth? Blanford in J. A. S. B., 1872, p. 166, says the Darjiling bird is the same as the Tenasserim type in the Calcutta Museum, but mentions that it has a rufous supercilium, which none of my specimens possess.

[Since writing the above, I have received from Mr. W. Blanford, in a letter from Calcutta in reply to some questions I wrote to him regarding this species, *Ix. striatus*, some remarks which I now quote. "I have two specimens of the Sikkim bird; I have re-compared them with the type from Tenasserim, and I cannot understand how I can have identified the two. The Tenasserim bird is, as Blyth describes it, greyish brown (ashy brown according to Tickell), the cap may have been a trifle darker, but very little, not so distinct I should say as in the Sikkim bird, and the white shafts are far more conspicuous in the Tenasserim type. Above all, the bill is much larger in the latter; the difference is so marked that I think I must have compared a Sikkim specimen differing from those I have now. The cheek patch is distinct but faint. In the specimen from Sikkim, (*Ix. rufigenis*, Hume) which I now have, the rufous supercilium is only indicated posteriorly." This last title was given to the Sikkim bird by Mr. A. O. Hume in Stray Feathers, Vol. V, p. 108. Mr. Blanford has now followed up his letter by sending me two specimens from Mr. Mandelli's collection of this Darjiling form, and on comparison I find that it is quite distinct from *plumbeiceps*. This last has the head of a decided ash-grey colour, and the feathers are more lengthened behind, so as to give a sub-crested appearance. Bill shorter and deeper. Legs stouter, altogether a larger bird. In one specimen from Darjiling, there is an extension shewn of the rufous of the ear-coverts round the nape, of which there is not a trace in the Sadiya examples. These are the dimensions of *rufigenis*. W. 2·45, T. 0·6, Bf. 0·47.

The wings run about equal. This genus presents us with an interesting example of modification of plumage in areas that are in a great measure separated now physically. We appear to have 5 forms:—

1. *Staphidea castaneiceps*, Moore, (1854). Gáro, Khási and Nága Hills.
2. „ *striatus*, Blyth, (1859). Tenasserim.
3. „ *rufigenis*, Hume. Sikkim Hills.
4. „ *plumbeiceps*, Godwin-Austen. Sadiya, Eastern Assam.
5. „ *torqueola*, Swinhoe. W. China.]

669. Garrulus bispecularis, Vigors.

This Himalayan Jay was obtained by Mr. Chennell at Shillong, and is in his collection.

*838. Sypheotides bengalensis, Gmelin.

873. Rhynchæa bengalensis, Linnæus.

North Khási Hills. Mr. Chennell.

In the neighbourhood of Calcutta these birds breed as early as March and April; two chicks were brought to me about the middle of the former month.

879. Ibidorhynchus Struthersii, Vigors.

♂. Noa Dihing.

W. 9·25, T. 5·5, t. 1·7, Bf. 3·02.

907*a*. Podica personata, G. R. Gray.

This bird, hitherto only recorded, on the Indian side, from Cachár, was found by Mr. Ogle on the Noa Dihing river near Sadiya; the specimen is a male, and has been compared with those in the Indian Museum from Tenasserim.

W. 9·5, T. 5·4, t. 2·0, Bf. 2·15, bill to nares 1·05.

908. Porzana akool, Sykes.

In Mr. Chennell's collection from North Khási Hills.

Length about 9·25, W. 4·4, T. 2·3, t. 1·8, Bf. 1·0.

Bill dusky green, yellow below, irides red brown, legs and feet dusky lake.

910. Porzana pygmæa, Naumaun.

Near base of the Hills. N. Khási. Obtained by Mr. Chennell.

935*a*. Gorsachius melanolophus, Raffles.

Dipur Bhíl. Eastern Assam, March, (Chennell).

The discovery of this interesting bird in this part of India is noteworthy, as I do not believe it has hitherto been obtained any where in India, certainly never recorded. Up to the present it has been only known as a native of Japan, Sumatra, Philippines, Arrakan (Ramri Island), Ceylon and the Nicobars (Hume). The specimen, a male, agrees well with Mr. A. O. Hume's excellent description from the last-named locality in "Stray Feathers, Vol. II, p. 313." Mr. Chennell's dimensions in the flesh are "wing 10·7, tail 5, tarsus 3·0, bill at front 1·9. Bill dark horny;" these I have checked and find correct, the wing I make exactly 11·0. The tarsus of the Nicobar bird appears to be very much shorter than in Schlegel's description and in this specimen from Assam.

950. Sarcidiornis melanonotus, Pennant.

There is a head of this species in Mr. Chennell's collection from Upper Assam.

*981. Larus ridibundus, Linn.

*987. Sterna melanogastra, Temminck.

Notes on Species recorded in former Lists.

79. Athene cuculoides.

Mr. Chennell writes me an interesting account connected with the habits of this bird "One evening last January while in search of *Polyplec-* "*tron*, several of which were calling about my camp at Gorhanga, I came "upon two birds struggling desperately on the ground. I shot both, one "turned out to be an owl, *Athene cuculoides* ♀ and the other a thrush "*Myiophonus temminckii* ♂. The little owl had so furiously attacked the "thrush that even in death its strong talons were firmly fixed in the "victim's back."

157. Picus Macei.

In the colour of the ear-coverts there is, I find, very great variance from pure white to pale earthy brown; they are white in a female from Sadiya.

311. Muscicapula æstigma.

The young bird is dull umber-brown above, the feathers tipped pale rufous and edged darkly, giving it a very speckly appearance. Upper tail coverts rufous umber. Secondary coverts forming a narrow wing bar, 3 last secondaries edged in the same way. Beneath white, some of the feathers tipped dark brown. Wings and tail ashy umber-brown.

From Shillong Peak. July, (*ex* coll. Chennell.)

316. Niltava grandis.

I have a specimen of this species in its young plumage which is worth description.

Above, brown with a rufous shade, the feathers of the head shafted ferruginous, those of the wing coverts, lower back and rump broadly tipped with the same colour and edged black. Tail dark chestnut brown, wings umber-brown. Beneath, breast ferruginous brown with some dusky edgings, giving a slightly barred appearance, paling to whitish on abdomen.

330. Pnoepyga pusilla, var.

A specimen in Mr. Chennell's collection is in a very interesting stage of plumage. It is uniform brown, the feathers not so scale-like as usual, only a very few of the feathers on the lower back having terminal spots to them; in size and form of bill it is the same as the type. I was at first inclined to consider it distinct, but it is better to wait until we see more similar specimens before naming it, for it appears immature. The wings are rusty umber-brown, chin pale, breast and belly ashy umber with no bars or markings.

W. 1·8, T. very short, t. 0·7, Bf. 9·43.

From the N. Khási Hills.

346. Pitta cucullata, Hartlaub.

I have seen a specimen in Mr. Chennell's collection which he obtained in the N. Khási Hills, and he only saw one other. I have already alluded to the apparent rarity of the species in these Hills.

386*a*. Pyctorhis altirostris, Jerdon.
= *griseigularis*, Hume.

I observe that Mr. Hume is still of opinion that his Bhútán Duár bird is distinct from *altirostris*, and in Stray Feathers, Vol. V, No. 2, p. 116, he has named it *griseigularis* (relying on Dr. Jerdon's description being correct). Had Mr. Hume looked up the "Fifth List of Birds from the N. E. Frontier," J. A. S. B., Vol. XLV, Pt. II, p. 197, he would have seen that after the intimation of the re-discovery of the species (Ann. Mag. Nat. Hist., Jany. 1876) the type of *altirostris* turned up in the British Museum, and that my specimens had been compared with it, leaving no doubt in my mind that they are identical, both in plumage and bill. Mr. Hume's specimens and my own, moreover, come from the same line of country, the great plain north of the Brahmaputra. Dr. Jerdon's description is short, but applies very fairly in every way, save in respect to the bill, which is deeper than in *Sinensis*. Jerdon says "making an approach to *Paradoxornis*," by this he may have intended to convey only a very slight approach. The following appear to be the principal differences in the description of the plumage.

Above "slightly brownish ferruginous," Hume, Vol. V, or "rather dark ferruginous brown," Hume, Vol. IV. = "pale reddish brown," Jerdon.

Beneath "dull rusty," Hume, Vol. V, or "Brownish buff deeper coloured &c.," Hume, Vol. IV, = "pale fulvescent," Jerdon.

Under wing-coverts "pale yellowish fawn," Hume, Vol. V, = "pale ferruginous," Jerdon.

When such distinctions as these are made the basis on which to found new species, it is I think advisable to wait, and if possible compare with the type. But in *altirostris* we have one very marked character which Dr. Jerdon did not overlook, *viz.*, "forehead and streak over the eye hoary grey." No two men agree in describing various shades of brown, olive-green &c., an important element being the kind of light the skins are placed in, and individual sensitiveness to colour. It is satisfactory to know that the type of *altirostris* has been found, otherwise we should have been left in a cloud of doubt regarding even its very existence, for in Stray Feathers, Vol. III, p. 116, an idea is thrown out that Dr. Jerdon had got hold of a variety of *Pyctorhis sinensis* when he was at Thyet-Myo. Even had the type of *altirostris* been lost, I hold it would have been better to consider it as re-discovered in Assam, and then have waited for it to turn up again on the Irrawady (where I am sure it will be found*) before giving the Assam bird a new title.

427*c*. Actinura Egertoni, Gould. Var. *Khasiana*, Godwin-Austen.

This is referred to in my list of Dafla Hill Birds and is the species noted as near *Egertoni* in my First List.

437*a*. Malacocercus (Layardia) robiginosus, Godwin-Austen, described in J. A. S. B., 1874, p. 164, is the *Pyctorhis longirostris*, Hodgson, of Moore's Catalogue of Birds in the Indian Museum. I have compared my specimens with the type and only observe that those from Eastern Assam are larger. I was misled into describing it under a new name by a specimen which is only a slight variety of *Pyc. sinensis*, labelled wrongly *P. longirostris*, in the British Museum. At the time I described *M. robiginosus* the Indian Museum birds were still packed away and not to be got at, and I trusted to the correctness of Mr. Gray's identification of the British Museum bird. I was further misled by *longirostris* being placed in the genus *Pyctorhis*, with which it has no affinity, but is a true *Malacocercus*.

* It has been re-found by Mr. Oates, see Stray Feathers, V, p. 249.—Ed.

531*a*. Orthotomus atrigularis, Temminck.

= *flavi-viridis*, Moore. Dunsiri Valley, Assam.

On comparing this with a specimen from Tenasserim collected by Mr. O. Limborg, I notice that in the former the chestnut on the head does not extend so far back on the nape as in the latter, and in a specimen from the Gáro Hills it is confined to the frontal part of the head only. Assam birds have the darkish sub-terminal tip to the tail feathers as mentioned by Mr. Moore in his description. The abdominal portion is not so pure a white in the Assam bird.

619*a*. Minla rufigularis, Mandelli.

This is *Alcippe collaris*, Walden.

I have compared a specimen sent home lately by Mr. Hume and find it identical with the Assam form. Mandelli's title has priority.

619*b*. Minla Mandellii, Godwin-Austen.

Through the kindness of Mr. P. L. Sclater I have been able to compare Mr. Hume's *Proparus dubius* from South Burma with this bird; it is clearly distinct, one of those interesting representative races we so often find at the extreme limit of range. *M. dubius* is much paler beneath and has not got the white markings on the nape. It would be conferring a great service to ornithology if Mr. Hume would always send home similar doubtful species, which can only be satisfactorily determined by comparison with types in public and private collections.

V.—*An Account of the Tidal Observations in the Gulf of Cutch, conducted by the Great Trigonometrical Survey, under the Superintendence of* Colonel J. T. Walker, C. B., R. E., *during the years* 1873-74-75. *Compiled from the G. T. Survey Reports by* Captain J. Waterhouse, *Assistant Surveyor General.*

Origin and Object of the Observations.—In his Report on the Operations of the Great Trigonometrical Survey for 1866-67, Col. Walker writes:

"Dr. Oldham, the Superintendent of the Geological Survey of India, has recently drawn the attention of the Government to certain questions which have been raised regarding secular changes in the relative level of the land and sea, which are believed to be going on in various parts of the Bombay Presidency, and more particularly at the head of the Gulf which separates the province of Cutch from that of Kattywar. Dr. Oldham recommends that certain points should be selected on the south coast of Kattywar, and as far up the Gulf as possible, and that the existing relative levels of land and sea should be determined at those points by accurate tidal observations carried over as long a period as possible, the tidal stations being connected by lines of levels. Thus, by repeating the operations at a time sufficiently distant to allow the secular changes to reach an appreciable magnitude, this question, which is of much scientific importance, will be satisfactorily settled."

The Government of India sanctioned the observations being made, and Col. Walker was making arrangements for carrying them out, when a very considerable reduction in the expenditure of the Survey Department, in consequence of the financial difficulties in 1869-70, caused the indefinite postponement of the operations. It was not until August 1872 that steps could be taken for commencing them.

The delay which thus took place is, however, not to be regretted, because it resulted in the investigations being carried on in a more complete and elaborate manner than had been originally contemplated, with a view to acquiring more comprehensive and accurate results than were at first desired.

Happening to be present at the Meeting (in Edinburgh) of the British Association in 1871, Colonel Walker ascertained that a Committee of the Association, presided over by Sir William Thomson, had initiated a system of tidal investigations which was anticipated to secure scientific results of the highest value. On studying the details of these operations he found that his original programme, which contemplated tidal observations of only a few weeks' duration, would be inadequate to detect the existence of minute secular changes in the relations of land and sea, and that no conclusive results could be obtained unless the observations were carried over a period of rather more than a year at the commencement, and a corresponding period at the close, of the investigation. He further saw that if this were done, the value of the operations would be greatly increased, because the results would not only serve the purpose for which they were originally contemplated, but would materially contribute towards the attainment of the better knowledge of the law of the tides, which is considered by the British Association to be so important a desideratum, and which is expected to lead to an evaluation of the mass of the moon, to definite information regarding the rigidity of the earth, to an approximation of the depth of the sea from the observed velocities of tide-waves, to the determination of the retardation of the earth's rotation due to tidal friction, and also to the various practical benefits which necessarily accrue from accurate predictions of the height of the tide at any given time.

Preliminary Preparations.—With the sanction of the Secretary of State for India, Lieut. (now Captain) A. W. Baird, R. E., Assistant Superintendent G. T. Survey, who was then in England on furlough, was deputed to study the practical details of the mode of tidal registration and of the harmonic analysis of the observations, which were recommended and practised by the Tidal Committee of the British Association.

Lieut. Baird also tested at Chatham a new self-registering tide-gauge constructed by Adie, the well-known optician and mathematical instrument-maker, on the same principle as those he had previously sent out to India, which were provided with barrels of unusual length (five feet) in order that the tidal curves might be drawn on the largest scales practicable. The new tide-gauge was on the same pattern, but with a few modifications, the most important of which was the substitution of a chronometer escapement instead of a pendulum or gravity escapement for the driving clock, in order to permit of the instrument being erected on positions where the concussions of the sea waves would interfere with and perhaps stop the action of a pendulum clock. On trial it was found to work very satisfactorily.

No tidal registrations can be deemed complete without simultaneous registrations of the condition of the atmosphere, because it is well known that the rise and fall of the tides on a line of coast is materially influenced by the direction and force of the winds, and that it also varies inversely with changes in the barometric pressure. Arrangements were therefore made for supplying each tidal station with an anemometer and a barometer, both self-recording. The anemometers registered both direction and velocity and were similar to Beckley's, but smaller, in order to be light and portable. The barometers were aneroids, because safely portable self-registering mercurial barometers could not be obtained.

Selection of Stations.—On Col. Walker's return to India, in November 1872, he deputed Lieut. Baird to make a reconnaisance of the Gulf of Cutch, with a view to selecting tidal stations, and more particularly to ascertain how the instructions which had been received from the Government to establish a station "at a point as far into the Runn of Cutch as possible to which the tide has free access" could be best carried out. For a point to have free access with the sea it is necessary that it should always have at least 4 or 5 feet of water over it at lowest tides, and also that the sea should approach it directly, and not through tortuous channels; the point must also be either on the edge of the mainland or at no great distance beyond, because of the difficulty and expense of constructing a station on the foreshore. It seemed not improbable that it might not be possible to find a point at the edge of the Runn which would satisfy all the requisite conditions.

Lieut. Baird proceeded first to Júria Bandar, close to the head of the Gulf, where he fitted up a country boat for navigating the creeks and channels of the Gulf, and secured the services of an experienced pilot to accompany him in his explorations. After a month's cruising about and long searching along the muddy foreshores of the Gulf, three places well adapted for tidal observations were found. 1st, Nawanár Point, midway up the Gulf on the Cutch coast, 15 miles from Mundra; 2nd, Hanstal Point at the head of the Gulf, about 18 miles from Júria, and 3rd, Okha Point on the Kattywar coast, just at the mouth of the Gulf, opposite the Island of Beyt. At Nawanár there was a minimum depth of 19 feet of water within 336 feet of a site for a station; at Hanstal 72 feet within 160 feet of a site for a station, and at Okha 23 feet within 220 feet of a site for a station. Nawanár is about 9 or 10 and Hanstal 16 miles from the nearest village where drinking water can be procured; Okha Point has Beyt within 1 mile, but a boat is required for communication with it.

The three places selected were considered to be well adapted for the operations, which was the more fortunate in that Lieut. Baird believed them to be the only suitable points to be met with for the purpose. It is to be regretted, however, that an intermediate point could not be found on the Kattywar coast, between Okha and Hanstal, for Nawanár being on the opposite coast had to be connected with the other two stations by a very long line of levels passing round the head of the Gulf; and, as it afterwards turned out, Nawanár proved unsuitable by constant changes in the configuration of the foreshore.

Preliminary Arrangements.—The stations having been selected, preliminary arrangements were commenced.

The first question to be decided was whether the tide-gauges should be set up on stages erected in the sea beyond the low-water line, or on masonry platforms constructed on shore at the high-water line. It is obviously desirable that the communication between the surface of the ocean and the gauge should be as direct as possible, in order that the tidal curve may be accurately delineated. Thus, it is usual to erect tide-gauges in ports or harbours where the piers, quays and landing-stages constructed for the requirements of the shipping present facilities for their being set up in the vicinity of deep water. In the Gulf of Cutch, however, the stations were all at a distance from the nearest inhabited localities and presented no facilities whatever; for not only building materials and food for the workmen, but even fresh water, had to be brought to them from considerable distances. It was thus imperative that the plan of operations should be of the simplest nature possible, so as to be carried out with the least cost and the greatest expedition. Had any jetties or piers been available for the operations the stations would have been erected on them, but under existing circumstances it was only possible to connect the tide-gauges with deep water by erecting stagings for them in the sea; and these would have had to be very strongly built to withstand the full force of the sea, without undergoing any displacement whatever, and that, not for a short time only, but for several years, so as to include both the first series of tidal registrations, taken to determine the present relations of the land and sea, and the final series which will have to be taken to determine the future relations some years hence. The stagings would, moreover, have had to be connected with the land by piers, in order to permit of ready access to the instruments at all times. The cost of such stagings and their connecting piers would have far exceeded the funds available, and therefore Col. Walker decided, though with some reluctance, on having the tide-gauges set up on shore, over wells sunk near the high-water line and connected with the sea by piping.

Final Arrangements.—The following is a brief sketch of the arrangements adopted:

Masonry wells of a diameter of about 3 feet were sunk at the stations to a depth of several feet below the lowest tides; in these wells iron cylinders with an internal diameter of 22 inches, slightly exceeding the diameter of the float of the tide-gauge, were set up vertically and connected with the sea by an iron piping carried along the shore down to the low-water line, where a flexible piping was attached and carried out into deep water. The flexible piping terminated in a rose suspended by means of buoys a few feet above the bed of the sea, in order to prevent the entrance of silt as much as possible, and was attached to the iron piping in such a manner that it might be readily removed and cleaned whenever necessary. The tide-gauges were set up over the cylinders, and their iron bed-plates indicated the planes to which the tidal measurements were referred; they were connected by levelling with permanent bench-marks fixed in the ground in the vicinity of the stations.

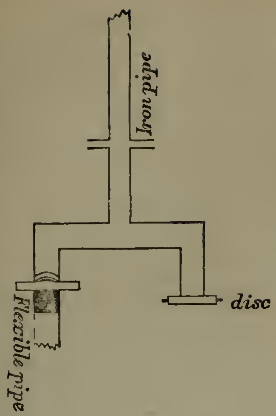
The iron cylinders were made up in sections of 50 inches in length, a sheet of wrought-iron being bent to the size required and rivetted to form a cylinder, a cast-iron flange was fitted on to each end and the faces of these carefully turned so as to fit exactly. The bottom section had a flat iron plate carefully screwed on to one end, so as to form the bottom of the well, and the whole when bolted together formed a water-tight well into which water could only enter through the piping connecting it with the sea. The size of the cylinders was decided on so as to utilise the iron sheets most economically, and when finished four men could carry one section. Before being let into the wells they were well painted over, inside and outside, with tar in order to keep them from rusting. The level of the top flange of the cylinder was about 6 feet above high-water spring tide, and about 2 feet 6 inches above the floor of the observatory. A board fitted on and screwed to the top of the cylinder, with holes for the float-bands to pass through, prevented anything falling accidentally inside the cylinder.

The rigid iron piping was ordinary gas-pipe in lengths of about 14 feet, with an internal diameter of 2 inches, which had been computed to be sufficient to permit of the transmission of the tidal wave from the sea to the cylinder in the well without sensible retardation, so that the height of the water in the cylinder should always be the same as that of the surface of the sea. In order to render the connections perfectly water-tight, as well as to facilitate the joining together of the lengths of piping, these were fitted with cast-iron flanges made to screw on to each end.

The piping was connected with the bottom of the cylinder, at 9 inches above it, by a small bend, and was then brought up vertically outside the cylinder to a height 1 or 2 feet below the lowest high-water. At this point was another bend with a stop-cock in it, and the pipe was then taken straight out down to the sea along the slope of the shore to reach low-water springs.

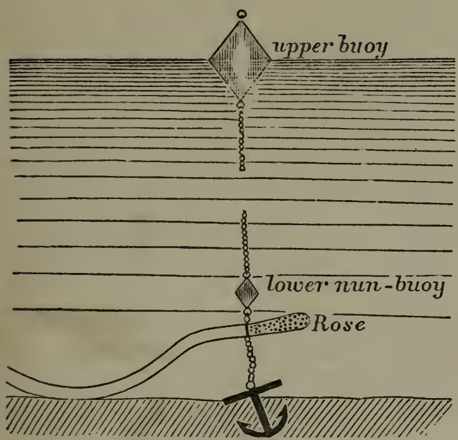
The rigid and flexible pipes were connected together by means of the following arrangement:

To the end of the rigid iron pipe a brass connecting piece, made as shown in the figure, was fitted, having two outer extremities, to one of which a flexible two-inch suction-pipe was fixed and the other closed by a brass disc with a good washer. When the flexible pipe had to be examined for cleaning, the brass disc was unscrewed and a short length of spare flexible piping with a rose at its end fitted on, and taken out to deep water temporarily. The original pipe was then taken off and cleaned, the disc being screwed on for the time in its place; then when finished the long pipe and disc were replaced in their original positions. The flexible pipe was



two inches in diameter with copper inside, just the same as the suction-pipe. It was provided in lengths of 50 or 60 feet, and in smaller one of 20 feet for temporary use only. The lengths were fitted with couplings and unions for connecting them with each other.

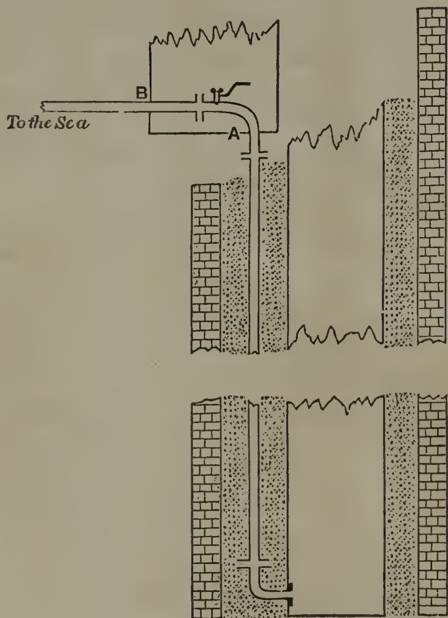
Lengths of this suction-pipe were joined on to the end of the iron piping in the manner above described, and taken out to deep water. At the end of the outer length a copper rose, of about 15 inches in length, 2 inches in diameter, and having about 150 holes of $\frac{3}{10}$ of an inch bored in it, was screwed on. This rose was sustained a few feet from the bottom, being attached to a small nun-buoy by a chain and shackle with swivel, the whole being held in position in deep water by an anchor. To the top of the small nun-buoy a chain was attached, to which was fixed the large buoy floating on the surface, with plenty of slack chain to allow for rise and fall of tide, and this buoy also served to mark the position of the flexible pipe. The arrangement will be understood by reference to the annexed figure.



The level of the water in the well should obviously always coincide with that of the sea, otherwise the registrations of the gauge are worthless; it is therefore imperatively necessary to compare the inside and outside levels from time to time, in order to remove all doubt as to the efficiency of the communication between the well and the sea. For this purpose an ordinary gauge was attached to a pile driven into the bed of the sea, and its zero was connected with that of the self-registering gauge over the well, by spirit levelling, and thus a comparison of the levels could be readily made whenever desirable. On taking these comparisons during certain trial observations at Bombay, Captain Baird was surprised to find that while the levels were generally identical, there were occasional large differences which at first could not be accounted for; eventually, however, he succeeded in tracing them to the accidental presence of air inside the piping.

He soon devised a simple method of expelling the air and restoring the requisite identity of level, by fixing a stop-cock for the exit of the air at the vertical bend, where the iron piping, after rising from the bottom of the well to within a few inches of the surface of the ground, begins to slope downwards towards the sea. This bend has necessarily to be made at a point a little below the level of the lowest high-water tide, and, consequently, on opening the stop-cock at high-water, all the air inside the pipe is of course immediately expelled, and then the water inside the well at once assumes the same level as that of the sea. But for this expedient it would have been impossible to carry on the operations continuously for any length of time, as there was found to be a decided tendency for air to collect in the pipes. It was most fortunate that this was discovered during the experimental observations at Bombay, for there stop-cocks could be readily constructed and attached to the piping, which could not possibly have been done at either of the stations in the Gulf.

At Okha Captain Baird found some difficulty in keeping the stop-cock dry and having access to it. He therefore had a water-tight box 3 feet long and 1 foot square made in halves and fitted over and under the stop-cock, holes having been cut to admit the pipes, and carefully caulked up after the box had been fitted over the pipe (see figure); in this way no water could get at the stop-cock except over the top of the box. Underneath the first 7 or 8 feet of the pipe leading to the sea, a layer of mud and stones of considerable thickness was made, and a wall of similar material built all round the stop-cock, leaving a space about 3 feet square for standing in and steps for getting down to it; also mud and sand were thrown down between the iron cylinder and the masonry wall right up to the level of the stop-cock bend. It was found that by this means the stop-cock was quite dry and access could be had to it at any time however high the tide was.



Captain Baird spent the recess of 1873 at Bombay in preparing for the operations of the field season of 1873-74. Cylinders as above described were constructed in suitable lengths to be easily transported to the tidal stations and there put together. The several self-registering instruments which were to be employed—the tide-gauges, the aneroid barometers and the anemometers or anemographs—were overhauled and put into good working order. The tide-gauges were tested by being employed to register the tides in the harbour of Bombay for several weeks continuously, and were set up over wells connected with deep water by piping, in order that the experimental observations should be taken under precisely similar circumstances to the actual observations. Sundry alterations and improvements were made in them, and in fact everything was done which could be thought of to ensure the instruments being found in a satisfactory condition when they were set up for work at the tidal stations. It was a matter of great importance to have all this done at Bombay, because the advantages of excellent workshops and skilled artificers were not to be met with in the places where the instruments had to be set up for observation.

While in Bombay, Capt. Baird also constructed three portable observatories for erection at the tidal stations. These observatories were made in such a manner as to be readily put together, or taken to pieces and re-erected at any other place where they might afterwards be required. They were about 12′ × 9′ × 9′ and about 12 feet high in the centre, the roof sloping from the ridge to the sides which were about 8 feet high. They were clinker-built, but it was found necessary to cover them with a tarpaulin to keep out the heavy rain during the monsoons.

Operations at Okha Station.—Okha station being near the mouth of the Gulf and the nearest to Bombay, where all the preliminary arrangements were made, was selected as the first to be taken in hand. There all the instruments and stores, and the European assistants, including Mr. Peters, a skilled artificer of the Bombay Harbour Works, whose services had been obligingly placed at Capt. Baird's disposal by Major Merewether, R. E., 6 sub-surveyors and 24 men were sent, on the 13th October, 1873, direct from Bombay in a large *pattimar* (or native sailing vessel). Meeting with contrary winds, the "Kotia Romani" took such a long time to perform the voyage that Capt. Baird began to fear that she was lost with all hands on board; at last, however, she arrived with her passengers and crew nearly starved, for they had only taken a week's provisions for a voyage which lasted a fortnight. On the 5th November the stores were landed and the first thing to be done was to make an excavation for the iron cylinder. At Okha, as well as at Nawanár, the soil being sandy, it was necessary to take measures to prevent the sides of the well from falling in during the excavation, and therefore a masonry well of sufficient diameter to receive the iron cylinder and vertical shaft of the piping had to be sunk in much the same manner as the wells so frequently used in this country for the foundations of bridges and aqueducts. The operations were considerably facilitated by the employment of Bull's Patent Dredgers for scooping out the soil under the sinking masonry. (At Hanstal, where the soil was firm, the masonry well was unnecessary). The masonry well was completed to the full depth of 25 feet by the 4th December, and by the 20th the cylinder had been set up, the piping connected with the sea had been laid out into deep water, the observatory was erected and the several self-registering instruments—a tide-gauge, an anemometer and an aneroid barometer—were all in position and ready for the preliminary trial of their performances. By the 23rd everything was complete, the instruments were all working well, and Capt. Baird was about to proceed to the next station, when an accident happened through a native boat drifting down past the station about 3 in the morning of the 24th December, and dragging her anchors across the flexible pipe, smashing it and carrying off a large portion of it as well as the buoys, anchors &c. Being on the spot, Capt. Baird was able to rectify the damage and to arrange for protecting the piping by laying out and anchoring hawsers around it. Guards were also provided to prevent boats from approaching the buoys. Thus this accident, though very annoying at the time, proved of use in showing the necessity of taking special precautions for the protection of the piping from injury. Similar measures were taken at the other stations, and these precautions were essential to the success of the operations, because in case of any similar accident happening to injure the piping, the native subordinate who would ordinarily be left in sole charge of the station to keep the instruments in order and look after their performances, would be unable to repair the damage without the personal help of Capt Baird or the European assistant, to obtain which would probably cause suspension of the tidal registrations for a fortnight or more, and greatly impair the value of the observations.

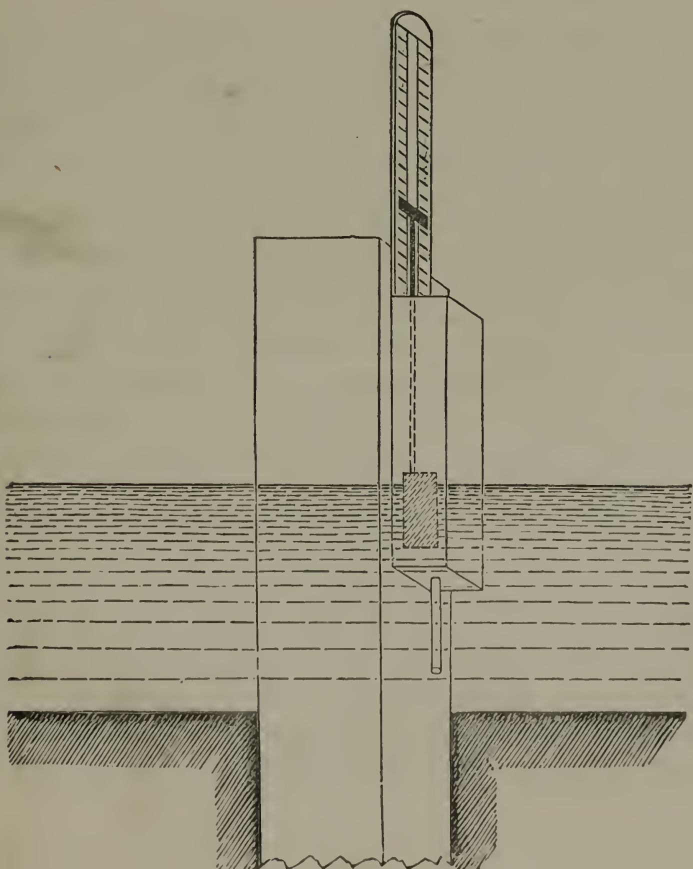
While engaged in completing the arrangements at Okha, Capt. Baird sent his assistants in advance to Hanstal and Nawanár to sink the wells, erect the observatories and get everything ready for him to set up the instruments.

The observatory at Okha was fixed on three cross-beams fitted on the tops of six large piles embedded 8 feet in the sand. The cylinder was about 2 feet from the eastern end; the tide-guage being of course as nearly as possible in the centre of the building. The aneroid barometer was placed carefully on a shelf at one corner. The anemometer was fixed to a shelf so that the upright pipe passed through the roof close to the ridge at the western end (the rain-gauge being close to it on the outside). A platform was made to get at the anemometer easily, and this served a double purpose, as it was also the framework for a guard to protect the pendulum and clock of the tide-gauge, and cloth having been fixed all round it, kept any wind from getting to the pendulum.

The self-registering tide-gauge was carefully so placed that the band allowed the float to be 3 inches from one side of the cylinder, while it was the same distance itself from the other side. The instrument having been carefully levelled by wedges, the trestle was secured with screws to the floor ; a hole was cut in the floor and a small box let down (properly fitted so as to allow no sand to come in), in order that the counterpoise weight might be able to act for the entire range of the instrument.

The float band was made 35 feet 6 inches long and 33 feet of chain was added to this, and fixed at its other end to the hook under the float, forming a continuous band as it were. The scale of wheels adopted here was $\frac{1}{4}$; the barrel being 5 feet long, that scale was the largest that could be used for a 14·90 feet range of tide. The float had a swivel to which the band was attached, and the band also passed through two guides fixed to an upright scale on one side, and through another guide fixed to the trestle on the other.

The temporary tide-gauge, consisting of a pile firmly imbedded in the sand and standing about 8 feet out of the ground, was placed about the



level of low-water neaps; to this was attached a box containing a copper float, and to the float was attached a deal rod with a pointer at the end of it about $6\frac{1}{2}$ feet above the float. In the bottom of the box a pipe, two feet long, of small diameter was fixed so as to permit the sea to have access to the float; the box itself was about 6 inches square and 6 feet high, the side of it attached to the pile was extended upwards for 6 feet and had a groove in it in which the upright rod with the index worked (*vide* figure), so that by having this upper part numbered from a certain zero, the level of the sea below this zero could be at once read off. It was found by careful trial in a bucket of water that the pointer always recorded 6 feet 2 inches above the level of the water in which the float worked—the scale was made accordingly; levels were taken to connect the temporary tide-gauge with the top of the cylinder, for comparison of level of water inside and outside.

It will be unnecessary to enter into details of the operations at each station as they were similar to those at Okha, of which the principal outlines have been given. Full details will be found in Capt. Baird's report appended to the General Reports of the Great Trigonometrical Survey for 1873-74 and 1874-75.

Commencement and Progress of the Observations.—The regular tidal registrations were commenced at Okha by the end of December 1873; at Hanstal by the end of March 1874, and at Nawanár by the end of April. It was hoped that they might have been carried on continuously for at least a year, or perhaps longer, at each station, in order to furnish the requisite data for investigations of the separate influence of each as well as the combined of all the principal tidal constituents, and the least that is needed for this purpose is a series of observations extending over a year. During this time the errors of the clocks for driving the barrels of the self-registering instruments would have to be frequently determined and the clocks corrected; the instruments would also have to be examined and cleaned, and possibly repaired also, and the relations between the curves on the diagrams and their zero lines would have to be carefully re-determined from time to time; and all this would have to be done either by Capt. Baird or by his assistant Mr. Rendell.

Capt. Baird accordingly drew up a programme for the periodic inpection of the stations and arranged that he and Mr. Rendell should make tours of inspection in turn. It was calculated that a tour embracing all three stations, would take about a month from the date of leaving to that of returning to recess quarters; these had been established in Rajkote, the nearest town to the Gulf where house accommodation suitable for Europeans could be obtained. Anticipating that during the monsoon months the weather at the tidal stations might be found too cloudy to permit of astronomical observations for determining the clock errors, Capt. Baird provided himself with two portable chronometers which were rated at Rajkote and carried about on the tours of inspection, for comparison with the clocks.

Difficulties of the Operations.—The operations were carried on under many and great difficulties, and Capt. Baird and his assistants incurred considerable risk when crossing the Gulf in native sailing vessels, as they frequently had to, whenever their presence was required at either of the stations. Huts had to be built and iron water-tanks provided at each station for the native subordinates who were placed in charge of the instruments, and for the men of the guard furnished by the Durbar of the Native State in which the station is situated. Arrangements also had to be made to supply these men with food and drinking water, which at Hanstal was no easy matter, for the nearest point whence these necessaries of life were procurable was about 25 miles off. At each station a line of post runners had to be established to the nearest points on the main line of postal communication, as it was essentially necessary that Capt. Baird should receive daily reports from the men in charge of the observatories.

The inspection of the observations necessitated a great deal of hard marching and entailed much exposure and privation. Even so early as in the month of May, before the setting in of the monsoon, the Runn of Cutch was covered with water, from six inches to a foot in depth, which had to be waded through for many miles distance to reach the station at Hanstal. At such seasons travellers usually cross the Runn by riding on the camels of the country; these animals are bred in large numbers along the borders of the Gulf, and are accustomed from their birth to wander about the swamps, browsing on the mangrove bushes, and thus they learn to walk with ease and keep their feet on ground which would be impossible to most other camels. Of his journey with Mr. Rendell, to Hanstal in the month of May, Capt. Baird writes, "Our only land-marks in the whole "of the last 14 miles were two small mounds of earth thrown up—when "there were postal chowkies there—at 4 or 5 miles apart, and the observa-"tory itself; we both felt a curious sensation as if we were being carried out "to sea, which was occasioned by seeing small branches of scrub floating "on the surface of the water and being driven by the wind inland; and "once, with the exception of one of the mounds above mentioned in the "distance, there were no fixed objects visible to destroy this optical illu-"sion." Later on, when the monsoon set in, the difficulties of locomotion were greatly increased; direct communication with Nawanár, by crossing the Gulf in a sailing boat, became impossible, as none but native vessels were available for the purpose, and they could not venture across in the strong gales then prevailing; and in order to reach that station a very long circuit had to be made round the head of the Gulf, crossing the Runn at its narrowest point opposite to Wawania. Moreover the common unmetalled roads in a black-soil country, as is the western portion of Kattywar, become all but impassible during the rains; and thus Capt. Baird was often unable to get over the ground more expeditiously than at the rate of about a mile an hour. Between the 7th July and the 8th September he was actually 38 days in the field, and marched nearly 800 miles under most adverse circumstances.

General Working of the Tide-gauges.—The general working of the tide-gauges at the three stations has now to be noticed.

At Okha the registrations went on most satisfactorily throughout 1874 and the following field season; there were very few breaks of continuity of the records, and they were very short and of no importance. At Hanstal where the water was very muddy, and not pure and clear as at Okha, the breaks were more numerous and longer; they were caused sometimes by the driving-clock getting out of order, but more frequently by the deposit of fine mud in the well and piping of the gauge, notwithstanding the precaution which had been taken to keep the rose at the extremity of the piping high above the mud-banks; this necessitated the occasional suspension of operations while the mud was being removed, and care was always taken to make the break between the times of high and low water, whenever possible; thus, as the record of the highest and lowest points of curves has been secured in almost all instances, the breaks may usually be interpolated between them by hand, in conformity with the collateral curves, without any risk of significant error. The foreshore at Okha being sand and rock without mud, there was no tendency there for the pipe to become choked. Both at Okha and at Hanstal air was found to enter the iron piping, whenever the latter was laid bare by the action of the surf, which frequently happened; but it was readily expelled at high-water, by opening the stop-cock which has already been described as attached to the piping for that purpose.

At Nawanár, matters went on less prosperously. When inspecting this station in July 1874, Capt. Baird found everything apparently in good order; the curves on the diagram seemed at first to be all that could be desired, but it was soon evident that they were erroneous, for the level of the water in the well differed very sensibly from the sea level. On examining the piping, the extreme end was found to be buried in sand above the low-water line, at a spot where a few weeks before, there had been a depth of 20 feet of water at low tide, but which was then left bare for some time daily. On further examination it was ascertained that the configuration of the foreshore had entirely changed, and an extensive sandspit had formed on the line of the piping; this had been caused by the drift from a belt of sand-hills to the south, under the influence of the strong winds which blew from the south-west during the monsoon, the registered velocities of which were 860 to 890 miles daily, for several days preceding the misadventure. This accident necessitated the suspension of the registrations at Nawanár until such time as the piping could be extracted and again put into communication with deep water. It was expected that the original configuration of the foreshore would probably be restored by natural causes, when the wind veered round to the usual direction, soon after the commencement of the cold-weather months; but this expectation was disappointed, and as the cold season wore on it became only too certain that the piping which lay beyond the low-water line would never be recovered. A supply of new piping was therefore obtained from Bombay and attached by Mr. Rendell to the land portion of the original pipe; and by the commencement of March 1875, after a break of 9 months' duration, the tide-gauge was once more in free communication with the sea, and there appeared to be every probability that it would so remain at least till the setting in of the next monsoon.

But within a fortnight after the re-starting of the tide-gauge at Nawanár, the foreshore again shallowed, and the new piping was covered with a deposit of silt and mud, nearly up to the level of the rose at its outer extremity. Mr. Rendell at once cut away the flexible piping and substituted several lengths of iron piping, supported by being attached to stakes driven vertically into the ground. By remaining on the spot for two months, taking measures to prevent the rose from being reached by the constantly rising mud and silt, Mr. Rendell succeeded in securing satisfactory and continuous readings for the whole of the time, and he checked them occasionally by hourly readings taken *pari passu* on a graduated staff, which had been set up in the sea in deep water, in order to afford a means of verifying the indications of the self-registering gauge. The station of Nawanár has thus been proved to be unsuitable for continuous tidal observations, extending over a long period, for it is only during the months of fine weather between November and May, that observations can be carried on there, otherwise than by setting up the tide-gauge on a staging erected for it out in deep water, the cost of which would be inadmissible.

Preliminary Results.—The preliminary results of the observations up to September 1874, as worked out by Capt. Baird, show that the greatest range of the tide was—

14·8	feet at	Okha.
19·6	,,	Nawanár.
21·2	,,	Hanstal.

or two to four feet more in each instance than the ranges given in the marine Charts.

Very fairly approximate values of the progress of the tidal wave, up and down the Gulf, have also been obtained, showing that—

High-water occurs at	Nawanár	1*h*.	5*m*.	after Okha.
,,	Hanstal	1	40	,,
Low-water occurs at	Nawanár	1	36	,,
,,	Hanstal	2	53	,,

The results obtained from the combined tidal and leveling operations show that the mean sea-level is higher by 7 inches, at the head of the Gulf, and by 4 inches, midway up, than it is at the mouth of the Gulf.

The curves of the self-registering aneroid barometers were compared four times daily with a mercurial barometer, and the differences met with—after allowing for index errors—were usually so trivial and unimportant that every confidence may be felt in the general accuracy of the curves. The aneroids are of a delicate construction and are liable to get out of order, but as spare ones were available, no break of importance occurred at either station.

The anemometers were less satisfactory in their working, probably because they were so much more exposed to the vicissitudes of the weather. The long continuance of winds coming from the same quarter caused the direction gear to clog, and until this was discovered the recorded directions are to some extent incorrect. On the other hand, the velocity gear was kept in constant action by the strong winds prevailing. Several severe gales were recorded. The greatest velocities registered in 24 hours were—

620	miles at	Okha	on the	20th June, 1874.
890	,,	Nawanár	,,	26th ,,
1130	,,	Hanstal	,,	5th August, ,,

On the latter date the anemometer of Hanstal recorded 270 miles in the three hours between 2 A. M. and noon. Capt. Baird is not entirely satisfied with the performances of these instruments; but, considering their small size (for the sake of lightness and portability), and their exposure to fierce winds, to rain and, worse than all, to the constant oxidising influence of the sea, Colonel Walker thinks it improbable that any instruments would, under similar circumstances, have given much better results.

The total rainfall during the monsoon of 1874, as registered by the rain-gauges set up at each station, was—

10·75	inches at	Okha.
13·61	,,	Nawanár.
18·40	,,	Hanstal.
21·91	,,	Rajkot (40 miles inland).

It will be seen that, a greater range of tide, a greater velocity of wind and a greater rainfall, have been registered at the head than at the mouth of the Gulf, and intermediate values at the midway station of Nawanár.

The scientific value of the observations is greatly increased by the contemporaneous observations of the barometric pressure, the velocity and direction of the wind, and the amount of rainfall; and it is believed that no series of tidal observations has been better furnished than these with the requisite data for separating local atmospheric influences from the true tidal constituents, which are caused by the varying position of the sun and moon.

Spirit-leveling operations.—At short distances round each station three blocks of stone were sunk in the ground to serve as bench-marks for future reference, and each of them was carefully connected with the zero of the tide-guage. Bench-marks were also placed in position, one at about every 10 miles, from Okha station along the road to Hanstal and thence to Nawanár in Kutch across the Runn. Bench-marks were also laid down with reference to the nearest Great Trigonometrical Stations. During the field-season of 1874-75, Capt. Baird conducted a series of spirit-leveling operations for determining the present relative levels of the datum points of the three tidal stations, and of the stone bench-marks which had been laid down a year previously along the lines to be levelled over. The length of the main lines connecting the three tidal stations was 275 miles, which was leveled over independently by Capt. Baird and Narsing Dass, in accordance with the rigorous system which has obtained for several years past in the G. T. Survey. 29 miles of branch lines were also executed, in order to connect the stations of the Kattywar triangulation with the tidal stations.

In working between Nawanár and Hanstal, Capt. Baird had to make a considerable *detour* round the head of the Gulf, crossing the Runn between Shikarpur and Mallia. Several bench-marks were fixed on the Runn, and they will be important points of reference when these operations are repeated with the tidal observations some years hence, when a sufficient interval shall have elapsed to allow of the rising or sinking of the surface of the ground to an appreciable extent. The existing surface-level of the Runn has been obtained at a number of points, for Capt. Baird took the precaution of having all the pins on which the leveling staves were set up, driven downwards until their heads were exactly flush with the surface of the ground.

Operations during the Monsoon.—Considerable anxiety was felt as to the possibility of securing continuous records during the monsoon, when heavy gales are prevalent; but every precaution was taken to strengthen the wooden observatories in which the instruments were set up, and to anticipate and provide for all possible contingencies; and it was most satisfactory that, although the monsoon of 1874 set in very severely and lasted long, the observatories all stood firm, and the tide-gauges and other self-registering instruments remained in good working order throughout the season.

Close of the Operations.—The carrying out of the periodical inspections during the monsoon was the most trying and difficult part of the operations.

During the monsoon of 1874 this duty was performed entirely by Capt. Baird, who had generously given his assistant leave of absence on urgent private affairs at that time. It had, however, proved to be so arduous and to entail so much exertion and exposure, that Colonel Walker felt he would not be justified in requesting Capt. Baird to carry on the inspections during the monsoon of 1875. He was therefore directed to continue the registrations up to within a few days of the commencement of the monsoon, and then to dismantle all the stations, and remove the instruments.

Accordingly at the close of the field-season of 1874-75, the instruments were taken down and the observatories dismantled. At each station the vertical iron cylinder, in which the float of the guage had acted, was left *in statu quo*, together with a length of the iron piping, extending about 50 feet seawards from the cylinder. The cylinder was filled with clean dry sand, and closed above with a thick planking, after which a massive pile of stones was raised over the ground around it, to serve the double object of a protection and an indication of the position for future reference.

The three bench-marks in the immediate vicinity of the cylinder, with each end of which the datum of the guage had been connected, were similarly covered over. Finally the several cairns were placed under the protection of the local officials; and it is to be hoped that the cylinders and bench-marks will be readily discovered whenever the second series of operations are commenced, and that they will be found to have remained undisturbed meanwhile.

Thus the periods during which the tidal heights have been continuously registered at the three stations are, 16½ months at Okha, 14 months at Hanstal, 2 months at Nawanár in 1874 and 2 months more in 1875. As already noticed, simultaneous observations of the direction and velocity of the wind and of the barometric pressure were made by the anemograph and barograph which were set up at each station.

The long break in the registrations at Nawanár is to be regretted. But as the station lies nearly midway up the Gulf, it is probable that the values of the difference between the mean level for the periods of actual observation and the mean level for the entire year, which are given by the registrations at Okha and Hanstal, may be applied proportionately to the results at Nawanár, to obtain the mean level for the year there, and Capt. Baird found that this plan gave very accordant and promising results.

When all the observations were completed, the ordinates of the several curves were measured, (taking full account of clock-error whenever there was any) and then tabulated for each hour of the day. The numerical results thus obtained serve as the data on which the analysis of the observations was subsequently based.

Thus ended the first series of operations, to determine whether the relations of land and sea are constant or changing. Col. Walker writes:

"Great credit is due to Capt. Baird for the manner in which he con-"ducted the task entrusted to him. The difficulties he had to contend with "in obtaining exact registrations continuously for such long periods were "very serious and formidable; all the stations were situated at points on the "coast line which were very far from the nearest habited localities; and the "inspections during the season of monsoons, which work was done entirely "by himself, necessitated constant travelling during the most inclement time "of the year, and entailed an amount of risk and exposure which would tell "on a constitution of iron."

Final Results.—The analysis of the results of the observations has necessarily been a work of time and has only lately been completed. Col. Walker felt assured that it would be best performed with the assistance of Mr. Roberts of the Nautical Almanac Office in London, by whom all the tidal observations taken for the British Association had been, and are still being reduced and analyzed, under the superintendence of Sir W. Thomson, and who had, previous to the commencement of the observations, aided Capt. Baird in the preparation of an account of the practical application of the harmonic analysis by which tidal observations are reduced for the British Association. Sanction was therefore obtained for Capt. Baird to remain in England and reduce his observations with Mr. Roberts' assistance. The results will be presently stated. But first it is necessary to give a brief epitome of the method of investigation which has been followed.

The rise and fall of the level of the ocean, twice, or nearly so, in twenty-four hours, is well known to be due to the attractions of the sun and the moon. If the orbit of the earth and that of the moon were quite circular and lay in the plane of the equator, and if the moon performed its revolution round the earth in the same time that the sun appears to revolve around the earth, then there would be two tides daily, differing from each other in form —should the sun and moon not be in conjunction—but recurring alike from day to day. The moon, however, makes her circuit of the earth in 48 minutes over the twenty-four hours, and thus the sun makes thirty apparent circuits of the earth while the moon is only making twenty-nine; moreover, the orbits of the earth and of the moon are not circular, nor are they situated in the plane of the equator. Thus the positions of the sun and moon, relatively to the earth, are momentarily varying in distance, declination and right ascension. Consequently, the level of the ocean is subject to momentary variations in the dynamical action of the disturbing bodies; and these cause a variety of tides which recur periodically, some in short, others in long, periods.

In the present investigations, the short and the long period tides have been analyzed by different methods. The former—which here embrace all tides recurring in periods of or about a day in duration, and in any aliquot part of the *quasi*-diurnal period—have been treated in accordance with the synthesis of Laplace. Thus a number of fictitious stars are assumed to move, each uniformly in the plane of the earth's equator, with angular velocities which are small in comparison with that of the earth's rotation, so that the period of each star is something not very different from 24 mean solar hours, and ranges between a minimum of 23 hours and a maximum of 27. Each star is supposed to produce a primary tide in its *quasi*-diurnal period, and also various sub-tides which run through their periods in $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ or some other aliquot part of the primary period ; but of these sub-tides it may here be observed that some are considerably larger than their so-called primaries, as for instance, the lunar semidiurnal tide, the magnitude of which is enormously greater than that of the lunar diurnal. The primary is simply the tide of which the period is nearest to 24 mean solar hours.

Thus the momentarily varying level of the surface of the ocean is supposed to be the resultant of a large number of tides, each of which is perfectly independent of all the others, and has its own amplitude and period of revolution, which remain ever constant throughout all time. Occasionally several of the most important tides are in conjunction, and then the range between high and low-water is a maximum, as at spring tides ; at other times some tides are in opposition to others, and then the tidal range is a minimum, as occurs at neap tides.

Every tide may be represented by a circle of known diameter ; and if we suppose a point to move uniformly right round the circumference of this circle so as to make a complete revolution in the time which is the tide's period, then the height of the point above or below the horizontal diameter of the circle at any moment, represents the height of the tide at that moment.

By the synthesis of Laplace we are able to find, from continuous observations of the varying level of the sea, the amplitude and the epoch (as they are called) of each of the several tides of which the height of the sea-level at any moment is the resultant. The amplitude is the radius of the representative circle, the epoch enables us to ascertain the point which the tide has reached at any given moment during its movement over the circumference of the circle. Thus when we know the amplitudes, the epochs and the velocities of rotation of any number of constituent tides, we are in a position to be able to compute and predict the height of the sea-level, at any future moment, at the station where the observations on which our calculations are based were taken.

The velocity of rotation of a tide rests primarily on certain combinations of the angular velocities of the earth's rotation round its axis, the moon's rotation round the earth, the earth's round the sun, and the progression of the moon's perigee, which are decided on *a priori* from theoretical considerations. These preliminary angular velocities are the arguments of the several fictitious stars of Laplace's method.

The portion of the height of the sea-level above or below its mean height (with reference to some fixed datum line), which is due to the combined influences of the several tides produced by any one of the fictitious stars, is given by the following well-known expression of the law of periodicity :—

$$h = R_1 \cos(nt - \epsilon_1) + R_2 \cos(2nt - \epsilon_2) + R_3 \cos(3nt - \epsilon_3) + \ldots$$

in which h is the height above mean sea at any moment, t is the time expressed in mean solar hours, commencing at 0^h, astronomical reckoning, and n is the angular velocity of the star in degrees of arc per mean solar hour, so that $360° \div n$ denotes the period of the star in hours of mean time. R_1 is the amplitude, and ϵ_1 the epoch of the full-period tide; R_2 and ϵ_2, R_3 and ϵ_3, &c., are the amplitudes and epochs of the sub-tides, whose periods are one-half, one-third, &c., that of the primary period. The amplitude is the semi-diameter of the circle whose circumference indicates the path of a tide. The epoch is the arc which, when divided by the angular velocity of the tide, gives the hour-angle when the height of the tide is a maximum; this occurs, on the day of starting, when $nt = \epsilon_1$ for a primary tide, when $2nt = \epsilon_2$ (and again 12 *quasi*-hours afterwards) for a tide whose period is half that of the primary, and so on.

Thus, if we now put h for the height of the sea-level at any moment, and A for the value of the height of the mean sea-level which results from the combined influence of the whole of the fictitious stars, we have—

$$h = A + \Sigma \left\{ R_1 \cos(nt - \epsilon_1) + R_2 \cos(2nt - \epsilon_2) + \quad . \quad . \quad . \right\}$$

where the symbol Σ stands for the summation of the whole of the terms within the brackets, which relate to all the fictitious stars.

There are two principal stars, respectively called S and M for brevity, the first of which represents the mean sun, or that point in the plane of the earth's equator whose hour-angle is equal to mean solar time; the second represents the mean moon, a point moving in the plane of the equator with an angular velocity equal to the mean angular velocity of the moon. The other fictitious stars respectively furnish the corrections to S and M for declination and parallax, to M for lunar evection and variation, and to S and M for the compound actions which produce what are called Helmholtz Tides, &c. The 24th part of the period of star S being an hour, that of any other of the fictitious stars may be conveniently spoken of, and is here called a *quasi*-hour.

To find the argument (the angular velocity n of the preceding formulæ) for each fictitious star, various combinations have to be made of the following fundamental angular velocities, *viz.* :—

γ, the earth's rotation	=	15°·0410686 per mean solar hour.	
σ, the moon's revolution round the earth ..	=	0·5490165	,, ,,
μ, the earth's revolution round the sun	=	0·0410686	,, ,,
$\tilde{\omega}$, the progression of the moon's perigee ..	=	0·0046418	,, ,,

The several fictitious stars whose tides have been analyzed in these investigations, are—

S,	with argument $n =$	$\gamma - \eta$	$= 15°.$
M	„	$\gamma - \sigma$	$= 14{\cdot}4920521$
K	„	γ	$= 15{\cdot}0410686$
O	„	$\gamma - 2\sigma$	$= 13{\cdot}9430356$
P	„	$\gamma - 2\eta$	$= 14{\cdot}9589314$
J	„	$\gamma + \sigma - \hat{\omega}$	$= 15{\cdot}5854433$
Q	„	$\gamma - 3\sigma + \hat{\omega}$	$= 13{\cdot}3986609$
μ	„	$\gamma - 2\sigma + \eta$	$= 13{\cdot}9841042$
N	„	$\gamma - \frac{3}{2}\sigma + \frac{1}{2}\hat{\omega}$	$= 14{\cdot}2198648$
L	„	$\gamma - \frac{1}{2}\sigma - \frac{1}{2}\hat{\omega}$	$= 14{\cdot}7642394$
ν	„	$\gamma - \frac{3}{2}\sigma - \frac{1}{2}\hat{\omega} + \eta$	$= 14{\cdot}2562915$
λ	„	$\gamma - \frac{1}{2}\sigma + \frac{1}{2}\hat{\omega} - \eta$	$= 14{\cdot}7278127$
MS	„	$\gamma - \frac{1}{2}\sigma - \frac{1}{2}\eta$	$= 14{\cdot}7460261$
and SM	„	$\gamma + \sigma - 2\eta$	$= 15{\cdot}5079479$

The *quasi*-hour angles of the several fictitious stars, other than S, at mean noon of the day of starting, were found by putting

$$\gamma = \text{the Sidereal time,}$$
$$\eta = \text{the Sun's mean longitude} = \gamma,$$
$$\sigma = \text{the Moon's mean longitude,}$$
$$\sigma - \hat{\omega} = \text{the Moon's mean anomaly,}$$

and taking the corresponding numerical values of each element, for the hour and station, from the Nautical Almanac and Hansen's Lunar Tables, and then substituting these values in the preceding symbolic expressions for the hourly variations of the several stars.

The number of stars and the angular velocity of each star having thus been decided on, *a priori*, from theoretical considerations, the values of the constants R and ϵ for the tidal constituents of each star have to be determined from the evidence afforded by the tabulated values of the height of the sea-level for every hour of the day during the entire period of observation; this should not be less than 371 days. The values of the constants have been computed for the several tides at the three stations of Okha, Nawanár, and Hanstal, and are given below. It will be remembered that Okha is situated at the entrance to the Gulf of Cutch, Nawanár midway up the Gulf, and Hanstal at its upper extremity; also that continuous observations over a period of not less than 14 months were obtained at the upper and lower stations, whereas at the middle station, Nawanár, there was a break of several months, in consequence of an alteration of the foreshore during the monsoon of 1874; thus the results for Nawanár are far from being as exact and complete as those for the two other stations.

Table of the Constants.

	Okha.	Nawanár.	Hanstal.
	Feet. °	Feet. °	Feet. °
The star S	R_1=0·0741, ϵ_1=149·89	Wanting.	R_1=0·1292, ϵ_1=164·01
	R_2=1·2224, ϵ_2= 14·37	R_2=1·8933, ϵ_2= 55·33	R_2=1·9277, ϵ_2= 84·51
	R_4=0·0132, ϵ_4=116·57	R_4=0·0131, ϵ_4=359·56	R_4=0·0211, ϵ_4= 61·74
	R_6=0·0030, ϵ_6= 20·92	Wanting.	R_6=0·0069, ϵ_6=166·57
	R_8=0·0006, ϵ_8=219·81	Ditto.	R_8=0·0025, ϵ_8=158·63
The star M	R_1=0·1122, ϵ_1=120·86	Ditto.	R_1=0·1208, ϵ_1=155·61
	R_2=3·6936, ϵ_2=348·08	R_2=5·8448, ϵ_2= 25·32	R_2=6·6291, ϵ_2= 46·52
	R_3=0·0289, ϵ_3= 22·10	Wanting.	R_3=0·0534, ϵ_3= 93·55
	R_4=0·1265, ϵ_4=108·88	R_4=0·1023, ϵ_4=275·00	R_4=0·6803, ϵ_4=331·55
	R_6=0·0056, ϵ_6=272·57	Wanting.	R_6=0·2760, ϵ_6=248·94
	R_8=0·0102, ϵ_8=100·06	Ditto.	R_8=0·0726, ϵ_8=154·36
The star K	R_1=1·5605, ϵ_1=146·60	R_1=1·6857, ϵ_1=156·00	R_1=1·6502, ϵ_1=174·60
	R_2=0·4207, ϵ_2= 24·82	R_2=0·4780, ϵ_2= 76·11	R_2=0·6767, ϵ_2= 88·63
The star O	R_1=0·8095, ϵ_1=322·67	R_1=0·7987, ϵ_1=332·04	R_1=0·8807, ϵ_1=340·76
The star P	R_1=0·3844, ϵ_1=319·94	R_1=0·2806, ϵ_1=342·02	R_1=0·3839, ϵ_1=353·65
The star J	R_1=0·1231, ϵ_1=176·32	R_1=0·1698, ϵ_1=191·77	R_1=0·1091, ϵ_1=222·61
The star Q	R_1=0·1596, ϵ_1=324·68	R_1=0·1697, ϵ_1=335·14	R_1=0·1618, ϵ_1=343·23
The star L	R_2=0·1511, ϵ_2=224·77	R_2=0·3569, ϵ_2=226·93	R_2=0·3892, ϵ_2=238·32
The star N	R_2=0·7551, ϵ_2=322·94	R_2=1·2205, ϵ_2= 11·72	R_2=1·1535, ϵ_2= 26·76
The star λ	R_2=0·0712, ϵ_2=204·40	R_2=0·1466, ϵ_2=251·10	R_2=0·2268, ϵ_2=219·57
The star ν	R_2=0·1592, ϵ_2= 8·50	R_2=0·2975, ϵ_2= 5·43	R_2=0·2864, ϵ_2= 48·24
The star μ	R_2=0·1896, ϵ_2=184·26	R_2=0·4026, ϵ_2=186·44	R_2=0·5569, ϵ_2=179·74
The star SM	R_2=0·0435, ϵ_2=291·24	Wanting.	R_2=0·1309, ϵ_2=297·74
The star MS	R_4=0·0619, ϵ_4=112·37	Ditto.	R_4=0·3388, ϵ_4= 13·01

It will be seen that the principal tides are first the *quasi*-semi-diurnal of M, and then the semi-diurnal of S and the *quasi*-diurnal of K, which range from one-third to one-fourth of the former. S and M being the principal stars, their sub-tides, down to the three-hourly tide of S and the corresponding tide of M, have been computed. For K the *quasi*-diurnal and semi-diurnal tides were computed; for the stars O to Q only the primary tides. For the stars L to SM there are no primaries, and the tides of longest period are the *quasi*-semi-diurnal; for MS the longest tide is the *quasi*-demi-semi-diurnal; these, being the principal ones for each star, have been computed.

Here it is necessary to observe that the number of sub-tides which have to be investigated in each instance, in order to evaluate the full influence of the star, is a matter which can only be decided after considerable experience of such investigations has been gained by the analysis of the tides at a great variety of stations. It was therefore left to Mr. Roberts, whose practical familiarity with the subject probably exceeds that of any other individual, to prescribe the number of terms to be computed for each star.

On inserting the numerical values of the constants R and ϵ in the general expression, and substituting for nt its values in succession for every hour from the starting-point, the height (in feet) of each tide and sub-tide may be computed for every hour. The sum of these gives the portion of the height of the sea-level at that hour which is due to the influence of the short-period tides. This usually far exceeds the portion which is due to all other causes, and is thus frequently taken to represent the whole height.

Should it be desired to compute the hourly heights for any day of any year, without commencing at the starting-point of the observations, as may be necessary when tidal predictions are required, the values of γ, η, σ, and $\hat{\omega}$ must be found, as stated on page 46, for mean noon of the day which may be adopted as the new starting-point; the *quasi*-hour-angles of the several fictitious stars, other than S, at that moment must then be found, after which those for the succeeding hours may be obtained by successive additions of the respective hourly increments which are due to each star.

The values of the constants R and ϵ having been determined for each of the three tidal stations, the next step taken was the calculation of the height of the sea-level at each hour, throughout the entire period of registration at each station. The differences between the observed and the computed values were then taken as the data for calculating the influence of variations in barometric pressure, and in the velocity and direction of the wind, on the sea-level. Equations were formed in which the unknown quantities were B, the effect of a barometric pressure of one inch, and N and E, the effects of the North and the East components respectively of winds blowing at the rate of 10 miles an hour. Of these equations there were as many as the number of days of observation; they were solved by the method of minimum squares. Corrections were then computed for the daily variations of the atmospheric influences on the sea-level, and were applied to the values of height resulting from the previous investigations of the short-period tides. Finally, the differences between the heights thus determined and those actually observed were taken as the data for calculating the influence of each of the long-period tides.

The evaluation of the atmospheric influences gave the following factors for changes of sea-level due to a barometric pressure of one inch, and to north and east winds travelling with a velocity of 10 miles per hour :—

	At Okha.	At Hanstal.
Barometric pressure	+ 0·356 feet	— 0·438 feet.
North Wind	— 0·191 „	— 0·262 „
East Wind	+ 0·161 „	+ 0·087 „

These results are not satisfactory; the height of the sea-level at Okha appears to increase with an increase of barometric pressure, which is scarcely possible. It happens that at this station the changes of pressure occurred, as a rule, simultaneously with the changes of wind; and thus it is impossible to determine the separate effect of each, otherwise than by some arbitrary method of treatment. The observations will therefore be again analyzed, with a view to ascertaining whether they may not be made to yield more consistent results. Meanwhile, the values of the atmospheric factors already obtained must be considered to be only approximate, giving fairly accurate results when employed collectively but not individually.

Of the constants for the long-period tides the following values have been computed for the stations of Okha and Hanstal, after the elimination of atmospheric influences, by employing the preliminary values of the factors which are given in the preceding paragraph. At Nawanár sufficient observations are not forthcoming for the evaluation of either the atmospheric or the long-period tides.

Long-period tides, and their Constants.

$(\sigma - \hat{\omega})$ Lunar monthly elliptic tide,
$2\,\sigma$ Lunar fortnightly declinational tide,
$2\,(\sigma - \eta)$ Luni-solar synodic fortnightly tide,
η Solar annual elliptic tide,
$2\,\eta$ Solar semi-annual declinational tide,

Okha. Feet.	°	Tide.	Hanstal. Feet.	°
R = 0·058,	ϵ = 311·38	$(\sigma - \hat{\omega})$	R=0·107,	ϵ = 14·17
„ 0·070,	„ 52·73	$2\,\sigma$	„ 0·142,	„ 45·74
„ 0·136,	„ 249·19	$2\,(\sigma - \eta)$	„ 0·163,	„ 11·76
„ 0·162,	„ 3·11	η	„ 0·024,	„ 195·32
„ 0·121,	„ 144·75	$2\,\eta$	„ 0·090,	„ 156·38

The present appears to be a good opportunity for giving the tidal constituents which were calculated by Mr. Roberts for the Port of Tuticorin, from observations taken there in the year 1871-72, by Captain Branfill, with a self-registering tide-gauge similar to those employed in the Gulf of Cutch.

Short-period Tides at Tuticorin, and their Constants.

	Feet.	°		Feet.	°
Star S	$R_1=0{\cdot}039$,	$\epsilon_1=108{\cdot}78$	Star P ...	$R_1=0{\cdot}064$,	$\epsilon_1=281{\cdot}78$
	$R_2=0{\cdot}429$,	$\epsilon_2=95{\cdot}59$	„ J ...	$R_1=0{\cdot}011$,	$\epsilon_1=181{\cdot}70$
	$R_4=0{\cdot}073$,	$\epsilon_4=282{\cdot}65$	„ K	$R_1=0{\cdot}274$,	$\epsilon_1=132{\cdot}80$
	$R_6=0{\cdot}003$,	$\epsilon_6=51{\cdot}34$		$R_2=0{\cdot}143$,	$\epsilon_2=116{\cdot}25$
	$R_8=0{\cdot}007$,	$\epsilon_8=262{\cdot}75$	„ Q ...	$R_1=0{\cdot}032$,	$\epsilon_2=359{\cdot}08$
Star M	$R_1=0{\cdot}006$,	$\epsilon_1=234{\cdot}64$	„ L ...	$R_2=0{\cdot}030$,	$\epsilon_2=242{\cdot}50$
	$R_2=0{\cdot}596$,	$\epsilon_2=55{\cdot}81$	„ N ...	$R_2=0{\cdot}072$,	$\epsilon_2=38{\cdot}69$
	$R_3=0{\cdot}015$,	$\epsilon_3=182\ 86$	„ λ ...	$R_2=0{\cdot}019$,	$\epsilon_2=248{\cdot}45$
	$R_4=0{\cdot}022$,	$\epsilon_4=192{\cdot}76$	„ ν ...	$R_2=0{\cdot}022$,	$\epsilon_2=35{\cdot}58$
	$R_6=0{\cdot}010$,	$\epsilon_6=45{\cdot}91$	„ μ ...	$R_2=0{\cdot}016$,	$\epsilon_2=183{\cdot}83$
	$R_8=0{\cdot}004$,	$\epsilon_8=319{\cdot}74$	„ 2SM ...	$R_2=0{\cdot}011$,	$\epsilon_2=246{\cdot}37$
Star O ...	$R_1=0{\cdot}112$,	$\epsilon_1=314{\cdot}25$	„ MS ...	$R_4=0{\cdot}018$,	$\epsilon_4=282{\cdot}99$

Long-period Tides at Tuticorin, and their Constants.

	Feet	°
Lunar monthly	$R=0{\cdot}024$	$\epsilon=313{\cdot}15$
Lunar fortnightly	„ $0{\cdot}065$	„ $69{\cdot}54$
Luni-solar fortnightly	„ $0{\cdot}016$	„ $307{\cdot}85$
Solar annual	„ $0{\cdot}399$	„ $313{\cdot}35$
Solar semi-annual	„ $0{\cdot}080$	„ $87{\cdot}50$

Here there were no data for evaluating the atmospheric tides separately, and it is probable that the magnitude of the amplitude of the solar annual tide is in great measure due to atmospheric influences.

Programme of Future Operations.

The following important orders on the systematic record of tidal observations at selected points on the Coasts of India, were issued by the Government of India in the Department of Revenue, Agriculture, and Commerce, under date 4th July, 1877 :—

"The Governor General in Council observes that the great scientific advantages of a systematic record of tidal observations on Indian coasts have frequently been urged upon, and admitted by, the Government of India. Hitherto the efforts in the direction of such a record have been desultory, and in many cases wanting in intelligent guidance and careful selection of the points where the observations should be recorded. Additional importance has recently been given to the subject by the institution of a Marine Survey Department, for whose operations accurate tidal observations are a necessity, without which no permanent record of the changes of ground in the different harbours of the coast can be kept up.

"2. The advantages to be expected from well-considered and carefully conducted observations of the tides are mainly the following:

"(1) They enable standards to be fixed for the purposes of survey.

"(2) They afford data for the calculation of the rise and fall of the tides, and thus subserve the purposes of navigation.

"(3) They are of scientific interest apart from their practical usefulness as stated above.

"The first two of these advantages are of strictly local bearing: an accurate survey of a port is essential to the safety of the shipping frequenting it, and correct tide-tables are necessary for the convenience of navigators and for engineering purposes within the port itself.

"3. The Governor General in Council is of opinion that, in view of these considerations, every port where a tide-gauge is set up should pay for its establishment and maintenance from port funds. The third object, the scientific results to be expected from the record, will be sufficiently provided for by the appointment by the Government of India of one of its own officers to supervise and control the local observations, and to arrange for their utilization to the utmost extent possible. The charges will thus be divided in a manner appropriate to the advantages to be secured.

"4. His Excellency in Council accordingly resolves to entrust the general superintendence and control of tidal observations upon Indian coasts to Captain Baird, R. E., Deputy Superintendent in the Great Trigonometrical Survey Department, who will be guided in his operations by the orders and advice of the head of that Department. This will involve no new charge upon Imperial Funds, for Captain Baird has for some years past been engaged upon observations of this nature in the Gulf of Cutch and in reduction of the observations in England: the work is of a nature which properly falls within the scope of the operations of the Great Trigonometrical Survey; and the object of the present change is merely to provide for its extension and systematization under an undivided control. Captain Baird will thus remain a member of the Department, and his operations will form one of the subjects to be treated by the Superintendent in his annual report.

"5. The first duty of the Superintendent will be to instruct Captain Baird to determine, in communication with the Governments of the maritime provinces, the points where observations should be carried out. The necessary gauges (where these do not already exist) will then have to be provided from port funds, and the establishments entertained under the sanction of the Local Governments. It will probably be most convenient that all Captain Baird's communications with the establishments in charge should pass through the Local Governments, but this point may be settled as may be found most expedient in practice."

In accordance with these orders, enquiries have been, and are being made, with a view to ascertain the ports at which it will be desirable to establish tidal stations. The suitability of a port for this purpose will depend, *first*, on a site being available thereat, on which a self-registering tide-gauge may be erected, so as to be either immediately over the sea, or connected by piping with the sea at some point where there is a depth of not less than 10 to 15 feet of water at the lowest tides; *secondly*, on the presence of a port officer, who will exercise a general supervision over the operations, and correct the clocks of the several self-registering instruments, whenever necessary, either by direct determinations of time, or by arranging to get the true time from the nearest telegraphic office; *thirdly*, on the feasibility of making arrangements for the periodical inspection of the instruments at intervals of not less than six months generally, and more frequently when no officer is resident on the spot to superintend the operations.

So far as has yet been ascertained, the ports which seem likely to answer all the required conditions are Aden, Kurrachee, Bombay, Carwar, Beypore, Paumben, Madras, Vizagapatam, Akyab, Rangoon, and Port Blair. The following ports are believed to be unsuitable: Surat, Mangalore, Cannanore, Cochin, Muttrun, Negapatam, Coconada, False Point, Diamond Harbour, Moulmein, and Mergui.

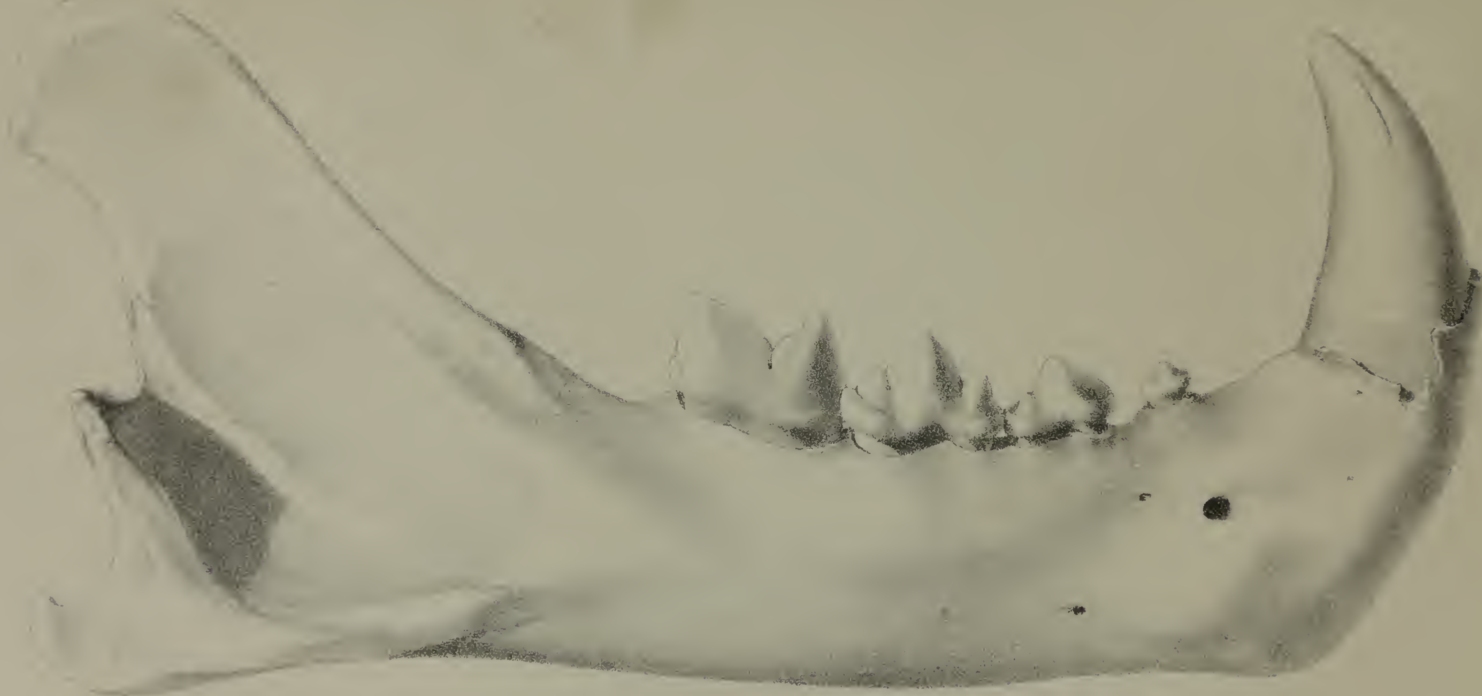
At Aden a self-registering tide-gauge was erected by the local officers about two years ago; but the registers have been taken in such an unsatisfactory manner that the results are not of the slightest use. Captain Baird is now arranging for the establishment of a tidal station there, with proper instruments, and trained men to take charge of them. At Kurrachee a tide-gauge, which was originally set up by Mr. Parkes, has been in work for several years, and has furnished the data from which tide-tables for the port have been computed annually by Mr. Parkes. In course of time the present gauge—the scale of which is very small—should be replaced by one of those which are used by Captain Baird, and an anemometer and a barometer (both self-registering) should be set up beside the gauge. But it is not desirable to interfere with the working of the present arrangements at Kurrachee until other ports, at which nothing is now being done in the way of tidal observations, are duly provided for. At Bombay, Carwar, and Madras, instruments are now being set up by Captain Baird.

E. Neale lith

Hanhart imp

RUTICILLA SCHISTICEPS, ♂♀.

Journ. Asiat. Soc. Bengal, Vol. XLVII, Pt. II, 1878. PLATE II.



S. Seagfield Lith. Calcutta.

ABNORMAL DENTITION OF TIGER.

J. Smit lith Hanhart imp

GARRULAX NUCHALIS

J. Smit lith Hanhart imp

ACTINURA OGLEI.

Owing to an accident at the last moment, I regret that I have been unable to supply the full number of copies required of the specimen of photocollotype printing referred to at page 93, and, therefore, am obliged to defer giving it till my return from England.

J. W.

JOURNAL

OF THE

ASIATIC SOCIETY OF BENGAL.

Part II.—PHYSICAL SCIENCE.

No. II.—1878.

VI.—*The Application of Photography to the Reproduction of Maps and Plans by Photo-mechanical and other processes.—By* Capt. J. Waterhouse, B. S. C., *Assistant Surveyor-General of India.*

This paper was originally submitted to the Geographical Congress at Paris in 1875, but as the Proceedings of the Congress have not been published and the paper may be of interest to Members of the Society, as giving an account of the photographic operations for the reproduction of maps, now so largely employed in this country, I have carefully revised and to a great extent re-written it, so as to bring the information up to date and hope that it may not be considered too much wanting in novelty or too technical for the Journal.

I. Introduction.

Among the many useful and important artistic and scientific applications of photography, one of the most valuable is the reproduction by its means, in absolute facsimile, of maps and plans, speedily and cheaply and on any scale—either the same, larger, or smaller. So fully are these advantages appreciated, that most civilized States now possess special photographic studios for the reproduction of maps, plans, &c., for fiscal, military and other purposes.

Before the introduction of lithography, about the beginning of the present century, the only means by which maps, or indeed, pictorial subjects of any kind, could be reproduced, was by engraving on metal plates or on wood, both tedious and expensive methods.

With the invention of lithography, a new impetus was given to cartography by the comparative ease with which maps could be produced and multiplied by direct drawing or transfer on stone. The young art was, however, scarcely out of its cradle when Joseph Nicéphore Niepce, of Chalons-sur-Saone, experimenting unsuccessfully in endeavouring to find a substitute for lithographic stone, conceived the happy idea of obtaining images on metal plates by the sole agency of light upon thin films of asphaltum or bitumen of Judæa—and thus produced the first permanent photographs by a method of heliographic engraving, which, with a few modifications, still serves to produce excellent results ; and it is worthy of remark in connection with our subject that Niepce's first essays were in reproducing engravings.

Since these first essays of Niepce, the idea of superseding the slow and laborious hand-work of the lithographic draftsman and engraver by the quicker, cheaper and more accurate processes of photography, has been steadily kept in view, and various modes of engraving, both for copper-plate and surface-printing, and of lithography by the aid of photography, as well as other special photo-mechanical processes, have been introduced from time to time with more or less success, till at the present time these methods have taken a high and important position among the graphic arts, and as they steadily progress towards perfection, are rapidly extending their artistic, scientific and industrial applications.

The attention of cartographers was very soon drawn to the advantages that might be gained by the employment of photography for the reproduction of maps and plans, but for some time progress in this direction was hindered by the difficulty of obtaining accurate images, free from the distortions caused by imperfect construction of the photographic lenses then employed. The first serious attempt to carry out the method practically appears to have been made, in 1855, by Colonel Sir Henry James, R. E., Director of the Ordnance Survey of Great Britain and Ireland, with the object of obtaining accurate reductions from the large-scale surveys more expeditiously and with more economy than could be done by means of the pantograph.

The result proved incontestably the great value of photography for this purpose and the enormous saving in time and money that could be effected by its use. The possibility of producing absolutely accurate photographic reductions was questioned in Parliament, but Sir Henry James satisfactorily showed that the employment of photography produced reductions more accurate than could be obtained by any method previously in use ; that the maximum amount of error could scarcely be perceived, and was much within the limit of the expansion and contraction of paper under ordinary atmospheric changes—which was all that could be desired.

For some time, however, the use of photography in the Ordnance Survey Office appears to have been limited to obtaining accurate reduced prints for the engravers to trace from on to their copper-plates, and was not extended to producing maps for publication, owing to the expense and comparative slowness of production of photographic silver prints, compared with the lithographic or copper-plate impressions, to say nothing of their want of permanence.

Experiments were next made with some of the so-called carbon processes, then recently discovered in France by Poitevin and first worked in England by Pouncy, with the object of transferring the photographic design at once on to the copper-plate, instead of tracing from the photographs by hand. The results obtained were not very satisfactory and a trial was made of Mr. Asser's photolithographic process, which had been published shortly before. Although this process was not found quite adapted to the purpose intended, the advantages of a method whereby facsimile prints in lithographic ink might be obtained and transferred to zinc or stone, so as to permit of a large number of copies to be printed off as easily as from an ordinary lithographic transfer drawing, and with precisely the same advantages in respect to cheapness and permanence, were obvious ; and in 1860, after several trials, Captain A. de Courcy Scott, R. E., who was in charge of the photographic operations at Southampton, perfected the process of photozincography, which has since been employed with so much success and advantage at the Ordnance Survey Office, Southampton, and in this country at the Survey Offices in Calcutta, Dehra Dún, Púna and Madras, as well as at other public and private institutions in other parts of the world.

By a curious coincidence, at the very time when this process was being worked out in England, Mr. W. Osborne, of Melbourne, Australia, independently perfected an almost identically similar process of photolithography, which has been extensively used in the Crown Lands Offices of Victoria and Adelaide for reproducing the maps of the Australian Surveys, and has also been worked commercially by Mr. Osborne in Europe and America.

These two processes, appear to have been the first instances of the practical application of photography to the reproduction and multiplication of maps for publication. They still remain, however, very extensively used, and are by the simplicity, cheapness and rapidity of their operations and the facilities they offer for the reproduction of maps of large size, of greater practical value than other processes which have since been brought forward with the same object, and are perhaps capable of producing finer results within the limits of a single negative.

In India, the ever-increasing wants in the way of communications by rail, road and river, and the rapid extension of irrigation and other engineering projects, as well as the ordinary military, administrative and fiscal requirements make the early production of accurate maps a matter of very great necessity and importance, and as skilled lithographic draftsmen and engravers are scarcely to be obtained and must be trained as required, or brought from Europe at great expense, the subject of photographic reproduction as a means of quickly producing and publishing copies of the original maps of the Surveys, is much more important in this country than it is in Europe or other countries where skilled cartographic lithographers and engravers are comparatively numerous.

The success that had attended the introduction of photography at the Ordnance Survey Office for the reproduction and reduction of maps immediately attracted the notice of the Surveyor General of India, and the services of two trained sappers, with the necessary apparatus, having been obtained from England, a small beginning was made in Calcutta in 1862. Owing to difficulties experienced in working photolithography in the peculiar climate of Calcutta, and the unsuitability of the original maps for reproduction by the process, owing to their being coloured and brush-shaded, little advance was made in the practical working of photolithography or photozincography in India till 1865, when Mr. J. B. N. Hennessey, of the Great Trigonometrical Survey, who had devoted part of his furlough in England to going through a practical course of instruction in photozincography at the Ordnance Survey Office, Southampton, fairly established the process at the Office of the Superintendent of the Great Trigonometrical Survey at Dehra Dún. I and other officers of the Survey Department were trained under Mr. Hennessey, and, in 1867, photozincography was finally started in Calcutta by Capt. A. B. Melville, who officiated for me during my absence on furlough, and since 1869 it has been carried on under my own supervision. Photozincographic offices have also been established under the Bombay Government at Púna, and at the Revenue Survey Office in Madras for the reproduction of the maps of the Revenue and Settlement Surveys in those Presidencies as well as miscellaneous work for other departments. In both of these offices the Southampton process of photozincography is used with a few modifications, but in Madras photolithography is also used with equally good results, and is, I am told, preferred for very fine work.

Before the introduction of photography the publication of the results of the Surveys by the Surveyor General's Office could only be accomplished by the ordinary methods of lithography and engraving; and though much good work was done in the former manner by the very limited native agency available in this country, many maps had to be sent to England to be lithographed, while the whole of the engraving connected with the Atlas of India, on the scale of 4 miles to one inch, was done in England under considerable disadvantages. Even with this help it was found quite impossible that the publication could keep pace with the surveys, and the consequence was that the record rooms became filled with valuable materials that often could not be turned to practical account till they had become antiquated and out of date. Now, on the contrary, by the aid of photozincography, the publishing branches are able to keep pace with the progress of the Surveys so closely that as a rule each season's mapping of all the 1-inch Topographical and some of the Revenue Surveys is reproduced and published before the drawing of the following season's maps is taken in hand. An immense amount of work is thus done that could never have been undertaken by lithography and engraving alone, even though the transfer of the engraving of the Atlas of India to Calcutta has greatly facilitated the early publication of the latest additions to the Atlas year by year. And not only are the ordinary departmental publications thus hastened, but a very large number of miscellaneous maps and drawings are reproduced specially for the use of other departments of the public service.

The following table of the work executed by the Photographic Branch of the Surveyor General's Office, Calcutta, during the year 1877, will give an idea of the very large extent to which photography is being used for the reproduction and publication of the results of the Imperial Surveys and other miscellaneous demands.

	Sections or Sheets.	Negative Plates.	Carbon Prints.	Silver Prints.	Photo:—Transfer Prints.	Transfers to Zinc or Stone.	Number of Pulls.	Number of Sheets Printed.
Topographical Maps, ...	167	272	..	218	241	106	20,775	21,215
Revenue Survey Maps, ...	233	263	..	..	297	71	22,370	18,320
District Maps, ...	6	22	..	..	8	3	6,664	5,084
General Maps, ...	42	199	..	46	176	44	9,359	6,629
City and Cantonment Plans,	59	104	..	63	122	37	8,580	8,580
Miscellaneous Maps, &c., ..	362	510	..	536	507	190	57,138	82,515
Proofs, ...	..	..	..	..	..	..	5,932	..
Photos. of Life Convicts, ..	..	..	348	..	..	..	..	..
Cadastral Maps, Bengal, ..	56	..	..	..	..	56	2,800	2,800
Total, ...	925	1,370	348	863	1,351	507	133,618	145,143
Cadastral Maps, N. W. P.,	2,113	3,973	..	..	4,047	2,218	99,450	99,450
Grand Total, ...	3,038	5,343*	348	863	5,398†	2,725	233,068	244,593

* 20,962·00 square feet. † 22,027·40 square feet.

In the Great Trigonometrical Survey Office at Dehra Dún, during the year 1876-77, 117 maps and 30 charts, besides miscellaneous diagrams were photographed, and 25,529 copies printed from them; 297 blue prints and silver prints were also made.

At the Govt. Photozincographic Office, Púna, during the same year, the number of negatives taken was 2,745, the number of maps photozincographed was 1,798, and the number of copies printed off (including copies of 79 lithographs) was 74,739. Since the formation of the office, in 1867, to the present time 9,100 maps have been photozincographed.

The specific advantages to be gained by the use of photography for the reproduction of maps and plans are:

1. Rapidity of production and multiplication, especially when employed for copying subjects containing close and intricate details. The gain varies according to the amount of detail and the time that would be taken by a skilled draughtsman or engraver to make the copy by hand. For instance, a highly finished map that would take several months to lithograph or engrave, may by the aid of photography be copied and some hundreds of copies printed off within a week.

2. The perfect fidelity with which the most delicately minute and intricate details are copied. The most skilful and careful draughtsman is liable to make errors in copying, and never can attain the same accuracy of delineation, especially of minute objects, as is obtained with the camera.

3. The facility with which copies may be obtained on scales larger or smaller than the original. The extent to which this may be taken advantage of depends very much upon the object in view as well as upon the style of the original, and the relative thickness and size of the lines and details composing it; but notwithstanding certain drawbacks and inconveniences it may sometimes be attended with, this facility of enlarging or reducing the scale of an original drawing with the most perfect accuracy and with the absence of all personal error, is one of the most important advantages of photography, and its immense superiority in this respect over the pentagraph and other methods has been proved to be beyond question.

4. The comparative cheapness of the photographic methods. The relative cost of hand labour and photography is affected by several considerations, *e. g.*, the nature of the subject, the process employed, the number of copies made and the pay of the photographers as compared with that of draughtsmen. In most cases it will be found that when it is really an advantage to employ photography in reproducing maps for any particular purpose, the cost will be far less than it would be by employing hand labour.

Notwithstanding these advantages, the use of photography as a means of reproducing maps and plans for publication has not extended so much as might have been expected, partly on account of defects inherent in photographic copying, and only to be overcome by great skill and long experience on the part of the photographer, and partly owing to the difficulty of making draughtsmen fully understand the requirements to be fulfilled when preparing maps to be reproduced by photography for publication, in order to produce satisfactory results, and that they must strictly refrain from using colour and draw the map neatly in black and white, so that every line may be reproduced of its proper strength, according as the map is to be copied on the same scale as the original or to be reduced.

It matters little how roughly drawn or highly coloured an original drawing or map may be, if it is intended to lithograph or engrave it, because a skilled lithographer or engraver can easily put it into proper and conventional form; but when such a drawing is handed to the photographer he can only produce a facsimile of it with all its deficiencies—the coloured details hidden under a black mass of shade, the finer parts perhaps wanting altogether, the writing rough and broken, or so small as to be almost invisible, besides other defects caused by the unsuitableness of the drawing for reproduction by photography, and these defects are liable to be unduly attributed to the process.

These difficulties were felt in all their force when it was first determined to introduce photozincography for the publication of the maps of the Imperial Indian Surveys, because till that time these maps had been drawn in a very delicate, highly finished style, with many of the details on them coloured and the hill features shown by brush shading. It was soon seen that an entire change of style was necessary and that the original maps prepared specially for photographic reproduction, must be drawn in pen and ink lines alone, without colour or brush-shading. It was some time before the desired results were obtained, but after several years' experience a high degree of excellence has been attained in the preparation of original maps suitable for photographic reproduction, and now all maps of the above Surveys and most of the miscellaneous maps and drawings received from other departments are drawn with this object.

The change of style has been regretted by some as spoiling the beauty and finish of the maps, and the want of colour certainly has some drawbacks, but there can be no doubt that the necessity for drawing the original maps so that they may be fit for immediate publication has effected here, as it has also been found to do wherever photozincography or photolithography has been introduced, an immense improvement in the style of drawing of the manuscript maps as well as in the accurate delineation of the ground. The photozincographed copies as a rule appear somewhat coarse and rough when compared with good lithographs or engravings, but they possess the great advantage of being produced quickly and cheaply; while being absolute facsimiles of the original maps submitted by the surveyors, they are entirely free from the errors that even the most careful draughtsman is liable to make when copying by hand, and they faithfully preserve the appearance and character of the ground exactly as delineated by the surveyor.

In most foreign topographical establishments, I believe, the principal use of photography is for making reductions, and not so much for the reproduction of maps on the same scale as the originals. In India, however, photozincography is very largely used for full-scale reproductions. Thus, the whole of the standard maps of the Topographical Surveys on the scale of 1-inch to the mile and the Cadastral village maps of the Revenue Survey, on the scales of 32 inches to the mile, for Bengal, and 16 inches to the mile, for the N.-W. Provinces, are reproduced on the same scale and are not reduced for publication on any smaller scale. In some cases, however, the surveys are made and drawn on the scale of two inches to a mile and are then reduced to one-inch, with a great improvement in the general appearance of the finished maps—reductions always appearing sharper and more highly finished than reproductions to scale. Some of the maps of the Revenue Surveys are reduced to the standard scale of 1-inch to the mile by a double reduction from the maps on the original scale of survey—4 inches to the mile. These are first photozincographed, in sections of convenient size, on the reduced scale of 2 inches to the mile and some prints are struck off in blue ink. Upon these blue prints, the draughtsman re-draws the map in a style suitable for a further reduction to one-half, leaving out all details not required on the 1-inch map and generalising the hill features, &c., so as to produce a proper effect when reduced. By the use of these blue prints, the labour of making a piecemeal reduction with the pantograph is saved, and the draughtsman can produce a more accurate result.

Silver print reductions to one-fourth of the standard 1-inch maps are made for the use of the engravers in preparing the sheets of the Atlas of India on the quarter-inch scale.

In the Photozincographic Offices at Púna and Madras more use appears to be made of reduction for the village maps than in the Calcutta Office.

The photographic processes applicable to the reproduction of maps are :

I.—*Photographic printing on Sensitive Papers.* In these methods prints are obtained on a sensitive surface of paper prepared with the salts of silver, platinum and iron, or with certain salts of chromium in conjunction with pigmented gelatine. In all of them the whole of the photographic operations connected with the printing have to be repeated for every impression.

II.—*Photo-lithography* or *Photo-zincography*, or the methods by which photographic image in greasy ink may be produced on, or transferred to, a lithographic stone or zinc plate and printed off in the lithographic press. The photographic operations cease with the production of the image in greasy ink, and the impressions are produced by the ordinary operations of lithographic printing. The use of these processes is, however, limited to the reproduction of subjects in line or dot, as they can only reproduce half tones in a very imperfect manner.

III.—*Photo-collotype*, or the method of producing a photographic image on a layer of gelatine applied on a suitable support, so that when the gelatine surface is moistened, impressions may be obtained from it in printing ink. By this method, also, a photographic image once produced on the printing surface of gelatine is capable of yielding some hundreds of impressions in the printing press; and instead of the subjects for reproduction being confined to those in dot or line, as in photo-zincography, any subject can be copied which is capable of giving a good photograph by the ordinary process of silver printing.

IV.—*Woodbury-type*, or the method whereby a photographic image is impressed into a soft metal plate, somewhat in the same manner as in the operation of nature-printing, forming a mould into which liquid coloured gelatine is poured and attached under pressure to a sheet of paper, thus yielding an image in which the lights and shades of the picture are formed by different thicknesses of coloured gelatine.

V.—*Heliography* or *Photo-engraving*, the method of obtaining on a metal plate a photographic image in intaglio capable of giving impressions in the copper-plate press In this method the engraved plate once obtained serves for the impression of a large number of copies and may be indefinitely multiplied by electrotyping.

VI.—*Photo-typography*, or the method of obtaining by means of photography an image in relief on a metal plate, which may be mounted on a block to be set up with type and be printed in the ordinary printing press. These blocks may also be indefinitely multiplied by electrotyping in the same manner as ordinary woodcuts.

It will be observed that the five last-named processes all possess the great advantage that, once the photographic image has been obtained on the printing surface, the operations of printing can be accomplished by the same means and at the same rate as by the ordinary industrial methods. The printing may be performed by night or by day, quite independently of the agency of light, and requires no further chemical manipulations.

It would be beyond the scope of this paper to enter fully into the practical details of these various processes of photographic printing, as my object is merely to review those applicable to cartographic purposes, and to give a summary of the principal methods that may be usefully employed with reference to the wants of the State or of private individuals, rather than to those of professional cartographers and map-publishers, though the latter may in many cases also find photography a useful auxiliary. Photographic methods can never entirely take the place of lithography or engraving by hand, either for public or private purposes, but their use may be advantageously extended. Those who wish for fuller details may consult the text-books by Abney, Carey Lea, Monckhoven, Vogel and others, and the special works referred to in this paper.

II. Preparation of the Original Drawing.

I have already adverted to the difficulty that has been found in this country and elsewhere in obtaining original drawings suitable for reproduction by photozincography, and to the fact that without a proper original drawing it is quite impossible to produce satisfactory results. Besides its principal use in reproducing maps of the Surveys, photozincography is very largely utilised in India by engineers for the reproduction of their plans and drawings, and by other public officers for an immense variety of miscellaneous maps and plans, and as we were constantly asked to photozincograph subjects utterly unsuitable to the process, a set of rules for the preparation of the original drawings for reproduction by photozincography was drawn up under General Thuillier's direction and published in the official Gazettes all over India, and the result has been a great improvement in the execution of the drawings we receive for reproduction.

The rules are as follows :—

1. All drawings should be on white, smooth-surfaced paper, free from dirt, pencil marks, creases and wrinkles. When possible they should remain stretched on the drawing-board.

2. The Indian ink should be freshly rubbed down and give good *black* lines, free from glaze.

3. The lines should be firm and cleanly drawn—not too fine or too close together. They must be quite *black*, and light effects must be produced by fine and open black lines, and never by the use of *pale* ink. Thick lines in the printing and borders of maps should be well filled in. Pencil marks should be carefully removed, so as not to injure the blackness and firmness of the lines.

4. All cross-hatching and shading should be as open and clear as possible, and the lines composing it firm and not too fine. Intensity of shade must be shown rather by an increase in the thickness of the lines than by placing them closer together, in order that the intermediate spaces may not become blocked up when transferred to zinc. It is better not to rule the shading of mechanical and architectural section-drawings, but to

show the shaded parts by a light tint of blue, violet, or *aniline* red (fuschine or roseine). These parts will reproduce white, and can have a ruled tint transferred on the stone or zinc in the usual way, which will give a much neater appearance.

5. In plans or drawings intended for photozincography, *washes* of any colour except very pale blue, violet, or aniline red, are absolutely inadmissible. Outlines, may, however, be drawn, if necessary, in any strong red, brown, yellow, orange or green pigment which will reproduce black. Any details required to be shown in the original, but not in the copy, may be drawn in pale blue, violet, or aniline red. Details that are not required to be reproduced may be painted out with Chinese white.

6. River courses, lakes and tanks should be left blank, and not filled in with fine lines. They may be indicated by a pale wash of *blue* without detriment to their reproduction.

7. When drawings are to be reduced care must be taken to draw the lines, lettering, and detail of sufficient thickness and size relatively to the scale of reduction, so that they may not be lost or illegible when reduced. Sufficient space must also be left between the lines to prevent subsequent blocking up.

8. When possible, drawings should be made on a larger scale than they are required to be copied. Photographic reductions are always sharper and firmer than reproductions to the same scale, and defects in drawing are lessened by reduction.

9. Where plans or drawings to scale are to be reduced, the scale should be given in terms of a single unit of measurement and not as relative to any second unit. Thus, the scale on a map drawn on the scale of 4 miles to an inch for reduction to 16 miles to an inch, should be shown simply as a "scale of miles."

10. As photography produces a more or less perfect *facsimile* of the original drawing, it is essential that drawings intended for publication should be complete and finished in every respect before they are made over to the photographer. The drawing, printing of names, &c., should be in as neat a style as possible, and not require to be altered or touched up. The hair-strokes of the printing should not be too fine.

The foregoing rules may be summed up in a few words :—White-paper, black-ink, and firm open drawing ; and as success in the after processes depends entirely upon the perfection of the original drawing and its capability of giving a negative on which the ground is perfectly opaque while the lines are quite clear and as transparent as the bare glass, these essentials must be most carefully observed. Their neglect will entail failure and disappointment.

For drawings intended for reproduction by the collotype methods these rules are equally applicable, especially No. 7, and there is even more necessity for perfect cleanliness of the paper and neatness and finish of the drawing, because the faintest tints will be reproduced by the gelatine printing surface and corrections cannot be made on it, as they can on zinc, stone or copper. For this reason also, the greatest care must be taken to complete the drawing in every respect before it is given to be reproduced. Drawings in line may be finer and more delicate than for photolithography, but still must not be so fine as to interfere with the obtaining of a perfectly dense and opaque negative, otherwise the ground of the print will appear dirty and stained. Pale ink may be used when necessary for effect, but not more than is really requisite. Colour may be used to any extent, having always due regard to the photographic effect when reproduced. On account of the difficulty of photographing certain colours so as to produce the same effect as in the original picture, the best results will be produced from drawings specially prepared in monochrome, such as Indian ink or sepia.

In the case of drawings for any special purpose or not intended for publication, the above rules may be relaxed, but the general principles laid down should be observed, as far as practicable, if the best results are desired.

When drawings are prepared specially for photographic reproduction, there need be no difficulty in taking all the precautions necessary for producing good results. It often happens, however, that the photographer is called upon to reproduce drawings, lithographs, or old MSS., printed records, or engravings, which either may never have been suitable for the purpose, or, if suitable when fresh, have become dirty and stained by age. Herr Scamoni, the skilful Chief of the Photographic Department of the Imperial State Paper Office at St. Petersburg, has given some useful hints on the treatment of such subjects under these circumstances.*

"Yellow, or otherwise objectionable, spots should be carefully covered over in the spaces between the lines with Chinese white, and whenever possible the lines should be strengthened in parts where they appear weak."

"Lithographs and engravings may be bleached, by immersion in a solution of chloride of lime, or *Eau de Javelle*, (1 to 10 or 15 of water), then soaked in water for some hours, after which they are treated with a weak solution of hyposulphite of soda and finally well rinsed in clean water."

"Fresh grease stains may be removed with chloroform, benzine and ether, or with a weak alkaline solution of caustic potash or its carbonate."

"Old grease stains may be removed with a more or less strong solution of potash, applied at the back of the subject."

* *Handbuch der Heliographie*, p. 67.

"Iron mould and ink spots may be taken out with a solution of oxalic acid or salts of sorrel."

When tracings are made on paper or vellum cloth to be reproduced without the aid of the camera, special care must be taken to keep the back of the drawing clean, and to choose paper or cloth free from stains and of as even a texture as possible.

Originals drawn on rough paper may be smoothed in a copper plate press, and, if dirty, should be carefully cleaned with india-rubber or bread.

III. The Production of the Negative.

After the due preparation of the original, the production of the negative is a point of the utmost importance, and may well be considered by itself before proceeding to the consideration of the various processes of photographic printing.

In order to obtain the most satisfactory results for photolithography, photozincography, or any other process specially applicable to line subjects, the negative must be perfectly sharp all over, free from distortion and possess the greatest amount of contrast between the lines and the ground. If care is taken to produce good negatives from suitable originals, results may be obtained which will compare with ordinary lithographs and engravings for sharpness and delicacy. The difference in the results of working with good negatives or bad ones is incredible; with a good negative from a good original every thing works well, but with a bad negative from a faulty original all kinds of difficulties may be encountered, and the attainment of a passable result is almost a matter of chance.

The first thing is to arrange the plan so that it may be copied without any distortion and be quite sharp all over.

To ensure freedom from distortion, the lens employed must give an image quite free from all curvature of the marginal lines of a rectangle. In practice the most suitable forms have been found to be the 'Rectilinear' of Dallmeyer; the 'Doublet' of Ross; 'Aplanatic' of Steinheil and others on the same principle. The lenses known as triple combinations are also good. In the Surveyor General's Office, Calcutta, Dallmeyer's Rapid Rectilinears are used and found to answer well. The lens should be worked well within its power, so as to use the most central rays; and to secure the sharpness of the image all over the plate, a small stop or diaphragm should be used.

The plan must be placed so as to be evenly illuminated by a good strong light falling as horizontally as possible, in order to avoid shadows being thrown by the grain of the paper, and thus diminishing the even opacity of the ground of the negative.

The apparatus for supporting the plans varies according to the nature of the work required, and may either be a perfectly smooth board fixed permanently in a truly vertical position against a wall or other support, a form which is very suitable when large plans have to be copied or reduced; or it may consist of a frame large enough to take a certain size of map and capable of being adjusted in various ways so as to move up and down in a vertical plane or horizontally right and left, so that different parts of the plan may be brought in front of the camera without moving the plan on the board.* In any case, arrangements must exist, either in the plan-board or in the camera-stand, for making the plane of the map or plan to be copied exactly parallel to the plane of the sensitive plate in the camera.

The map must be attached to the plan-board so that it may lie perfectly flat and free from ridges. This is best secured by placing in front of it a sheet of glass which is fastened down on the board with pins at the corners. Or a glazed frame may be used for holding plans of a medium size. In either of these cases care must be taken to avoid any reflection from light objects in front of the plan-board.

It is convenient to have the plan-board and the focussing glass of the camera ruled in squares of 1 inch or other convenient size, in order to at once test the perfect parallelism of the sensitive plate and the plan-board.

When the work is confined to the reproduction or reduction of maps or other subjects of one fixed size on a single plate, it will be found convenient to draw a rectangle of the required size on the ground glass of the camera. When the image of the subject exactly fills this rectangle the adjustments of focus and parallelism will be correct.

The camera used for reproduction to scale should be at least of sufficient length to draw out to twice the equivalent focal length of the largest lens it is to be used with, and may be furnished with cone fronts to give further extension if necessary. With large cameras of a long range of focus it will be found convenient to have the back part of the camera fixed and the front part carrying the lens moveable, so as to enable the operator to focus conveniently. The camera may be fixed on a stand furnished with adjustments for moving it horizontally right or left, and have a tilting motion up and down, in order to adjust the camera perfectly level, or tilt it slightly so as to correct any want of verticality of the plan-board. The camera-stand should run upon rails fixed in the ground at right angles to the wall carrying the plan-board, thus enabling the distance of the camera from the plan-board to be easily and accurately adjusted according to the scale required. When using a reversing mirror or prism for taking re-

* See my '*Report on the Cartographic Applications of Photography*,' plates V, VII and X, and Sir H. James' '*Photozincography*', plates I and II.

versed negatives for collotype and other purposes, it is a good plan, when possible, to have an arrangement for laying the plan horizontally under the lens at any convenient distance from it.

The whole of the apparatus connected with the camera and plan-board must be rigid and firmly fixed, so as to be free from vibration. The slightest vibration is sufficient to destroy the perfect sharpness of the image. In the glass-house attached to the Photographic Branch of the Surveyor General's Office here, I have endeavoured, and I think with success, to overcome all vibration caused by carriages passing in the street close by, by dividing the floor of the camera-room into isolated blocks resting on a bed of sand, so that each camera shall stand by itself on a block isolated from adjoining blocks and from the walls and floor of the building. The plan-boards are fixed on a separate wall quite isolated from the walls of the building.

Plans may be copied either in the open air or under shelter—coloured and old stained manuscripts, maps or drawings are better copied in full sunlight. The glass-house I have constructed at the Surveyor General's Office faces the south and is glazed with ground glass, so that a strong diffused light may be thrown upon the plan-boards. When circumstances permit, it is well to have the camera and plan-board mounted on a firm stand working on a pivot, so that, as the day wears on, the position of the plan-boards may be changed so as always to face the sun. I adopted this arrangement at the Trigonometrical Survey Office, Dehra Dun, and I believe it has many advantages over the fixed glass-house rendered necessary in Calcutta by the constant wind and dust, and the greater necessity of being able to carry on work without interruption at all times of the year.

The negatives of maps &c., drawn in line only, for reproduction by photozincography, are taken by the ordinary wet collodion process with iron development, modified so as to secure the greatest transparence in the lines and density of the ground; but as the ordinary wet collodion process by itself will not give all the intensity required to produce an almost opaque ground, it is obtained by intensifying the negative in the usual way with pyrogallic acid and silver, after fixing; then treating it with a saturated solution of bichloride of mercury till the film becomes white, and finally applying a dilute solution of hydrosulphate of ammonia, which instantly changes the colour of the film to a dense black or brown throughout. The negative is afterwards varnished with a resinous varnish, or flowed over, while wet, with a solution of gum or gelatine and allowed to dry. All defects, pin-marks &c., are then stopped out with Indian ink or black varnish. In taking the large negatives on plates 32×24, that we are now producing for copying the maps of the Cadastral Surveys, it has been found that the first intensification may be produced by washing the plate after the first development and applying a weak solution of nitrate of silver followed by a second application of the iron developer.

Other methods of obtaining the extra density required for these negatives have been proposed and are in use,* but, notwithstanding several inconveniences arising from the use of bichloride of mercury and hydrosulphate of ammonia, the above appears to be the best and most certain when working on the large scale.

When maps are not drawn entirely in pen and ink but have the hills brush shaded, and it is desired to reproduce them by the collotype or engraving processes, great care and skill are required on the part of the photographer to get the ground of the negative dense enough to give a perfectly clean impression in the white parts of the map, and at the same time prevent the grain of the paper from showing and give the faintest tints of the shading their proper value. Coloured maps also give a good deal of trouble, and when allowable the colour should be washed off as much as possible before the negatives are taken. Colours may sometimes be removed by chemical means, but there is risk of injury to the original.

In many of the processes about to be described it is necessary to use a negative which instead of giving an image reading the same way as the original shall give it reversed as to right and left. There are several methods of obtaining these reversed negatives.

(1.) By coating the original unreversed negative with a thick transfer collodion,† or a layer of gelatine, and then stripping off the film and, either laying it down again on a sheet of glass in a reversed position, or using it as a film negative which may be used for giving both reversed or unreversed images. This method is practical and useful, but is not suitable for map work on account of the liability to contraction and distortion of the image. There is also difficulty in keeping the film negatives flat, and they have been found to become brittle and perish very soon in this climate.

(2.) By turning the sensitive plate in the camera, so that the light acts, through the glass, on the back surface of the film. This method is also practical, simple and useful, but requires care in the selection of glass plates free from scratches, &c., and in wiping the back of the plate before it is put in the camera. It is used in the Belgian Topographical Bureau with dry tannin plates, but I have not found it suitable for reproducing very fine map-work on wet plates.

(3.) By placing a reversing mirror or prism in front of the lens—the image thus passes through the lens reversed and is impressed directly on the sensitive plate. This is one of the simplest and most effectual of all methods. If a mirror is used it should be one silvered by depositing silver

* See Abney, *Instruction in Photography*, p. 22.

† See the same work, p. 160.

on the front surface and should be large enough not to cut off the oblique rays entering the lens. A large solid reversing prism is expensive and heavy, but for moderate sizes an efficient instrument may be made by building up a hollow prism with glass plates and filling it with a transparent fluid having a suitable index of refraction. M. Derogy, of Paris, has just invented an ingenious and economical method of employing a reversing prism by placing a small prism between the lenses. I have not seen any results of this arrangement, but it seems likely to be as effective as it is simple.

(4.) By what is known as the 'dusting on' or 'powder' process. A glass plate is coated with a mixture of gum, sugar and bichromate of potash dissolved in water, thoroughly dried with heat, and then exposed to light under a negative. After removal from the printing frame, the gummy film is dusted over with very fine plumbago which adheres to it in inverse proportion to the action of light, *i. e.*, those parts on which the light has acted refuse the powder in proportion to the intensity of the action of light, while the protected parts, attracting moisture from the air and so becoming 'tacky,' take the powder readily, and thus an exact transcript of the original negative is produced, but reversed. This method is simple and effective and seems to be one of the best that can be employed when a mirror or prism is not available, or when, as is frequently the case, the reversed negative can only be obtained by copying from a single original unreversed negative.

(5.) By making a copy, either in the camera or by contact, on a film of collodio-bromide of silver. The image is developed as usual by the alkaline method, and then treated with nitric acid which dissolves the reduced silver in the exposed parts of the film, leaving the bromide in the unexposed parts; the plate is then again exposed to light and developed. This method, proposed, I believe, by the late Mr. Sutton, is said to give very good results, but the use of nitric acid is an obvious disadvantage.

(6.) By copying in the camera, first making a transmitted positive either by the collodion process or with a special pigmented gelatine tissue. This method is most useful when the reversed negative is required to be either larger or smaller than the original.

(7.) By means of the reversing action of the red and blue rays of the spectrum. This method is a discovery of my own and has not yet been thoroughly worked out; it is, however, simple and could, I believe, be successfully utilised. A film of collodio-bromide of silver stained with anilin blue is exposed to light for a few moments, then placed under a negative in a printing frame in front of which is a sheet of red glass, and exposed to light. The action of the light passing through the red glass in the clear part of the negative is to neutralise or destroy the effect of the previous exposure of the plate to light, and on development a more or less perfect reversed negative image is obtained. For line subjects a blue glass may also be used, but for half-tone work only a red glass can be employed.

In some processes also, it is convenient to use either direct or reversed transparent positives instead of negatives. These can be obtained either by contact printing on dry collodion plates or gelatine tissue, or in the camera, in the manner adopted for making transparencies, as described in the text-books.

Having now described the preliminary operations for preparing the original and producing the negative, which are common to all processes, we may proceed to the consideration of the different printing processes which, as stated in the introduction, may be divided into 6 classes, *viz.* :

I. Printing on sensitive papers. II. Photo-lithography or Photo-zincography. III. Photo-collotype. IV. Woodbury-type. V. Heliography or Photo-engraving. VI. Photo-typography.

IV. Photographic Printing on Sensitive Papers.

The processes under this head may be divided into three classes—

First :—Those in which the sensitive papers are prepared with salts of silver and the results are not permanent.

Secondly :—Those in which the sensitive papers are prepared with the salts of iron, platinum and other metals, and the prints though not absolutely permanent are more so than silver prints.

Thirdly :—Those in which coloured gelatine or other colloid mixed with an alkaline bichromate forms the sensitive surface and yields prints which, for all practical purposes, may be considered perfectly permanent.

Silver-printing.—Notwithstanding its expensiveness and the want of permanence of the prints, silver printing has hitherto maintained the first place among photographic printing processes, and though very nearly equalled, is as yet unsurpassed for the beauty and delicacy of its results. It is the process in most extensive use for producing copies of portraits and views, and although rapid advances are being made in more permanent methods, it is likely to be a long time before the beautiful but perishable silver print is entirely superseded.

The following brief outline of the operations will be sufficient to show the nature of the process.*

A sheet of paper coated with albumen containing an alkaline chloride, such as common salt, or paper which has merely been immersed in a solution of such salt and dried, is floated on a solution of nitrate of silver and allowed to dry in the dark. It is then placed above the negative in a copying frame, which is so constructed that the light may pass freely through the negative, and at the same time may admit of the examination

* For details, see Abney's *Instruction in Photography*, p. 113.

of the print while the back surface of the sensitive paper is shielded from light. The exposure to light lasts for some minutes, by which the parts unprotected by the denser parts of the negative are darkened more or less, according to its translucency, while the parts entirely shielded from the light remain quite white. When the action of the light is judged sufficient, the sensitive paper is removed from the frame in a dark place, and must then undergo an operation of *fixing* to remove the unchanged salts of silver, which would cause the print to darken unless carefully protected from the light. This is effected by steeping the print for a short time in a solution of hyposulphite of soda; but before the print undergoes this indispensable operation it is usual to place it in a solution of chloride of gold, by which part of the reduced silver forming the image is replaced by a film of gold and the print takes a more agreeable tone, also becoming more permanent than it would be if this operation, called 'toning,' were omitted. It is, however, impossible to ensure perfect permanency of these prints, by reason of the sulphur contained in the albumen or in traces of sulphur salts formed by the decomposition of the hyposulphite of soda, and left in the print after even the most careful washing, slowly acting on the reduced silver forming the image and converting it into a sulphide, by which the tone and brilliancy of the picture are lost, and the lighter shades appear to fade away entirely. It should, however, be stated that prints prepared on plain, or unalbumenised, paper are more permanent than the albumenised prints, though not so brilliant, sharp and delicate; and they have the further advantage of being less liable to shrinkage and distortion than the albumenised prints, and are thus more suitable for the reproduction of maps where accuracy of scale is a desideratum.

It is evident that owing to the expensiveness of the materials used in producing these prints and their want of permanency, together with the slow rate at which they can be produced, this process is almost useless for the reproduction of maps in large numbers; and, in fact, its use in cartography is limited to making copies of special maps for immediate reference or temporary purposes, and as guides for engravers or lithographers in preparing compilations from maps on a larger scale. Silver prints have also been used by engravers to obtain a correct tracing on the waxed surface of their copper plates, but unless these prints are prepared with great care they are open to the objection of becoming distorted and untrue to scale by the contractions and expansions caused by the successive washings they have to undergo. Prints on plain paper are better for this purpose than those on albumenised paper, and prints on paper containing a large proportion of resin in the size are better still.

In the English Ordnance Survey the topographers are furnished with silver-print reductions from the large scale outline survey, on which they insert the features of the ground, suitably delineated according to the scale.

A very early application of this process has lately been re-introduced in Germany by Herr Romain Talbot, of Berlin, under the title of the *Licht-paus* process, with the object of enabling engineers and others to readily prepare a few copies of their plans without the necessity of using a camera and other expensive appliances. In this method a print on a sensitive chlorised paper, prepared with nitrate of silver and an organic acid, so that it may be kept for some time in stock ready for use, is first taken by exposing it to light under the original drawing itself, which to secure the best results should be drawn in very black ink on thin paper or vellum cloth. This print, on which the lines are clear and the ground opaque, is simply fixed in a solution of hyposulphite of soda and then thoroughly washed and dried. A second copy is now made from this negative print in exactly the same way, and as, this time, the lines darken under the clear parts of the negative and the ground remains clear, we obtain a perfect transcript of the original. This process is said to be largely used in Germany for copying maps and engineering plans. It is no doubt useful in many cases where it is undesirable or impossible to make more extensive photographic arrangements, but besides being limited to the reproduction of copies on the same scale as the original, it labours under the disadvantages of expense and want of permanency common to all the silver printing processes.

In the processes just noticed the exposure to light is usually from 15 to 30 minutes, but in dull weather, or with certain negatives, it may be much longer ; it is obvious, therefore, that even under the most favourable conditions comparatively few prints can be produced from a single negative in a day. In order to shorten the exposure and permit prints to be produced with much greater rapidity than with the ordinary process, a method has been introduced by Major Libois of the Belgian army, by which, instead of the image being produced at once in its full strength by the action of light, the latter is only allowed to act for a few seconds, and the full effect is produced by treating the print with a developing agent composed principally of gallic acid, which at once reduces the silver in the parts acted on by the light, and thus produces a visible image in place of the almost invisible one formed by the action of the light alone. This process was extensively used in the Depôt de la Guerre, Paris, some years ago, and large numbers of maps were turned out by it, I was told, almost as quickly as they could have been printed in the press, and it had the further advantage that facsimile copies could be made of maps from which good results could not have been obtained by photolithography. The same process was used at the Depôt de la Guerre in Brussels, but not on so large a scale. I have also used it with success in India, and it may be recommended in cases where silver printing is required for maps &c. It is more economical than the ordinary process, and much more rapid in working, the exposure being counted by seconds instead of by minutes. The operations are briefly as follows:

Thin photographic paper is salted by floating on a solution containing 2 per cent each of chloride of ammonium and citrate of soda in water slightly acidified with citric acid. The paper is dried and may be kept for use. It is sensitised by floating in the dark on a bath containing 5 per cent of nitrate of silver acidified with a little citric acid. The exposure to light is conducted in the same way as in the ordinary process, but is exceedingly short—a few seconds to one minute being generally sufficient. When taken from the printing frame only a very feeble image is visible, it is therefore developed in a mixture of a solution of gallic acid (1 to 3800 water) with a solution of acetate of lead (1 to 200 water), to which a little acetic acid is added. The detail gradually strengthens, and in about a quarter of an hour the prints are fully developed and of a good black colour. After being washed they are fixed in a bath of hyposulphite of soda at 30 per cent., then well washed and dried.*

The foregoing are the principal methods of silver printing suitable for cartographic purposes, but, however convenient and useful they may be for special objects where photolithography is not applicable, they cannot be considered adapted for purposes of publication, and their want of permanency is an insuperable defect.

Printing with Salts of Iron.—From time to time attention has been drawn to the possibility of replacing silver-printing by processes depending on the use of the salts of iron and other cheap materials, but, though certainly useful in some respects, they have never been brought into extensive practical use.

One of the best known of these processes is the 'cyanotype', invented by Sir John Herschel, and lately re-introduced by Messrs. Marion & Co., of Paris, who prepare and supply the ferro-prussiate paper ready for use. Good even-textured paper is brushed over with a mixture containing nearly equal proportions of 10 or 12 per cent solutions of ammonio-citrate of iron and the ferridcyanide of potassium, dried and exposed to light under a print or drawing placed with the printed side uppermost. The resulting faint photographic image is developed and fixed by a mere washing in plain water, yielding a print in white or light blue lines on a dark blue ground.

This process is rapid, simple and cheap. The camera is dispensed with, and the only photographic apparatus required is a printing frame and

* Maës and Hannot's *Traité de Topographie et de Reproduction des Cartes au moyen de la Photographie*, p. 295.

one or two dishes or trays. The sensitive paper is easily prepared and can be kept indefinitely in the dark until required for use. There is no messing with chemicals after the preparation of the paper, pure water only being required to develope and fix the prints. The exposure to the light is very short, two or three minutes in the sun being ample to make a clear legible copy from a line negative or from a drawing on tracing cloth. The chemicals employed are both very inexpensive.

The objections to the process are two: first the difficulty of obtaining clear whites; this, however, is of no consequence so long as the details are clearly legible; and secondly, the colour of the prints—white on a dark blue ground. Although this does not interfere with the practical use of the process for special work, it completely prevents it from being employed as a means of multiplying copies of maps or plans on a large scale. Another defect is, the want of sharpness arising from the necessity for placing the reverse side of the original in contact with the sensitive paper in order to get an unreversed print. These objections may be partly obviated by printing from a negative on paper or glass, in which case the lines will be dark blue on a light blue or white ground, but then cameras and other expensive photographic apparatus will be required to produce the negative.

M. H. Pellet has recently recommended a process of this kind whereby prints are obtained in dark lines on a clear ground. Paper is sensitised in a mixture of—

Oxalic acid,	...	...	...	5 parts
Perchloride of Iron,	...	...	...	10 ,,
Water,	...	...	...	100 ,,

dried and exposed as usual under a drawing. The print is developed in a bath of yellow prussiate of potash at 15 or 18 per cent, well washed and fixed with dilute muriatic acid, then finally washed and dried.

The blue prints thus produced can also be used as the basis of drawings for photozincography.

Another process, which, though not quite so simple as the above, has the advantage of giving a print in black on a white ground, forms one of the numerous important photographic methods for which we are indebted to the illustrious Poitevin.

Paper is coated in the dark with a solution of perchloride of iron and tartaric acid in water; when dry, it is exposed under a tracing on cloth or paper, or a reversed positive on glass, and as soon as the parts exposed to the light have become thoroughly bleached the print is removed and developed in a bath of gallic acid. The parts protected from the light turn to an inky black, while the exposed and bleached parts remain white or only take a slight tint. The print is then thoroughly washed and dried. The whole operations of printing, developing and washing can be finished in half an hour. This process, simple as it appears, requires certain precautions in using a strongly sized paper for the prints, and a very transparent original to obtain the most successful results.

It is capable of the same applications as the cyanotype last described, and, like it, is quite unsuitable for producing maps for publication.

Another process of Poitevin's is dependent on the property possessed by the ferric salts of rendering gelatine insoluble, the solubility being, however, restored when the ferric salt is decomposed by the action of light into the ferrous salt.

Paper is thinly coated with a 6 per cent solution of coloured gelatine and when dry immersed in a solution of—

Perchloride of Iron,	10	parts	or* 1 to 3	parts.
Tartaric acid,	3	,,	,, $\frac{1}{3}$ to 1	,,
Water,	100	,,	,, 100	,,

and dried in the dark. After exposure to light under a positive, such as a map on tracing paper, the print is immersed in hot water, and the gelatine in the parts exposed to light dissolves out, leaving an exact transcript of the original drawing with dark lines on a white ground. The print may be rinsed in water acidulated with hydrochloric acid to remove the iron salt.

Salmon and Garnier have taken advantage of the fact that if paper is coated with a solution of the percitrate of iron and exposed to the light, the parts exposed to the light become hygroscopic in inverse proportion to the intensity of the action of light, and therefore if such paper is exposed to light under a map or drawing on thin paper or vellum cloth, and afterwards brushed over with a fine powder, such as lamp-black or plumbago, more or less of the powder will adhere to the parts protected from the light, while the exposed parts will scarcely take it at all. After development the print has only to be washed to remove the unaltered iron salt from the film.

Other similar processes of printing with the salts of iron, uranium &c., will be found in the text-books. They are, however, very little used and may be regarded more as curiosities than as practical printing methods.

Platinum printing process.—There is, however, one process which deserves mention as producing very beautiful and permanent prints, in which the image is formed of reduced platinum. This process has been patented by the inventor, Mr. W. Willis, junior. Paper is floated on a weak solution of nitrate of silver and dried. It is then brushed over with a solution of double oxalate of potassium and iron, together with a solution of chloroplatinite of potassium. After exposure under a negative the print is floated on a warm solution of oxalate of potash, which causes the platinum

* Boivin, in *Moniteur de la Photographie*, 1st April, 1878.

salt to be reduced in the parts exposed to the light. The prints are fixed first with hyposulphite of soda, and then with oxalate of potash and finally washed with water.

Collo-chromate printing.—We now come to the more important processes depending on the reaction of the salts of chromium, particularly the alkaline bichromates, on gelatine, gum, albumen and other colloid substances under the influence of light, whereby these substances become more or less insoluble in and unabsorbent of water in proportion to the amount of the action of light, and further acquire the property of taking up greasy ink and not attracting plumbago or other fine dry powder, also in proportion to the amount of the action of light upon them.

This simple reaction, only partially discovered in 1839 by Mungo Ponton, was first worked out and turned to practical account, some twelve years afterwards, by Fox Talbot in his process of photoglyphic engraving; and after him Pretsch and, notably, Poitevin employed it in processes which have been the foundation of nearly all the modern methods of permanent photographic printing.

The simplest of all these processes, and one which may render useful service in the cases already noticed where only a few copies are required, was one of the first published by Poitevin. It consists in coating paper with a mixture of albumen, gum, or gelatine and bichromate of potash, coloured with Indian ink or any other suitable pigment; or, if preferred, the paper may be coated with coloured gelatine and then made sensitive in a separate bath of bichromate of potash, and this is sometimes the best method, because the paper will not keep good for long in its sensitive state. The sensitive coloured paper is exposed under a very clear line negative in a copying frame for a few minutes, and then taken out and plunged into water, either hot or cold, according as gelatine, gum or albumen have been used. The unaltered colloid in the lights of the print, which have been protected from the light under the dark parts of the negative, dissolves in the water, leaving a clear image in pigment on a white ground.

This simple method is capable of extensive use in copying maps or topographical sketches, but is only applicable to subjects in line, well drawn in black and white in accordance with the rules in Sect. III. These prints have the advantage of being quite permanent and, as the collo-chromate mixture is more sensitive to light than the chloride of silver, they can be produced at a quicker rate than the silver prints, and are, of course, cheaper on account of the inexpensiveness of the materials used.

For reproducing subjects in half tones a different procedure must be followed. In the process just described the exposure to light and the development of the print by washing are effected on the coloured side of the paper, and as the light can act with full power through the clear spaces on the negative, representing the lines of the subject, it renders the colloid coating insoluble throughout the thickness of the coloured film, so that the lines withstand the solvent action of the warm water, which entirely removes the rest of the coloured film from the ground and parts which have not been influenced at all by the light. If, however, instead of a negative of a line subject, on which the lines are transparent and the ground opaque, we take a negative of a subject in half tones, possessing various degrees of translucency in the lights and shadows of the picture, and make a print from it on a piece of the pigmented paper, we shall find that the light will only be able to penetrate through the entire thickness of the colloid film in the deepest shadows, represented, as before, by nearly clear glass; in the darker half-tones it will penetrate nearly through the coating; in the middle tones about half-way through, and in the lightest tones the light will be able to act only on the surface of the gelatine. We shall therefore have a print with an insoluble surface of varying depth, and underlying this a more or less soluble layer; it will thus readily be understood that when exposed to the action of warm water this layer will dissolve and carry away with it the partially insoluble surface-film forming the half shades of the picture, leaving only the stronger shades and giving a rough, hard, and unfinished appearance to the print.

For a long time this difficulty proved a stumbling-block in the way of the progress of permanent printing and gave the silver-printing processes a supremacy of which it has now become difficult to deprive them. The Abbé Laborde was the first to see the necessity for adopting the principle of exposing on one side and developing on the other. Blair, Fargier and Swan applied this to the carbon process, and the latter finally succeeded in introducing a practical method of pigment-printing applicable to the same class of subjects as silver-printing. Swan prepared a tissue by coating paper with a thick layer of gelatine mixed with bichromate of potash and coloured with any suitable pigment. After the exposure to light the gelatinous surface of the tissue was caused to adhere closely to a second piece of paper coated with india-rubber. The whole being immersed in hot water, the paper on which the gelatinous layer was originally supported, became loosened and could be removed, allowing the hot water to gradually dissolve away the unaltered and soluble gelatine. In this manner the exposure to light takes place on one side of the gelatine film, while the washing away of the superfluous gelatine is effected from the other, or unexposed side, without disturbing in any way the exposed parts of the film, and thus the most delicate shades in the half tones are perfectly preserved. Since its introduction by Swan this process has been much improved by Messrs. J. R. Johnson, R. Sawyer and other members of the London Autotype Company which acquired Swan's patents, and under the name of the 'Autotype' process, it has been worked on a large commercial scale for the reproduction of works of art, and is now fairly beginning to come into active competition with silver-printing for all ordinary purposes of portrait and landscape photography.

On the Continent, the pigment-printing process is largely used by the well-known houses of Braun and Goupil for the reproduction of works of art, and is also coming into extended use for general purposes.

The following is an outline of the operations as now practised by the Autotype Company.*

The pigment tissue is prepared by coating long bands of paper with a moderately thick layer of gelatine coloured with any suitable pigment, and is sold ready for use either in an insensitive or sensitive condition.

The tissue is sensitised by immersion for a minute or two in a 5 per cent solution of bichromate of potash in water, to which some alcohol may be added with advantage, especially in hot climates; the bath should also be cooled down with ice if its temperature exceeds 65°. The tissue is then carefully dried, and when dry is ready to be exposed under the negative. This is done in a printing-frame in the usual way, the only precaution necessary being to paste slips of thin grey paper round the edges of the negative, so as to cut off a great portion of the light and form what is called the 'safe edge'. As the tissue generally appears black all over, the progress of the printing cannot be ascertained by inspection, and it is necessary to use a little instrument called an 'actinometer', by means of which, the degree of exposure necessary for any negative having been once ascertained, it is easy to give the same amount of exposure to successive prints. Up to this point the operations are the same whatever may be the nature of the support upon which the picture finally rests. The subsequent operations, however, differ accordingly as the image is developed on a final support, by what is called the 'single transfer' method, or on a temporary support, by the 'double transfer' method. In any case, some support is indispensable to retain the image and preserve it from injury during the washing.

In the single transfer process the support is paper coated with a gelatinous substance which, though insoluble in water, retains sufficient adhesive power when moistened to enable it to hold the picture during development and afterwards permanently.

After exposure under the negative the pigmented tissue having been immersed in cold water, together with a piece of the transfer paper, the two surfaces are applied to one another under water, and both drawn out together. They are then laid on a zinc plate, tissue uppermost, and brought into close

* See "*The Autotype Process*", 6th edition. Also Monckhoven's, Vidal's and Liesegang's treatises on Carbon-printing.

contact, all intervening air being driven out by means of an india-rubber scraper, or 'squeegee', which also removes all superfluous moisture. The prints and support are allowed to remain together for a short time, and are then immersed in warm water. After a little while the soluble gelatine will soften and become partially dissolved, when the paper forming the original support of the layer of gelatine may be gently removed, leaving a dark slimy-looking mass on the transfer paper. The soluble gelatine gradually clears away by the action of the hot water and reveals the image in more or less perfection of details according as the exposure has been properly timed. When fully developed, the print is washed with cold water, then passed through a solution of alum, rinsed again with water and allowed to dry.

Instead of paper, any other suitable permanent support may be used, but whatever the support may be, a reversed negative must be used if it is desired to obtain non-inverted pictures by the single transfer method.

When it is inconvenient to use a reversed negative, and it is desired to obtain a non-inverted picture—the development of the tissue-prints must be conducted by the double transfer method upon a temporary support, either rigid or flexible. The discovery that the pigment pictures might be developed upon any impermeable surface is due to Mr. J. R. Johnson, who also found that if such surface previously receive a coating of some fatty or resinous compound, the picture may be transferred, after development, to a final support.

The most suitable surface for the temporary support is a sheet of zinc, which may be either polished or grained; opal glass, or porcelain plates may also be used with advantage.

The plate employed as the temporary support first receives a coating of a solution of wax and resin in turpentine, and some operators coat the plate with collodion after the waxing, in order to improve the surface. The pigment tissue carrying the image is attached to the support under water in much the same way as in the single transfer method, and after remaining for a time, is developed in the same way and allowed to dry. The plate with the picture on it is then rinsed in water, and a piece of what is called double transfer paper—a fine paper coated with an enamel surface—having been soaked in water till quite soft, is laid on the wet plate, avoiding air-bubbles, and pressed into perfect contact with it by means of the india-rubber scraper. The picture with the transfer paper attached is now dried carefully, and when dry separates of itself from the temporary support.

Mr. J. R. Sawyer of the Autotype Company has introduced a flexible support, consisting of paper coated with a solution of gelatine rendered insoluble with chrome alum. When dry this is coated again with an alkaline solution of shellac, dried and well rolled under powerful pressure—it is afterwards coated with a waxing compound. The use of this flexible support is said to be advantageous with small pictures, but I have not found it answer very well in this country.

All these operations, which seem so complicated, are in reality very simple, and as the sensitised tissue is very sensitive to light a great many prints can be produced in a single day. The number may, moreover, be increased by a plan proposed by Capt. Abney, R. E., of exposing the print for only half the usual time and then letting it lie by in the dark for some hours. The decomposing action set up by the light goes on in the darkness, and on development a picture is produced quite as good as if it had received a full amount of exposure and been developed at once. This discovery is largely utilised by those working the process in England, and enables an amount of work to be done in the winter months which would otherwise be impossible.

The single transfer process has been successfully worked at the Surveyor General's Office in Calcutta for the production of photographs of the convicts transported for life to the Andamans. No great difficulties were met with in working it, even in the hot weather, but it was found necessary to ice the solution of bichromate of potash used for sensitising the tissue, and to add a certain proportion of spirits of wine to it, in order to keep the gelatine from softening too much. Messrs. Bourne and Shepherd, the well-known Indian photographers, have made arrangements for working the Autotype process at Simla, the climate of Bombay having been found unsuitable.

The pigment prints are perfectly permanent for all practical purposes, and, though they may under certain circumstances change colour slightly or lose their brilliancy, there is no such absolute fading and loss of details as in silver prints. The process may be applied in all cases to replace silver printing where permanency of results is an object. As I have mentioned before, the process is not quite suitable for the reproduction of coloured or shaded maps, owing to difficulties in obtaining prints comprising large surfaces of clean white paper together with the delicate half tones of hill-shading. For maps in line the simple carbon process is more suitable, or if many copies are required, photozincography would be better.

Anilin Printing.—Before proceeding to the consideration of the processes employed for producing prints in the printing press, mention may be made of an ingenious process of printing which depends upon the use of salts of chromium, and is largely used in Europe for the reproduction of maps and plans. It is known as the 'Anilin printing process' and is the invention of Mr. J. Willis, who has patented it.

Paper is impregnated with a solution of bichromate of potash to which a little phosphoric acid has been added. After exposure to light under a transparent positive, such as a drawing on thin paper or vellum cloth, or even an ordinary engraving or manuscript, it is exposed in a closed box to the vapour of anilin, which developes a greyish image. The print is then fixed by merely washing with water. As a positive original yields a positive print, maps or drawings may be copied without the necessity of making a negative by means of a camera, which is a great recommendation in certain cases. The process has hitherto been worked only by the inventor and his licensees and has not come into general use.

V. Photolithography and Photozincography.

In all the processes noticed in the last section, it is necessary to repeat the printing operation by exposure to light for every print produced. The rate of printing will consequently be more or less dependent on the sensitiveness of the paper, the strength of the light at the time of exposure and the state of the weather; the printing operations can, moreover, only be carried on during the few hours of daylight. In the photo-mechanical processes, now about to be described, these grave disadvantages are obviated, and, once the photographic image has been produced upon the printing surface, prints may be made in any numbers, quite independently of light or weather.

The simplest and most generally useful of these mechanical processes is photolithography, or the analogous photozincography, the principal difference between the latter and the former being merely the substitution of a thin smooth plate of grained zinc for the thick heavy lithographic stone. For maps of large size, zinc is certainly the most suitable and offers in other respects all the advantages of stone, but the latter being better known is generally preferred for ordinary work of moderate size.

In ordinary lithography, the image may be produced on the stone or zinc either by *transfer* from a drawing on paper with the solution of resinous soap known as 'autographic ink', or by *drawing direct* on the stone with a similar ink or crayon; so in photolithography there are two similar methods of obtaining the photographic image—either by transfer from a photographic print in fatty ink—or by impressing the image direct on the stone, by applying a photographic negative on a suitable coating sensitive to light and removing by means of a solvent the parts unaltered by light. The transfer method being the most convenient is the one in general use.

The first photolithographic process on record is that proposed by Jobard, of Brussels, who, in 1839, obtained lithographic proofs from stone or zinc plates that had been treated with iodine or bromine. This process never came into practical use and has been quite superseded by two distinct methods—one dependent on the alterability of asphaltum under the influence of light—the other on the reactions of the alkaline bichromates upon gelatine and other colloid substances.

Asphaltum methods.—In 1852, MM. Lemercier, Lerebours, Barreswil and Davanne, proposed a method of litho-photography, in which a stone was coated with a solution of bitumen in ether, exposed to light under a reversed negative, and developed with ether, which dissolves the parts not affected by the light, while the exposed parts being insoluble remain and form the image. (Benzole, chloroform or turpentine may also be used instead of ether). After development the stone was prepared with acid and gum and inked in the same way as an ordinary lithographic drawing.*

Since then many other similar asphaltum processes have been proposed and have been worked with great success, both for subjects in line and half-tone; but, owing to the length of exposure required and the uncertainty of the results, this process is not well adapted for general use, and has, I believe, been almost abandoned in favour of the collochromate methods.

Collo-chromate Processes.—Paul Pretsch, whilst working out his photo-galvanographic process, hereafter to be described, discovered that if a mixture of gelatine and bichromate of potash be spread upon a suitable support and when dry exposed to light, then again moistened and inked in with a roller charged with printing ink, the ink would only take upon the parts altered by the light, and thus impressions could be obtained by transferring the design to zinc or stone.

Pretsch does not seem to have made any practical use of this discovery, but shortly afterwards, in 1855, Poitevin independently worked out a photolithographic process on the same principle, which has been the foundation of all the present processes of photolithography and photocollotype and is worked to the present day for the reproduction of the Belgian topographical maps. Poitevin impressed his photographic image direct upon the stone and not by transfer.

The first practical *transfer* process of photolithography seems to have been suggested by Asser, of Amsterdam, early in 1859. He coated unsized paper with starch, and then floated it on a strong solution of bichromate of potash. When dry it was exposed to light under a well intensified negative. The print was next heated with a flat iron, then moistened and inked in with transfer ink, by means of a roller, and thus an impression was obtained which could be transferred to stone or zinc.†

The next transfer processes were the Southampton process of photo-zincography, which was founded on Asser's, and Mr. Osborne's process of photolithography. These two processes, though quite independent one of the other, were identical in principle and almost so in details; the only difference being that Mr. Osborne added a certain proportion of albumen to the mixture of gelatine and bichromate and then treated his prints with boiling water, in

* See Davanne, *Chimie Photographique*, p. 456.

† *Photographic News*, Vol. III, p. 146.

order to congulate the albumen and leave a slight coating of it on the paper, so as to obtain a 'grip' on the stone during the process of transfer.*

At the Ordnance Survey Office, Southampton, and at the various photographic offices in India, in which the process has been introduced from Southampton, photozincography is used, with the best results ; but in Australia, America and the Continent of Europe photolithography is more usual and it is also used at Madras.

These processes have occasionally been used with fair success for the reproduction of shaded maps, architectural views and other subjects in half-tones, but they are not by any means suitable for such subjects, and are best adapted for the reproduction of maps and drawings boldly executed in dot or line alone.

They may also be used for copying prints or engravings of all kinds on the same, larger or smaller scales, but engravings, and even many lithographs, are generally more or less unsuitable for the purpose. The best results are obtained from original drawings specially prepared to suit the requirements of photographic reproduction, in strict accordance with the rules already given.

The following outline of the Southampton method will give an idea of the operations. Like the pigment-printing process, already described, it depends upon the property possessed by a dried layer of gelatine and other colloids, when mixed with an alkaline bichromate, of becoming insoluble and repellent of water under the influence of light. The procedure, too, is much the same as in the simple pigment-printing process, except that, instead of the fatty ink which forms the image on the photo-transfer print being mixed with the gelatine, it is applied to the surface of the print after exposure to light. The inked print is then washed in hot water, by which the colloid coating in the unexposed parts is dissolved and carries away with it the superfluous ink not retained by the lines forming the image.

The negatives are obtained by the methods already described applicable to the reproduction of subjects in line.

Having obtained a suitable negative, the next operation is to produce from it a photograph in greasy ink which may be transferred to zinc or stone.

To prepare the sensitive paper, a sheet of bank-post paper is coated twice with a mixture of 6 parts gelatine and 4 parts bichromate of potash, dissolved in 100 parts of water, dried in the dark and glazed to give it a smooth surface. It is then exposed to the light under a negative for one or two minutes in the sun, or until the finest lines are distinctly visible. When sufficiently exposed, which may be ascertained by the whole of the detail appearing in brown upon a bright yellow ground, the print is taken out of

* *Photographic News*, Vol. IV, p. 374.

the printing frame and passed through a lithographic press in contact with a polished stone, or zinc plate, which has been coated with a lithographic transfer ink, and thus receives an even coat of the greasy ink. The inked print is immersed for a few minutes in tepid water, to soften the gelatine still remaining soluble in the parts not acted on by light, and then laid on a sloping glass or metal plate and gently washed with a sponge and warm water till all the unaltered gelatine is removed, carrying the superfluous ink with it. The lines, on which the light has acted, remain insoluble and retain the ink, forming a clear image of the subject in a greasy transfer ink, precisely similar to the ordinary lithographic transfer drawing. When all the details are clearly and sharply defined, and the ground is quite free from ink, the print is rinsed in clean water and dried. It is then ready for transfer to stone or zinc.

It often happens that a map is too large to be photographed in a single section. In this case the transfer prints of the different negatives are carefully joined together with gelatine and transferred to the stone or plate; or if too large to be printed in one sheet, the joined-up transfers may be cut up into as many convenient-sized sections as may be necessary.

Zinc plates possess great advantages over lithographic stones on account of their superior lightness, cheapness, facility for storage and less liability to breakage, and are therefore to be preferred in reproducing plans of large size. For fine work stone is considered by some to give better results than zinc, but I believe that if due care be taken as good prints may be made from zinc as the best from stone.

The plates used for this purpose are about $\frac{3}{16}$ of an inch in thickness, and have one side carefully planed and smoothed; but in order to give a somewhat porous surface to the plate, so that it may be more absorbent of moisture and hold the greasy ink better, the planed side of the plate is grained, or roughened by grinding it evenly all over with very fine sand and water. After the transfers are made, the plate is etched with a preparation of gum and decoction of gall-nuts to which a little phosphoric acid is added.

If the transfers are made to a lithographic stone instead of to a zinc plate, the operations are exactly the same as for transferring an ordinary lithographic transfer-drawing, except that the stone need not be heated. The operations of printing, whether from zinc or from stone, are precisely the same as in ordinary lithography.

Various modifications have been introduced, but the above process is still one of the best and most simple, and, if care be taken with suitable subjects, results may be obtained by it not to be surpassed by any other method. Full details regarding it will be found in Sir H. James' '*Photozincography*,' also in the *Photographic News*, Vol. XII, page

280 *et seq.* The accompanying specimen of a reduction from an old engraved map will give an idea of the results that may be obtained.

In the Southampton process the whole of the unaltered gelatine is removed from the paper, and the objection has been made that, in consequence of this, the ink on the lines being left on ridges of gelatine is more liable to spread in transferring, that the fine lines are liable to be washed away by the dissolution of the gelatine beneath them, and that the prints are liable to slip during transfer. To remedy these defects various methods have been proposed for retaining the gelatine on the paper.

One of the best of these methods has been perfected by Capt. Abney, who has patented it under the name of 'papyrotype.'*

A tough paper is coated with gelatine, and subsequently treated with alum or chrome alum. It then receives a coating of gelatine and bichromate of potash as in the Southampton process. After exposure to light the print is drawn through *cold* water, and is then 'squeegeed' down on to a smooth metal plate, and inked in with a soft gelatine roller charged with transfer ink. The ink 'takes' only on the parts exposed to light, while the ground of the print remains clear. When the image is fully inked up, the print is dried and exposed to light, to harden the gelatine thoroughly by the action of light on the bichromate salt still remaining, and is then ready for transfer to stone or zinc.

Among the advantages claimed for this process, the principal are that—

The ink which forms the lines is not left on ridges of gelatine, as in the Southampton method. The fine lines are not liable to be removed. The surface of the transfer will have no tendency to slip during transfer.

In practice this method was not found to answer in this country so well as the ordinary one, but a modification of the latter has lately been introduced in the Surveyor General's Office, with the same object as the papyrotype, and seems to answer well.

The paper is prepared as usual with two coats of gelatine and bichromate of potash. It is then put away for a few days, in order to allow the gelatine to become hard and insoluble. When required for use, it is coated again with a mixture of gelatine and bichromate of potash of about one-third the usual strength, and is then exposed to light and inked in the usual way. The washing is done with cold water instead of with hot.

Instead of allowing the gelatine to harden by keeping, which takes from 3 to 12 or 14 days according to the season, the hardening action may be hastened by laying the sensitive paper face downwards on a board, and allowing the light to act on the back surface for a minute or two. This may be done, either after the print has been obtained from the negative, or just

* '*Instruction in Photography,*' p. 155.

after the preliminary coating has been given to the paper. The gelatine may also be hardened with alum or chrome alum.

It has been found that this method has the advantage that a base of hard insoluble gelatine remains on the paper and retains the finest lines, while the fresh and easily soluble final coating preserves the clearness of the ground. It is necessary that the underlying gelatine should be thoroughly hardened, otherwise the transfers stick to the zinc plate in transferring, and are difficult to remove ; the soft gelatine is also liable to spread over the lines and prevent their transfer.

Another advantage is that warm water is not required for washing the prints, and the ink is not so liable to become pasty as in the usual mode of working. The lines are found to keep crisp and the spaces between them free from scum, thus giving clearer and sharper transfers.

Mr. Herbert Deveril, Government photolithographer in New Zealand, found that, in working Osborne's original process of photolithography, which is still generally used in the Australian Colonies, great inconvenience arose from the use of boiling water to coagulate the albumen added by Mr. Osborne to the gelatine in order to produce an insoluble surface with a 'grip' on the stone. He has therefore substituted the following method of producing his transfer prints. Paper is first coated with gelatine to which a small proportion of chrome alum has been added. This is allowed to dry and is then sensitised in a solution of bichromate of potash. The prints are exposed and inked as in the Southampton process, and are washed off in cold water.* Mr. Deveril claims for this method the further advantage that the sensitive paper can be kept in good condition for a long time. The keeping properties of papers coated with gelatine and bichromate are, however, very dependent on climatic conditions. The results which I have seen by the process are exceedingly good.

A method of photolithography by transfer which yields excellent results in line, and even reproduces half-tones fairly well, is a modification of Asser's process, invented by Mr. Toovey, of Brussels, who coats paper with a solution of gum arabic mixed with bichromate of potash, and after exposure to light under the negative in the usual way, places the transfer-print face downwards on the stone with several thicknesses of wet blotting paper over it, and leaves it under pressure for some hours in a powerful press.

The gum on the parts not exposed to light being soluble is forced into the stone and prepares it, while the lines being hardened and rendered insoluble leave the stone quite free from gum and ready to take printing ink from a roller when passed over them, thus producing an image which may be printed from as soon as the soluble bichromate salt has been washed out, because the bichromated gum is a most powerful preparation for the stone

* '*Photographic News*,' Vol. XIX, p. 585.

and, indeed, is difficult to remove without grinding the stone down to some depth.

This process requires care in adjusting the amount of moisture to be applied to soften the gum, so that it may not be squeezed under the lines and block them up, and it has not, I believe, come into general use.

There are two disadvantages which militate against the employment of the transfer processes of photolithography for the finer and better class of maps. The first, is the difficulty of obtaining reproductions perfectly true to scale, owing to the unequal expansion of the transfer paper in the various washings and squeezings it has to undergo. Although this unequal expansion and contraction is very slight, and for most practical purposes may be disregarded, it has greatly hindered the more universal adoption of this valuable method for the reproduction of the official maps in England and foreign countries.

Mr. Rodriguez, of Lisbon, has, however, lately introduced an improvement into the transfer process with the object of doing away with the possibility of stretching in the course of any of the operations.* Instead of using paper as the support of the coating of gelatine on which the photographic image is impressed, he uses a sheet of tinfoil about the thickness of thin paper. This is first smoothed on a very finely grained lithographic stone and then laid down quite flat on a sheet of zinc. After being cleaned with alkali and well washed, the tinfoil is brushed over with a solution of gelatine and bichromate, dried rapidly, and is then ready to be exposed under a negative in the usual manner. To ink the print, the sheet of tin is first plunged into water, and then carefully laid down wet on a lithographic stone so as to avoid folds, the gelatine side being uppermost. The film is then inked in with a roller. After the first inking in the print is left for about a couple of hours and is then inked in again and afterwards washed with a sponge and water. It may then be lifted off the stone and dried. The operations of transfer are the same as usual.

The second disadvantage of the transfer methods is the almost unavoidable spreading of the lines under the operation of transferring, which makes a photolithographed map look heavy and unsightly compared with a lithographed one. This defect may, however, be diminished very much by skilful manipulation and taking care to have as thin a coating as possible of gelatine on the paper, and to use a good hard transfer ink in small quantity. With these precautions and with a suitable original, results may be obtained from photolithographic transfers which will well compare with ordinary lithography, or even engraving, in sharpness and delicacy.

These special defects of the transfer methods may be in great part obviated by impressing the photographic image direct on the stone, as origi-

* '*British Journal of Photography*,' Vol. XXV, p. 232.

nally proposed by Poitevin, but this plan has again other disadvantages of its own which render it less suitable for map work than the transfer process. It has, however, been used extensively, and very successfully, in the production of the Belgian topographical maps on the scale of 1 : 20,000.

In the process used for the Belgian maps, the stone is covered with a very thin coating of a mixture of gelatine and bichromate of potash, rapidly dried and exposed to light under a reversed negative, which is obtained by reversing the position of a dry tannin plate in the camera and allowing the light to act through the glass on the underside of the collodion film. A thin coating of printing ink is then applied all over the stone with a roller, and the surface is afterwards washed with warm water in which a little starch has been dissolved. This gradually removes all the soluble parts of the gelatine coating, leaving on the stone a clear image of the map. The stone is then covered with gum and after drying and remaining for a short time is ready for printing and capable of yielding 1500 good impressions.*

For line-work zinc plates are also used and prepared in much the same way.

This process has undoubtedly some advantages as regards accuracy of scale, and the quickness and cheapness of the operations, but on the other hand it has disadvantages as regards the difficulty of securing perfect contact between the stone and the negatives, the necessity for a reversed negative, the prints being limited within a single negative and the inconveniences of working with heavy stones.

Besides the foregoing, many methods of photolithography have been proposed, but as for the most part they are only modifications of the processes I have described, which are all good and may be considered typical, it will be unnecessary for me to go further into details regarding them.

VI. Photocollotype.

The great defect of all the processes of photolithography described in the last section is, that they can only be applied with advantage to the reproduction of drawings or subjects in which the gradation of shade is shown by lines or dots separated by white spaces of varying sizes and at different intervals apart, as in line or stipple engravings and lithographs in line or chalk. Even such drawings to be successfully reproduced must be in a good bold open style and have all the lines or points composing them of an equal and perfect blackness. In the many attempts that have been made to reproduce photographs from nature by photolithography or photo-engraving, or to copy paintings and brush-shaded drawings in which gradation of shade is continuous, success, only partial at best, has been secured by

* Maës and Hannot's '*Traité de Topographie, et de Reproduction des Cartes au moyen de la Photographie*'; also Hannot's '*La Photographie dans les Armées.*'

breaking up and destroying the continuity of gradation. By the processes of photocollotype, so called from the printing surface being of gelatine, these defects are entirely obviated, and absolutely permanent photographic prints may be produced in the printing press equal to silver prints in perfect delineation of detail and delicate gradation of shade, but vastly superior to them in permanence and cheapness of production.

Poitevin was the first to recognise, so early as 1855, the fact that the half-tones were better preserved on stones that had been treated with a chromated colloid mixture if, after exposure to light under a negative, instead of being inked all over and then washed with water to remove the superfluous ink, they were first moistened and then inked in with a lithographic roller charged with printing ink*. He seems, however, to have always regarded the stone as the principal printing surface and treated it by the ordinary methods of lithography. Only a few impressions could be obtained from stones thus treated.

In 1866, Messrs. Tessié du Mothay and Marechal, of Metz, discovered that the stone or metal plate hitherto used as a printing surface might be replaced by a mixture of isinglass, gelatine and gum, treated with an acid chromate, and evenly spread upon a well polished metal surface; because if, after exposure to light under a photographic negative, such a gelatinous surface were moistened, greasy ink applied upon it with a roller would adhere well to the parts of it that had been acted upon by light, and would be taken up by those parts in proportionate quantities, according to the intensity of the gradations of light and shade produced on them by the action of light, and their consequent impermeability to water. Photographic prints in fatty ink reproducing the most delicate gradations of shade without any apparent grain or break of continuity could thus be produced.†

It will be seen that this process was based on exactly the same principle as Poitevin's photolithography, but differed from it in the distinct recognition of the colloid film as the printing surface. Messrs. Tessié de Mothay and Marechal were also the first to recognise the necessity of adding a certain proportion of acid or of oxydising or reducing agents to the chromate salt used for sensitising the gelatine, with the object of rendering the colloid surface more apt to receive the greasy ink and also of hardening the film so as to enable it to withstand the wear and tear of printing. This they did by exposing the sensitive plates to a high temperature before using, but the effect was produced in great measure by the decomposition of the chromate salts by the acids or other substances added to the colloid mixture.

Messrs. Tessié du Mothay and Marechal printed off their 'phototype' plates in a lithographic press in much the same way as ordinary lithographs,

* '*Traité de l'impression photographique sans sels d'argent*,' p. 78.

† '*Photographic News*,' Vol. XI, p. 260.

but with certain modifications due to the peculiar nature of the printing surface. The principal of these was the use of two inks, one stiff, for giving force to the shadows, the other thin, for bringing out the more delicate half tones.

The 'phototype' process as at first proposed laboured under the defect of not being able to yield a large number of prints from a single plate, but, in 1869, it was improved upon in this respect by Albert, of Munich, who substituted a thick glass plate for the metal plate used by Tessié du Mothay and Marechal as a support for the colloid film. His films consisted of albumen, gelatine and bichromate of potash alone, and he gave them the required solidity and adherence to the glass by first coating the plate with a sensitive colloid mixture containing a large proportion of albumen, and then giving the under side of this first coating a preliminary exposure to light through the glass. The second coating containing more gelatine was then applied, and after it had dried, and the photographic image had been impressed upon it, the plate was again exposed from the back, in order to thoroughly solidify and combine the under part of the compound film. The gelatine films so prepared were capable of yielding some hundreds, or even, it is said, thousands of perfect copies. This process is still largely used by its inventor and is known by the name of Alberttype.*

According to some authorities, Messrs. Ohm, Grossmann and Gemoser, of Berlin, took out a patent, in 1867, for a method of photocollographic printing comprising, in addition to the use of glass as the support of the gelatine film, of the double coating of the plate and of the hardening of the film by exposure of the back surface, the introduction into the sensitive gelatine mixture of certain resinous compounds dissolved in spirit, by which the gelatine film is rendered quite insoluble and admirably adapted to form a fine printing surface. It is said on the other hand that the credit of all these improvements is due to Albert; but, in any case, it is certain that until after the publication of Albert's process early in 1869, Ohm and Grossmann's was almost unknown and had not come into general use. In October 1869, the Autotype Company in London acquired the patent, and have since worked the process with the greatest success.

About a year after the publication of Albert's method, Mr. Ernest Edwards, of London, introduced, under the name of 'Heliotype,' a very important modification of the photocollotype process.

He first waxed a glass plate and then coated it with a substantial layer of gelatine and bichromate of potash, containing a small quantity of chrome alum, with the object of hardening the gelatine and rendering it insoluble, without destroying its impermeability to water. When dry, the gelatine

* '*Photographic News*,' Vol. XIII, p. 121.

film was removed from the waxed glass plate, and the side which had been next to the glass was exposed under a reversed negative in the usual way, and, then, as in Albert's process, the back surface of the film was hardened by exposure to light. After this, the film was attached under water to a metal plate, preferably pewter, coated with india-rubber, and 'squeegeed' into perfect contact with it. The bichromate salt was then removed by washing and the plate was ready to be printed in an ordinary Albion printing press.

In this process the peculiarities were the use of chrome alum for hardening the gelatine ; the separation of the colloid film from its original support, by which perfect contact with the negative was secured, as well as less risk of breakage of the latter ; the subsequent transference of the film to a metal plate, by which the liability to breakage of glass plates in the progress of printing was obviated, and, lastly, the substitution of vertical instead of a scraping pressure in printing, by which the gelatine films were not exposed to injury by wear and scraping of the surface.

This process is still, I believe, largely practised and full details of it, with various improvements suggested by Capt Abney, R. E., will be found in the latter's excellent little work—"*Instruction in Photography.*"

About the same time, Herr Obernetter, of Munich, proposed another process of the same kind offering some peculiarities, and said to produce very satisfactory results.

A sheet of glass is coated with a mixture of gelatine, albumen, sugar and bichromate of potash, dried and exposed to light under a negative. The plate is then dusted over with finely powdered zinc, which attaches itself only to the parts protected from the light and in proportion to the amount of protection they have received. The plate is then heated to about 369° F., or exposed to light till the whole surface of the film has been rendered insoluble. Before printing, the plates are treated with dilute muriatic or sulphuric acid. By this operation the parts of the gelatine film covered with zinc, are rendered, by the formation of hydrogen, susceptible of attracting water to a greater or less degree, while the other portions, upon which no zinc has settled, are capable of receiving a fatty ink. The printing is then proceeded with in the usual manner.*

Since 1869, when these processes first began to come into practical use, many methods of working have been introduced, chiefly in Germany and France, but so far as known they are nearly all of them more or less modifications of one or other of the above, merely differing in the manner of preparing and hardening the gelatine film. A good deal of information on the subject will be found in Husnik's "*Gesammtgebiet des Lichtdrucks,*" Geymet's "*Phototypie,*" Moock's "*Traité pratique d'impressions photo-*

* '*Photographic News,*' Vol. XIII, p. 483.

graphiques aux encres grasses," and A. Martin's "*Handbuch der Emailphotographie und der Phototypie oder des Lichtdruckes.*"

The great difference between the photocollotype processes and lithography is, that whereas the lithographic stone receives a like quantity of ink in all parts of the image, and is incapable of producing a true and continuous gradation of shade, the moist gelatine film possesses the valuable property, not possessed by the stone, of receiving a greater or less amount of ink in different parts of the image, in exact proportion to the intensity of the action of the light upon them, and is thus capable of reproducing the most delicate gradations of shade as perfectly as they are shown in an ordinary silver print.

It will thus be readily understood that instead of the advantages of photographic reproduction by cheap and speedy mechanical processes being confined to the reproduction of certain special subjects, they can be extended to all classes of subjects, such as photographs from nature, brush-shaded and coloured maps, MS. records, drawings and paintings of all kinds. Even for line subjects, the process surpasses most of the known processes of photo-engraving, photozincography or photolithography in the delicacy, sharpness and clearness with which the finest lines can be reproduced, as well as in perfect accuracy of scale, owing to there being no intermediate process of transfer, with its attendant washings and pressings, and the plate being printed by vertical pressure.

The process has the further advantage that the prints do not require mounting, and this makes it very suitable for book illustration, for which, indeed, it is now being very largely used. It is especially valuable for illustrations of a scientific character in cases where otherwise only the highest class of lithography or engraving would be applicable and at an enormously increased expense.

For the most successful application of the photocollotype processes to the reproduction of maps, the result depends, as in photozincography, very much on the quality of the negative, and that again on the original.

Any negative that will give a good photographic print will answer, but the successful reproduction of shaded maps or drawings demands considerable care in the execution of the original drawing as well as in taking the negative. The precautions to be taken in these respects have already been indicated in sections II and III.

For some years past my attention has been given to the utilisation of this valuable process for the reproduction of maps and other photographic work which the Surveyor General's Office is called upon to do for various Government departments. In the Proceedings of the Society for November 1871, I described a process which I had found to answer well for line work, and strenuous efforts were made to bring this and other methods into practical working. It is much to be regretted that owing to the many difficulties met with in manipulating the gelatine films in the hot damp climate of Calcutta, and in getting printers with the special artistic skill required to produce the best results, our efforts have not been quite successful, and, as photozincography is found more convenient for most of the work passing through the office, the photocollotype process has not been brought into general use.

As the process previously described in the Proceedings has since then been modified and is, I know, exceedingly good for line work, the following description of the manipulations, extracted from the Annual Reports of the Surveyor General's Office for 1871-72 and 1872-73, may prove of interest, especially as the working details of few of the other processes have been published.

The printing plates are of plate glass, about $\frac{3}{8}$ or half an inch in thickness, evenly ground on one side with fine sand. When required for use they are thoroughly cleaned to remove all grease, and then carefully levelled.

The composition of the gelatine coating is as follows :—

A.	Gelatine,......	1 ounce.
	Glycerine, ...	1 dram.
	Distilled water, ...	6 ounces.
B.	Albumen,*	1 ounce.
	Distilled water, ...	1 ounce.
C.	Tannin, ...	10 grains.
	Water, (in hot weather, Spirits of wine,)...	1 ounce.

The above quantity will be sufficient for two square feet of plate.

As soon as the gelatine in solution A is quite dissolved, B is added and then C is poured in gradually with constant stirring. The whole is strained through two thicknesses of cotton cloth and poured evenly over the plates on the ground side, any air bubbles being carefully removed. The plates are then covered over with a light paper cover, to prevent dust falling on them, until they are *set*, when they may be removed into the open air and turned face downwards to dry. Or they may be dried with gentle heat in a drying box, but too quick drying is to be avoided because the gelatine films will dry unevenly.

When the plates are dry, they may be put away till required or sensitised in a bath of—

Bichromate of Potash,......	1 part.
Water, ...	20 parts.

They are allowed to remain in this for 5 minutes, then removed to a drying box and dried with a gentle heat. When dry, the deposit at the back of the plates, and any inequalities at the corners of the gelatine film are

* 30 grains of carbolic soap may be used instead of the albumen.

removed, and the plates are ready for exposure under the negative, which must be a reversed one obtained as described in section III.

If the reversed negative has been taken direct on glass, the exposure to light is performed in a pressure frame, in the same way as for ordinary photographs. It is advisable, however, to secure clean margins by shielding the borders of the negative by means of a mask, cut out in yellow or brown paper, which should well overlap the edges of the printing plates. The sensitive plate may be rubbed over with a little powdered soapstone to prevent any adherence to the negative. Some sheets of dark-coloured paper or cloth should be placed behind the sensitive plate and then a thick sheet of glass to give a good even pressure.

If, however, the negative has been stripped from the glass and is in the form of a thin skin, the most perfect contact will be produced by transferring the negative on to the surface of the printing film, in such a manner that it may be removed again after the exposure.

This operation presents some difficulties, but I have found the following method answer well. The sensitised and dried gelatine surface of the printing plate is covered with a very thin even coating of wax dissolved in turpentine or benzole. The plate is then placed in a dish containing sufficient spirits of wine to cover it. The thin negative film is laid down upon the gelatine in its proper position, the plate and film are then removed from the spirit, and the negative film carefully squeegeed into close contact with the gelatine surface. The plate is then covered with a few thicknesses of blotting paper, under a thick glass plate, and allowed to dry. When dry, the plate is ready for exposure. After exposure, the negative film is removed from the gelatine surface ; and, if sufficient wax was used and the film is fairly tough, it comes away without tearing. Should it tear, it should at once be dissolved off with ether, or there will be a continuating action of light on the parts of the gelatine surface protected by the negative film, so that they will print darker than the rest of the plate. Before printing, the wax should be removed from the gelatine with turpentine. The object of effecting the transfer in a bath of spirits of wine is, that neither the gelatine, wax, bichromate of potash or negative film are in any way affected by it.

The duration of the exposure to light varies from 10 minutes in the sun for a clear line subject, to from 25 to 50 minutes for a subject in half tones, according to the density of the negative and the intensity of the light. It is almost impossible to judge of the progress of the printing by inspection, and it is necessary to use an *actinometer* as a guide to the exposure. The following form of actinometer has been found to answer well for the purpose. It consists principally of a box, in the lid of which is fixed a translucent scale divided in 14 squares of different densities, No. 1 being almost transparent, while No. 14 is almost quite opaque; and numbers corresponding to the densities are painted in opaque colour on the scale. The scale is made by taking a collodion negative of a drawing shaded in tints of different strengths, and should be intensified so as to correspond in density with the kind of negatives it is intended to be used with.

The body of the box contains a block for carrying the sensitive surface, which may be spread on paper or on a glass plate, and a strip of vulcanised rubber below it presses the block into close contact with the scale.

I prefer to use in the actinometer a sensitive film of the same composition as the printing plate; small slips of glass are therefore coated with the gelatine mixture, sensitised, dried and exposed to light at the same time and in the same manner as the printing plates, and thus the progress of the action of light can be watched and timed very closely.

When the exposure to light is considered sufficient, the printing plate is removed from the pressure-frame and laid, gelatine side downwards, on a board covered with black cloth. The back, or under surface, of the gelatine is then exposed to light, for about 10 minutes, to thoroughly harden the gelatine and prevent it from swelling too much in the after processes. It is well to conduct this second exposure under a piece of ground glass, in order to prevent any scratches that may be on the back of the glass from showing as white lines in the print. The edges of the plate are then protected by strips of paper coated with solution of india-rubber, and when the india-rubber is dry, the plate is soaked in water until all the soluble bichromate has been removed, and is then ready for printing.

The plates can be printed in a lithographic press, but then they require to be fixed on a level stone with plaster of Paris. It has been found, however, more convenient, and in some respects better, to print them with vertical pressure in an ordinary Albion platen press; and in order to prevent the glass being broken, the bed of the press is fitted with two or three thicknesses of kamptulicon, besides a sheet of vulcanised india-rubber on which the plate rests. It is also desirable to place a piece of white paper over the bedding in order to enable the state of the plate when it is being inked up, to be better seen.

The inking in requires great skill and care on the part of the printer and is the most difficult part of the whole operation. The plate having been well soaked in water is laid on the press, and after being wiped to remove the excess of moisture, is inked in, if a line subject, with an ordinary lithographic roller charged with an ink composed of lithographic chalk ink thinned with a little olive oil, followed by rolling with a smooth roller to clear away the superfluous ink; a mask of the required size is laid on the plate to preserve the margins clean; over this comes the printing paper covered with a piece of soft felt, to drive the paper well into the hollows of the plate; the tympan is lowered and the impression pulled in the ordinary way. The plate is then damped and inked in again, and so on.

Half-tone subjects are treated in the same manner, but it is sometimes advisable to use two kinds of ink of different consistence or depth of colour; a stiff or dark ink gives force to the shadows, while a thin or lighter coloured one will bring out the delicate half-tones. Rollers made of gelatine, glycerine and castor-oil may be used with advantage, as they drive the ink better into the hollows of the lines than the leather rollers. Capt. Abney, who has given great attention to these processes, says that the great secret of producing good results is to have the command of first rate rollers. Glazed enamelled paper is generally used for printing half-tone subjects, but in some cases unenamelled paper answers well. The most suitable paper for printing seems to depend partly on the composition of the sensitive surface and partly on the ink.

One of the great drawbacks to the extended use of the photocollotype process for the reproduction of maps is the difficulty of making corrections on the plates. When the printing surface is a metal plate or lithographic stone, upon which a map has been either engraved, zincographed or lithographed, additions and erasures may easily be made without any risk of the loss of the printing surface or even of much damage to it. With the tender gelatine films the case is different, and although writing or simple lines may be inserted without much difficulty, it would be almost impossible to successfully alter gradation of shade or to insert shaded details. On the other hand, the taking out of details must be done by some chemical means which must always be attended with the imminent risk of raising the gelatine film from its support and the consequent utter destruction of the printing plate.

As maps, almost more than any other printed subject, require that it shall always be possible to make corrections on the printing plates, it is obvious that the use of any process which will not permit of this being done must be confined more to the reproduction of maps already printed or of an ephemeral character than to the preparation of new or standard ones. And thus, though photocollotype is admirably adapted for reproducing copies of old or other special maps, which are, or can be, finished once and for all, it is not suited for maps on which corrections are likely to be required.

With the plates prepared as described we have found that details may be inserted by two or three methods. The first is by writing in the required additions on the dry gelatine surface, using an ink composed of bichromate of potash, either alone or coloured with Indian ink. After the insertion of the additions the plate is exposed to the light for a few minutes to reduce the bichromate, and may then be washed and printed as usual.

Or an ink composed of solution of chrome alum may be used and will not require exposure to light. In some cases the part to be corrected may be washed over with a solution of bichromate of potash and allowed to dry, and then the required details may be printed in from another negative.

The taking out of details is more difficult and requires care. It may be accomplished by washing the part with a strongish solution of caustic potash or cyanide of potassium. Should a plate print dirty, it may be cleaned up and greatly improved by being washed with a weak solution of cyanide of potassium, or better, with a solution of citric acid, which not only clears up plates that print dirty, but at the same time facilitates the inking in. A weak solution of ammonia is also said to be useful in this respect.

The process just described was found to answer better in Calcutta for line-work than for half-tones, and for the latter the following formula for the gelatine films appeared preferable :—

Gelatine, ...	1½	ounce.
Glycerine, ...	1½	dram.
Albumen, ...	1	ounce.
Bichromate of Potash, ...	40	grains.
Chrome Alum, ...	7	grains.
Water, ...	12	ounces.

The plates coated with this mixture have to be dried in the dark, but in other respects the operations are much the same.

The processes in which a thick film of gelatine is spread upon a glass plate were found to present in Calcutta many inconveniences in the drying of the films, and the tendency there is in dry weather for the films to peel away from the glass plates and utterly break up and destroy the surface of the latter. There is also the constant risk of breaking the plates in the press. I was therefore led to go back to the old process of Tessié du Mothay and Marechal, in which a thin film of gelatine is supported upon a metal plate, and finally succeeded very well with the following method which I have fully described in the '*Year Book of Photography*' for 1877.

A flat plate of copper, such as used for engraving, is finely grained on its best side, and having been carefully levelled, is washed with warm water and coated on the grained side, while wet, with a mixture composed of—

Gelatine (Nelson's opaque), ...	15	parts.
Water, ...	100	„
Bichromate of Potash, ...	4	„
Formic acid (when the former are dissolved), ...	4	„

The excess is poured off, so as to leave enough to give a thin even coating. Half an ounce of gelatine is more than sufficient to cover 450 square inches of plate.

The plate is then replaced in the drying box and when dry is ready for exposure to light in the usual way; but it will be found desirable, in order to secure perfect contact, to transfer the negative film on to the gelatine surface in a bath of alcohol as before described.

Formic acid varies in strength and other properties, and if it should be found that the films made by the above formula are too soft, the plates may be kept a few days before printing. The addition of a very small quantity of tartaric acid (about $\frac{1}{30}$ of a part) will improve the films in this respect, and so will the cautious addition of some hardening agent, such as chrome alum, glycerine, glucose, honey, &c.

The printing operations are the same as for the plates already described, but the use of glue rollers and vertical pressure will be found advantageous. The thin films have been found to stand the wear and tear of printing well and to have no tendency to chip or tear away from the plates.

In all cases where the photographic image is impressed directly on the printing surface, a reversed negative must be used, as before explained, and these are sometimes rather troublesome to produce. I have lately tried whether the use of this reversed negative could not be dispensed with in the photocollotype process, by taking the negative in the usual way direct on to the thick ground glass plate and then, while still wet and without varnishing, coating this negative with a thin layer of any of the foregoing mixtures of gelatine, either with or without bichromate. When the sensitive gelatine coating is dry, it is exposed to light through the negative on the under side and allowed to print well through the film. This plan was found to have many conveniences to recommend it, and to answer very well for subjects in line, but not for half-tones. For map-work it has the undoubted advantages of perfect accuracy of scale and the greatest possible sharpness of the image.

The foregoing descriptions will give an idea of these interesting processes which are now being very largely used for producing photographic prints of all kinds, though, I believe, the successful working of them still presents some difficulties, even in better climates than India. Against their employment for map-work on the large scale there will, however, always remain the impossibility of joining up several sections of a large map on the printing surface, the difficulty of reproducing the finest tints of a shaded map with a perfectly clean white ground, and, above all, the difficulty of making additions and corrections on the plates.

The accompanying specimen of a reproduction of an old map of Bengal will give an idea of what may be done by the process described at page 93.

VII. Woodbury-type.

We have already seen that the great drawback to the production of photographs in printing ink with continuous gradation of shade, by either photography or photo-engraving, is the necessity for breaking up the continuity of gradation by a more or less marked 'grain', and that this difficulty has been overcome by the photocollotype processes.

By a very ingenious process, invented in 1864, Mr. Walter Woodbury succeeded in solving the problem in another way, and, by a mode of operation analogous to 'Nature-Printing', has been able to produce absolutely permanent prints with such perfect photographic gradation, combined with the most exquisite transparent delicacy and richness of tone, that none but the initiated would know that they were not the ordinary silver prints.

A tissue is first made by coating a tough film of collodion with a moderately thick even layer of gelatine and bichromate of potash, slightly coloured in order to see the progress of the development. When dry, the tissue is laid collodion side next to the negative film, and exposed to light proceeding from one direction only, in order to prevent diffused rays acting through the thick gelatine coating and so blurring the image. This tissue of gelatine and collodion is then temporarily attached to a glass plate and treated with hot water, very much in the same way as in the pigment printing process already described. The whole of the gelatine upon which the light has not acted, and which therefore remains soluble, is dissolved away, leaving an image in relief, the highest parts of which represent the deepest shadows of the picture, while the parts intervening, down to the lowest, represent the intermediate gradations between the deepest shadows and the highest lights.

When dry, the gelatine composing this image will be quite hard and capable of resisting the heavy pressure required to indent it into soft metal, without itself being injured.

The tissue bearing the image having been stripped from the temporary support, is laid face downwards on a sheet or block of lead or type-metal, about $\frac{1}{8}$ of an inch thick, between two finely surfaced steel plates and submitted to the pressure of a very powerful hydraulic press. The prominent parts of the relief are thus forced into the soft metal and produce a mould the deeper parts of which represent the shades and the shallower the lights of the picture. As the relief obtained from gelatine and bichromate of potash alone will impart to this mould a smooth surface without grain, such plates could not be printed with printers' ink, like a copper-plate engraving. Mr. Woodbury therefore uses a semi-transparent ink consisting of gelatine coloured with any suitable pigment.

The leaden plate or mould is laid in a suitable press of peculiar construction* and slightly greased. A small quantity of the coloured gelatine having been poured in a liquid state into the middle of the mould, a piece of suitable paper is laid above it and pressed strongly down, so as to force the ink thoroughly into the depressions all over the plate and squeeze out all the ink between the surface of the metal and the paper in the parts forming the highest lights of the picture. The gelatinous ink is allowed a short time to 'set' and attach itself to the paper; the paper is then removed and brings with it a perfect impression of the picture in coloured gelatine, of different thicknesses corresponding in intensity and gradation of shade to the depth in different parts of the plate. The print has now only to be 'fixed' in a solution of alum and when dry is perfectly permanent and ready to be trimmed and mounted.

The rate of impression is about the same as of ordinary copper-plate printing and may be carried on quite independently of the light. If very large numbers are required of a single subject, it is easy to produce as many printing plates as may be required from the original gelatine relief, which may afterwards be put away and kept indefinitely. The cost of printing is exceedingly small and prints are produced in large numbers at a marvellously cheap rate. As the process requires special mechanical appliances and apparatus it has generally been worked on the large scale by public companies.

The Woodbury-type is unfortunately not well adapted for the reproduction of maps, because it has been found very difficult to produce impressions of large dimensions, and, owing to the peculiar method of printing, it is almost impossible to obtain the clear black lines and pure white ground so indispensable in a good map. The prints also have to be mounted, which is an objection. However, in special cases where the work is within the capabilities of the process, it will be found valuable, because it possesses the great advantage over the collotype processes for the reproduction of half-tone subjects that the printing of an almost indefinite number of copies can be carried on with as perfect certainty as in ordinary lithography or engraving, while in beauty, transparency and delicacy of gradation the Woodbury-type prints are undoubtedly superior to collotypes.

VIII. Photographic Engraving.

As was noticed in the Introduction, the earliest practical process of photography was a method of photographic engraving invented by Nicéphore Niepce, and since his time nearly every great improvement in photography has been applied to this object. Thus, no sooner was the Daguerreotype invented than essays were made by Fizeau, Donné and others to engrave

* For a drawing of this press, see Abney's *Treatise on Photography*, p. 175.

the images produced on the metal plates. In like manner, the earliest application of the peculiar action of the alkaline bichromates upon colloid substances was Fox Talbot's photoglyphic process, which was soon followed by the photo-galvanographic and helioplastic processes of Pretsch and Poitevin. Engraving processes have also been based upon Swan's pigment-printing process, the Woodbury-type and the collotype. With the exception, perhaps, of the second, all these methods, from the earliest to the latest, are in use at the present time in a more or less modified form.

The object of engraving maps upon copper is to obtain a plate taking but little storage room and not liable to break, which shall yield a large number of impressions of uniform quality and, with due precautions, be capable of being preserved in a good condition for printing during any length of time.

Copper-plates have the further advantage that they may be multiplied to any extent by electrotyping, and corrections may be made when required, either on the original plate or on the electrotyped matrix or copy. Transfers may also be made from them to stone or zinc and printed in the same way as ordinary lithographs. This procedure is specially applicable when very large numbers are required or when the subject is to be printed in colours.

Besides these more practical advantages, the superior beauty and finish of copper-plate engraving give it the preference for all maps of a permanent or standard character.

With these objects in view nearly every civilised nation has at least one engraved map giving the results of the State Surveys on a convenient scale for general use. For the same reasons map-publishers generally engrave the maps composing their atlases and other standard publications.

Notwithstanding its many advantages copper-plate engraving is a very slow process and is also expensive, because the art of the engraver is one requiring great artistic and manipulative skill, only to be fully acquired by an almost life-long apprenticeship. Map-engraving, it is true, does not require so high a degree of artistic skill as line or aquatint engraving, but it nevertheless requires a long training, particularly in the more difficult branch of hill-etching which demands almost as much skill to produce first-rate results as ordinary line-engraving.

Although the advantages of photographic engraving as a means of avoiding the long and costly labour of engraving maps by hand are obvious, for various reasons these processes have not yet come into general use. A successful commencement has, however, been made by the Italian and Austrian Governments of employing photography in the production of their engraved maps, and there is little doubt that before long, photographic engraving will be more extensively used for this purpose than it is at present, especially as processes are now available by which gradation of shade may be obtained without difficulty, and the expensive hand-work of the engraver in biting in or finishing may to a great extent be dispensed with.

The processes of photographic engraving that have been proposed from time to time for producing incised images on metal plates capable of being printed in the copper-plate press, are very numerous. I shall, however, confine myself to those which have been most successfully worked and of which the details have been more or less fully published. Further information on the subject will be found in the special works referred to in the footnotes, and also in Hammann's "*Des Arts Graphiques destinés à multiplier par l'Impression*" and A. Martin's "*Handbuch der Emailphotographie und der Phototypie oder des Lichtdruckes,*" which both give very complete resumés of the early progress in this branch of photography, with details of many of the processes. The Photographic Journals and the Patent Office records may also be consulted.

The principal methods of obtaining an incised image on a metal plate by means of photography are:

1. Obtaining a photographic image on a metal plate coated with asphaltum and then etching or 'biting in' with acid.

2. Obtaining a photographic image in gelatine on a metal plate and etching the latter with some substance that will not attack the gelatine.

3. Obtaining an image by the direct action of light on a metal plate, as in the Daguerreotype process, then forming a metallic reserve to protect either the lights or shadows of the image and etching with a suitable mordant.

4. Electrotyping from a relief obtained by the swelling or partial solution of a chromated gelatine film, either directly or by the intervention of a cast in wax or plaster.

5. Electrotyping from a relief in insoluble gelatine obtained in the same way as in the 'Autotype' or Pigment-printing process.

6. Electrotyping from a leaden plate on which an image has been impressed from a gelatine relief, as in the Woodbury-type process.

7. Electrotyping from a relief obtained directly on a collodion positive cliché.

It will be seen that these methods divide themselves into two principal groups of etching and electrotyping processes.

Etching processes with Asphaltum.—We have already seen that Niepce in his experiments to find a substitute for lithography, made use of the property possessed by bitumen of Judæa, or asphaltum, of becoming insoluble in oil of lavender and other solvents, after exposure to the action of light, to obtain photographic images on metal plates which were then bitten in with acid, so as to form engraved plates, usually copies of engravings, though he also obtained images from nature.

Owing to the imperfection of photographic appliances in those early days of the art, the results obtained by Niepce could not have been very satisfactory, but with better appliances the same process has yielded in the hands of Niepce de St. Victor, the nephew of the inventor, Amand Durand and others, results which prove its practicability, and its capabilities for reproducing images direct from nature or for copying fine line engravings and similar subjects, for which latter it is much better adapted.*

A process on this principle has been very successfully used at the Imperial State-Printing Office, Berlin, for the engraving of plates for bank notes and other purposes, and I have also tried it myself with fair success.

The following outline will give an idea of the operations.†

A perfectly smooth copper plate, having been thoroughly cleaned and polished, is coated with a solution of asphaltum in turpentine, to which a little oil of lemon is added. It is then carefully dried in the dark so as to preserve an even coating, free from dust.

The image may be impressed upon the sensitive surface by sun-printing through an ordinary negative on glass, but as there is by this plan great risk of losing perfect sharpness by want of close contact between the glass and the copper plate, it is better to remove the collodion film from the negative and transfer it on to the surface of the asphaltum, so that it may be in absolute contact with it all over, and thus secure the utmost possible sharpness of the image. The collodion film is loosened from the glass in an acid bath, containing 1 part each of sulphuric and acetic acids in 320 parts of water, and the transfer is then effected in a bath of 1 part glycerine and 4 parts of water. The transferred film being dry, the plate is ready to be exposed to light, and as the asphaltum is not very sensitive, the exposure is somewhat long—extending from 6 to 36 hours; but it is better to over-expose and to work in diffused day-light rather than in the full sunshine.

When the plate is judged to have been sufficiently exposed, the collodion film is removed and the asphaltum surface is rubbed lightly with a tuft of cotton dipped in olive oil, to which after a short time a little turpentine is added. The image gradually begins to appear, and by degrees the unaltered asphaltum is all removed, so that the design appears in clear brown upon the polished copper. The plate is then washed with soap and water and allowed to dry.

The next operation is the etching or biting in of the image. The back of the plate having been well coated with a thick varnish of asphaltum, to protect it from the action of the acid, the plate is plunged into a trough

* See '*Traité pratique de Gravure Héliographique sur Acier et sur Verre*', par M. Niepce de St. Victor.

† Full details will be found in my '*Report on the Cartographic Applications of Photography*,' p. 79.

containing a mixture of 1 part chlorate of potash, 10 parts muriatic acid and 48 parts water, and allowed to remain till the weakest lines of the drawing begin to appear. It is then well washed and the asphaltum covering the lines is removed with benzole. The design will now be seen standing in a slight relief, and an electrotype must be made in order to obtain a printing plate from which impressions may be taken in the ordinary way. The sharpness of the lines is better preserved by making a relief and electrotyping, than it would be by biting in.

The best results by this process are obtained from subjects in line, and even with these the operation of 'biting in' demands a little manipulative skill. Good results have, however, been obtained in reproducing half-tone subjects, but they require the greatest skill on the part of the manipulator and generally much re-touching by a practised engraver.

A modification of Niepce's process, by which good results have been obtained, has been introduced by M. Négre, it is briefly as follows :

A plate of steel is covered with a coating of bitumen or bichromated gelatine and exposed to light under a negative. After development by a suitable solvent, which removes the parts not acted on by light, the plate is placed in a solution of gold and, by means of a galvanic battery, a thin regular coating of gold is deposited on those parts which present a clean metallic surface ; the remainder of the sensitive coating is then removed, and a beautiful damascened design in gold is obtained. The gold adheres well to the metal surface and as it is not attacked by the etching liquid, the design may be etched without injuring the ground of the plate.

This process also appears only suitable for line work, though it is said that satisfactory results in half-tone have been obtained with it.

M. Baldus, of Paris, is said to have used a similar process, but to have etched his plates in a solution of sulphate of copper by attaching them to the positive pole of a galvanic battery.

The processes dependent on the use of asphaltum are all more or less slow and uncertain in practice, and if not already quite abandoned in favour of the quicker and more certain processes dependent on the use of gelatine and bichromate of potash, are rapidly becoming so, especially as their usefulness is almost entirely confined to reproducing subjects in line. Exceedingly fine results can, however, be produced in this manner, and it is particularly valuable in cases where an 'etching' or 'biting in' process is required, because the bitumen forms a much better 'resist' for the acid or etching liquid than does gelatine, as we shall now see.

Etching processes with Gelatine.—In 1852, Mr. Henry Fox Talbot brought forward a method of photographic engraving called 'Photoglyphy,' which is of some interest as being the first practical photographic process founded on Ponton's discovery of the decomposition of bichromate of potash in contact with organic matter under the influence of light. Talbot found that by the action of light, a dried film of gelatine mixed with an alkaline bichromate became impermeable to certain fluids in proportion to the intensity of the action of the light upon it. He coated steel plates with a thin film of gelatine and bichromate of potash, and after exposure to the light under a photographic positive, he etched the image so produced with a solution of bichloride of platinum which, penetrating the unaltered gelatine in the parts protected from the light and attacking the underlying metal, produced the shadows of the resulting picture. Some very promising results were obtained in this manner, and great expectations were entertained of its utility in producing engraved plates for book illustration and other purposes. These hopes, however, have not been fulfilled and the process, though remarkable as the first of the many valuable methods of photographic press-printing dependent on the use of gelatine and the alkaline bichromates, has inherent defects and difficulties which seem to render it of little practical value.*

M. Baldus has successfully employed a modification of the photoglyphic process for line-work.† He coats a copper-plate with gelatine and bichromate and exposes it under a negative or a positive, then etches in a solution of perchloride of iron, which attacks the copper in all the parts not acted upon by the light, and thus a first relief is obtained. As this relief is not sufficient, the plate is inked in with a printing roller, when the ink attaches itself to the parts in relief and protects them from the action of the etching liquid. This procedure is repeated till the desired effect is produced. If a negative is used an incised plate is obtained, which may be printed in the copper-plate press. If a positive is used the image is in relief and suitable for being printed with type. I have found that the reliefs obtained in this way are exceedingly sharp, though the gelatine films will not stand the action of the etching fluid for very long.

Messrs. Leitch and Co., of London, have lately introduced a similar process, called by them 'Photogravure.' It appears to be due to M. Garnier, who has had great experience in these processes and produced some very fine results. The method of working is a secret, but it is said that a metal plate is coated with a sensitive composition capable of resisting the action of acids. The photographic image is impressed on the sensitive surface through a negative and is then etched with perchloride of iron. The etching is said to be to a certain extent automatic, that is to say, the etching action on the lines ceases at different periods in proportion to their fineness.

* A full description of Talbot's process, with specimens, will be found in the appendix to the English translation of Tissandier's '*History and Handbook of Photography*,' edited by J. Thomson.

† See the above work, p. 207.

Daguerreotype Etching.—Many attempts have been made to engrave the beautiful and delicate photographic image formed on the Daguerreotype plate. Thus, Donné simply etched the image with dilute nitric acid, which attacked the silver forming the shadows, leaving the whites protected by the mercury untouched. Grove etched the plates with the aid of the galvanic battery. Fizeau first etched as deeply as possible with dilute muriatic acid and then, having filled up the hollows with drying oil, deposited gold upon the lights; the oil having then been removed, the plate was bitten with dilute nitric acid. In order to render the silver plate more capable of standing the wear and tear of printing it was covered with a thin film of copper, which could easily be removed and renewed when required.

Other processes were also put forward, but they all failed, from the difficulty of biting the image to a sufficient depth and of obtaining the requisite 'grain' to enable a large number of impressions to be pulled off. None of them seem to have ever come into practical use and, like the Daguerreotype, they have almost fallen into oblivion.

If with the superior knowledge and appliances of the present day, any such process could be successfully worked, it would probably offer many advantages over any other etching process, especially for maps and other works in line.

Several ingenious processes of chemical engraving applicable to photography have been proposed by Messrs. Garnier and Salmon, Vial, Dulos and others; but as they do not appear to have come into practical use, it will be unnecessary to enter into details regarding them. Descriptions of them will be found in Roret's '*Manuel du Graveur*'.

Though they have the advantage of rapidity, all these processes, in which the image is obtained by etching or biting in with acids or other etching fluids, are open to the objection that for all subjects containing fine and delicate lines the etching and stopping out require almost the same manipulative skill and care as in ordinary engraving, and the processes consequently become expensive to work. There is also a tendency for the lines to become coarse and heavy. In those gelatine processes in which the etching fluid acts through the gelatine it gradually loosens the latter from its support and attacks the parts which should not be bitten at all. These defects are to a great extent obviated in the processes we are now about to consider, in which the printing plates are produced by the electro-deposition of copper on the photographic image.

Electrotyping methods.—In nearly all the electrotyping methods the printing plate is obtained by depositing copper on a gelatine relief obtained by the agency of light, or on a cast in plaster, gutta-percha, &c. taken from such a gelatine relief.

If a dry film of chromated gelatine on a suitable support be exposed to light under a photographic cliché, and then plunged into hot water, the parts acted on by light being insoluble will remain on the support in different degrees of relief according to the intensity of the light, while the unexposed parts will be washed away. An image in high relief formed of hard and insoluble gelatine will thus be obtained, from which a cast or electrotype in intaglio may be made.

If, however, instead of using hot water, the plate be plunged into cold water, the gelatine will be found to absorb water and swell up in the parts protected from the light, while in the parts acted on by the light it will only slightly absorb the water, and these parts will thus form hollows. The power of absorbing water will also be found to be in exact proportion to the degree of protection from light. In this case, an image in low relief is obtained which may also be moulded from, or electrotyped.

Upon these two principles several processes of producing printing-plates both for copper-plate and letter-press printing have been founded with more or less success.

The first process of the kind was Paul Pretsch's 'Photogalvanography', invented in 1854. He appears at first to have obtained his plates by coating a glass with gelatine and bichromate, exposing to light and then washing away the soluble gelatine and taking a mould of the resulting relief, in gutta-percha, from which an electrotype was made in the usual manner.*

This process gave fair results both in line and half-tone, but, owing to the washing away of the soluble gelatine being effected on the side of the film exposed to light, the plates were defective and required a good deal of touching up by skilled engravers, which vastly increased the expense of their production. The process failed as a commercial speculation.

Almost immediately afterwards, in 1855, Poitevin published methods of obtaining plates from the gelatine reliefs obtained by swelling the sensitive films in cold water. Plaster casts were either made from them or the gelatine surface itself was metallised and electrotyped in the usual way.†

This method produced tolerable results, though the prints were always somewhat coarse, owing to the fact that swollen gelatine will not give the same sharpness as when dry.

Both these processes were more or less unsuitable for reproducing subjects in half-tone—Pretsch's because in the process of washing away the soluble gelatine, the lighter half-tones were liable to be lost—Poitevin's because of the difficulty of keeping the swelling in proper relative proportion, owing to more absorbent parts of the film lying underneath less absorbent parts. Both processes also failed to give the necessary 'grain,' without which the proper inking of the engraved plates could not be effected.

* See '*Journal of the Photographic Society of London*,' Vol. III, p. 58.

† See '*Traité de l'impression photographique sans sels d'argent*,' p. 49.

Various attempts were made to improve on these processes, but unsuccessfully, until M. Placet showed that it was necessary to adopt in them the same principle of exposing on one side of the gelatine film and developing on the other, which, as we have seen, had previously been shown to be necessary for the preservation of the half-tones in the pigment-printing process, and for a similar reason.

M. Placet indicated several ingenious ways of obtaining his results.* They may, however, be briefly summed up as follows:

A film of chromated gelatine is exposed under a transmitted positive cliché, so that the light acts on the under side of the film; this is done either by covering the collodion side of the cliché itself with the sensitive coating, or by using a thin transparent sheet of transfer collodion or mica as a support for it. After exposure to the light, the film is soaked in water, whereupon those parts which have been protected from the light swell up in proportion to the amount of the action of light upon them. By treating the mould in relief thus obtained with metallic solutions, an electrotype copy in copper may be produced, which can be printed from in the copper-plate press.

If a negative cliché is used, the unaltered gelatine must be dissolved or a second electrotype must be made.

M. Placet also suggested the employment of a sensitive surface which would become soluble under the influence of light, such as a mixture of gelatine, or other colloid, with perchloride of iron and tartaric acid, as recommended by Poitevin for pigment-printing. In this case the solvent acting on the exposed side hollows out the image, in the same way as an etching fluid does on copper, but with the advantage that each line has only the exact strength given to it by the intensity of the cliché. Or the altered parts of the gelatine film may simply be swollen with cold water, producing an image in relief. In either case, a mould is taken from the gelatine and electrotyped, or copper may be deposited on the gelatine itself.

By his process M Placet was able to obtain very perfect gradation of shade in the half-tones of his pictures, with a fine natural grain produced by some means which he did not divulge. He has lately, however, described a method of producing the grain, which consists in plunging the gelatine plate into a solution of bichromate of potash and then treating it with a solution of protosulphate of iron containing acetic acid.† The principle he lays down is first to treat the gelatine with a solvent and then with a solution of some substance that will tan or contract it.

Messrs. Fontaine, Avet and Drivet have also proposed similar processes, in which they have partially overcome the difficulty of obtaining a proper

* See Davanne, '*Les Progrés de la Photographie*,' p. 185.

† See '*Bulletin de la Soc. Franc. de Photographie*,' Vol. XXIII, p. 130.

'grain' by interposing between the cliché and the gelatine film a fine network or an impression of an engraved or roulette tint; but these artificial grains have a disagreeable effect, and the methods seem to have fallen into disuse, except for line-work and photo-typography, which will be described further on. Avet's process is, however, I believe, still in use for producing the maps of the Italian Surveys.

Geymet's method.—The fourth method, that of electrotyping from a gelatine relief obtained by the pigment-printing process, is somewhat similar in principle to Placet's process, but as there are important differences and the process appears likely to prove of some utility, it may well be treated separately.

According to M. Geymet, who has very fully described the process and all the manipulations of preparing and electrotyping the reliefs in his "*Gravure Heliographique*," it was the invention of M. Audra, a French amateur.

Pigmented gelatine tissue is sensitised and exposed to light exactly in the manner described at p. 78 for the 'Autotype' process. It is transferred to a smooth glass or a polished copper plate, developed in warm water, and when dry is metallised and electrotyped. If the subject is one in line or dot only the above operations are sufficient, but if the subject is a photograph from nature, or any other with gradation of shade, it is necessary to obtain a 'grain', and this M. Geymet does by taking a copper-plate with its surface grained or engraved with a ruled or roulette tint, inking it up in the ordinary way and then covering it with a coating of transfer collodion. When dry, the film of collodion is stripped off the plate and carries with it the impression of the grain. This film is then placed between the cliché and the sensitive gelatine film and serves to break up the shadows in the more transparent parts of the cliché.

A similar process has been used at the Depôt de la Guerre, in Belgium, for the reproduction of maps.*

Last year, whilst making some experiments on this process, I succeeded in obtaining the necessary 'grain' by chemical means which produce a finer and less artificial effect, and I have also made a few other modifications in the process, which may be worth recording at length.

A piece of the ordinary autotype tissue is sensitised in a 5 per cent solution of bichromate of potash. When dry, it is exposed to light under a reversed negative and then transferred in cold water to the surface of a well polished copper plate and squeegeed down into close contact with it. In order to prevent subsequent adherence to the newly deposited copper in the electrotyping bath, the copper plate is silvered by rubbing it with a little of the following solution mixed with tripoli.

* See Maës and Hannot '*Traité de Topographie, &c.*,' p. 330.

Nitrate of Silver, ...	1	part.
Cyanide of Potassium, ...	10	,,
Water, ...	100	,,

The gelatine tissue attached to the copper plate is allowed to dry, and then developed in warm water in the usual manner, great care being taken not to loosen the lines, an accident which is very liable to happen, though the preliminary drying of the tissue before development tends to prevent it.

When the image is quite clear from all soluble gelatine, the plate is well drained and plunged into a bath containing—

Tannin, ...	5	parts.
Strong Spirits-of-wine, ...	100	,,

This at once removes all moisture from the gelatine relief, hardens it, and gives it a fine grain, coarser in the shadows than in the lights. The plate remains a few minutes in this bath till the action is complete in the deepest shadows; the tannin is then washed off with a little spirits-of-wine, and the plate is allowed to dry.

The gelatine relief has now to be prepared for receiving the electrotype deposit. A band of copper having been soldered to it, the back of the plate is coated with Brunswick black, to prevent deposition of the copper upon it. When the backing is dry, the margins of the picture are cleaned with a little of the silvering solution. The gelatine surface then receives a very slight coating of wax dissolved in turpentine, which is well polished off, and is rubbed over with fine plumbago or silver-bronze powder to render the surface conducting. The plate is then ready to be placed in the depositing bath.

Any good electrotyping arrangement may be used, but I prefer a Smee's battery with a separate depositing trough, containing a solution of 10 parts each of sulphate of copper and sulphuric acid in 100 parts of water.

A plate of copper, to serve as an anode and connected with the silver plate of the battery, is laid horizontally about an inch above the bottom of the depositing trough which should be large enough to allow the plate bearing the gelatine relief to be slipped under the anode. The relief-plate is connected with the zinc plates of the battery and, when everything else is ready, the circuit is completed by slipping it into the depositing trough under the anode. By laying the plates horizontally in this manner the deposit is more even and the gelatine film seems to be more readily covered with copper.

When the deposit of copper is of sufficient thickness it is separated from the matrix, and only requires a gentle 'oil-rubbing' to be fit for printing.

The plates obtained by this method show very good half-tone with an almost imperceptible grain, giving the effect of a fine chalk-drawing.

I have lately tried to obtain the images upon the copper by the double transfer process, making use of a flexible temporary support, consisting of paper coated with india-rubber, as first proposed by Swan, which can easily be removed with benzole after the transfer of the gelatine image to the copper. The 'grain' is given to the image by soaking it in water after the removal of the india-rubber paper, and then applying the solution of tannin in alcohol. This plan seems likely to be successful, if so, it will greatly simplify the operations and enable engraved plates to be obtained from any ordinary negative without the trouble of reversing.

By electrotyping direct from the gelatine relief, the results are always rather heavier and coarser than they should be, because, although hardened and insoluble, the gelatine relief can always absorb a little of the copper solution in the depositing trough and consequently the image swells and loses sharpness.

The strong tanning given to the gelatine film and the preliminary coating of wax before metallising the surface obviate this defect to a considerable extent; but it may perhaps be better to obtain a matrix in lead by pressure from the gelatine relief, and then to obtain the printing plate by electrotyping twice from the lead matrix. This is a more round-about and expensive method, but is likely to yield finer results and has been adopted by Woodbury and Rousselon in the processes next to be considered.

The process is simple and if it could be successfully worked out it might be usefully employed in this country in reproducing shaded maps and for other miscellaneous purposes. It has the very great advantage over photo-collotype that the plates can be corrected, if necessary, and can be printed in any numbers in the ordinary copper-plate press without risk of breakage or damage to the printing surface.

Woodbury-type methods.—It has already been shown that in the Woodbury-type process the photographic image is impressed into a soft metal plate by means of a relief in insoluble gelatine on a collodion support, and that instead of impressions being printed in ordinary printers' ink they are made in coloured gelatine. In such prints the gradation of shade is continuous and there is no perceptible grain.

Mr. Woodbury has proposed an ingenious method for obtaining gelatine reliefs with a granular surface, so that, when impressed into soft metal, electrotypes in copper may be obtained from the latter, which will serve as printing-plates for printing with printers' ink in the copper-plate press, and yield superior results to those obtained by electrotyping immediately from the gelatine relief.

A plate of glass is waxed and coated with a thin film of collodion, and a mixture of gelatine and bichromate of potash, containing a quantity of fine emery, powdered glass or charcoal is poured over it and allowed to 'set'. The gelatine film is then dried and taken from the glass, and the collodion side exposed beneath a negative. After a sufficient exposure, it is temporarily attached, on the collodion side, with india-rubber solution, to a sheet of glass and washed in warm water.

The resulting granular image is then pressed into a sheet of soft metal by means of the hydraulic press. The soft metal plate has an electrotype made from it in copper, and another plate, subsequently covered with a coating of iron, is again made from this to serve as the printing-plate, the first copper plate being kept as a reserve.*

Mr. Woodbury also describes another method which in some respects resembles Geymet's, before described.

Paper is successively coated with three or more mixtures of gelatine, bichromate of potash and some granular substance in different degrees of fineness—first with the coarsest and lastly with the finest. When dry, the tissue is exposed under a negative, transferred under water to a finely polished plate of zinc or steel, then washed in warm water as usual, and when dry is ready for pressure into the soft metal block. In this case, the light tones are composed of the finest grains and the shadows of the coarsest.

M. Rousselon, the manager of Messrs. Goupil's photographic works at Asniéres, near Paris, has obtained engraved plates with remarkably good half-tones by a process somewhat similar to the Woodbury-type, which is also largely worked by Messrs. Goupil. The peculiarity is in the grain, which is obtained by the addition to the sensitive mixture of gelatine and bichromate of some substance which has the property of causing the film to become granular under the influence of light, the granular effect being increased in proportion to the intensity of action of the light. The other operations are the same as in the first of Mr. Woodbury's processes just described. The details of this process are a secret, but it is said that the substance used for producing the grain is chloride of calcium.

I am not aware of either Woodbury's or Rousselon's processes being utilised for the reproduction of maps, but in certain cases they could, no doubt, be usefully employed. The only difficulty seems to be that an immensely powerful hydraulic press is required for large subjects.

Photo-mezzotint.—The Editor of the '*British Journal of Photography*' has lately suggested a process of photo-mezzotint engraving founded on the 'dusting on' or 'powder' process, already alluded to.†

A polished steel plate is thinly coated with—

* '*British Journal Photographic Almanac*,' 1872, p. 40.

† '*British Journal of Photography*,' Vol. XXIV, p. 170.

Saturated solution of bichromate of ammonia,...	5	drachms.
Honey,......	3	,,
Albumen,...	3	,,
Water, ...	$1\frac{1}{2}$	pint.

When the coating is thoroughly dry, the plate is exposed to light under a transparency. A large camel's hair brush is charged with a mixture of the two finest kinds of emery powder, and applied with a circular whisking motion all over the surface. The powder attaches itself to those parts of the plate on which the light has not acted, precisely in proportion to the amount of protection they have received, owing to the unaltered parts of the film attracting moisture and becoming 'tacky.' The most 'tacky' parts, forming the deep shadows of the picture, will attract the coarsest particles of the emery, the finer parts will take finer emery and the highest lights will take none at all. When the picture is fully developed, it is placed face to face against a polished plate of softer metal and passed between a pair of rollers, so that the emery powder image may be indented into the polished metal. The plate is then burnished in parts by a skilled engraver and when the desired result is obtained, is printed in the usual way in the copper-plate press.

This process seems capable of rendering useful service in the reproduction of maps.

Scamoni's method.—The last method is that recommended by Herr G. Scamoni, of the Imperial Russian State-paper Office, and is fully described in his '*Handbuch der Heliographie*,' already referred to. The results are exceedingly good, but the process is only suitable for line work.

Herr Scamoni having obtained a suitable negative of a drawing or other line subject, makes a positive copy of it in the camera by the wet collodion process, and after fixing, treats this positive with various successive intensifying solutions, so as to give it a very sensible relief. After drying the plate is varnished with a thin varnish and coated with fine plumbago, after which it is electrotyped in the usual way.

In the specimens I have seen of this process the lines are exceedingly sharp and fine, and it would seem well adapted for map-work.

A photo-mechanical process has lately been introduced by Messrs. Aubel and Kaiser of Lindenhohe, near Cologne, and called 'Aubeldruck.' The results for line-work are very superior but the process is a secret. It is believed to consist in some method of etching a glass negative, so that prints may be obtained direct from the glass surface or by transfer to stone.

In all cases where the printing-plates are obtained by electro-deposition of copper, and many copies are required, it is necessary to protect the engraved surface of the plate with a coating of iron by the process known as 'acierage' or 'steel facing.' This enables a very large number of copies to be printed without deterioration of the plate, and the coating can easily be removed and renewed whenever required. Details will be found in Ure's '*Dictionary of Arts, Manufactures and Mines,*' article ENGRAVING.

IX. PHOTO-TYPOGRAPHY.

The object of the photo-typographic processes is to obtain a surface block by photographic agency, that may be set up with type in the same way as woodcut, stereotyped or electrotyped blocks, and be printed in the ordinary printing press. The process offers great advantages in the rapidity with which the blocks may be made and printed off in large numbers. Up to the present time no entirely satisfactory method has been discovered for printing subjects in half-tones in this way, though Mr. Duncan Dallas has produced some very promising results. The processes are, therefore, almost entirely limited to the reproduction of subjects in line or dot alone.

The operations in this branch of photographic reproduction are based upon exactly the same principles as the photo-engraving processes just considered, and in some of them the only difference is the substitution of a positive cliché for a negative, or *vice versâ.*

The existing processes may be divided into three classes:

1st. Those in which a mould is made from a relief in swollen gelatine.

2nd. Those in which the image is obtained in asphaltum or gelatine on a metal plate and bitten in.

3rd. Those in which an image in a waxy and resinous ink is obtained by the methods described under the head of photozincography, then transferred to a metal plate and bitten in.

Moulding Processes.—Of the first class several methods have been introduced from time to time, but they are all on the same principle and are modifications of Pretsch's and Poitevin's processes already described, differing, as a rule, merely in technicalities which being trade secrets have not been fully published.

The following method is a typical one. A glass plate or other suitable surface is coated with a mixture of gelatine and bichromate of potash and when dry exposed to light under a negative. After this, it is immersed in cold water till the parts unaltered by the light, which represent the whites of the original drawing, swell up to the required height, leaving the lines quite sunk. The plate is then removed from the water and, the superfluous moisture having been carefully blotted off, is ready to have a cast made from it.

This may be done in two ways first, by metallising the gelatine surface either by means of plumbago or bronze powder, or by reducing silver upon it by applying a solution of nitrate of silver followed by treatment with a solution of pyrogallic acid or of phosphorus in bisulphide of carbon. The gelatine relief then receives a thin deposit of copper in the usual way. The thin copper electrotype is backed up with type metal, planed and mounted on a wooden block so as to be of the height of type.

This method gives the finest results but takes time.

The second method is to take a cast of the gelatine relief in type-metal. A cast in plaster, wax, &c. must first be taken from the gelatine, a second cast in plaster is made from this, and then stereotyped in the usual manner. This method is quicker than the last, but the results are coarser.

These processes are now largely used for illustrations in books and newspapers, but, so far as I know, have not been regularly applied to the reproduction of maps.

Etching processes.—The processes in the second class, in which a metal plate on which the image has been obtained on a sensitive coating of asphaltum or gelatine is bitten in with an etching liquid, though capable of giving very perfect results, are not, I believe, so much used as the other methods which are quicker and more simple.

A photographic image is impressed from a reversed negative on a copper or zinc plate prepared as in the Berlin engraving process described at p. 103, and, after development with olive oil and turpentine, is bitten in so as to yield an image in sufficiently high relief for surface printing, the precaution being taken of protecting the finest parts of the work as soon as they are sufficiently bitten, by covering them with stopping-out varnish.

If the sensitive surface is chromated gelatine, the soluble gelatine may be removed or not, but the etching fluid must be such that it will not dissolve or remove the gelatine from the surface of the plate—solutions of perchloride of iron, bichloride of platinum, nitrate of silver in alcohol, bichromate of ammonia in dilute sulphuric acid are some of the most suitable mordants for the purpose. In any case, the full amount of relief cannot be obtained through the gelatine at one operation. After the first biting-in the gelatine film must be removed and the lines protected from the further action of the etching fluid.

Gillotage.—The last class, in which a photographic transfer in resinous ink is made on a metal plate, and then bitten in, comprises the simplest and most largely used of these processes.

The process generally employed is substantially the same as Gillot's "paniconography", now commonly called 'Gillotage,' which is largely used for illustrated papers and various other purposes.

A polished zinc plate, which has been strongly varnished at the back to protect it from the acid in the subsequent operations, receives a transfer in greasy ink, either from an engraved copper plate, a lithographic drawing on paper, or a photo-transfer print prepared as for photozincography.

The plate is then etched in the usual way and rolled up with a varnish ink, containing a large proportion of resinous matter ; it is then dusted with powdered resin, which sticks to the lines and renders them more capable of resisting the acid ; the superfluous resin is brushed off and the plate is gently heated.

The edges of the plate and the large white spaces are covered with shellac varnish and when the varnish is thoroughly dry, the plate is plunged into a trough containing very weak dilute nitric acid, kept in constant motion, and is left until the finest parts are sufficiently bitten, which generally takes about a quarter of an hour ; it is then taken out of the trough, washed, dried, and placed on a sort of grating over a charcoal fire. Under the influence of the heat, the coating of ink and resin on the lines, being gently softened, flows down and protects the sides of the hollows formed by the first biting, filling up the spaces where the lines are very close. As soon as this effect is produced the plate is allowed to cool and then inked with a lithographic roller, as if a proof was going to be pulled. It is again dusted with powdered resin, and is then ready for a second biting in, which is to attack the parts somewhat lighter, and therefore may be effected with stronger acid.

The operations of inking, dusting with resin, heating and biting with acid are repeated several times till the plate presents only a uniform black colour. Then the plate is bitten with strong dilute acid which bites out the parts to be left completely white. The large whites, which have been covered all along with a strong shellac varnish, are then cut out with a saw, and the plate is ready to be mounted on a wooden or leaden block for printing. These plates usually require considerable touching up to take off the ragged edges of the lines caused by the spreading of the ink, though this may also be done by repeating the inking and biting in, so as to remove the steps formed by the successive bitings.*

This process has been applied at the Imprimerie Nationale, Paris, for producing large geological maps, but the special precautions that had to be taken in "overlaying" the plates in the press so as to print properly were very tedious, and must have largely increased the expense and lessened the use of the process. Messrs. Yves and Barret, of Paris, are said to use it largely for reproducing maps and engineers' plans, &c.

Photo-blocks in half-tone.—Many attempts have been made from time to time to obtain surface blocks from photographs from nature and other shaded subjects, but with imperfect success. If this object could be successfully attained, it is easy to understand that it would be of immense value for book and newspaper illustration and many other purposes. There are, unfortunately two grave difficulties to be overcome—one caused

* See Davanne, '*Les Progrés de la Photographie*,' p. 201.

by the fact that to produce a successful printing block the surface of all the lines or dots which receive the ink must be very nearly on one uniform level, and therefore the moulding processes above described are inapplicable. The second and greater difficulty is to obtain a suitable grain to break up the continuous gradation of shade in the photograph.

M. Rodriguez, of Lisbon, has proposed an ingenious method by which promising results have been obtained. He makes a paste of sugar of milk, or some other substance in powder soluble in nitric acid, with a little oil of lavender and bitumen, and adds a sufficient quantity of it to a solution of bitumen in turpentine. The metal plate is thinly coated with this in the ordinary way, exposed to light and developed with turpentine. The plate is then plunged into a bath of dilute nitric acid which gradually penetrates the resinous coating and dissolves the substance used for forming the grain, breaking up the preparation more or less according to the thickness of the bitumen, and thus reproduces the half-tints of the originals.*

In many processes of collotype the gelatine film presents a very marked grain, which may be coarse or fine according to the composition employed. It is probable, though I have not tried it nor, so far as I can recollect, seen it proposed, that blocks showing very fair half-tone could be obtained by taking a print from such a plate with a grain, transferring it to zinc and then biting it in by a method similar to Gillot's already described. Very great care would have to be taken in the successive etchings to preserve the uniformity of surface and protect the finest tints from being bitten too much.

The prints in half-tone obtained by Mr. D. Dallas' process, known as "Dallastint", appear to have been produced by some such method. This, however, is only a conjecture on my part, because no details of the process have been published.

M. Rousselon has, I believe, obtained fair results by similar transfers from his engraved plates, and it is probable also that a transfer to zinc from one of the plates, prepared by the modification proposed by myself of Geymet's photo-engraving process, bitten in in the same way, might also answer the purpose, though the grain is perhaps scarcely strong enough.

Details of several of the methods of photo-typography will be found in Motteroz's "*Essai sur les gravures chimiques en relief*" and Scherer's "*Lehrbuch der Chemigraphie.*"

X. Miscellaneous Processes.

In addition to the processes by which photographic prints are obtained directly by the aid of light, there are several ways in which photography can be employed as a useful auxiliary in obtaining correct tracings for the

* See '*Bulletin de la Soc. Franc. de Photographie,*' pp 208, 254.

use of the draughtsman, engraver or lithographer, thus saving all the labour of hand-tracing and obtaining also a far more accurate image than could possibly be obtained in any other way.

Blue-Prints.—It is well known that when photographed a pale blue colour acts exactly as if it were white. If, therefore, we can obtain by photography an accurate image of any original drawing or other subject in pale blue ink, either on the same, an enlarged or reduced scale, it will be possible to redraw the whole or part with black ink over the blue print, in a style suitable to be again reproduced by photography, without fear of obtaining a double image. It will also be obvious that the blue ground-work will be more complete and more accurate than any tracing by hand or pantograph could possibly be.

It has already been stated that this method has been extensively used in the Survey of India for making reductions of maps to smaller scales, and at the same time generalising the details on the large-scale maps so as to adapt them to and render them more suitable for the smaller scale.

The same system may be applied to the production of maps or plans in several colours, thus: supposing a map is to be reduced and printed in three colours, black for the outline and names, brown for the hills, and blue for the streams and other water.

Three blue prints are given to the draughtsman who draws on the first only the outline and names, on the second the hills, and on the third the water. These three drawings are then very carefully photographed all on the same scale, and transfers are made from them on to three stones or zinc plates, which are then used for printing the different colours of the map just as in ordinary chromo-lithography.

There is no limit to the number of colours that may be employed, and as the blue-prints are all on the same scale, very perfect 'register' may be secured, if due care be taken in the drawing and subsequent photographic operations.

The advantage of using photo-zincography for preparing the blue-prints is that in reducing a large-scale map, the transfers of the several sections may be joined together and printed off in one sheet, and thus may be redrawn in a more complete manner than if the sections had each to be drawn separately and afterwards joined up.

It is not, however, always desirable or possible to obtain the blue prints by photozincography, and they may be obtained in a more direct manner by coating paper with bichromate of potash and gelatine, exposing under a negative, well washing the print with hot water to dissolve the gelatine, then steeping it in a solution of proto-sulphate of iron, again well washing and then applying a solution of ferrocyanide of potassium, and finally well washing. A pale blue print is thus obtained which will answer every purpose. The 'cyanotype' process, before described, might also be used, but the blue is much more intense and would be liable to produce a double image on the copy.

Besides its uses in the Survey Department, the blue-print method is also appreciated and utilised by engineers and other public officers in India, who desire from time to time to show alterations or improvements on a standard plan, or wish to make use of a standard map for showing their own special requirements.

Bichromate-prints.—In the case of miscellaneous subjects which it is desirable to lithograph, photography can also be usefully applied in giving the lithographic draughtsman an accurate tracing over which he may make his transfer-drawing in the usual way. This was formerly done by making a silver-print on the required scale, and then either tracing over it on lithographic tracing-transfer paper, or coating the print itself with the composition used for lithographic transfer paper and re-drawing on the print itself; but in either case, the dark colour of the photograph interferes very much with the drawing.

A method of overcoming this difficulty has been suggested by Mr. Fraser S. Crawford of the Government Photo-lithographic Office, Adelaide, S. Australia, and has proved exceedingly useful here in Calcutta. A print is taken from the negative, on the paper prepared with gelatine and bichromate of potash for the photozincographic transfers, but it must be printed as deeply as possible, so that the lines may remain clearly visible after the bichromate has been washed out. Instead of inking the print, it is simply washed till all the soluble bichromate is removed, and is then dried. The surface of the print is coated with the ordinary composition of starch or isinglass used for preparing lithographic transfer paper and, according as the drawing is to be executed with the pen or chalk, receives a smooth or grained surface by passing it through the press either on a polished or grained copper plate. The draughtsman then makes his drawing with autographic ink or lithographic chalk over the faint russet image on the photographic print. An ordinary silver-print can be given as a guide in cases where the bichromate print is not sufficiently distinct for the details to be easily made out. This method is very suitable for copying maps, sketches, or photographs from nature, especially if the former are to be on a smaller scale than the original. The light colour of the photographic print renders it easy to see the effect of the drawing above it. The saving of time and labour in tracing and the superior accuracy of the ground-work are also great advantages gained by its use.

Photographing on Stone.—The following method of photographing direct on stone may sometimes be of use with the same object, when the lithographic drawing is to be made on the stone itself and not transferred.

The surface of the stone is made as level as possible and carefully polished, it is then washed with an 8 per cent solution of chloride of calcium and dried. A 12 per cent solution of nitrate of silver is then washed over the stone in the dark, and when dry it is exposed to light under a reversed negative. The print is fixed with a 20 per cent solution of hyposulphite of soda, and then well washed with plenty of water to remove all traces of the hyposulphite.

This method is used at the Topographical Department at the Hague to give the ground-work for the beautifully engraved chromo-lithographed maps of the Dutch Netherlands, and for the reproduction of photographs of Dutch artillery material, by a similar system of engraving upon stone permitting several shades of the same tint to be printed from one stone.*

Photographing on Copper.—A photographic image may also be obtained upon a copper plate by the following method, proposed by M. Mialeret, which may be of use to engravers in giving them an accurate image of their subject to work upon.†

The copper plate, being well cleaned and ready for engraving, is plunged into a solution of

Sulphate of Copper, ...	125	parts.
Sea Salt,...	75	,,
Water, ...	960	,,

and allowed to remain for about a minute, it is then taken out of the bath, well washed and polished with a soft cloth. It is next exposed to light for about 5 or 10 minutes under a reversed negative, or even under a paper print on thin paper, care being taken that the design appears reversed on the plate. The plate is then removed from the printing-frame and plunged into a 20 per cent solution of hyposulphite of soda containing a little chloride of silver. After a few seconds the ground whitens, while the design becomes of a deep black. The plate is then taken out and well washed. The black deposit forming the shades may be removed or allowed to remain, in which case the plate should be varnished. It is said that these images may be etched by the use of menstrua which will attack the copper without affecting the silver, but I have not been successful in this application of the process.

XI. Concluding Remarks.

Having now described the different processes most capable of being utilised by the cartographer, it may be as well to briefly sum up the cases in which they are applicable, and to indicate the direction in which improvements should be looked for.

* '*Report on the Cartographic Applications of Photography,*' p. 58.

† '*Photographic News,*' Vol. X, p. 190.

The applications of photography to copying purposes may be divided into two principal classes, according as the original subjects have or have not been specially prepared for photographic reproduction.

As regards subjects in the first class, it is possible to adapt and prepare the original drawings, so as to fit them for the requirements of any photographic process considered most suitable to meet the object in view. As a rule such drawings will be intended for publication or reproduction in large numbers by the photo-mechanical processes rather than by silver or pigment-printing, which will do very well for small numbers.

For the reproduction of maps and plans a process is required which will admit of large-sized sheets being produced. Many processes capable of yielding very beautiful results when employed for subjects of small size are quite unsuited for larger work.

For map-work in line, photozincography will generally be found most suitable and convenient on account of the simplicity of the operations, the facilities it gives for joining several small sections into large sheets, and the short time required for turning out a large number of copies. Under favourable conditions, photozincography will give very excellent results for all practical purposes. If anything finer is required for permanent or standard purposes, then one of the engraving processes would be most suitable, and in certain cases the photocollotype could also be applied with advantage. For diagrams and small maps &c., to be printed with type, photo-typography will prove useful.

For shaded or coloured maps and drawings, photozincography and phototypography are not applicable, and recourse must be had either to photocollotype or to one of the engraving methods with bichromate and gelatine which will give gradation of shade, such as Rousselon's, Woodbury's or Geymet's. It is probable that these latter processes will prove of great use as soon as their requirements and capabilities are better known.

It may be as well to repeat that whenever it is possible, drawings specially prepared for reproduction by photography should be drawn on a larger scale than they are ultimately required.

With regard to subjects in the second class, it is evident that the choice of a photographic process must depend very much on the nature of the original subject and its suitability for photographic reproduction by any particular method, as well as on the number of copies required.

It would be impossible to notice here all the cases coming within this class, it will therefore perhaps be sufficient to state that in most instances when only a few copies are required and permanency is not an object, ordinary silver printing will be found most convenient for all classes of subjects; and where the original is sufficiently translucent and photographic cameras not available, both negative and copy may be obtained in this manner sufficiently good for many practical purposes.

If the greatest simplicity in the printing operations is an object, the cyanotype or other iron processes may be used. If the prints are required to be permanent, the simple pigment process or the autotype may be employed, according as the original is in line or shaded.

If a large number of copies are required, then it will be more advisable to employ one of the photo-mechanical processes. The choice will depend much upon the nature and importance of the subject. As a general rule, in cases where the original is a lithograph, engraving or wood-cut, the best effect will be produced by employing an analogous photographic process.

Photolithography or photozincography is generally applicable to all subjects in dot or line, which can be printed in the lithographic press, except very fine delicate engravings or drawings; but if a block is required for printing with type it must be produced by one of the photo-typographic processes. The photo-collotype processes are of more general application and may be used for every kind of subject whether in line or half-tone. Their use is, however, restricted to subjects within the limits of a single negative, and they do not present the same facilities for carrying out alterations and corrections as the lithographic and engraving methods do, and thus their value for reproducing maps &c. on which corrections may be required is very much diminished. The fact of the printing surface being composed of an unstable organic substance like gelatine gives these processes an element of uncertainty which is a great drawback to their extended use on the large scale, especially in hot climates, and a really satisfactory and simple photo-mechanical process capable of reproducing any kind of subject without limit of size within ordinary dimensions is still a desideratum. The photo-engraving methods are the most suitable for high-class work which is likely to repay the cost of the skilled hand-labour required to finish and prepare the plates for the press. A simple method of photo-engraving of general applicability would be most valuable, and it is hoped that such a process will before long be available.

Use of Photography in War.—For the reduction and enlarging of military and topographical sketches, and for multiplying copies of maps and sketches required for use during a campaign, photography can render great services. The principal supply of such maps should, of course, be provided by a permanent office, established in a capital town and well provided with the proper appliances. The extent to which photography can be used in the field will depend on the character of the theatre of operations, available water-supply and means of transport, as well as other military considerations. In an open country with tolerably good roads, a complete photographic equipment might be carried in wagons specially fitted up for the purpose, and arrangements made for copying, enlarging or reducing sketches, maps or plans, and printing them by photozincography or on a paper specially prepared for photocollotype printing, which would only have to be sensitised when required and, after exposure under the negative, could be fastened down on to a metal plate and printed in an ordinary printing press. In this way also views or other subjects unfit for photozincography might be printed if required in larger numbers than could conveniently be accomplished by silver-printing.

In connexion with such a method of printing by photocollotype, it would be very convenient to arrange for drawings being made on a tissue consisting of a transparent basis, such as waxed paper or sheet gelatine, covered with a thin opaque film which could be easily cut through with an etching-point. Such drawings would form very perfect reversed negatives.

Apparatus and appliances for taking views by the dry and wet processes and for taking prints of them in the ordinary way should also form part of the equipment.

A military photographic travelling field equipment of this kind has been organised in the English service and attached to the Field Train of the Royal Engineers. A description of it was given by Capt. Abney in a paper read before the British Association in 1874.*

In the case of operations in a wild or hilly country, the photographic equipment must be limited to the most indispensable requirements, and be regulated by the nature of the transport available and by other local and military considerations. It is very doubtful whether photozincography could be advantageously carried out in such localities, and the photographic outfit might be limited to some moderate-sized sets of apparatus for views and copying, with a large stock of dry plates and the necessary appliances for silver-printing. Some of the simple iron processes of printing might perhaps be usefully employed. Recent improvements in the preparation of dry plates by what are called the emulsion processes have greatly facilitated and simplified the practice of photography in the field, so far as taking the negatives is concerned, and a sensitive tissue has been prepared by Mr. Warnerke for this purpose, by which the use of glass plates may be dispensed with.

The apparatus, &c., should be strongly packed in moderate-sized parcels so as to be carried either by men or pack-animals.

At the same time it should be stated that it seems very doubtful whether photography can really be employed with much advantage *in the field* under the conditions of modern warfare in civilised countries. Its main use in any case will be the copying of reconnaissances and sketches of positions preparatory to a battle and of sketches and views of positions on the battle-field after the event. The delicate operations required either for taking negatives or for printing copies from them cannot satisfactorily

* '*British Journal of Photography,*' Vol. XXI, p. 415.

be carried out on the move; and therefore the photographic establishment must be more or less stationary, and this may prevent its employment in many cases where it might perhaps be of use. In the Abyssinian Campaign, a staff of photographers from the School of Military Engineering, Chatham, accompanied the force and did good service, under great difficulties, in copying route maps and sketches, and in taking pictures of objects and points of interest. In the Franco-German Campaign in 1870-71, the Germans organised a photographic brigade to accompany the Head Quarters of the army. It was found, however, that the photographers encumbered with apparatus, &c. could not keep up with the movements of the Head Quarters and, indeed, the want of them does not seem to have been very much felt.*

If facilities exist for the transport and working of a small lithographic press, it will be found more convenient to have original sketches drawn with transfer ink for immediate transfer to zinc than to reproduce them by photography, and for this purpose an excellent ink has been devised by Capt. Abney, which may be used on any kind of paper without preliminary preparation. It will also be found a great advantage to print copies of maps on ordinary calico, because it can be folded and packed away much more easily than paper and does not so readily get worn by use. This plan has been adopted in the Surveyor General's Office with success in preparing maps for the Camps of Exercise in this country.

Another use photographic reproduction can be put to in time of war is the preparation of miniature despatches to be sent by pigeon-post. Such despatches were largely used in the Franco-German Campaign for communicating with the beleaguered garrison and residents in Paris. This is a service that photography alone can render and it is likely to be largely utilised in any future European war in similar cases.

* See Capt. Hannot's '*La Photographie dans les Armées*'.

Reduced from the original map in Valentyn's "Beschryving van Oost-Indien."

Photozincographed at the Surveyor General's Office Calcutta.

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VII.—*Notes on some* Reptilia *from the Himalayas and Burma.—By* W. T. Blanford, F. R. S., &c.

(Read 5th June.)

The species described in the following pages are chiefly from a very interesting collection made by Mr. W. Davison in the Tenasserim provinces. One snake is from another collection made in Sikkim by Mr. Gammie.

Draco major, sp. nov.

D. peraffinis D. dussumieri, *naribus superne versatis, pede posteriore axillam haud attingente ; tympano nudo ; tuberculo parvo utrinque superne post supercilium oriente, cristâ nuchali nullâ ; sed multo major, appendiculâ gulari longâ squamis majoribus indutâ, nonnullis squamis majusculis distantibus in lineâ unicâ interruptâ laterali ad insertionem alæ collocatis, nec aggregatis ; alis aliter coloratis, fusco-transfasciatis, vel omnino pariter marmoratis nec versus margines saturatioribus.*

Hab. *in provinciâ* Tenasserim, *haud procul ab urbe* Tavoy *atque ad radices montis* Nawiabu *dicti.*

Description. The hind limb falls a little short of the axil, when laid forwards. Nostrils directed upwards, tympanum naked. Upper labials large, some of them exceeding the nasal shield in length. A small tubercle above at the hinder extremity of the orbit. No crest of enlarged scales. Dorsal scales sub-equal in size, not keeled, a few much larger scales, usually at a considerable distance apart, in a single interrupted row along each side of the back at the insertion of the wing. Gular appendage covered with large scales, each fully twice as long and broad as the scales of the abdomen. Abdominal scales keeled. A fringe of large pointed triangular scales, many of them nearly equal to the tympanum in breadth, along the hinder part of the thigh and each side of the basal portion of the tail. Tail triangular near the base, with a row of slightly enlarged and sharply keeled scales along its upper edge. Scales below the tail, near the base, but not just behind the anus, larger than those at the sides.

The colouration above in spirit is nearly uniform, the wings are marked with very distinct dusky cross bands, broken up by light spots in the only female collected, but these markings are less distinct or wanting in the males, in which the wings are mottled with pale irregular spots. In some the wings are rather darker near the margins, but this is not so distinct as in *D. dussumieri*, and there is never the dark fringe with narrow sub-parallel pale transverse lines of that species. Throat unspotted, greenish yellow in spirit, pale scarlet beneath the lateral appendages.

This is probably the largest species of the genus known. The largest specimen, a male, measures 14 inches in extreme length, of which the head and body from nose to anus measure 4·75. Two other males have the body of the same length, the tail being about an inch shorter. A female is less in all its dimensions, nose to anus 3·5, tail 5·75. The sex has been ascertained by dissection. In the female the gular appendage is very short. From the condition of the ovary the specimen is probably adult. All the examples captured were obtained in the forest east of Tavoy, two being from the foot of Nawlabú hill, a high ridge some eight miles east from Tavoy town.

The nearest described species are *D. quinquefasciatus* of Penang and *D. dussumieri* of Malabar, and strange to say the latter, although so widely removed in locality, is the more closely allied of the two in structure. The present form is distinguished from both by its much larger size and from *D. quinquefasciatus* by its naked tympanum and longer hind limbs. From *D. dussumieri*, *D. major* is known by having much larger supra-labials, each plate near the middle of the lip on each side exceeding the nasal in length, by the enlarged scales at the sides being single and not aggregated into groups, by the much larger scales on the gular sac, and by the colouration of the wings.

Besides the new form, *D. maculatus* and a species which is probably *D. tæniopterus* were obtained in the same forest. The typical specimen of the last named species, a male from Chartaboum, was said by Dr. Gunther,* who described it, to have a very low nuchal crest and no tubercle above the orbit. Now in two males of the Tenasserim dragon, there is a

* Rept. Brit. Ind., p. 126.

small tubercle above the orbit and there is no nuchal crest, but as in one specimen there is a longitudinal row of scales very slightly larger than the others along the back of the neck, and as the supra-orbital tubercle is small, these characters may be variable, and I hesitate to separate the species upon such slight data without actual comparison. Still it is not quite certain that the Tenasserim lizard is the true *D. tæniopterus*.

BRONCHOCELA BURMANA, sp. nov.

B. omnino viridis, affinis B. cristatellæ, B. molluccanæque, *sed squamis lateralibus minoribus, in series longitudinales ad* 25 *dispositis, serie dorsali parum majore, cristâ nuchali parvulâ, scutis majoribus post supercilium nullis.*

Hab. *ad* Tavoy *in* Tenasserim.

Description. Scales of the sides of moderate size, smaller than in *B. cristatella,* larger than in *B. jubata,* in about 23 to 25 longitudinal rows, fewer behind, scales of the abdomen much larger, in about 12 rows, all sharply keeled. Dorsal row of scales distinctly larger than those of the sides, nuchal crest very low, formed of a series of triangular flat spines, passing between the shoulders into the dorsal row of scales. No fold before the shoulder. There are no enlarged scales behind the superciliary ridge, all the scales between the eye and tympanum are nearly similar, those in the middle are a little larger than the others, but there is no distinctly enlarged scale. The hind limb, laid forwards, does not quite extend to the end of the snout, the fore limb extends to the thigh, the fourth hind toe is one-fifth longer than the third. Colour grass green throughout, paler below, no dark patches nor yellow bands on the body. On the top of the head, the supra-orbital regions are surrounded by slightly enlarged scales of a dusky purplish colour, but this may be individual or due to change of tint in spirit.

This species is at once distinguished from *B. cristatella* (and from *B. molluccana* if that be really different)* by its larger lateral scales, by its much lower nuchal crest and by the absence of any enlarged scales behind the supercilium. From *B. jubata,* on the other hand, the present form may be known by the lateral scales being larger, as well as by the want of enlarged scales behind the supercilium. There is no specimen of *B. smaragdina*† in Calcutta for comparison, but that species has evidently much larger lateral scales, no true nuchal crest, longer limbs, different colouration, and very much larger scales on the throat, for there are said to be only 16 series between the angles of the mouth, whereas in *B. burmana* there are double that number.

* Stoliczka, J. A. S. B., XXXIX, Pt. II, p. 179.

† Günther, Rept. Brit. Ind., p. 138.

The only specimen of *Bronchocela* collected by Mr. Davison was procured near Tavoy. The size is about the same as that of other species; from nose to anus 3·7 inches, tail about 12 inches when perfect.

Liolepis guttatus.

Mr. Davison's description of the habits of this lizard, of which he has procured several specimens, supplements Mr. Theobald's.* All the specimens procured were found in perfectly open places devoid of vegetation, a favourite position being in the hard threshing floors made in the middle of dry rice-fields. Here *Liolepis* makes its burrow and is seldom found far away from the mouth of its hole. This appears to confirm Mr. Theobald's opinion that *Liolepis* never ascends trees, as Cantor supposed.

Mr. Theobald classed together *Uromastix*, *Liolepis* and *Phrynocephalus*, in a distinct family, which he called *Uromasticidæ*. The distinction of the family has been accepted by other naturalists, and so far as the genus *Uromastix* is concerned, has some important structural peculiarities in its favour, but I have already given my reasons† for dissenting from Mr. Theobald's views as to the alliance between *Uromastix* and *Phrynocephalus*, and I now feel some doubt as to whether there is any close connexion between *Liolepis* and *Uromastix*, despite the circumstance that both burrow, and that there is some slight similarity in their habits. *Liolepis* wants the peculiar dentition of *Uromastix* and is no more exclusively herbivorous than *Stellio*. I have examined the stomachs of three specimens of *Liolepis*: in one I found nothing except insects, (chiefly crickets and termites,) whilst in the other two there was a mixture of insects and vegetable substances, fragments of small fruits and apparently of leaves. The intestinal tract is much shorter than in *Uromastix*; in a specimen of *L. guttatus* 16½ inches long, the whole length of the stomach and intestine (preserved in spirit) is 16 inches. In *Uromastix* the length of the intestine is much greater than that of the body and tail; in a fresh specimen of *U. hardwickei*, measuring 12½ inches, the intestinal tract was 27 inches long. In a large example of the Mesopotamian *U. microlepis*, preserved in spirit and 17 inches in length, the intestinal tract was also 27 inches long. Moreover, in *Uromastix* the form of the cœcum is different, and much more complicated than in *Liolepis*, in which there is simply an expansion of the intestine.

Ulupe,‡ gen. nov. *Lycodontidarum*.

Corpus gracile, compressum. Caput breve, depressum, collo paullò latius. Oculi pupilla elliptica, verticalis. Scutum loreale cum præoculari

* Jour. Lin. Soc. X, p. 34. Descriptive Catalogue, Rept. Brit. Ind., p. 119.

† Eastern Persia, II, p. 334, note.

‡ Etym. Ulúpí, a princess of the Nágas or serpents, mentioned in the Mahá Bhárata.

junctum ; nasale haud bipartitum. Squamæ corporis in tredecim seriebus longitudinalibus, læves, ventrales ad latera angulatæ, subcaudales biseriatim ordinatæ.

ULUPE DAVISONI, sp. nov.

U. scutis præfrontalibus cum postfrontalibus longitudine fere æqualibus, verticali mediocri, occipitalibus duplo majoribus ; loreali longo ad oculum attingente ; præoculari alio nullo, postoculari unico ; supralabialibus 7, *tertio quartoque infraorbitalibus ; ventralibus* 265, *anali integro ; subcaudalibus* 108 ; *superne nigra, albo-transfasciata, annulis antice latioribus atque magis distantibus, subtus albida.*

Hab. in provinciâ Tenasserim Burmaniæ, *haud procul ab urbe* Tavoy.

Description. Body, slender, compressed. Head a little broader than the neck, short, depressed. Pupil elliptical, vertical. Shields of head regular, nostril in a single shield ; loreal and præocular united. Scales of body smooth, in 13 rows. Ventrals 265, strongly angulate at the sides, anal undivided, subcaudals in 108 pairs. Maxillary teeth few in number, a space behind the anterior tooth, followed by three or four teeth close together, the two anterior rather the longest ; mandibular teeth small.

Head shields.—Rostral much broader than high, scarcely extending to the upper surface of the head. Anterior frontals as long and nearly as broad as the posterior, the anterior edges of the former meeting at a slight angle directed backwards, and each anterior edge being about equal to the suture between the two shields. Vertical of moderate size, about half of an occipital, the sides convex, curving gently towards each other at first, more rapidly behind. Occipitals rounded behind. Nostril small, rather nearer to the anterior than to the posterior extremity of the nasal shield, which is much longer than high, and has only one shield, of about the same shape, and apparently consisting of the loreal and præocular united, between it and the eye. No other præocular is present ; one postocular ; the superciliary descends on the side of the head before and behind the eye. Upper labials 7, the 3rd and 4th forming the lower edge of the orbit ; temporals 1 + 2.

Colour in spirit, above black with white cross-bands, each about a third of the width of the intervening dark space, becoming broader on the sides ; lower parts white ; so the colour may be described as white with large black spots above. The white rings and black interspaces are broadest near the head and become much narrower behind, and still narrower on the tail, but the proportion of the two colours remains the same. On the single specimen collected there are 36 white rings on the body, 26 on the tail, the last being terminal. The white sides and lower parts, on the hinder part of the body and the tail, are spotted and mottled with dusky. Head, blackish above, but with a white band on each side from the white sides of the neck passing over each occipital to the superciliary shield, the two bands being only separated by a narrow dusky space behind the vertical. Lower portion of upper labials white.

A single specimen of this interesting snake was obtained by Mr. Davison at the foot of Nawlabú Hill, east of Tavoy, in evergreen forest, at an elevation of about 1,500 feet above the sea. This specimen measures 28 inches, of which the tail is 6.

It appears to me that this snake must be considered the type of a new genus of *Lycodonts*, distinguished from all other Indian forms by the small number of scales round the body. The single nasal shield, the union of the præocular and loreal, and the strongly angulated ventral shields are also a peculiar combination of characters, although all are found in some other genera of the same family.

Ophites gammiei, sp. nov.

O. squamis corporis in 19 *series longitudinales ordinatis, dorsalibus carinatis, lateralibus lævibus; scutis præfrontalibus pariter longis atque latis, postfrontalibus tripliciter majoribus; verticali vix longiore quam lato, lateribus convexis; loreali parvo, longiore quam alto; præoculari unico, postocularibus duobus; supralabialibus* 8, *tertio, quarto, quintoque infraorbitalibus; ventralibus* 214, *anali integro, subcaudalibus* 101. *Color fuscus, annulis antice albidis, postice griseis, marginibus irregularibus, variegatus.*

Hab. *in* Sikkim.

Description. Scales of the body in 19 rows, the 9 dorsal rows keeled, 5 rows at each side smooth. Body slender, compressed, head rather broader, flat. Eye small, pupil apparently vertical. Ventrals 214, bluntly angulate at the sides, anal entire, subcaudals 101 pairs.

Head shields.—Rostral about as broad as high. Nostril large, between two nasals, but scarcely separate from the anterior frontal. Anterior frontals small, each about one-third of a postfrontal and about as broad as long; postfrontals much broader in the middle than they are in front or behind, their anterior and posterior outer corners being hollowed out to receive the nasal and præocular shields, between which each postfrontal is bent over the side of the head above the small loreal. Vertical very little longer than broad, with convex sides. Each occipital is about twice as large as the vertical, rather attenuate behind, with the posterior termination rounded. Upper labials 8, the 3rd, 4th and 5th entering the orbit. Loreal small, longer than high. One præocular, just reaching the upper surface of the head; 2 postoculars. Temporals irregular. Two elongate chin shields of about equal length, the anterior in contact with 5 lower labials.

Colour in spirit, evidently somewhat faded. The body is surrounded by alternating dusky and light rings with very irregular crooked margins. Head above dusky olivaceous with pale spots in the middle of most of the shields; upper labials and anterior lower labials pale with dusky margins. An imperfect pale collar behind the head: all the lower part of the head and neck whitish. There are 30 pale rings on the body, the first pale ring imperfect above, and the dark patch in front not continuous across the throat, the rest of the rings encircle the animal. Farther back the pale rings become grey with pale margins and light spots occur in the dark rings. On the belly, throughout the anterior part of the body, the dark rings are only about half as broad as the white, above the difference is less, and near the head the dark rings are much broader above than the white. There are 16 rings on the tail.

This snake is distinguished from all other species of *Ophites* by having 19 instead of 17 rows of scales round the body. It approaches nearest to *O. septentrionalis**, the precise habitat of which is unknown, but is probably the Himalayas or Assam, the type specimen having been collected by Dr. Jerdon soon before his departure from India, and found unlabelled amongst his collections after his death. From *O. septentrionalis* the present species appears to be distinguished by more numerous scales, by its differently shaped anterior frontals, and by the dark rings extending across the belly.

A single specimen was procured by Mr. Gammie at the Cinchona plantation in South-eastern Sikkim. This specimen measures 31½ inches, of which the tail is 7. It is rather surprising to find a new snake in so well explored a locality.

VIII.—*Notes on the Earthquake in the Punjab of March 2nd*, 1878.—*By* A. B. Wynne, F. G. S.

(Read 5th June.)

Earthquakes in the Punjab are not uncommon, but little effort seems to have been made to record their occurrence in any way that might prove useful; indeed as a rule they are neither sufficiently frequent nor pronounced to leave more than a passing impression, though the directions from which the undulations come are occasionally noticeable, and doubtless, with proper appliances, they would form an interesting study.

On the 2nd of last March the most severe shock which has occurred within the memory of the present generation, so far as I can learn, affected the whole of the northern part of the province. With regard to it I have collected a few notes which I offer more as a record of the event than as

* Günther, P. Z. S., 1875, p. 233.

an exhaustive or abstrusely scientific treatment of the subject. Accurate details concerning so large an area are not within the reach of every one to collect, and I have had a little difficulty in learning even so much as I have put together. Some of this information has been derived from personal observation, some from the accounts given by friends or acquaintances, and some from the reports in the "Pioneer" newspaper, and "Civil and Military Gazette."

It may be as well to give the localities from which information has been received in the form of a list, with the hour of the shock, where known, reduced to Madras time,* and the duration of the earth-movement, opposite.

Punjab Earthquake of March 2nd, 1878.

Locality.	Hour felt, (Madras time).†	Duration.	Sound wave.	Authority.
Bannu, ...	Uncertain, ...	Uncertain..	None ..	R. Udny, Esq., Deputy Commissioner.
Kohát, ..	About noon,....	About 2 minutes.	No information.	Major Swinton Browne, 6th P. I.
Kohát, ..	Noon, Madras (11·37 Station.)	Uncertain..	Rumbling sound.	Major Ross, 1st Siks per Capt. Plowden, C. S.
Peshâwar, ..	About noon,....	Over a minute.	Noticed ..	Capt. M. S. Wynne, 81st Regiment.
Naoshera, ..	No details, ...	....	....	Reported.
Hoti Mardán,	No details, ...	....	....	Major Stewart—Guides.
Attock, ...	About noon,....	Over a minute.	Unnoticed..	Capt. C. F. Massy, C. S.
Abbottabad,	Noon, ...	1 minute, 50 seconds.	Unnoticed..	Personal.
Ráwalpindi,	Immediately after noon.	Over a minute.	No sound ..	Dr. Henderson, Col. Surgeon.
....	....	....	Sound noticed	Mr. P.——
Jhelum, ...	Noon, ...	Uncertain..	No sound ..	Buchanan Scott, Esq., R. E.
Murree, ...	Noon, ...	½ a minute to 3 minutes.	Unrecorded	Rev. Mr. Corbyn, Mr. W. L. Holman.
Lahore, ...	11·56 A. M., ...	3 minutes..	....	"Civil and Military Gazette" Mar. 4th, 1878.
Lahore, ...	About noon ? ..	Unrecorded	....	"Pioneer" Mar. 6th, ,,
Lahore, ...	12-50 P. M. ?	Unrecorded	....	R. Dick, Esq.
Ferozpúr,..	Unrecorded,....	5 minutes ..	Noticed, loud	Ditto.
Simla, ...	12 h. 1 m. ? ..	9 minutes ..	Unrecorded	Ditto.
Masurí, ...	Unrecorded,....	No information.	No information.	"Pioneer" Mar. 1878.

* Where the time of the place is unknown to be that of Madras, or the reduction thus rendered doubtful, a note of interrogation is inserted.

† Madras time according to Frontier authorities is 23 minutes faster than the local time kept, by which Station guns are fired.

A few days before the greater shock, I felt an earthquake at Abbottabad, on February 26th, at 3·40 P. M. It was of the kind usual in these parts, lasted only a few seconds and did no damage. A sharp shock was reported in the "Pioneer" to have occurred at Kángra on the 19th of March (after the greater one), and others occurred in Hazára—on March 29th at 7 P. M.; on April 4th at 6·11 A. M., (a short and sharp one); on April 19th at 5·9 A. M., a more considerable one; on April 21st at 9·20* A. M., lasting about five seconds. That of April 19th was, though short, rather severe yet insufficient to bring down tall chimneys at Abbottabad badly shaken and bulged by the earthquake of March 2nd. The shock of the 21st caused the roof beams of the dâk bungalow at Haripur to creak, while on the night of the same day there was a slight shock after midnight at Ráwalpindi.

In all the cases just mentioned except the Kángra one, of which I have no information in point, and that of April 4th, the undulation was more or less clearly felt to be from west to east, as seems to be the case most frequently in the N. W. Punjab, but on April 4th, it appeared to come from north to south. In none, so far as I am aware, was any sound-wave heard, indeed I have only once heard this: some years ago at Murree, when an east and west shock occurred (at about 10 o'clock P. M.) in the silence of the night. I find, however, that a noise was heard in some cases accompanying the shock of March 2nd, 1878, though entirely unnoticed in others, and positively absent at Ráwalpindi, according to a careful observer.

The detailed information, such as it is, which I have been able to collect with regard to this severely-felt earthquake is as follows:—

Earthquake of March 2nd, 1878.

Bannú. The shock was felt here severely and lasted unusually long. This is all the information I can gather.

Kohát. Captain Plowden, Deputy Commissioner of Kohát, replying to a letter, informs me that the shock occurred there at 39 minutes past 11 o'clock A. M., station time, or noon? by Madras. The motion came from the west with a rumbling sound like that of the underground railway-trains, followed by a roll and three sharp shocks: no shocks were observed before or after this earthquake and its duration was not accurately determined.

Major Ross, 1st Sikhs, who gave this information, was bathing at the time, and says the water was driven out of his tub to the height of eight inches or so, and the bath-room seemed to heave like the cabin of a ship at sea.

* All local, not Madras time, for which add 23 minutes.

Several houses and public buildings in the district were cracked and otherwise damaged.

I am informed by another Officer (Major Browne) who was then in Kohát that he felt the shock at about the same time given above, it lasted some two minutes, shook the whole place very violently, so that people left their houses, and it seemed to come from the westward.

A considerable portion of one of the walls of the strongly built Fort of Kohát was thrown down. No accompanying sound was noticed by my friend, and the whole character of the disturbance seems to have resembled that of other places.

Pesháwar. My informant felt the shock here as he was "marching out" with his regiment towards Jamrúd. It occurred at noon nearly, Madras time, (or after 11·30 station time) and he was then about three miles from Pesháwar on the Jamrúd road. A halt having been made, some of the men who were sitting down jumped up, startled by the motion. He noticed that a low rumbling sound immediately preceded the shock: the earth was plainly seen to undulate, and a water-cut beside the road, after the shock had passed, showed a lately wetted margin of two feet or more, consequent upon the transit of a longitudinal wave caused by the undulations. The motion came from the westward in the direction of Jamrúd. Some of the people present felt nausea.

On his return to the station he found the front of his bungalow thrown down. A wall of the fort also fell, and several other houses were damaged. The Barracks escaped, owing to their having been built with iron couplings in the walls, and in the city, from the use of wooden tie-beams in the masonry, because of the damage often done here by slighter earthquakes, the injury done was less than in the Station.

Naoshera. Reports say the shock was severely felt here.

Hoti Mardán. I can only learn that the earthquake-wave here set things which were suspended swinging in an east and west direction.

Attock. At Attock the earthquake occurred late in the forenoon (station time) about noon by Madras. A wall of the Serai or fort was thrown down, and the motion of the earth was strongly felt even by people on foot, by whom a strong shock may often pass unnoticed.

Abbottabad. Here the movement commenced within a minute or so before or after 12, noon, (Madras time) as nearly as I could estimate from the time usually kept at the station. I was lying sick in bed but happened to have my watch in view; there was a palpable undulation crossing my bed from westward to east. At first it commenced with a slight tremor of the usual kind and after a short pause of perhaps 3 seconds, this returned with greatly increased strength. The wall of the room cracked from the crown of the arch over the door to the roof, which being of wooden shingles creaked and strained so loudly, that I may have been unable to notice any sound-wave. I got up but could only move slowly, and after some delay in securing my watch by which I was noting the time, I reached the outside of the house, and heard the crash of chimneys falling at the neighbouring bungalows, while the stones of the one belonging to the dâk bungalow I had been in, were all shaken asunder, though the chimney (a low one) did not fall. A cup half filled with milk in my room had its contents violently thrown out, and projected nearly to the distance of a foot on each side towards the east and west.

During the shock the vibration was so continuous or so quickly repeated as to seem without intermission after the first one I have mentioned, and the motion died away more gradually than it commenced. I timed its duration as 1 minute and 50 seconds from first to last.

Doctor Grant, then acting Medical Officer of the station, who had left me shortly before, was walking up an inclined open space when the shock occurred; he observed the ground to undulate and the trees to sway about considerably, though there was no wind, he felt a sensation of nausea and found it difficult to walk. Next he saw a man thrown from a ladder and then a cloud of dust rising from the falling wall of a bungalow. On reaching his own he found the wall cracked, also above an arch.

Some time afterwards I was staying at another two-storied house in this station which had suffered very much. Some of the walls were cracked from near the ground to the roof; the cracks passing through weak places, such as openings for windows or doors. I noticed that it was in most cases those walls which ran east and west that were cracked; as if a short wave to which they could not conform had passed longitudinally beneath them.

No one in the place remembered an earthquake of such severity to have occurred before.

Ráwalpindi. At this station the earthquake occurred immediately after gun-fire (12, noon, Madras time), possibly a little later than at Abbottabad, but the time kept there is scarcely to be relied upon to a minute. The movement appeared to come from a direction north of west, to judge from the observations of Dr. Henderson, and from the directions in which he found water to have been thrown out of vessels. It lasted for over a minute. Dr. Henderson is certain there was no sound-wave, but another person stated that a low rumbling sound did precede the shock.

Dr. Henderson felt the heaving of the earth very distinctly; his little boy fell down and asked what was the matter with the ground.

Dr. C—— of the 10th Hussars was talking to the Mess Sergeant in the compound of the Mess, he did not recognise the occurrence as an earthquake, but felt sick and walked to a tree for support. On returning a minute or two afterwards, the Sergeant said he too had felt sick, and asked for medicine.

Some of the houses in the station were rent and shaken, and a forge at one of the workshops was thrown down, but the damage done seems to have been less than elsewhere. The place is situated on an open plain and stands upon a considerable depth of sandy and coherent brick clay, overlying highly inclined sandstones and clays, often vertically bedded.

Jhelum. The shock was felt at Jhelum at noon, Madras time. It appeared to come from N. E. and to pass to S. W., and it was unaccompanied by any rumbling sound. It damaged the steeple of the Church near the top, cracking it across and shifting the upper part both by lifting it to one side and turning it horizontally on the base of the broken part, as far as can be seen from below.

The Officer who communicated this thought he must have got a sunstroke ; he was out of doors when the shock occurred and the ground moved, and he noticed an interval after the first, between it and the (?) stronger shock which followed, much in the same way as occurred at Abbottabad.

Murree. In a letter from Murree it was mentioned that the shock was severely felt, and house-property sustained considerable damage: no further details have reached me.

By another letter (from Mr. Holman) I learn that the time the shock occurred was 12 o'clock, noon : its direction so far as he could remember was from south to north.* (From another observer I learn that the direction appeared to be from west or west by south.) Its duration he supposes was about half a minute, though most people said three minutes. (N. B. The average of these would give one minute and three quarters, very nearly the time observed of Abbottabad.)

There were three distinct shocks, the last the most severe, and he only remembers one as bad during a long-continued residence of many years in Murree.

Some damage was done to the station, walls fell, and several chimneys also. One observer heard two distinct loud sounds like volley-firing, which he attributed to the working of the shingle roofs.

Lahore. My information concerning the earthquake at Lahore comes partly from the " Pioneer"—or the local press (Civil and Military Gazette), partly from a friend who was kind enough to make enquiry for me.

From the report in the " Pioneer" of March 6th, 1878, though the shock is said to have been severe, the writer did not himself notice the occurrence at all, but was told of it afterwards, and gives the time as *noon,* presumably Madras time.

In the local paper of March 4th, the time of the shock is given as 4 minutes to 12 o'clock noon. " A continuous vibration of the ground lasted

* The ridge on which Murree stands at an elevation of over 7000 feet runs nearly N. E.—S. W.

for 3 minutes," and the earth " wave appeared to travel from east to west."

One of the gentlemen who wrote to my friend, says, he was sleeping at the time, and being suddenly awakened by the earthquake, he ran into his bathroom to observe the tub. In this, the water was oscillating and had wetted its sides 5 inches vertically above the level shown when at rest. Hanging plants and a bird cage in the verandah set in motion by the earth-wave swung to the north and south, a direction corresponding to that marked by the water in the tub.

As to duration the same observer thinks the time given in the local paper excessive, and that it could not have been many seconds, perhaps 30. He does not state that any sound-wave was heard.

A wall in his house was cracked and the filling of an archway showed a complete separation all round the arch. In the city many old houses fell and one in falling was reported to have killed three men.

Mr. Scott, R. E. of Jhelum, heard from Lahore that two friends playing at billiards in the latter station observed a N. E.—S. W. oscillation in the lamp-frame above the table, on the occurrence of the shock, which took place at noon, the same time as in Jhelum.

Ferozpur. Although at Lahore the earthquake passed unnoticed by at least one person, in a station so near as Ferozpur, according to a correspondent of the " Pioneer," something like a panic occurred. He writes —" The first shock was quite violent enough to cause a very sensible movement on the earth's surface, and the dull rumbling noise was so unusually loud as to attract general attention. Half a minute after came the second shock, a very rude one indeed, making floors upheave, walls oscillate, and beams and rafters start and crack. Every one rushed into the open air only to find the ground shivering under their feet. The third shock was gentler, the tremor of the earth, however, continued for a long time, and it was fully five minutes if not more from the beginning of the first shock till the last trembling passed away. No buildings fell, but many beams were started, and some walls were cracked."

The time of the first shock is not given.

Simla. If Madras time is kept at this station, as seems probable, the shock was felt there at the same general time as elsewhere, *i. e.*, one minute past 12, noon. See " Pioneer" March 6th, 1878. The reports in this paper say, the earthquake shook Simla to its foundations, and was one of the longest continued ever known there. " The wave or movement came first from east by south and lasted for about a minute, when it shifted to north-east, and increased in intensity from a tremor to a roll, the shocks occurring without intermission for nine full minutes, the last being at ten minutes past noon. It was the third shock within six months, each being severe."

The coincidence apparent as to time would seem to identify the shocks here as part of the same earthquake felt in the other places mentioned, but the directions and duration are so very different as to suggest that the undulation, if generated near a line reaching from the Simla portion of the Himalaya, towards and beyond Peshávar, met with some resistance or disturbing force by which it was deflected or even reflected, and its effects rendered cumulative, so that the shock was felt for a greatly longer period.

Masúrí. An earthquake shock at Masúrí is so mentioned in the "Pioneer" as to render it presumably that of March 2nd, and as a result it is stated that springs had ceased to flow.

The following table of the directions from which the shock was felt to come at different places may be useful.

Kohát, Pesháwar, Hoti Mardán, Abbottabad,	From the west.
Murree, ...	From the south ?
Ráwalpindi, ...	From west by north.
Lahore, ...	Uncertain.
Simla,..................	From south of east and north-east.

It will be seen from these brief notes that the effects of the shock of March 2nd were more or less forcibly felt over the whole of the Upper Punjab and neighbouring regions. The space being so large, the most favourable conditions for observing earthquake phenomena—*i. e.*, constant homogeneity and elasticity of the rocks forming the earth's crust—could scarcely have been expected. Mountain regions being exceptionally unfavourable from the form of the ground and liability to variety of formations, fissures, planes of displacement &c., much disturbance of the earth-wave, and variation of effect might have been anticipated; and yet it would appear that the shock must have been almost simultaneously felt along the whole western outer Himalayas and their continuation, from Masúrí to Pesháwar, in a direct line some 455 miles apart.

Assuming 30 miles a minute to be a high rate for transmission of an earthquake wave (Mallet, Admiralty Manual of Scientific Enquiry) and that this shock originated near either Pesháwar or Masúrí the passage of the wave from one station to the other would have occupied about 15 minutes, and it should have been observed so much later at one of these places, which would perhaps be a large error to attribute to the time recorded. But if the shock started from a point near midway between and occupied half the time in reaching these points almost simultaneously, then a smaller error of time would be both possible and difficult to detect from the records at hand. There is, however, no information available regarding the earthquake from the vicinity of Kishtwár, which would be about half way in the Himalayas, though at Lahore, nearly in the same relative situation, on the plains, the time given is "*about noon*" according to observations made, or the same as at either extremity of the region known to have been disturbed.

However these considerations might indicate a seismic centre among the mountains somewhere on the Simla side of Kashmir, the observed motion of the undulations both at Simla and towards Pesháwar are against the supposition of such an origin, even though a considerable amount of this motion be attributed to secondary vibrations masking the main earth wave.

If the disturbance had one common source, and if the *primary* undulation reached the earth's surface at almost the same time at all the widely distributed points indicated, it may perhaps be a legitimate deduction that the place from which it originated was very deep-seated, or else that the conditions of the earthquake were somewhat peculiar and the disturbances were initiated along an extended line rather than at any particular point.

It will be noticed that the greatest differences in the results, so far as the information collected extends, took place at Simla, Lahore, and Ferozpur; differences both in the duration and direction of the motion* which would render further information most desirable, and it will be observed that this disparity coincides in a way with the marked general change in the alignment of the mountain ranges. All the stations close to the outer Himalaya in the upper Punjab, whence I have obtained any details, stand among or adjacent to ranges belonging to the east-west, or west-by-south system, prevailing on the Pesháwar side of the Jhelum valley, while Simla and Masúrí are upon or near ranges having the north-westerly bearing common to the main direction of the western Himalayan chains. On the supposition that the earth-wave travelled from the west as indicated by so many of the upper Punjab observations, it would have passed longitudinally amongst the western mountains and under the adjacent Ráwalpindi plateau towards the east as far as the Jhelum valley sinus, and, meeting the oblique ranges beyond, might have manifested itself in a different manner.

The varying geological structure of the whole region does not appear to have appreciably influenced the results of the earthquake's manifestation at different places. Pesháwar stands in an alluvial plain; Attock close to the edge of the Indus flats (at their junction with, but more correctly,) upon a mass of slates. Abbottabad is close to, if not actually traversed by, a long line of fault having a very large (unestimated) displacement and

* In the case of Murree my informant seems rather uncertain, as to the direction, but my Lahore information is positive as to this being N. and S. though from which is not stated.

cutting off limestone mountains from others formed of slate. Ráwalpindi is on a plateau formed of tertiary rocks, alternating sandstones and clays, just there nearly vertical and horizontally overlaid by post-tertiary and perhaps even newer clays, sands, and boulder-beds. Lahore and Ferozpur are on the alluvial Punjab plains.

In most of these places, the shock occurred at the same time, as nearly as can be judged, and its results were similar, whether it lasted under two or as much as five minutes.

Kohát, close to east and west ridges of limestone or of sandstone, and standing upon a stony detrital deposit at the mouth of the Hangú valley, is about 80 miles due west of Ráwalpindi: in both places the undulation approached from the westward, in the latter more nearly west-north-west.

Simla is entirely differently situated from these stations; at a great elevation and nearer to crystalline masses which would probably afford a better conducting medium for the earth-waves. Yet here the time of the occurrence was presumably the same as elsewhere, and though the movement is said to have come from opposite directions and to have lasted fully nine minutes, I have no evidence that the damage caused, which would be a measure of the force exerted, was at all greater than at Abbottabad or other localities.

I have heard it more than once observed that these Punjab earthquakes usually occur after rain has succeeded a spell of fine weather; indeed Dr. Henderson tells me that from this he predicted the occurrence of the earthquake previous to that of March 2nd, felt at Ráwalpindi as well as by myself in Hazára. With reference to this point it should be remembered that the nine distinct shocks which I have mentioned as having recently occurred in the Punjab within fifty-three days, have followed a season of excessive rainfall preceded by an exceptionally and disastrously dry summer.

Whether the access of meteoric water by gravitation through the rocks to hotter regions below be a sufficient cause in the present case for the phenomena observed, or a better one can be suggested, I must leave for the enlightened consideration of competent seismologists; and though several minor shocks are not unusual attendants upon a greater earthquake, I venture to suggest that something exceptional in the way of cause must have occurred to account for the greatly increased frequency of late of the earthquakes in the Punjab, where they have rarely taken place more than once in a twelvemonth, at least for the last nine years: and also for the greater than usual intensity which has marked one of them, almost simultaneously felt over an area, which may be roughly estimated at 67,000 square miles.

IX.—*Notes on the* land *and* fresh-water shells *of* Kashmir, *more particularly of the Jhilum valley below Srinagar and the hills North of Jamu.*—*By* W. Theobald, *Geological Survey of India.*

(Received 27th June ;—Read 3rd July, 1878.)

The present notes embody the results of a hasty traverse of the ground from Mari to Srinagar and thence *viâ* the Mohu pass to Jamu, during the very unfavourable months of March and April last year, and it is to be hoped that the rather meagre list here given may be hereafter enlarged very considerably by others who may have more leisure, and a more favourable season for their investigations than I could command.

In the list of Kashmir mollusca appended to these notes, an asterisk marks those species not obtained by myself personally.

MELANIA TUBERCULATA, Müll.

A small race of this widely spread shell occurs in the outer hills.

VALVATA PISCINALIS, Müll.

Abundant on the river mud in pools under the Travellers' Bungalow at Soper.

BITHYNIA PULCHELLA, B.

Common in the valley.

HYALINA LUCIDA, Drap.

H. FULVA, Drap.

Both species occur on the Panjál range and are common in the debris of streams running into the valley.

MACROCHLAMYS INDICA, B.

M. vitrinoides, auctorum *(non vera)*.

M. petrosa, Hutton.

This widely spread species is rather rare in the outer hills. A single mature shell only was met with, much smaller than the type, and measuring only 18 × 15 × 7 mm. An immature shell was a trifle larger.

M. SPLENDENS, Hutton.

Colour bright chestnut, with a lustrous polish. My largest shell is not quite adult, and measures 15 × 13 × 8 mm. A dead adult shell is a trifle smaller. It shows the mouth very oblique and shaped much as in *M. aspides*, with the lip thickened inside as in *Hemiplecta monticola*. This species occurs rather plentifully in places above Uri, nestling under stones.

M. PATANE, B.

A few dead specimens of what seems a small race of this species were obtained above Uri, one specimen measured 9 × 7·7 × 5 mm.

MACROCHLAMYS, sp.

A single dead shell of a species resembling *M. levicula* was found with the last, above Uri, measuring 6 × 5 × 4·5 mm.

KALIELLA BARRAKPORENSIS, Pfr.

A single specimen of this widely spread species, measuring 6 mm. in height, was found in Kashmir. The specific name is badly chosen, as this is a hill species, (not found on the plains, unless transported on plants), and ranges throughout the Himalayas and also the mountain ranges of Southern India.

HEMIPLECTA MONTICOLA, Hutton.

H. labiata, Pfr.

Generally distributed throughout the Western Himalayas. In the valley of the Bichlári river, an affluent of the Chináb, this species occurs remarkably fine and in incredible numbers in the fissures of rocks, though few live specimens were procurable at the time of my visit. The colour of the shell is dark chestnut both above and below, and there are four or five prominent pale bars or transverse stripes, marking the seasonal arrest of growth and the position of successive epiphragms, formed during the period of hybernation. The epidermis is very thin and pale yellow, and the shell does not attain maturity under seven or eight years. The first five whorls are minutely shagreened, the remaining ones smooth but more or less transversely rugose.

My largest specimen measures 47 × 39 × 23 mm. The species is particularly common below Nachilana in the Bichlári valley.

H. JAMUENSIS, n s.

Aspectu inter H. monticolam *et* H. ligulatam. *Testâ solidâ, convexâ, anguste umbilicatâ, supra levissime granuloso-corrugata (H. ligulatæ modo) subter lævigatâ. Colore supra pallide brunneo, subter albido. Anfractibus sex, lente crescentibus. Labio intus incrassato, simplici. Attinet ad* 27 × 23 × 14 mm.

Habitat in valle Jawi, *inter* Chineni *et* Adampur.

This species might be regarded by some as an impoverished race of the last, from which I have little doubt it is proximately derived, but it differs too much in size, colour, form, and range to be properly united therewith. Mr. W. Blanford suggests it may be the *H. monticola* of Pfeiffer, which is very likely. I have unfortunately no live shells, but the type of colouration in my best specimens is more of the type of *ligulata* than of *monticola*, being white below. It is I think clearly a species descended from *H. monticola*, and modified to meet the climatal conditions of the Jawi valley below Chineni, where the winter cold and summer heat are both more intense than is suitable for *monticola* on the one hand, or *ligulata* on the other.

Trochomorpha hyba, B.

Two dead adults and a living half grown shell were obtained by me on the hills behind Aijas, to the east of the Walar lake. The largest specimen measured 17 × 16 × 11 mm. It recalls the Nilghiri *Thysonota guerini*, but the animal belongs to the *Zonitidæ.*

This species occurs occasionally in thickets between Dalhousie and Chamba between 6000 and 7000 feet above the sea.

Helicarion flemingii.

This species is not rare in the outer hills and two distinct races are discernible : the one (*a*) being confined to the higher and moister hills, whilst the other (*b*) occupies the warmer valleys and the drier ranges of less elevation.

a. My finest specimens of this race are from near Mari (Murree) where they were collected by my colleague Mr. Wynne. The finest measure 42 × 31 × 20 mm., though shells rarely attain this size. Shells of the ordinary dimensions of 35 mm. are not rare in parts of the Jhilum valley about Uri, and even among the outer hills, and occur subfossil in the valley deposits (clays) in many places outside the main ranges and in the Sutlej valley. The reputed locality of the type, 'Sind', is open to considerable doubt, unless the specimen was imported in a plant case. In five specimens the lower part of the shell is lustrous, whilst the upper half has a dull silky sheen, from innumerable fine *striæ* which cover the surface.

b. This race runs considerably smaller than the last, the largest specimen of some hundreds measuring 22 × 17 × 12 mm. It is a miniature of the last, and occurs abundantly in the Chináb valley above the junction of the Bichlári river and also at Dharmsála in the Kángra valley. The shell is almost wholly enveloped by the mantle when the animal is in motion.

There is yet another race which may perhaps prove a distinct species, but which at present I prefer to consider as a variety of the larger form of *H. flemingii*, and which I will term provisionally :—

c. var. *altivagus.* Of this form I have only a few dead shells. The largest measures 31 × 23 × 14 mills. and it differs from the type by being much flatter. I only met with it sparingly above Uri.

H. scutella, B.

Sparingly distributed in the Western Himalayas at moderate elevations. The body delicately arched, like the outline of a triton's tail. This species occurs with the small race of *H. flemingii* both in the Chináb valley and at Dharmsála though nowhere so numerous.

H. monticola, B.

There is some confusion between this species, the last, and the next, which, without more information, I cannot clear up. Specimens received by me from Benson under this name were certainly closely allied to the last. In the Conchologia Indica, however, a very different shell is figured (Plate CLII, figs. 1, 4,) and one which seems barely distinct (save in size only) from *H. cassida*, Hutton, also given on the same Plate. My coadjutor, Mr. Hanley, purchased most of Benson's types, but has most unfortunately not said if the figure is taken from one of them.

My own impression is, that *H. monticola*, B. is a near ally of *H. scutella*, B. and that the *monticola* figured in the Conchologia Indica is a mere immature specimen of *H. cassida*, Hutton. It is true the shell is said to be in one 'dull' in the other 'lustrous', but this may be the result of its condition, as in *H. flemingii*, the lustrous surface of the shell is covered with a dull epidermis, which in *scutella* is wanting, and I was much struck with the presence of this dull epidermis, as it is covered by the mantle; the shells of other *Zonitidæ* under such circumstances being usually lustrous.

H. cassida, Hutton.

A single adult specimen of what I consider this species was taken by me under a stone above Uri. Two young shells (one of them forwarded to me by Mr. Lydekker) also seem to belong to this species, though the mouth is rounder and deeper than in the adult (*vide* Conch. Indica, Plate CLII, figs. 2, 3). This species might almost be ranged in *Paryphanta* and would seem to be rare as I have only seen the above three specimens.

Vallonia pulchella, Müll.

V. costata, Müll.

The higher ranges.

Fruticicola huttoni, Pfr.

Widely distributed, but individuals do not seem anywhere numerous.

Peronæus cœnopictus, Hutton.

Widely distributed and individuals numerous. In the North-western Punjab, this species harbours under stones, and is variable in size.

Napæus candelaris, Pfr.

N. domina, B. This is a common species being found about Mari and in various places in Kashmir, usually above 6000 feet, but occasionally lower. Sinistral shells are most numerous, but dextral ones also occur not rarely. My largest sinistral shell measures 35·6 × 9·2 and my smallest 27·7 × 8·7 mm. The dextral shells are smaller, ranging from 33 × 8·8 to 24 × 8·5 mm.

The shells vary somewhat in a large series, in tumidity and in the attenuation of the spire, and even in the number of whorls, a remark which applies to all the species of the genus, and proves the risk of creating new species from single examples.

I do not think that *N. domina*, B. can be separated, as the main distinction seems to be in the texture of the shell; but in this group the texture varies from horny and sub-diaphanous, in which the striped markings are conspicuous, to creamy porcellanous, in which they are more or less if not wholly obsolete. The difference too in this respect is considerable between the living and dead shells, and largely depends (unless I am much mistaken) on the conditions of climate and alimentation under which the animal lived.

A slender form is seen in places, with a thinner shell than the type, and indicating a passage to *N. kunawarensis*, Hutton. A typical example of this variety measures 26·5 × 8 mills.

In the above and in all the measurements which follow the short axis is measured just behind the aperture.

N. SINDICUS, B.

Of this species both dextral and sinistral shells occur, the former most numerously. The size ranges between 27 × 8 and 17 × 3 × 6·6 mm. for dextral shells and 22 × 7 and 18·2 × 6·2 mm. for sinistral ones out of a large series. It occurs abundantly in the Jhilum valley about Chatur, (above Kohalȧ) at low elevations, and elsewhere less commonly up to 3000 feet or thereabouts.

N. CŒLEBS, B.

This is a forest species, usually ranging from 5000 feet upwards. It is the most variable species of the group, both as regards size and form ranging from 22 × 8 to 14 × 6·2 mm. Some systematists might easily make six or eight species out of the varieties of this shell; but with a large, but by no means exhaustive, series before me, I cannot venture to specifically separate the very variable shells which a large series displays. I have never seen a sinistral specimen, but *N. boysianus*, B. looks like a sinistral example of the largest form of *cœlebs*.

N. ARCUATUS, Hutton.

Kashmir specimens range between 2 × 6·1 and 13·7 × 5 mills. A single dextral shell found by me measures 12 × 4 mills. It does not seem a common species. The habitat 'Moulmein' given in the Conchologia Indica is of course absurd, but for this and similar blunders I am nowise responsible, since the publishers declined to furnish me with proofs, as the work went through the press.

N. SEGREGATUS, B.

A single specimen of what seems a variety of this shell was found, but it had an abnormal look about it. It measures 11·2 × 5 mm and has the ordinary horny appearance of *cœlebs* and its allies. A smaller form, var. *pusillus*, would seem to belong to this species and is far from rare on the Chináb valley above 6000 feet. It only measures 9 × 3·8 mills.

N. PRETIOSUS, Cantor.

The type was obtained near the Jhilum on the well-contested battle-field of Chilianwalla. The species also occurs sparingly throughout the Jhilum valley below Uri, but is nowhere common except about Kathai fort on the right bank, where it is abundant, though I saw only dead shells. The range of this species must be very limited, as I have not noticed it to the eastward, or anywhere in the cis-Rávi country.

N. SMITHII, B.

An occasional individual of what I take to be this species, is here and there met with in the Jhilum valley below Uri, but I have only seen dead shells. It also occurs at Mari, where I have seen a few specimens, a trifle smaller than the type. My best specimen measures 11·1 × 3·5 mm. and exhibits the characteristic dilatation of the peristome.

N. RUFISTRIGATUS, B.

Common on the outer hills from the Jumna to the Indus. Closely allied to this species and with difficulty separable in a large series, are *N. eremita*, B., *N. sindicus*, B., *N. salsicola*, B. and *N. spelæus*, Hutton, these two last forms being erroneously placed in my Catalogue (Thacker and Co., 1876,) under *Cylindrus.*

OPEAS GRACILIS, Hutton.

The outer hills bordering the plains, but not noticed in the valley.

CYLINDRUS INSULARIS, Ehr.

The outer hills and plains.

PUPA MUSCORUM, L.

P. GUTTA, B.

Both these species no doubt spread over the higher ranges of Kashmir, though the type of the latter species has only been taken by me in Spiti.

P. HIMALAYANA, B.

P. HUTTONIANA, B.

Both these species occur abundantly on the Panjál range and in the debris of streams flowing therefrom, whence they are carried down during floods into the plains.

P. — sp.

A single specimen of a *Pupa* somewhat of the *plicidens* type occurred in the Jhilum valley with numbers of the last two species. I do not know it, but hesitate to describe it as new, till it has been compared more fully than I have at present means of doing.

Alt. 2·5 mm.

CLAUSILIA CYLINDRICA, Gray.

I did not take this species in Kashmir, but as I took it in Dharmsála a little east of the Rávi, I have no doubt that it should be included in the Kashmir fauna.

C. WAAGENI, Stol.

A single dead shell of what is probably this species was found by me a little below Rámpur the first stage below Baramula. The type was found near Mari, and it doubtless ranges into Kashmir in suitable localities.

ENNEA BICOLOR, Hutton.

The outer hills, where it is almost invariably associated with *Opeas gracilis* and *Peronæus cœnopictus.*

CŒLOSTELE SCALARIS, B.

GEOSTILBIA BALANUS, B.

Both these species are found in the outer hills bordering the plains, the former rather rarely.

LYMNÆA.

The species of this genus do not call for remark.

PLANORBIS.

Several small species of this genus, which my opportunities did not allow of my recording, have no doubt to be added to the Kashmir fauna.

CORBICULA KASHMIRENSIS, Desh.

My largest specimen, from near Soper, measures 45 × 39 × 23 mm. Smaller specimens occur lower down the Jhilum near Baramula.

C. OCCIDENS, B.

Accompanies the last. My largest specimen measures 21 × 17·5 × 11·5 mm. In Kashmir specimens the rufous rays (which Hanley says are rarely present) are rarely absent, but never very strongly marked and sometimes with difficulty visible.

SPHÆRIUM INDICUM, Desh.

PISIDIUM HYDASPICOLA, n. s.

Testâ sub-cordate ovali-tenui, exilissime striatâ, antice rotundatâ, postice vix truncatâ 4 × 3·4 × 2·5 *mm.*

Habitat valle Kashmirense, in fluminibus ad Hydaspem fluentibus, prope Shypion.

The nearest ally of this species is *P. clarkeanum*, Nev., but it is more rounded in front and hardly truncated behind.

A single specimen only was found in the stream near Shypion, a feeder of the Jhilum.

The above is a very imperfect list of the shells of so diversified a region as regards surface and climate as Kashmir. The correct determination of the smaller fresh-water species of *Bithynia* and *Planorbis*, and of the species of *Sphærium* and *Pisidium* which almost certainly occur is difficult. *Unio* I have not noticed in the valley.

At page 41 of my Catalogue of Indian shells, I have given the Púnch Hills as a habitat of the operculate *Megalomastoma funiculatum* of Sikkim, on the authority of shells received from Mr. Lydekker with that habitat, which subsequent enquiry has served to render extremely doubtful, and I have accordingly excluded the species from the Kashmir fauna.

In conclusion I would urge that visitors to Kashmir could hardly fail to add many species to the above list if they carefully collected in the higher ranges, and along routes not visited by me, especially the smaller species of *Pupa*, &c. which are most conveniently sought for among the light *rejectamenta* and vegetable refuse swept down by floods, and heaped up along the banks of streams in sheltered spots.

List of land and fresh-water shells, presumably inhabiting Kashmir and its vicinity. Shells, not seen by me, marked by an asterisk.

Paludomus tanjoriensis, Gmel.*
Melania tuberculata, Müll.
M. variabilis, B.*
Valvata piscinalis, Müll.
V. stoliczkana, Nevill.* (Cat. Moll. Ind. Mus.)
Vivipara bengalensis, Lam.*
V. dissimilis, Müll.*
Bithynia pulchella, B.
Hyalina lucida, Drap.
H. fulva, Drap.
Macrochlamys indica, B.
M. splendens, Hutton.
M. patane, B.
M. sp.
Kaliella Barakporensis, Pfr.
Hemiplecta monticola, Hutton.
H. jamuensis, Theob.
Trochomorpha hyba, B.
Helicarion cassida, Hutton.
H. flemingii, Pfr. (type and *var. minor.)*
H. flemingii, var. *altivagus*, Theob. *(an* sp. nov. ?)
H. monticola, B.
H. scutella, B.
Fruticicola huttoni, B.
Vallonia pulchella, Müll.
V. costata, Müll.
Peronæus cœnopictus, Hutton.
Napæus candelaris, Pfr.
N. sindicus, B.
N. cœlebs, B.

N. arcuatus, Hutton.
N. pretiosus, Cantor.
N. segregatus, B.
N. smithii, B.
N. rufistrigatus, B.
N. vibex, Hutton.
Cylindrus insularis, Ehr.
Pupa muscorum, L.
P. gutta, B.
P. himalayana, B.
P. huttoniana, B.
P. sp.
Succinea pfeifferi, Ross.*
Clausilia cylindrica, Gray.
C. waageni, Stol.
Ennea bicolor, Hutton.
Opeas gracilis, Hutton.
Zua lubrica, Müll.*
Glessula huegeli, Pfr.*
Cœlostele scalaris, B.
Geostilbia balanus, B.
Carychium indicum, B.*
Lymnœa luteola, Lam.
L. peregra, Müll.
L. stagnalis, Müll.
L. auricularia, Müll.
L. truncatula, Müll.
Planorbis calathus, B.*
P. exustus, Desh.
P. carinatus, Müll.
Corbicula kashmirensis, Desh.
C. occidens, B.
Sphærium indicum, Desh.*
Pisidium hydaspicola, Theob.

X.—*On some Mammals from Tenasserim.—By* W. T. Blanford, F. R. S.

(Received and read March 6th, 1878.)

(With Plates VI, VII, VIII.)

The mammals described in the following notes are from two collections. The first and largest was made by Mr. W. Davison for Mr. Hume, to whom I am indebted for the specimens; the second, which although smaller, comprised several very interesting forms, was collected by Mr. Limborg. The bats procured by the latter have already been described by Mr. Dobson.*

The localities, and, in almost every case, the sexes have been carefully recorded on the specimens obtained by both the naturalists named. Mr. Davison's labels in many cases contain detailed measurements taken before skinning. As will be seen, several important additions are made to the Tenasserim fauna, and the most of these are from Bánkasún in Southern Tenasserim, where some Malay forms have been obtained, which had not previously been noticed so far north.

In addition to the Tenasserim specimens, Mr. Hume has very kindly given to me a large portion of his mammalian collection, and has entrusted me with the whole for examination and description.

Insectivora.

Gymnura rafflesi.

Vigors and Horsfield, Zool. Jour. III, p. 246;—Wagner, Schreber's Säugth. Supp. II, p. 46; V, p. 534.

This species was mentioned in Mr. Blyth's list of the mammals of Burma,† as probably existing in Mergui, although its occurrence within British limits had not been recorded. It has since been obtained at Bánkasún in Southern Tenasserim, by Mr. Davison, to whom I am indebted for a perfect female in spirit. The anatomy of the animal is almost unknown, but I hope to induce a more competent anatomist than I am to examine the specimen.

The skins from Bánkasún vary much in the extent of white on the fore part of the body. Generally the head and neck are white with the exception of a broad black patch above each eye and a variable amount of black bristles mixed with white on the crown. The anterior portion of the back is clad with mixed white and black bristles, the proportion varying; on the hinder back, sides, limbs and lower parts from the breast, the long hairs are generally black, but in one specimen there is a line of white bristles down the middle of the breast and belly; this line is wanting in the other two

* J. A. S. B. 1877, Pt. 2, p. 312.

† J. A. S. B. 1875, Pt. 2, extra number, p. 32.

skins which I have examined. The extent of the white varies so much that it is not at all improbable that specimens wholly white or wholly black may occur. The fine woolly under fur is dusky olivaceous at the base, brown at the tips on the upper parts, ashy with brownish ends beneath. The terminal portion of the tail is compressed, and in some specimens partially or wholly white in colour, and the under surface of the tail is thinly clad throughout with scattered short bristles, about a quarter of an inch long. These bristles are wanting on the upper part of the tail, which has very much shorter scattered hairs. The small scales covering the tail are indistinctly arranged in rings, and subimbricate; on the lower surface the scales are convex and distinctly imbricate, the bristles arising from the interstices. Thus the under surface of the tail is very rough and may probably be of use to the animal in climbing.

The characters of the tail just mentioned do not appear to have been noticed in the published descriptions of *Gymnura*, all of which are probably copied from that by Horsfield and Vigors. Another important difference from the original account is to be found in the claws of the specimens before me not being retractile. In the original description* the retractility of the claws is mentioned, both in the Latin characters and in the English note pointing out the distinctions between *Gymnura* and *Tupaia*. It is possible that the Tenasserim animal differs from that found in Sumatra, but the distinction between retractile and non-retractile claws would in all probability be of generic importance, and it is difficult to conceive that two genera of insectivora, so closely resembling each other in their very peculiar external characters, and yet differing in so important a detail, should inhabit two regions of which the fauna is, for the most part, identical. At the same time it is possible that I am mistaken in referring the Tenasserim animal to *Gymnura rafflesi*.

The following are the dimensions of the female specimen in spirit—

	inches.
Length from nose to anus,	12
,, of tail,	8·5
,, of ear from orifice,	0·94
,, of tarsus and hind foot (claws not included),	2·15

The stuffed specimen is nearly the same, except that the tail is rather longer. The dimensions given by Horsfield and Vigors for an adult are rather more;—head and body 14·25 inches, tail 10·5, whilst the tarsus is stated to be only 2 inches long, but the difference is trifling.

Mr. Davison informs me that *Gymnura* is purely nocturnal in its habits, and lives under the roots of trees. It has a peculiar and most offensive smell, not musky, but rather alliaceous, resembling decomposed cooked

* Zool. Jour., III, p. 248.

vegetables. There is a slight smell in the dried skin. The contents of the stomach in the spirit specimen appear to consist entirely of remains of insects, amongst which I can, I think, detect termites, but most of the fragments are too much broken for identification.

Tupaia peguana.

Jerdon, Mam. Ind. No. 88 :—Blyth Mam. Burm. No. 65.

Blyth in his Catalogue of the Mammalia in the Museum of the Asiatic Society classed the Peguan *Tupaia* as a variety of *T. ferruginea*, but in his Mammals of Burma he separated the Burmese species, as Jerdon had done. He, however, pointed out that the two are barely separable, and that a ferruginous tinge is present in some Burmese specimens.

Skins collected by Mr. Davison in Southern Tenasserim have all the posterior portion of the back distinctly ferruginous. Others from Myáwadi, west of Moulmain, are almost equally rufous on the rump, whilst other specimens again from the same neighbourhood have no rufous tinge. A specimen from Tavoy has scarcely a trace of rufescent. Without a larger series of Malaccan specimens than I have at hand, I cannot positively say that the two forms pass into each other, but I am strongly disposed to suspect that they do so.

The following dimensions taken on the animals when recently killed are recorded by Mr. Davison on his tickets.

	1 ♂ ad.	2 ♂ ad.	3 ♀
Nose to anus,	6·8	6·8	6·6
Tail from anus,	7·	6·8	6·4
Hairs at end of tail,	1·1	1·2	0·8
Total	14·9	14·8	13·8
Length of fore foot (claws excluded),	0·88	1·	0·9
„ hind foot („),	1·65	1·75	1·69
„ of ear externally,	0·3	0·2	0·35
„ „ inside from orifice,	0·6	0·55	0·45
Breadth of ear laid flat,	0·8	0·7	0·6

No. 1 is from Kaukaryit on the Houngdarau river, 2 and 3 from the neighbourhood of Myáwadi, all localities to the eastward of Moulmain.

Carnivora.

Prionodon maculosus, Pls. VI, VII.

W. Blanf. Proc. As. Soc. Bengal, March 1878, p. 93.

P. affinis P. gracili, *sed major, atque maculis fasciisque fuscis majoribus ornatus; dorso nigrescenti-fusco, lineis sex albis angustis transfasciato, fasciâ albâ laterali utrinque post aurem oriente, usque ad femorem decur-*

rente, lateribus maculis longis fuscis superne majusculis, subtus minoribus signatis, collo sursum duobus fasciis latis subnigris longitudinalibus, inter se vittâ albâ angustâ, medio fusco-lineatâ, discretis, notato ; caudâ annulis septem fuscis albisque alternis circumdatâ, illis fere duplo latioribus, apice albescente.

Long. a rostro ad anum 18·25, *caudæ sine pilis ad apicem* 16, *pilorum* 0·75, *tota* 35 ; *cranii* 3, *tarsi a calcaneo* 2·8 *poll. angl.*

Hab. in provinciâ Tenasserim, (Davison, Limborg).

Upper part brownish black broken up by greyish white bands, lower parts white, tail brownish black with 7 white rings, tip whitish. Two broad black bands run down each side of the upper part of the neck, between them is a narrow greyish white band with a faint mesial dark streak, somewhat interrupted, and passing into two bands of elongate spots between the shoulders. The two broad dark bands pass into the dark patches of the back ; on each side of these bands is a white rather wavy stripe, commencing at the ear and continued along the neck, above the shoulder, and down the side to the thighs, becoming more irregular behind ; below this again is a dark band somewhat broken up into spots in front, passing over the shoulder, and continued as a line of large spots along the side. The back is chiefly brownish black, crossed by six narrow transverse whitish bands, the first five equidistant, the foremost communicating with the mesial neck band, and the hinder all uniting with the white band on the side, so as to break up the dark colour into large spots. There are small black spots on the fore neck, lower portion of the sides, and outside of the limbs, the spots on the fore neck forming an imperfect gorget. The white rings on the tail are not much more than half the breadth of the dark rings ; the last dark ring, near the tip, and the first white ring are narrower than the others. Nose dark brown mixed with grey, a dark ring round each orbit with a streak running back to below the ear and another passing up to the crown ; forehead between and behind the eyes, and in front of the ears, and cheeks, pale grey. Ears rounded and clad with blackish hairs outside and near the margin inside, a few long pale hairs on the inner surface of the ear conch. Whiskers long, extending to behind the ears, the upper brown, the lower entirely white. Soles, except the pads, which are naked, covered with fine hair.

The fur is soft and short throughout, that on the upper parts is ashy grey at the base; lower fur very fine, tips of the longer hairs black or white; none of the hairs are more than half an inch long on the back, being much shorter than in *P. pardicolor*.

The following dimensions are taken on a fully adult male specimen preserved whole in spirit. The length of the body would perhaps be an inch or two more in a fresh specimen, the other dimensions are probably unaltered.

	inches.
Length from nose to rump over curve of back, ...	18·25
„ of tail without the hairs at the end, ...	16·
„ of hairs at end of tail, ...	0·75
Total	35.
Length from nose to rump in a straight line, ...	16·75
Height at shoulder* about, ...	6·
Hind foot and tarsus from toe to tarsal joint, ...	2 8
Length of ear from orifice,........................	1·05
„ „ from base of helix, ...	1·1
„ „ outside from crown of head, ...	0·65
„ from orifice of ear to eye,...............................	1·2
„ from anterior angle of eye to nostril, ...	0·97
Longest whisker, ...	3·6

The skull of the same specimen measures :

	in.	metre
Length from occipital plane to anterior end of premaxillæ,...	3.	·076
„ from inferior margin of *foramen magnum* to do.,......	2·9	·073
Greatest breadth across zygomatic arches, ...	1·5	·038
Breadth of brain case at posterior termination of zygomatic arches, ...	1·	·025
Least breadth of brain case behind post-orbital processes, ...	0·45	·0115
Length of suture between nasal bones, ...	0·62	·015
„ of bony palate from opening of posterior nares to incisors, ...	1·4	·035
Breadth between posterior molars, ...	0 53	·013
Length of mandible from angle to symphysis, ...	2·05	·0515
Height of ditto,..	0·8	·020

The stuffed skin was most carefully set by Mr. Davison himself, the dimensions being made exactly the same as those taken on the body before skinning. The present measurements are—nose to insertion of tail 19 inches, tail with hair 16½ in., total 35½, nearly the same as in the specimen in spirit. It is probable that this skin also has contracted a little in drying.

This species appears well distinguished from *P. gracilis* and *P. pardicolor* by its larger size, and by the much greater prevalence of dark colour on the upper surface generally. In external characters *P. maculosus* is nearer to the Malay species, *P. gracilis*, the Himalayan *P. pardicolor*

* Measured from the posterior foot pad to the top of the back between the shoulders, the leg being straight.

having the upper parts covered with comparatively small spots, and more numerous rings on the tail.* With *P. gracilis* I am only acquainted by description and figures.† Judging by these, the principal difference in the colouration is that, in *P. gracilis*, the pale tint prevails very much more than in *P. maculosus*, the upper parts of the former being marked by irregularly shaped blackish spots on a pale ground, whereas the upper surface of the latter is dark, with a few white streaks dividing the colour into patches. On the tail of *P. gracilis* the dark rings are represented as narrower, and, towards the tip, much narrower than the white rings, and there is a long white tip. In *P. maculosus* the dark tail rings are nearly twice as broad as the light, and the white tail tip is very short, shorter than the last dark ring. The distribution of colour on the head also appears different, the whole nasal region in front of the eyes being dark in *P. maculosus*, but not in the figure of *P. gracilis*. The more important dimensions of *P. gracilis* as given by Horsfield are; length of the body from the extremity of the nose to the root of the tail 1 ft. 3½ in., length of tail 1 ft. ½ in. It is probable these measurements are from a stuffed specimen, but the much smaller size of *P. gracilis* is shewn by the dimensions of the skull given by Dr. Gray‡ whose measurements of the two species *P. gracilis* and *P. pardicolor* are the following. Those of *P. maculosus* are appended for comparison.

	P. gracilis.	*P. pardicolor.*	*P. maculosus.*
Length of skull, ...	2″ 7‴§	2″ 6‴	3″
Width at brain case,..............	11‴	10½‴	1″
Width of zygomatic arch, ...	1″ 3¼‴	1″ 2½‴	1″ 6‴

This gives the idea that the skull of *P. maculosus* is longer and that the breadth across the zygomatic arches is greater in proportion to the width of the brain case than in the other two species, and judging from an imperfect skull of *P. pardicolor* in my possession, this is the case. I think it probable that *P. maculosus* is a much more powerful animal than either of the other species. The nose is proportionally narrower, more pointed and shorter in *P. pardicolor*, and the bony palate extends a shorter distance behind the posterior molars. From the opening of the posterior nares to the anterior palatal foramina the distance is 0·93 inch in *P. pardicolor*, 1·27 in *P. maculosus*, the form and position of the foramina being similar in the two.

* Jerdon, Mam. Ind. p. 124, says eight or nine. I count ten pale rings besides the whitish tail tip on two Sikkim specimens, received from Mr. Mandelli. The rings near the base and tip of the tail are narrower than in the middle.

† *Felis gracilis*, Horsfield. Res. in Java. This work is not paged, and the plates are not numbered. The animal is described and figured, and the head, feet and dentition are separately represented on another plate.

‡ Cat. Carn. &c., Mam. Brit. Mus. 1869.

§ In the original 1″ 7‴ but this is, I think, clearly a misprint for 2″ 7‴.

The first specimen of this species (a very beautiful and perfect skin) was obtained by Mr. Davison at Bánkasún in Southern Tenasserim. The animal was caught in a trap. The second specimen was procured by Mr. Limborg to the East of Moulmain.

Martes flavigula.

Blyth, J. A. S. B., XXVI, p. 316; XLIV, Pt. 2, extra number, p. 29:—Jerdon, Mam. Ind. p 82.

A skin belonging to the Malayan race, distinguished from the Himalayan form by the crown of the head and nape being brown instead of black, by wanting the white chin, and by the fur being shorter, was obtained at Bánkasún in Southern Tenasserim by Mr. Davison. The Himalayan form is recorded from Arakan by Mr. Blyth, so that both are found in British Burma.

Rodentia.

Sciurus rufigenis, Pls. VII, VIII.

W. Blanf. Proc. As. Soc. Bengal, March 1878, p. 93.

S. medius, S. atridorsalem canicepemque *magnitudine subæquans, sed caudâ corpore cum capite paullo breviore, rostro longo; superne fusco-olivaceus, punctiunculis minutis nigris fulvisque variatus, subtus albus, maculâque albâ post aurem utram signatus, fronte rufescente, genis ferrugineis, mystacibus nigris, caudâ distichâ, superne canâ, pilis nigris albo-terminatis atque semel annulatis indutâ, subtus castaneâ. Long. corporis a rostro ad anum* 8, *caudæ, pilis ad extremitatem non inclusis* 6·5, *plantæ sine unguibus* 1·8.

Hab. in sylvis densis, ad latera montis Muleyit dicti, in provinciâ Tenasserim Burmaniæ, (Davison, Limborg).

This squirrel is nearly the same size as *S. caniceps* and *S. atrodorsalis,* but the tail is much shorter, its length, without counting the hairs at the end, being always considerably less than that of the head and body; it is distinctly distichous below. Fur soft throughout.

Upper parts dark olive, frizzled, cheeks ferruginous, a small white spot behind the ear, lower parts white, tail hoary, black with white rings and tips above, chesnut below.

The colour of the back and sides resembles that of specimens of *S. caniceps* in which there is no yellow or rufous tinge, being a fine mixture of black and pale yellow, the sides rather paler. The fur on the back, as in several allied species of squirrel, is of two kinds, the finer and shorter hairs being dark leaden colour at the base, pale yellowish grey at the tips, and about a quarter of an inch long in the middle of the back, the longer hairs are coarser, about half an inch long, and black with a pale yellow ring near the end, the tips being black. As usual the longer hairs are most abundant near the middle of the back, less so on the sides. Forehead rufous mixed with black, the sides of the head are dark ferruginous above, paler below, shading off gradually into the colour of the face and throat. Ears rounded, covered thinly inside and out with short hairs; a little patch of silky white hair behind each ear is concealed by the ear conch when the ears are laid back.* Whiskers black. The hairs of the lower parts are dark grey at the base, white at the ends, there is a tinge of rufous on the fore neck and throat in some specimens. Fore limbs yellowish olive outside, like the sides, whitish inside, hind limbs also whitish within, but more rufous outside. Tail clad above with black hairs, having a white ring near, but not at their base, and white tips, so as to produce a very beautiful hoary appearance, lower surface of the tail chesnut, the longer hairs on the sides with black and white tips

The following dimensions in inches were taken by Mr. Davison on fresh specimens:

	♂	♀ ad.	♀ ad.
Length from nose to insertion of tail,.........	7·3	8·2	8·1
„ of tail without hairs at end, ...	5·7	6·0	6·5
„ of hairs at end of tail, ...	1·5	2·1	1·3
Total	14·5	16·3	15·9
Length of fore foot (palma) (claws not measured),..	1·15	1·1	1·1
Length of hind foot from heel without claws,	1·75	1·85	1·8
Height of ear outside, ...	0·5	0·5	0·55
„ inside from orifice, ...	0·8	0·8	0·8

The skull (Plate VII) differs considerably from those of *S. lokrioides*, *S. atridorsalis*, *S. caniceps*, *S. phayrei*, *S. blanfordi* and all other allied species with which I have been able to compare it, in the narrow and singularly elongate nasal portion, in which character the present species shews an approach to *Rheithrosciurus* of Gray.

The following are the dimensions of the skull of the present species, compared with those of some of the other Himalayan and Burmese forms.

	S. rufigenis. ♂ ad.	S. lokrioides. ♀ ad.	S. atridorsalis. ♂ ad.	S. caniceps. ♂ ad.
Length from occiput to end of nasals,...	2·07	1·85	1·95	2·33
Breadth across zygomatic arches,.........	1·2	1·06	1·18	1·37
„ of brainpan at posterior termination of zygomatic arches,	0·95	0·9	0·93	1·02

* This white mark is represented too large in the plate.

	S. rufigenis.	S. lokrioides.	S. atridorsalis.	S. caniceps.
Breadth across behind post orbital processes, ...	0·75	0·65	0·7	0·82
„ of frontals between orbits, ...	0·62	0·63	0 75	0·9
Length of suture between nasal bones,...	0 62	0·53	0·52	0·73
„ of upper row of molars, ...	0·42	0·36	0·37	0·44
„ of bony palate behind incisors,...	0·9	0·82	0·82	1·
Width of bony palate between posterior molars, ...	0·27	0·24	0·23	0·3
Length of mandible from angle to symphysis,..................................	1·	0·96	1·05	1 25
„ of row of lower molars,............	0·42	0·37	0·38	0·44

Four specimens of this squirrel were obtained by Mr. Davison at the end of January and beginning of February 1877; all were procured in dense forest, at an elevation of above 5000 feet, on the sides of Mooleyit, a lofty mountain east of Moulmain on the range separating the Houngdarau from the Thoung Yin valley. A single specimen was subsequently procured in the same locality by Mr. Limborg and this was the first to reach me.

None of the other Burmese or Himalayan squirrels resemble the present form, nor am I acquainted with any Malay species with similar colouration. The nearest approach is perhaps made by *S. pernyi*, found at Sechuen in China.* This species has a yellow spot behind the ear, the lower surface of the tail is ferruginous, and the belly white, but it wants the ferruginous cheeks, it has no white tips to the hairs in the upper surface of the tail, and it is more rufous above, the latter character being, however, of little or no importance.

The Himalayan *Sciurus lokriah* also possesses, I find, the small whitish tuft behind the ear, though less developed than in *S. rufigenis;* the colouring of the lower parts and tail are, however, conspicuously distinct in the two forms. The presence of the white spot in *S. lokriah* affords an excellent character for distinguishing this species from *S. lokrioides.*†

* Milne Edwards, Rev. et Mag. Zool. 1867, p. 230, pl. 19.

† According to Gray, A. M. N. H. Ser. 3, XX, pp. 274, 281, the true *S. lokrioides* of Hodgson is the species with a black tail tip, *S. assamensis* of McClelland and Blyth. The species called *S. lokrioides* by all Indian naturalists is re-named *Macroxue similis* by Gray. As Hodgson's types are in the British Museum and are quoted by Dr. Gray, he may be right, though it is very remarkable that he should be, because the species commonly referred to *S. lokrioides* abounds in Nepal, where Hodgson of course collected it, whilst I doubt if *S. assamensis* be found there. Dr. Anderson has especially examined the British Museum specimens, and will I believe clear up these difficulties.

Sciurus atridorsalis.

Gray, Ann. Mag. N. H., 1842, Ser. 1, Vol. X, p. 263; 1867, Ser. 3, Vol. XX, p. 284;—Blyth, J. A. S. B. XXIV, p. 477; XXVIII, p. 276; XLIV, Pt. 2. Extra number, p. 36;—Beavan, P. Z. S. 1866, p. 428.

This is certainly the most variable of the Burmese squirrels. The back varies in colour from dark speckled grey, with scarcely a tinge of fulvous, to grizzled rufous tawny, the head being in the former case the same colour as the back, or slightly rufescent, in the latter distinctly ferruginous, the ears being usually even deeper rufous than the forehead. Occasionally the whole back from the nape to the insertion of the tail, is black; more commonly there is a black patch from between the shoulders to the rump, but frequently the area of black is shorter and narrower, and occasionally, especially in the more rufous specimens, not a trace remains. The whiskers are sometimes entirely white, sometimes all black, occasionally mixed white and black. The tail is normally grey like the sides, with more or less distinct transverse bands, due to the hairs being ringed greyish white and black, but in some specimens all the hairs are black except at their extreme tip, and in others, they are entirely pale rufous, save at the extreme base, and even this amount of dark colouration disappears towards the tip of the tail. The lower surface, including the breast, abdomen and inside of the limbs is normally rich bay, but sometimes chesnut, pale ferruginous or even pale rufescent, in the dark rufous form the red sometimes extends to the throat, in other cases the lower neck is grey, or the whole central portion is pale rufous, and only the lateral parts bay, especially on the breast. I have two specimens also in which the middle of the breast and abdomen is grizzled like the sides and throat, the lateral portions of the lower parts alone being bay. This shews a complete passage into *S. gordoni**: it is true that in the latter, so far as I know, there is no black on the back, but as this peculiarity is not constant is true *S. atridorsalis*, the distinction is evidently insufficient. The paler under parts may possibly be due to immaturity; with this exception however I cannot find that the variations I have mentioned are due to either sex or age. All specimens from Myawadi appear to have black whiskers, and all from Moulmain white, but from Kaukaryit, on the Houngdarau river, south of Myawadi, I have both forms. I am indebted to Mr. Hume for a superb series of this species and of *S. caniceps*, and I have also a considerable number of both from the collections made by Mr. Limborg. These two are in fact the commonest squirrels of Tenasserim.

The following are measurements by Mr. Davison:

* Anderson, P. Z. S., 1871, p. 140.

	1	2 ♂ juv.	3 ♂	4 ♀ ad.	5 ♂ ad.	6 ♂ ad.
Length from nose to anus,.........	8·	8	8·5	8·65	8.9	7·62
„ of tail from anus, ...	7·5	7·9	7·4	7·7	7·75	8·3
„ of hairs at end of tail,......	2·5	2·5	2·7	2·4	2·5	2·
Total	18·0	18·4	18·6	18·75	18·15	17·92
Length of fore foot (without claws),	0·82	1·15	1·18	1·2	1·2	1·19
„ hind foot and tarsus (do.),	1·55	1·85	1·7	1·8	1·9	1·8
Height of ear outside,..................		0·5	0·55	0·4	0·5	0·55
„ inside from orifice,	0·55	0·65	0·71	0·9	0·92	0·68

Some measurements of spirit specimens differ but little from the above.

I have only seen *S. atridorsalis* from the northern portion of the Tenasserim provinces, the species has not yet, so far as I am aware, been recorded from Mergui or Tavoy, nor is it known to occur west of the Salween river. It abounds around Moulmain and Amherst, and in the valleys of the Houngdarau and Attaran rivers.*

S. phayrei.

Blyth, J. A. S. B., XXIV, 1855, p. 476; XLIV, Pt. 2, Extra number, p. 36;—Peters, P. Z. S. 1866, p. 429,—Gray, Ann. Mag. Nat. Hist. Ser. 3, XX, p. 277.

S. hyperythrus, Blyth, J. A. S. B., XXIV, p. 474.

This species, as noticed by Blyth, is only known to occur west of the Salween. It is not, so far as I am aware, found west of the Sitoung; in the Irawadi valley in Pegu, it appears to be replaced by *S. pygerythrus*, whilst further north, around Ava, it is represented by the closely allied *S. blanfordi*, into which it doubtless passes. *S. phayrei*, Mr. Davison tells me, is found north as far as Pah-Khyoung at the southern extremity of Kareni; (the country of the Red Karens).

The following are dimensions of a female from Thatone:

	in.
Length from nose to anus,..	9·6
„ of tail from anus, ...	8·8
„ of hairs at end of tail, ...	2·3
Total	20·7
Length of fore foot (without claws),............................	1·2
„ of hind foot and tarsus (do.), ...	1·8
„ of ear outside, ...	0·5
„ „ inside from orifice, ...	0·7

* Error is proverbially immortal, and consequently, attention cannot be too frequently called to the circumstance that the localities assigned to this species and to many other Asiatic squirrels in Dr. Gray's lists are incorrect.

S. caniceps.

Gray, Ann. Mag. Nat. Hist. 1842, Ser. 1, Vol. X, p. 263; Ser. 3, XX, p. 280; Blyth, J. A. S. B., 1876, XLIV, Pt. 2, Extra number, p. 36.

S. chrysonotus, Blyth, J. A. S. B., XVI, p. 873; XXIV, p. 474.

S. concolor, Blyth, J. A. S. B., XXIV, p. 474.

Although there is nothing like the variation in colouring in this species that there is in *S. atridorsalis*, still a wide difference is found between different specimens, especially in the colouration of the upper parts, as Blyth and Gray have noticed; some having the back pale ferruginous, whilst others have the whole upper surface dull olivaceous grey, minutely punctulated with scarcely a trace of rufous. The most rufous specimens I have seen are from the Houngdarau valley, east of Moulmain, in these the crown of the head, the back from the nape to the commencement of the tail and the sides are pale rusty red with scarcely a trace of punctulation. Moulmain specimens, as a rule, are punctulated and merely washed with rufous, especially on the anterior part of the back, or the rufous tinge is very faint, and sometimes wanting. Blyth has noticed* that the least rufous specimen he had seen came from Mergui. Southern Tenasserim specimens, judging from one skin collected by Mr. Davison in Tavoy, and several from Bánkasún, want the ferruginous tinge entirely. To the Bánkasún specimens I will refer further presently.

There is also some variation in the colouration of the abdomen. Some specimens are almost white below, others more or less cinerous and more or less punctulated. In some the colour of the lower parts is olivaceous grey, scarcely paler than the sides. In very many specimens there is a dark mesial line more or less developed, but it is not constant. These differences of colouration in the under surface are apparently quite independent of the degree to which the upper parts are washed with rufous, and none of the differences, so far as I can judge, are due to age or sex.

The specimens from Bánkasún in the extreme south of the Tenasserim provinces are decidedly darker, both above and below, than any I have examined from farther north, much darker even than the Tavoy specimen. The Bánkasún skins are almost olive green above, distinctly punctulated, and scarcely paler but rather greyer below. In two specimens out of three there is a darker mesial line beneath. The only difference between these skins and *S. concolor* of Blyth from Malacca, of which species I have examined the type in the Indian Museum, consists in the latter having a slight rufous wash on the upper surface. I have no doubt that the Bánkasún squirrel passes into the Malaccan *S. concolor*. These dark olivaceous forms may perhaps be sufficiently distinct to constitute a local

* J. A. S. B., 1855, XXIV, p. 475.

race, for which Blyth's name may be retained, but they are not, I think, really separable from *S. caniceps.*

The following dimensions in the flesh of two adult females, are taken from Mr. Davison's tickets; both specimens are from Kaukaryit in the Houngdarau valley. I also add (3 and 4) the measurements of two spirit specimens from Mr. Limborg's collection.

	1♀	2♀	3♂	4♀,
Length from nose to anus, ...	8·2	8·7	9·25	8·75
„ of tail from anus, ...	9·2	9·8	7·75	9 25
„ of hairs at end of tail, ...	2·5	2·3	3	3·25
Total	19·9	20·8	20·	21·25
Length of fore foot (without claws),.........	1·2	1·2	1·32	1·22
„ of hind foot and tarsus (do.), ...	1·8	1·85	2·	2·05
Height of ear outside, ...	0·4	0·52	0·45	0·45
„ inside from orifice, ...	0·8	0·9	0·83	0·8

S. caniceps ranges throughout the Tenasserim provinces from Moulmain to the banks of the Pakchoung. I have also one specimen labelled from Thatone, which is to the west of the Salween, but the skin so precisely resembles the peculiarly dark olive specimens from Bánkasún that I am inclined to suspect the label must have been changed by accident.

S. mouhoti.

Gray, P. Z. S., 1861, p. 137.

S. berdmorei, Gray, Ann. Mag. Nat. Hist. Ser. 3, XX, p. 279. (? an *S. berdmorei verus* Blyth.)

Several skins were procured by Mr. Davison, and a specimen in spirit was collected by Mr. Limborg, of a species of striped squirrel differing somewhat from the Museum specimens of *S. berdmorei,* but agreeing very well with Gray's description of *S. mouhoti* from Camboja.* The museum specimens of *S. berdmorei,* said by Blyth† to have been collected by himself in Martaban‡, have three broad black stripes along the back, whereas in the specimens before me there are no black stripes and no distinct darker

* Especially with the second description quoted above from the 'Annals and Magazine of Natural History.' In the original description the interspace between the pale lateral lines was said to be black, in the second account blackish, which accords better with Mr. Davison's specimens. The remark appended to the original description of *S. Mouhoti,* that it differs from most squirrels of the same size by having the three streaks on the upper part of the back, I understand to refer to the lateral bands, a dark one between two pale stripes, on the upper part of the side, not on the lower as in *S. vittatus* and its allies.

† Cat. Mam. Mus. As. Soc. p. 106.

‡ J. A. S. B., 1862, XXXI, p. 333.

band in the middle of the back, although there is a slight indication of darkening in one specimen. In the original description of *S. berdmorei*,* it was said to have an obscure pale central dorsal streak, flanked by a blackish band, but in a subsequent description† of an example sent from Moulmain the three black bands of the back were especially noticed. Subsequently *S. mouhoti* was described by Gray and then identified by the describer with *S. berdmorei*, an identification adopted by Blyth.‡ It is possible that the two forms pass into each other, but they look very different, and for the present I prefer retaining Gray's name for the variety before me, of which the following is a description.

The upper surface is yellowish brown, puncticulated, the hairs being black with two buff rings. The fine woolly under-fur is dark slate-coloured at the base with buff tips. On each side of the back there are two longitudinal pale lines extending from the shoulder to the thigh, the upper narrow and well defined, the lower broader and less marked. Between the two and above the upper pale line, the fur is darker in some specimens, but apparently this is not constant. The sides below the lower pale lateral bands are greyish brown puncticulated. The lower parts throughout are white, sometimes tinged with buff. The tail hairs are light brown at the base, then black, then brown again, then black to near the tips, which are whitish. Whiskers black. The ears are rounded with very short hairs outside.

The bare planta on the hind feet extends further towards the heel than in the more typically arboreal squirrels, *S. caniceps*, *S. atridorsalis* and *S. phayrei*, in which the bare portion ends about $\frac{1}{4}$ to $\frac{1}{3}$ of an inch from the proximal extremity of the tarsus, whereas in *S. mouhoti* it extends to the joint. The claws too in *S. mouhoti* are rather less curved, and the pads on the feet appear more raised.

The following are measurements in inches taken by Mr. Davison, before skinning, on two females, the first from Kaukaryit, the second from Myawadi, both east of Moulmain, and of the male preserved by Mr. Limborg in spirit.

	1♀	2♀	3♂
Length from nose to anus, ...	7·3	6·8	6·4
„ of tail from anus,..........................	5 8	5 6	5·4
„ of hairs at end of tail, ...	2·	2·	
Total	15·1	14·4	

* J. A. S. B., 1849, XVIII, Pt. 1, p. 603.

† J. A. S. B., 1859, XXVIII, p. 418.

‡ J. A. S. B., 1875, XLIV, Pt. 2, Extra number, p. 37.

	1 ♀	2 ♀	3 ♂
Length of fore foot (without claws),.........	0·88	0·85	0·85
„ hind foot and tarsus (do.), ...	1·53	1·5	1·65
Height of ear outside,..........................	0·4	0·5	0·35
„ inside from orifice, ...	0·8	0·8	0·65

Blyth in his list of the Mammals of Burma, suggests that *S. berdmorei* should perhaps more properly range as a species of *Tamias*. In the specimen of *S. mouhoti* in spirit, obtained by Mr. Limborg, I cannot detect any cheek pouches. Unfortunately the skull of this specimen is too much injured to be extracted for measurement.

The only specimens of this squirrel hitherto obtained are from the country east of Moulmain. Mr. Davison informs me that he has never seen either this or *S. berdmorei* in Southern Tenasserim. The latter is, however, reported with some doubt by Blyth from Mergui.

S. barbei.

Blyth, J. A. S. B., XVI, p. 875, Pl. XXXVI, fig. 3; XVIII, p. 603; XLIV, Pt. 2, Extra number, p. 38.

The following are the dimensions of three fresh specimens recorded by Mr. Davison: 1 and 3 from Kaukaryit on the Houngdarau river, 2 from Myawadi.

	1 ♂ ad.	2 ♂ ad.	3 ♀
Length from nose to anus,....................	4·65	4·6	4·7
„ of tail from anus, ...	5·	4·9	5·
„ of hairs at end of tail, ...	0 85	1·5	1·
Total	10·5	11·0	10·7
Length of fore foot (without claws),.........	0·75	0·7	0·7
„ hind foot and tarsus (do.), ...	1·	1·12	1·15
Height of ear outside,..........................	0·4	0·45	0·45
„ inside from orifice,.....................	0·58	0·6	0·6

This species appears to be found throughout Tenasserim, extending south to Malacca. Specimens from Southern Tenasserim and from Malacca have much darker dorsal bands and shorter ear tufts than those from the neighbourhood of Moulmain. Judging from the specimens before me too, the southern form appears smaller, with a comparatively shorter tail, but I have no fresh measurements. The original types came from Yé, about half way between Moulmain and Tavoy, and probably belonged to the Northern variety.

Pteromys cineraceus.

Blyth, J. A. S. B., XVI, p. 865; XXVIII, p. 276; XLIV, Pt. 2, Extra number, p. 35.

A fine female skin from Wimpong, 15 miles from Thatone, (west of the Salween) has the tip very little darker than the remainder of the tail, and is easily distinguished from *P. oral* of Southern India by its greyer colour, and by the lower parts being white. The following are the dimensions noted by Mr. Davison on the fresh specimen.

	in.
Length from nose to anus,	18·5
„ of tail from anus,	22·5
„ of hairs at end of tail,	3·
Total	44·0
Length of fore foot (without claws),	2·4
„ of hind foot and tarsus (do.,)	3·
Height of ear outside,	1·5
„ inside from orifice,	2·

Rhizomys castaneus.

Blyth, J. A. S. B., XII, p. 1007; XLIV, Pt. 2, Extra number, p. 41.

A specimen from Thatone in Martaban, west of the Salween river, and another from, I believe, the same neighbourhood, differ from Arakan and Pegu specimens by having a white spot in the middle of the forehead, as in some other species of the genus. As there appears no other distinction, and as the spot is evidently variable, being far more distinct in one specimen before me than in another, I do not think this form is more than a variety.

Mus robustulus.

Blyth, J. A. S. B., XXVIII, p. 294; XLIV, Pt. 2, Extra number, p. 39.

Specimens in spirit from near Maulmain collected by Mr. Limborg do not appear to me distinct from the common tree rat of lower Bengal, *M. rufescens* of Blyth and Jerdon, but not, I think, of Gray, as in the original description by the latter the tail is said to be shorter than the body, whereas in both the Bengal and Burmese rats the tail exceeds the head and body in length. I can see no difference in the skulls of the Bengal and Tenasserim rats.

Ungulata.

Tragulus napu.

Moschus napu, Raffles, Linn. Trans. XIII, p. 262.

Tragulus napu, A. Milne-Edwards, Ann. Sc. Nat. Ser. 5, II, 1864, pp. 106, 158, Pl. II, fig. 2;—Blyth, J. A. S. B., XLIV, 1875, Pt. 2, Extra number, p. 44; P. Z. S., 1864, p. 483.

T. fuscatus, Blyth, J. A. S. B., XXVII, 1858, p. 278.

T. javanicus, Blyth, Cat. Mam. Mus. As. Soc., p. 155, nec Pallas.

As was suggested by Blyth in his remarks on *Tragulus kanchil*, the larger form of chevrotain is also found in Southern Tenasserim, Mr. Davison having procured an adult and a young animal from Bánkasún. Owing to the extreme confusion which formerly prevailed as to the synonymy of the *Traguli*, the nomenclature and distribution of the different species cannot be said yet to be rightly determined in all cases, but it is clear that two distinct forms are found in the Tenasserim provinces and these forms appear to be the *T. kanchil* and *T. napu* of A. Milne-Edwards' monograph of the *Tragulidæ* in the 'Annales des Sciences Naturelles', as has already been pointed out by Mr. Blyth.

The most striking differences between the two species are,—first, size; *T. napu* being probably thrice the weight of *T. kanchil*;—second, the much stouter limbs of the former; the length of the tarsus and hind foot in two specimens before me of *T. napu* and *T. kanchil* respectively being 5 85 and 4·8, whilst the circumference of each tarsus in the middle is 1·3 and 0·85;—and, third, colouration, especially below. There is but little difference above; both are brown, becoming paler and greyer on the sides, but the dark line from the nape down the back of the neck is much more distinct in *T. kanchil*. The colouration of the throat and belly, however, is very different; in *T. napu* there are five white stripes on the throat, one longitudinal in the middle, and two oblique stripes on each side, the upper lateral band being much shorter than the lower. In the adult skin from Tenasserim all these bands unite in front, but not in the young specimen, in which the median stripe is separated from the others, as described by Milne-Edwards. The interspaces between the white bands are dark brown, darker than the sides of the neck, but this appears sometimes to be the case in *T. kanchil* also. The abdomen in adult *T. napu* is mostly white, the breast and the space between the thighs purer white than the rest; in the young all the middle portion of the abdomen between the broad white breast and the narrower white groin is smokey brown; in both there is a rudimentary dark median band, not nearly so distinct as in *T. kanchil*.

In *T. kanchil* there are but three white stripes on the throat, the median line being sometimes entirely distinct from the two broad and long oblique lateral stripes, sometimes coalescing with them in front; the abdomen is pale rufous and white in patches, the centre of the anterior portion and the sides of the posterior portion being white, and the remainder rufous, but the proportion of the two colours varies; there is, however, a well marked dark median line along the anterior half beginning from the dark transverse band on the breast.

In both species the rump is rufous, and the tail brown above, white below and at the tip. All the differences noticed, except the number of white stripes on the throat, have already been pointed out by Blyth.

XI.—*List of* Hymenoptera *obtained by* Mr. Ossian Limborg *east of Maulmain, Tenasserim Provinces, during the months of December* 1876, *January, March and April* 1877, *with descriptions of new species:—by* Frederick Smith, *Biological Department, British Museum.* (*Communicated by* J. Wood-Mason.)

(Received 30th August, 1878.)

Scoliadæ.

1. Elis lindeni, St. Fargeau, Hym. III, 500.
2. Liacos analis, Fabr.

Pompilidæ.

3. Pompilus peregrinus, Smith.
4. Pompilus vitiosus, n. sp.

Male. Ferruginous: the thorax with black markings, and the abdomen fusco-ferruginous towards the apex. The antennæ fuscous above; the eyes and tips of the mandibles black; the front, before the antennæ, pale reddish yellow. The mesothorax with a black longitudinal stripe on each side; the thorax at the sides and beneath paler than the disk, and with a golden lustre; the pectus black; wings fusco-hyaline. The extreme base of the abdomen black; the first, second and third segments with their apical margins fusco ferruginous, the following segments entirely so.

Length $6\frac{1}{2}$ lines.

Sphegidæ.

5. Ammophila nigripes, Smith, Cat. Hym. Ins., Pt. IV, p. 215.
6. Chlorion lobatum, Fabr., Ent. Syst., II, p. 206.

Bembicidæ.

7. Bembex fossorius, n. sp.

Female. Black, with lacteous fasciæ and markings above, the legs faintly yellow. The clypeus, labrum, mandibles, the scape in front, a narrow line at the inner orbits of the eyes, and a broad one behind, not extending to their summit, white, faintly yellow behind the eyes; the tips of the mandibles, and a transverse spot at the base of the clypeus, black; the vertex with a downy white pubescence. Thorax smooth and shining above, and very finely punctured; the margin of the prothorax, a line over the tegulæ, uniting with a curved one on the hinder margin of the scutellum, a narrow transverse one on the post-scutellum, a curved transverse one on the metathorax, and its posterior lateral angles, lacteous; the sides of the thorax and the legs more or less faintly yellowish; the coxæ and femora with black markings; the claw-joint of the tarsi fuscous; wings hyaline, the nervures fusco-ferruginous. The segments of the abdomen with broad lacteous fasciæ a little before the apical margins of the segments; the fasciæ with their anterior margins emarginate laterally; black beneath, with the lateral posterior angles lacteous.

Length 8½ lines.

Eumenidæ.

8. Eumenes arcuatas, Fabr., Ent. Syst., II, p. 276.

Vespidæ.

9. Polybia sumatrensis, Sauss.

10. P. orientalis, Sauss., Mon. Guépes Soc., p. 208.

Poneridæ.

11. Diacamma scalpatrum, Smith, Cat. Hym. Ins., Form., p. 84.

Apidæ.

12. Megachile dimidiata, Smith, Cat. Hym. Ins., Apidæ, Pt. I, p. 174.

13. Xylocopa latipes, Drury, Illust. Exot. Ins., II, p. 98.

14. X æstuans, Linn., Syst. Nat., I, p. 961.

15. X. collaris, St. Farg., Hym. II, p. 189.

16. X. amethystina, Latr., Ins. III, p. 375.

17. Bombus eximius, Smith, Cat. Hym. Ins., Apidæ, II, p. 403.

18. Bombus montivagus, n. sp. ♀.

Black: head elongate, the clypeus shining and finely punctured; the pubescence black. Thorax with rufo-fulvous pubescence above, and with black on the disk; the posterior tibiæ and tarsi obscurely ferruginous, palest beneath; the tarsi with ferruginous pubescence within; wings dark brown with a purple and violet iridescence in certain lights; the tegulæ obscurely rufo-piceous. Abdomen: the basal segment with bright yellow pubescence, on the second and third it is black, and on the following segments it is bright ferruginous; beneath, obscurely ferruginous, and the segments fringed with rufo-fulvous pubescence.

Length $9\frac{1}{2}$ lines.

Hab. Moolaiyet. Alt. 3-6000 ft.

19. Apis indica, Fabr., Ent. Syst., Supp. p. 274.
20. Apis florea, Fabr., Ent. Syst., II, p. 341.
21. Trigona terminata, n. sp.

Worker. Black: head and thorax semiopaque, abdomen smooth and shining. The anterior margin of the clypeus, the labrum, mandibles, and basal half of the scape in front, pale ferruginous; the apical joint of the flagellum pale. The margins of the mesothorax pale ferruginous; the scutellum fringed with short fulvous pubescence, the tarsi, except the basal joints, ferruginous; wings hyaline and iridescent, the nervures and tegulæ testaceous. The base and apex of the abdomen rufo-testaceous, the former with two black spots; beneath pale rufo-testaceous.

Length $2\frac{1}{2}$ lines.

XII.—*Preliminary diagnoses of new Coleopterous Insects belonging to the families* Dytiscidæ, Staphylinidæ, *and* Scarabæidæ *obtained by the late* Dr. F. Stoliczka *during the 2nd mission to Yarkand under* Sir Douglas Forsyth.—*By* D. Sharp.

DYTISCIDÆ.

1. Agabus dichrous.

A. *oblongo-ovalis, nitidus, subtus niger, supra testaceus, vertice nigro, rufo-bimaculato, antennis pedibusque testaceis, femoribus in medio late nigris; scutello fusco; elytris apicem versus vix fusco-nebulosis.* Long. 8 mm., lat. 4 mm.

Hab. A single male individual found on the road across the Pámir from Sarikol to Panjah.

2. Ilybius cinctus.

I. *ovalis, angustulus, parum convexus, subtus ferrugineus; supra fusco-æneus, prothoracis elytrorumque lateribus late testaceis; subnitidus, subtilissime reticulatus.* Long. $8\frac{1}{4}$ mm., lat. vix $4\frac{1}{2}$ mm.

Hab. Yangihissár.

STAPHYLINIDÆ.

1. Tachinus stoliczkæ.

T. *parvulus, sub-depressus, niger, elytris castaneis vel piceo-castaneis, antennis pedibusque sordide testaceis; prothorace fere impunctato, elytris parce punctatis, obsolete strigosulis, abdomine sat crebre sub-obsolete punctato.* Long. 6 mm., lat. $1\frac{5}{8}$ mm.

Hab. On the road across the Pámir from Sarikol to Panjah.

2. Philonthus stoliczkæ.

P. rubido, Er. *similis et affinis: angustulus, sub-parallelus, niger, elytris rufis, antennis fuscis, basi cum pedibus testaceis, abdominis segmentis ferrugineo-marginatis; thorace angustulo, subparallelo, serie discoidali punctarum* 5, *et punctis lateralibus sat numerosis, elytris rufis basi summo paullo obscuriore, crebre, fere fortiter punctatis; abdomine dense, æqualiter subtiliterque punctato, opaco.* Long. 5 mm.

Hab. Yárkand.

3. Philonthus pamirensis.

Ex. affinitate Staph. tenuis, Fabr. *Angustulus, haud parallelus, niger, elytris rufis, antennis pedibusque posterioribus fuscis, illarum basi pedibusque anterioribus testaceis; abdomine subtiliter punctato.* Long. 6 mm.

Hab. On the road across the Pámir from Sarikol to Panjah.

SCARABÆIDÆ.

1. Onthophagus concolor.

O. *niger, fere nudus, supra opacus, subtus sat nitidus; prothorace peropaco, parcius subtiliter punctato, lateribus ad angulos anteriores evidenter sinuatis; elytris subtiliter striatis, interstitiis parcius et subtiliter punctatis, punctis haud perspicue setigeris.* Long. 7—9 mm.

Masc. *Capite vertice medio breviter tuberculato, prothorace fere mutico.*

Fem. *Capite medio lineâ curvatâ sat elevatâ, vertice medio laminâ elevatâ (ad apicem plus minusve emarginatâ) brevissimâ*

Hab. Sind valley, Káshmir; and Murree, Panjáb hills.

2. Aphodius æger.

A. Scarabæi granarii, Lin. *similis; oblongus, leviter convexus, nitidus, niger, elytris piceis vel fere nigris, pedibus rufis, clypeo medio emarginato, fronte fere muticâ; prothorace subtiliter punctato, versus latera punctis* *majoribus crebribus, margine basali integro, angulis posterioribus sinuatis; elytris vix subtiliter striatis, striis indistincte crenatis, 7° et 8° ante apicem conjunctis, humeris longius ciliatis.* Long. 5—5½ mm., lat. 2½ mm.

HAB. Two small specimens were found at Yangihissár; of some others the exact locality is not recorded.

3. Aphodius kashmirensis.

A. *niger, nitidus, sat convexus, pedibus rufo-piceis, antennis rufis, clavâ fuscâ; clypeo anterius emarginato, et utrinque subacute prominulo; prothorace punctis magnis profundis sat numerosis, aliisque minutis, margine basali distincto, sulculo ante eum crenulato, elytris fortiter crenato-striatis, interstitiis subtilissime sparsim punctatis.*

Long. 6—6½ mm., lat. 3⅓ mm.

HAB. Drás, Kargil and Leh, in Ladák.

4. Aphodius tenuimanus.

A. Aphodii melanosticti, Er. *persimilis; oblongus, subconvexus, nitidus, infuscato-testaceus, capite thoraceque nigris, hoc lateribus testaceis; elytris luteis, maculis dorsalibus* 4 *vel* 5, *strigâque sublaterali nigris, pedibus metasternoque medio testaceis; fronte medio vix tuberculato; tibiis anterioribus tenuibus, intus conspicue ciliatis.* Long. 5—6 mm.

The exact locality where Dr. Stoliczka procured the specimens is unknown.

5. Geotrupes kashmirensis.

G. Geotrupis stercorarii (Haroldi) *persimilis, sed elytris longioribus; oblongo-ovalis, supra viridescente-niger, nitidus, subtus purpureus, fulvo-pubescens; antennis piceo-rufis; mandibulis extus rotundatis, ad apicem leviter unisinuatis; elytris striis* 14, *minus distincte punctatis; abdomine etiam in medio punctato, sed illo minus pubescente; tibiarum posticarum carinâ tertiâ (ab apice) omnino carente.* Long. 24 mm., lat. 13 mm.

HAB. Drás, Kargil or Leh, two individuals.

6. Hoplia concolor.

H. *oblonga, sat elongata, ferruginea, squamulis pallide griseis, magnis, fere æqualiter vestita; tarsorum posticorum unguiculo mutico.* Long. 8 mm., lat. 4¼ mm.

HAB. Kugiár.

7. Serica læticula.

S. *obovata, convexa, nitidula, tantum abdomine opaco, brunneo-ferruginea; prothorace fortiter punctato, elytris seriatim punctatis, seriebus leviter depressis, interstitiis planis, tantum juxta series punctatis; antennis* 10-*articulatis, flabelli articulo primo apice emarginato.* Long. 8½ mm., lat. 4 mm.

Locality not recorded.

8. Lachnosterna stridulans.*

L. *testacea, capite, thorace scutelloque fere ferrugineis, supra opaca, opalescens, subtus abdomine inflato nitido, pectore minus dense villoso; capite brevi, fortiter punctato; prothorace sparsim punctato fortiter transverso, margine laterali integro, sinuato, angulis posterioribus obtusis; elytris sat crebre parum profunde punctatis.* Long. 15½ mm., lat. 8 mm..

Hab. Murree, a single individual.

9. Lachnosterna stoliczkæ.

L. *oblonga, picea, nitida, pectore prosternoque griseo-villosis; capite haud parvo, clypeo fortiter reflexo-marginato, anterius vix emarginato; prothorace lateribus rotundatis, anterius quam posterius magis angustato, crebrius punctato, angulis posterioribus obtusis, margine laterali serrato; elytris crebrius fortiter punctatis, areis longitudinalibus parcius punctatis, haud argute elevatis.* Long. 15—16 mm., lat. 8 mm.

Hab. Murree.

* I am acquainted with only one other species closely allied to this, it is as yet undescribed and is labelled in my collection "*Ancylonycha pulvinosa*, Reiche, *India bor*;" it has the same appearance as *L. stridulans*, and has, like it, the epipleural line finely crenulate, but it differs considerably in the structure of the antennæ and of the claws; in *Lachnosterna stridulans*, the flabellum of the antenna is rather long, and composed of five joints, the first is, however, very short, not half the length of the second, which itself is a good deal shorter than the three following ones; the claws are divided into two rather divergent portions of equal length. In the undescribed Reicheian species the flabellum is short and composed only of three joints, and the claws of the feet are strongly dentate in the middle.

I add a short diagnosis of this insect.

Lachnosterna pulvinosa, n. sp. *Ferruginea, elytris dilutioribus, supra opaca, opalescens, subtus abdomine inflato, medio nitido, pectore parcius villoso; capite brevi dense rugoso-punctato; prothorace sparsim punctato, punctis in margine anteriori magnis, fortiter transverso, lateribus valde sinuatis, in medio perdilatatis, angulis posterioribus valde obtusis, margine laterali subcrenulato; elytris sat crebre subtiliter punctatis.* Long. 16 mm.

10. Rhizotrogus bilobus.

R. *antennis* 10-*articulatis; oblongus, colore variabilis, ferrugineus vel piceus, subopacus, prothorace in medio sæpius nitido, ad latera albido-pruinoso; clypeo in medio profunde emarginato; prothoracis lateribus anterius crenulatis; elytris indistincte et inequaliter punctatis, lateribus dense ciliatis; pygidio ventreque pruinosis; pectore prosternoque dense villosis.*

Long. 17½—20 mm., lat. 9—10 mm.

Hab. Yangihissár and Kugiár, Eastern Turkestan.

11. Anomala stoliczkæ.

(Genus *Callistethus*, Blancd.) A. *ovata, minus convexa, lætissime viridis, nitidissima; elytris subopacis, antennis nigris; capite thoraceque lævigatis; elytris seriebus duplicatis punctorum tribus, et inter eas sat crebre punctatis.* Long. 12½ mm., lat. 6½ mm.

Hab. A single individual was found at Murree.

12. Adoretus nudiusculus.

A. *testaceus, clypeo ferrugineo, fronte fusca, nitidula, parcius brevissimeque setosus; prothorace fortiter punctato, lateribus subcrenulatis, angulis posterioribus omnino rotundatis; elytris obsolete costatis, fortiter punctatis.*

Long. 9½ mm., lat. 5¼ mm.

Hab. Jhelum valley, a single individual.

13. Adoretus simplex.

A. *angustulus, parallelus, sat elongatus, densius albido-setosus, subopacus, subtus parcius setosus, nitidus; clypeo rotundato, in medio alte reflexo; prothorace basi æqualiter et tenuiter marginato, angulis posterioribus rotundatis; elytris obsoletissime costatis, crebius punctatis.*

Long. 10 mm., lat. 4½ mm.

Hab. Jhelum valley.

14. Pentodon truncatus.

P. *nigro-piceus, nitidus, capite anterius truncato, angulis inter se distantibus, tuberculo longitudinali acuto, fronte in medio tuberculis duobus minutis; prothorace fortiter punctato, basi ad angulos posteriores tenuiter marginato. Elytris sat crebre haud profunde punctatis, seriebus duplicatis haud distinctis.* Long. 19—20 mm., lat. 12 mm.

Hab. Kugiár. Two individuals, which are no doubt both males.

15. Pentodon pumilus.

P. *nigro-piceus, nitidus, capite anterius truncato, angulis inter se distantibus, tuberculo longitudinali acuto, fronte in medio tuberculis duobus minutis ; prothorace fortiter punctato, basi ad angulos posteriores tenuiter marginato ; elytris fere dense, subrugulose punctatis, seriebus duplicatis haud distinctis.*

Long. $14\frac{1}{2}$—$15\frac{1}{2}$ mm., lat. 9—10.

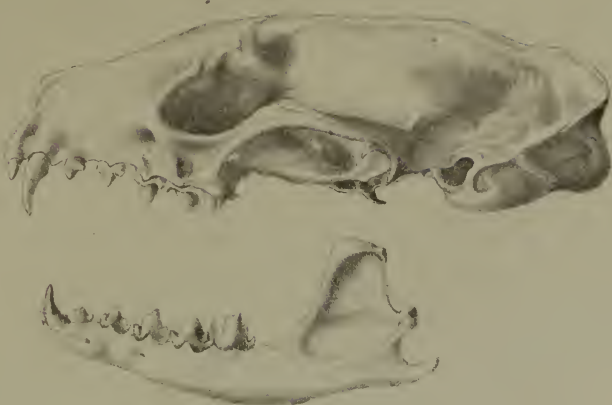
Hab. Kugiár.

Pl. VI

J Smit lith

Hanhart imp

PRIONODON MACULOSUS



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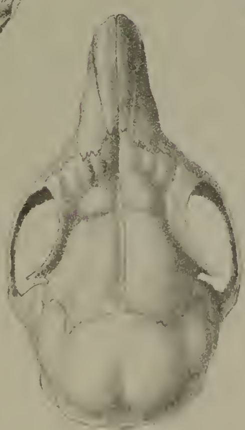

4

J. Schaumburg Lith.

1.2.3 PRIONODON MACULOSUS.
4 SCIURUS RUFIGENIS.

J.Smit lith Hanhart imp

SCIURUS RUFIGENIS

JOURNAL

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Part II.—PHYSICAL SCIENCE.

No. IV.—1878.

XIII.—*Description of a new Lepidopterous Insect belonging to the genus* Thaumantis.—*By* J. Wood-Mason.

(With Plate XII.)

Besides the fine and beautiful insect described below, there are represented in the Zoological collections formed by Mr. Ossian Limborg and staff in Upper Tenasserim during the months of December, 1876 and January, February, March, and April 1877, 225 other species of *Lepidoptera*, partly butterflies, 50 to 60 of which are considered to be undescribed, and several of which are referred to new genera, by Mr. F. Moore, who has worked out the whole collection and written a paper upon it which will shortly be published and illustrated by three or four coloured plates in the Proceedings of the Zoological Society of London.

LEPIDOPTERA.

Fam. Morphidæ.

Thaumantis louisa.

Th. louisa, Wood-Mason, P. A. S. B., July 1877, p. 163.

♂ Th. *alis supra albis, anticis dimidio basali, posticis partibus duabus basalibus lætissime et purissime fulvis ; singulis, ut in* Th. howqua, *fasciâ submarginali lunularum cum maculis hastiformibus coalitarum saturatissimè violaceo-fusca, ornatis ; lunulis maculisque alarum posticarum valdè majoribus : alis infra luteo-fulvis, anticarum parte media sola alba luteo vix tincta ; strigis quatuor sinuatis, duabus basalibus saturate brunneis, alterisque duabus submarginalibus obsoletis et tantum ad angulum analem brunneo-coloratis ; anticarum ocellis omnibus (5) obsoletis, posticarum au-*

tem duobus (intermediis tribus obsoletis) rufis, pupilla alba, iride tenui nigra.

Expans. alarum antic. unc. 5 *lin.* 3.

Habitat in Tenasserim in montibus "Taoo," dictis ad alt. 3—6000 *ped.; O. Limborg detexit.*

This fine and distinct species belongs to the same division of the genus as *Th. camadeva*, *Th. nourmahal*, *Th. cambodia*, and *Th. howqua*, to the last of which it is most nearly related, but from which it differs in having the upper surface of the wings white and fulvous instead of fulvous throughout, and in having five spots, the red rings of the ocelli, on the under-surface of the fore wings, and only two well-developed ocelli on the hinder wings, instead of three and five ocelli respectively.

Both the specimens obtained are males and each is furnished, like the same are in all the allied species and in some at least of those belonging to the other section of the genus, with a tuft of erectile hairs situated on the upper surface of each hinder wing near the base of the organ. Dr. Fritz Müller has recently communicated to the Entomological Society of London a valuable paper in which the tufts of hairs and the glandular patches he has discovered on different parts of the body in the males of many Brazilian *Lepidoptera* are considered to be odoriferous organs serving, in all probability, to attract the females. In the species of *Thaumantis* the tufts by their erection probably serve to scatter a scented secretion poured out by skin-glands at their base; and I hope that some one of the three gentlemen (Major Badgley and Messrs. Peal and Mandelli) who are located in districts in or near to which two of the species* *(Th. camadeva* and *Th. diores)* abound, will before long examine living specimens of the male of one or the other of these species so as to be able to tell us whether these structures are odoriferous or not. The accompanying plate is from a characteristic coloured drawing of the typical specimen (presented by me to the Oxford Museum) by Professor Westwood, Hope Professor of Zoology in the University of Oxford.

* Short descriptions, by the aid of which and of that of the accompanying illustration any one ought to be able to recognize these two species, are subjoined:—

Th. camadeva, has the fore wings above white tinged with leaden blue, brown at the base, and with a submarginal band of blotches and another of lunules fuscous; the hinder wings fuscous brown at base and with a band of leaden white lunules behind the middle; and five red ocelli, each provided with a black iris-like ring, on the under surface of each of the four wings. The expanse of the fore wings is $4\frac{1}{2}$ inches. The species is well-figured by Westwood in his 'Cabinet of Oriental Entomology,' pl. iv.

Th. diores belongs to the other section of the genus: it is to be recognized at a glance by the fuscous black upper surface of its wings, each of which has in the centre a huge band or spot of indescribably brilliant metallic changeable blue; on the fore wings this spot is much paler and less changeable externally, while on the hinder wings it is paler in the centre. Expanse $3\frac{3}{4}$—$4\frac{3}{4}$ inches.

XIV.—*Great Snow-fall in Kashmir.—By* R. Lydekker, B. A.

Among the inhabitants of the Kashmir Himalaya, the winter and spring of 1877-78 will long be memorable on account of the enormous quantity of snow which then fell on their mountains and valleys, and still more on account of the grievous famine which followed this excessive snow-fall. So excessive indeed was this snow-fall, that no tradition or record exists even among the oldest inhabitants of anything approaching to such a fall. I have therefore thought that a short account of this abnormal snow-fall, and of the destruction inflicted by it on the indigenous animal life, might be thought not unworthy of a place in the records of the Asiatic Society, and have accordingly put together the following notes :

Early in the month of October 1877, snow commenced to fall in the valley and mountains of Kashmir, and from that time up to May 1878, there seems to have been an almost incessant snow-fall on the higher mountains and valleys ; the inhabitants have indeed informed me that in places it frequently snowed without intermission for upwards of ten days at a time. It is extremely difficult to obtain from the natives any correct estimate as to the amount of snow which fell in any place ; but at Dras, which has an elevation of about 10,000 feet, I estimated the snow-fall from the native account as having been from 30 to 40 feet thick on the level.

The effects of this enormous snow-fall are to be seen throughout the country. At Dras, the well-built travellers' bungalow, which had stood, I believe, some thirty years, was entirely crushed down by the weight of the snow which fell on it. In almost every village in the neighbouring mountains more or less of the log-houses have likewise fallen ; while at Gulmarg and Sonamarg, where no attempt was made to remove the snow, almost all of the huts of the European visitors have been utterly broken down by the snow.

In the higher mountains, whole hill-sides have been denuded of vegetation and soil by the enormous avalanches which have swept down them, leaving vast gaps in the primæval forests and choking the valleys below with the debris of rocks and trees.

As an instance of the amount of snow which must have fallen on the higher levels, we will take the Zogi-pass, leading from Kashmir to Dras, which has an elevation of 11,300 feet. I crossed this pass early in August last, and I then found that the whole of the ravine leading up to the pass from the Kashmir side was still filled with snow, which I estimated in places to be at least 150 feet thick. The road at that time was carried over the snow up the middle of the ravine ; the true road which runs along one bank of the ravine being still entirely concealed by snow. It seemed to me quite impossible that even half the amount of snow then remaining could be melted during the summer.

I heard subsequently from a traveller who crossed the pass on the 5th of September, that the road was then just beginning to get clear from snow, and that some of his loads were carried along it, while others were taken over the snow in the ravine.

In ordinary seasons this road on the Zogi-pass is clear from snow some time during the month of June; if we refer to page 223 of Mr. Drew's "Jammoo and Kashmir Territories," we shall find that in speaking of this pass, he says, "About the beginning of June the snow-bed breaks up, and the ravine is no longer passable."

It is thus apparent that the road across the Zogi-la was not clear of snow during the past summer until three months later than it is in normal seasons, while the ravine early in September was still filled with snow. I crossed the same pass in August 1874, and at that time there was not the slightest trace of snow to be seen anywhere on the pass, or in the ravine leading up to it. As another instance of the great snow-fall, I will take the valley leading from the town of Dras up to the pass separating that place from the valley of the Kishenganga river. About the middle of August, almost the whole of the first-mentioned valley, at an elevation of 12,000 feet, was completely choked with snow, which in places was at least 200 feet in thickness. In the same district all passes over 13,000 feet were still deep in snow at the same season of the year. In ordinary seasons the passes in this district which are not more than 15,000 feet in height are completely cleared of snow at the beginning of August, except in a few sheltered ravines. During last summer, however, it was quite impossible, that the snow could have even melted on the passes.

Traces of this great snow-fall were even to be observed in the outer hills in September, since at the end of that month, I saw a patch of snow resting in a hollow of the Haji Pir ridge above Uri, which is only a little over 9,000 feet in height. The Thakadar of this place told me that he had never before seen snow there after the beginning of June.

It is almost unnecessary to point out, that if a snow-fall similar to the above were to be of constant occurrence in the Himalaya, the permanent snow-line would lie at a much lower level than it does at present, and that the glaciers would greatly increase in size, and descend much lower into the valleys.

In conclusion, it remains to notice the destruction of animal life caused by this unusual snow-fall. In the upper Wardwan valley I was told by some European travellers that they had several times seen numbers of Ibex embedded in the snow; in one place upwards of sixty heads were counted, and in another the number of carcases was estimated by my informant as little short of one hundred. I myself twice saw some fifteen carcases of small Ibex embedded in the snow-drifts of the Tilail valley.

The most convincing proof, however, of the havoc caused among the wild animals by the great snow-fall, is the fact that scarcely any Ibex were seen during last summer, in those portions of the Wardwan and Tilail valleys, which are ordinarily considered as sure finds. Near saline springs in the latter valley, Ibex are always to be found in the later summer, but this year I only heard of one solitary buck, probably the sole survivor of a herd, having been seen at these salt-licks. The native shikaris say that almost all the Ibex have either been killed by the snow, or have migrated into Skardo where the snow-fall was less.

The Red-Bear *(Ursus isabellinus)* was also far less numerous during the past summer than in ordinary seasons, and the shikaris say that numbers of them have perished, owing to their winter quarters having been snowed up so long that the occupants perished from hunger.

The same explanation will probably account for the fact that in the higher regions I found many of the marmot burrows deserted.

Much has been said lately as to the destruction inflicted on the game of the Kashmir Himalaya by the rifle of the European sportsmen, but I think that the destruction caused by the snow of the past winter has far exceeded any slaughter which would be inflicted by sportsmen during a period of at least five or six years.

XV.—*Physiographical Notes &c. on Tanjore (Tanjá-úr).—By* Lieutenant-Colonel B. R. Branfill, *Deputy Superintendent, Great Trigonometrical Branch, Survey of India,—Communicated by* Colonel J. T. Walker, C. B., R. E., *Surveyor-General of India.*

The Tanjore district of the Madras Presidency is nearly contained within an equilateral triangle of 75 to 80 miles on each side, on the Coromandel coast (Chóramandal = Chólan's region) immediately south of the river Kolladam (*Anglice* "Coleroon"), which is the north and north-west boundary, running S. W. by W. 75 miles inland from the river mouth. The Bay of Bengal forms the east side, running from the same point nearly 75 miles due south to Point Calimere (Kalliméd). The third side is an irregular line of much the same length from Point Calimere to the "Cauvery" (Kávéri and Kolladam) 10 miles east of Trichinopoly (Trisirápalli). This triangular area contains about 3,000 square miles, two thirds of which is Kávéri delta, and two thirds of this portion, or about 1,400 square miles is irrigated, and there is scarcely another acre of it that could be profitably brought under irrigation. In addition to this, some 650 square miles of undulating country, running 40 miles to the southward along the shore of Palk's Bay to the Pámbanár, the border of Shivagangai Zamindári estate (Madura District), and extending 12 to 20 miles inland, also belongs to Tanjore. But the scope of these notes does not embrace more than the deltaic portion of Tanjore, the country to the south having been traversed the previous season, and reported on.

Although there are several places named "hill" (malai), or "mound" (méḍu), there is nothing at all worthy to be called a hill, except the *dunes* or sand hillocks along the sea-board, the height of which (at Negapatam) barely attains an elevation of 50 feet above sea level, and a few insignificant sand-drifts in the E. N. E. corner of the delta, near the mouth of the Kollaḍam river.

The whole delta consists of an even plain of alluvial deposit containing a comparatively large proportion of sand and having a good slope of 3 or 4 feet per mile. The fall, however, decreases as the coast is neared to 2 feet per mile or less. The following particulars of slope are from the railway levels of the South India Railway, according to which the bed of the Káveri for nearly one hundred miles, from Karúr to within 30 miles of the present coast line, has a pretty even fall of near 4 feet a mile. The next 10 miles the gradient decreases to about 3 feet per mile, and the next to within 10 miles of the coast to 2 feet per mile.

Continuing the examination of the declivity (by means of the recent Government Hydrographic or Marine Charts), the fall of the ground out at sea beyond the coast line increases in the first fourteen miles to 5 or 6 feet per mile, to 8 or 9 feet per mile for the next nine miles, to 24 feet per mile for the next six, and to 38 feet per mile for the last ten miles examined up to 37 miles from the coast. This rapid deepening of the sea is a noticeable fact, but it seems only natural if the present coast line is of purely fluviatile formation.

The character of the alluvium alters and generally deteriorates in fertility as the distance from the head sluices of the Káveri channels increases. It varies from a rich red or black loam to a pale sandy clay, the sand increasing and the clay diminishing from west to east, and but for the annual fertilizing floods would be anything but rich and productive. Without artificial manure the land usually bears but one crop yearly.

The sea-board flats are usually well raised above sea-level, and further protected from high tides and storm waves by a high sand-ridge along the coast. Cyclones have been frequent on the coast, but have not made the great devastating inroads they appear to have made elsewhere on the coast. The formation of this coast-ridge or sea-wall appears to be explained by the strong sea breezes which prevail in the hot and dry season, and, blowing strongest at the hottest part of the day, when the sand of the sea beach is driest and most easily raised, continually drift it up inland to accumulate under the shelter of the coast vegetation.

It is thus formed into a ridge, or line of hillocks, parallel to the shore-line at the inner and upper edge of the beach, frequently standing at a steep slope on both sea-ward and land-ward sides. The blown sand does not appear to extend far inland, being kept down by the fringe of palms and other vegetation that usually grows near the coast. This advanced vegetation equally protects the sand-ridge from being blown down again and out to sea in the violent westerly winds of the south-west monsoon.

This coast sand-ridge is a common feature on the coasts of Southern India, and it seems likely that the devastating storm-waves which have visited the coast have only or chiefly destroyed the towns and villages that were unprotected by it, such as those most conveniently situated for trade at the mouth of a river or inlet, and those opposite to a muddy coast line where there is no sand that will drift. In such places (in the number of which Madras may be included), it would be prudent to raise an artificial wall or 'levée'; a small price to pay for immunity from such a calamity as befel Masulipatam in 1864, when many thousands of persons* perished miserably, and such as has probably swept out of existence many a flourishing port on the Coromandel Coast.

As to whether the coast line of the Kávéri delta is altering, it may be well to consider the elements of change at work. We notice first the silt-bearing floods of the autumnal rains, which are doubtless yearly raising the level of the land generally and tending to make it encroach on the sea, extending the coast line eastwards and shoaling the sea-bed, a slow but unceasing process, albeit the effects may seem to wax and wane and even to contradict what must inevitably occur sooner or later. The process of new land-formation may be much slower now than it was before the great irrigation works were begun, but so long as fresh silt is brought down by the annual floods, it cannot cease altogether. The heaviest grains are dropped first as the current slackens, whilst the lightest are carried on until the river current is lost in the quiet depths of the open sea.

The next element of change is the wind, which acts both directly and indirectly and in various ways. First, there is the north-east monsoon (wind), acting indirectly by means of the southward, long-shore current which carries the silt-bearing floods more or less down the coast, and so to deposit their heaviest burden to the south of the river outlets, thus commencing the sand-banks which help to shift the river mouth northwards. This wind cannot act directly on the shore sand to the north of

* 30,000 persons are stated to have perished in one night.

the river mouths, because the sand is then moist from the recent autumnal rains, the heaviest rain of the year, and therefore unmoved. But the southward set of the rollers and beat of the surf must tend to drift the shore-sand loosened by its violence, southward across the river mouths, which it shoals, helping to form the bar of sand-banks and islands usually formed in such situations.

In January and February the north-east monsoon (wind) gradually changes into land and sea breezes, which increase as the spring advances with clear weather and a hotter sun. The sand of the sea-shore rapidly dries and is drifted by the sea-breezes to the top of its slope, as long as there is loose sand to drift and nothing to shelter it.

The sea-breezes veer gradually to the south-east and southward until in May they become strong '*long-shore*' winds from the south, directly transporting northward much of the blown sand collected along the coast-ridge, in clouds of dust which settles in the hollows and tends to fill up and choke the southern edges of the river out-falls and so to shift them northwards.

With the change of wind from the north-east in January to south-east and south in April and May, the 'long-shore' current changes from south to north, latterly running rapidly northwards and bringing in the heavy sea-rollers obliquely to the coast from the south-east, to dash in lines of roaring surf on the shore, washing the sand of the beach northwards at every stroke. This double action it is (perhaps chiefly) that drives the river mouths northwards.

Whether this is the right explanation or not, the fact remains that the mouths of the rivers of the Coromandel Coast are continually shifting northwards.

This is seen best in the Mahánadi and Kávéri; also in the Pennér (Pináka), Nagari river, Kordaliyár, Kú-am, Pálár and Vaigai.

It is less noticeable in the Gódávéri, Vellár, and Támraparani. The Kistna seems to contradict this tendency, and the Gódávéri also has one outlet apparently to the south of its delta, but these apparent exceptions probably admit of some explanation. On the west coast, the Nétrávati exhibits a similar tendency to make its outlet into the sea considerably north of the spot it seems to be going to, as it approaches the coast. The northward shifting of the Nétrávati mouth is probably due to the northward set of the current, and the violent beat of the breakers during the south-west monsoon, which has nothing to counter-balance it. It seems probable that where the beach is sandy, the same tendency of the river-mouths to shift northwards may be observed in Ceylon.

After shifting for an indefinite period to the north, during which it seems probable that the bed of the river must be silting up, especially near the outfall where the current is less, some unusually high flood may be expected to top the bank and thus form a new outlet to the south. This may possibly occur near the head of the delta, and the new channel may take its course along the southern edge or border and recommence the process of shifting its mouth northward again. This may be the explanation of the Kistna apparently flowing along the southern border of its delta ; it also points to a possibility of the Kávéri doing the same thing some day.

When a river has opened a new mouth and abandoned the whole or a portion of its course, especially that which ran parallel to the coast, it seems only likely that a lagoon or *back-water* will be formed, which will sooner or later silt up and eventually be reclaimed entirely from the sea.

Having thus considered the causes of the northward shifting of the river mouths on the Coromandel Coast, to which the Kávéri has been subject continually during the formation of its delta, to the east of Trichinopoly, the probable history of its more recent inland course offers itself for consideration.

Dr. Burnell of the Madras Civil Service states he has met with no mention of the Kollaḍam (Coleroon), which is now the principal bed of the lower Kávéri, by the early geographers, and thinks that the channel which passes by Kumbakónam and Máyaveram and enters the sea at Kávéri-paṭṭanam, having retained the name of Kávéri throughout its course, was the main channel of the river till the 10th or 12th century.

From Ptolemy's map of the Coast of India, it would appear that 1,500 to 2,000 years ago, there was a spit of land jutting out into the sea at the Kávéri mouth near "*Chaberis Emporium*" (Kávéri-paṭṭanam), of which there is now no trace, either above or below the sea-level contour line.

Such a spit or shoal would, however, naturally disappear if the river mouth shifted, or if any thing stopped the deposition of silt which formed it, and this must have happened when the great irrigation works at the head of the delta were constructed.

At present the Kávéri-paṭṭanam mouth of the Kávéri is nearly silted up, and the principal outlet of the surplus flood-water is now by the mouth of the Kolladam, where, according to recent maps, a new deltaic projection and shoal are forming.

The great irrigation works are supposed to have been constructed in the 10th and 12th centuries, but local traditions represent them as early as the year 200 A. D. In any case, the delta has been under irrigation from time immemorial. The story of the Kávéri main channel would seem to be somewhat thus :—After some long period of silting up from the deposit left by the annual floods, the river in some unusual inundation must have overflowed its banks and found a new and easier course.

This diversion may have occurred either above or below what is now the island of Srírangam, lying like a sand-bank in mid-river. If it occurred above, it seems likely that the new channel or northern branch (the Kolladam*), soon became the deeper bed of the two, and then either approached and threatened, or actually breached the north bank of the southern or old Kávéri branch below the island, and the 'grand anaikaṭ' (dam or weir), which is strictly a river-wall or 'levée', must have been built to prevent or repair a breach.

If, on the other hand, the breach or bifurcation occurred below Srírangam, the 'grand anaikaṭ' was probably made to repair it and keep the stream back in its own channel: but if so, the attempt was ineffectual, for the river must have then formed a new bed for itself, some miles higher up the channel, at a point nearly opposite a place marked on the map (Indian Atlas, Sheet 79) as 'Palaya Cauvery' (Old Cauvery).

In either case, the northern channel, which flows along the left or northern border of the delta, and immediately under the gravel up-lands of north-east Trichinopoly, became the deeper and wider one, carrying off the high floods, whilst the south or old Kávéri branch, kept at a higher level with impeded stream and checked by numerous irrigation works, gradually silted up and threatened to leave Tanjore unwatered, for the bed of the Kolladam was too deep to admit of irrigation channels being profitably led from it. The difference of level of the two beds at the grand anaikat is variously stated to have been from 10 feet to 20 feet early in this (19th) century and to be rapidly increasing.

In this state the British Government took charge of the district and, after trying many other expedients to save and restore the Kávéri irrigation, in 1836 constructed first the upper anaikaṭ, a weir or dam across the head of the northern branch or Kolladam, in order to raise the stream, so as to flow into the Kávéri Proper or southern branch. This proved more than sufficient in times of high floods, and there was danger of overwhelming Tanjore by a sudden inundation from pouring in an excessive supply. To remedy this, sluices were formed in the 'grand anaikaṭ' to provide an escape for the sand and surplus water that was not wanted, and finally a head-sluice or regulating dam was made across the Kávéri channel where it enters the delta, below the 'grand anaikaṭ,' thus giving the means of regulating the supply as desired.

The Kávéri proper continues its course through the delta with a

* ? Kolai-(y)-iḍam = 'Slaughter place', from a legend that men were cast into a chasm through which the Kávéri had disappeared, in order to fill it up; a story that looks as if a human sacrifice had been performed at the repair or filling up of a great breach. Kolláyi = a breach in a bank (Gundert). Another suggests Kilai-y-iḍam = 'bifurcation-place', from kilai, a branch, bifurcation &c.

continually diminished stream, giving off numerous supply channels all the way to the Coast, when little stream remains to enter the sea at Kávéri-paṭṭanam or Kílúr ('*East-bourne*').

There is no projection beyond the normal (north and south) line of the coast here, nor any spit or shoal to witness to any old projection of the river mouth, nor do the Marine Chart soundings indicate anything of the kind. That the diminished stream flows in its old bed, is proved by the name of the channel and the port at its outlet, and also by the traditions at the places on its course, Kumbakónam, Máyaveram &c., where the sanctity of the Kávéri water is still highly esteemed.

The other and now chief branch, the Kollaḍam, takes a north-easterly course, keeping more and more to the northward along the low ground that probably existed on the north edge of the Kávéri delta, and has, by its rapidity and volume, made for itself a deep and wide bed, too deep below the surface of the country to allow of irrigation channels being led from it, and in most places three-quarters of a mile in width. To utilize the surplus water escaping to the sea by this channel, the 'Coleroon lower anaikaṭ'* was built, to supply the Máyaveram and Shi-yáli Táluks of N. E. Tanjore, and the Chidambaram ('Chilambram') Táluk of South Arcot.

The water overflowing the final anaikaṭ flows with a greatly retarded current and in a very tortuous course along the last few miles before it enters the sea near Dívu-kóṭai ('*Isle-fort*', the "Devikotta" of Atlas Sheet No. 79), the name of which indicates, that it was on an island when first named (tívu being the Tamil form of the Sanskrit dvípa, *an island)*.

Notwithstanding published statements to the contrary, it appears that sand-banks are still forming at the mouth of the Kollaḍam, and the Marine Chart of the coast gives the position of a shoal called the "Coleroon shoal," whence Porto Novo, or Muhammad (? Mahmúd) Bandar, seems likely to be left far inland in course of time.

The direction of the Kollaḍam bed being more north and south than that of the so called S. W. monsoon wind—of which fact, there is ample proof in the permanent eastward set of the stems, twigs and branches of the trees exposed to it—the fine blown sand of the river bed in the dry and hot season (April and May), is drifted up into heaps and lines along the southern or right bank of the river, tending to form a natural river wall there and to keep the stream nearer to the northern bank.

The Kávéri delta is only about 10 miles in width at Tanjore and it is flanked by comparatively high ground, composed of previous sedimentary formation, stratified beds of laterite, conglomerate and mottled grit, with quartz pebbles mixed, through which the river first cut its way, whilst depositing the material of its present delta.

* Locally "Anaikarai" or Dam-bank.

There are some 50 or 60 different river channels, by which the Káveri water is distributed for irrigation, or for drainage over the whole extent of the delta, the names of which being mostly derived from those of reigning princes, should throw some light upon the history of the country, for there are representatives of the old Pándiyan and Chólan dynasties, who reigned before the 16th century, as well as of the Telugu Nayakans who superseded them, and possibly also of the Mahrattas whom the British Government succeeded. There are thirteen tidal mouths of the Káveri that enter the sea and are more or less navigable for small boats.

There has been little change in the principal river channels of late years, due in a great measure to the conservative measures adopted under the British Government, and to the great regulating works, constructed for keeping the floods under control. There must be a tendency for the channels to silt up, as well as for the whole of the irrigated part of the delta to rise, but there seems to be no apprehension at present of danger to the province from this source.

Near the coast, and more particularly at the south-east corner of the delta, towards Point Calimere (Kalliméd), there are extensive salt-swamps, with patches of jungle and desert.

The Kóḍikarai salt-marsh covers nearly 100 square miles, being about 20 miles long east and west, and 5 miles wide north and south. It is used as a vast salt-pan under Government supervision. The two highest spring tides of May and June (called by the natives 'Chittrai Parvam', '*full-moon of April and May*', and Visákha Vellam, '*May—June flood*') overflow the sea-wall and fill the swamp with brine, which is, in favourable seasons, soon crystallized under the evaporation from the sun and the dry west winds. The south-east and southerly breezes that prevail in May, probably combine to make the spring tides of this season unusually high.

A considerable degree of sanctity is locally attributed to Védáranyam, ('*Véda-forest*') and to Kóḍikarai ('*Promontory-shore*') from a tradition that here, as subsequently, at the Rámésvaram promontory, the mythic hero Ráma tried to make a causeway to Lanka, Ceylon. There is now daily postal communication by open boat, between India and Ceylon at this place.

An impression exists that this sea, Palks Straits and Bay, is silting up, but this process must be exceedingly slow, inasmuch as no large rivers now discharge any large proportion of their silt into this receptacle. The Vaigai (? Veghavati) outlet scarcely ever discharges, and as more irrigation works are introduced, this proportion must diminish.

Still this is to a great extent an inland sea surrounded by a sandy shore from which the land-breezes and strong southerly and westerly winds must bear some drift to deposit. Moreover, the northward beat of the surf along the north-east Coast of Ceylon from April to September, and the southward beat along the east Coast of Tanjore from November to January, must tend more or less to shoal the entrance to Palk's Bay from the Bay of Bengal.

This sea was known to the old geographers as *Sinus Argaricus* (Colonel Yule's map of ancient India has *Sinus Argalicus* for Palk's Bay, and a town marked at the mouth of the Vaigai named "Argari? Argalu? Marallo? (Maravár)"; I would venture to suggest that the sea may very likely have been so named from *Anaikarai, The barrier, cross-bank* or *dam-bank*, by which term the great natural 'bund' or causeway, Adam's bridge, between India and Ceylon was probably known. The early Arabian voyagers knew it as (and thence called the country beyond it) 'Ma,abar', *i. e., The ford, ferry* or *passage*. I understand, however, that the name appears in Ptolemy as Αγχειρουπόλις (? *Anakarai-town*) from which the Bay may have been called, and, if so, this town may have been the old town now called A'ttankarai (from A'ru a *river*, and Karai a *bank, shore*) situated at the old mouth of the Vaigai river.

It is an interesting question whether the line of sand-banks and islets forming 'Adam's bridge', between Rámésvaram and Mannár, is undergoing any permanent change. I could learn nothing reliable on the subject when I was there in 1874, '75 and '76, but it can scarcely be at a perfect stand-still. On the one hand, there appear to be traditions that at one time it was possible to walk across at low water dry shod, but I could not learn that this had actually occurred within modern historic times. On the other hand, it would appear that there was a considerable trade carried on between Arabia and China through these Straits, and one would hardly suppose that it could have been carried on in such small vessels as can alone have passed through the passages in "Adam's bridge" previous to the excavation of the Pámban channel by the British Government, unless there were passages that have silted up since. Dr. Burnell tells me, he has a reliable Portuguese MS. of 1685, by a Captain J. Ribeiro, stating that there was then "no passage, except two narrow canals, one by Ramanacor and the other by Manar"; and that "a small 'sumaca' only can pass by either at high water."

At the present time, there is a single channel at Mannár answering this description, and none elsewhere, except the new passage at Pámban, which has been cut artificially through the rocky reef at a place where in quite recent times, the old built-stone causeway had been breached by storm-waves (in 1484 and since) which also destroyed the adjacent town on the spit of land west of Pámban between Tóni-turai and Vettilai Mandapam.

The surf beats heavily all along "Adam's bridge" during both monsoons, and a strong current sets constantly the same way as the wind; at other times the current varies with the tide, and one would suppose that no sand-banks could withstand the violence of the wash over them at every change of tide. Still the islets and sand-banks do remain as a whole, albeit probably in a state of frequent change individually. But the growth of coral is active here, and new islets are said to be forming where there were none, and old ones increasing.

The blown sand too, seems to have some effective element of conglomeration in it, by which sand-stone is forming constantly. If, however, the available waterway is curtailed by new islets and sand-banks, it would appear likely, that the passage between them must probably become deeper by the increased violence of the water that has to pass. It seems therefore likely, that the land may gain superficially on the sea in Palk's Straits, but equally so that some of the channels may remain as deep as hitherto, or possibly become even deeper for an indefinite time to come.

Tanjore appears to have been occupied from very early times by Tamil people, over whom the Chólan or Sóran dynasty held sway for many centuries prior to the 16th century, and their country was known as the "Chóramandalam" (whence Coromandel).

The Chólan capital was at different times at Kánchipuram (Conjeveram); at U'raiyúr, near Trichinopoly; at Tanjore; at Kumbakónam and other places.

The Telugu Nayaks succeeded the Chólan kingdom and ruled in Tanjore for more than a century up to 1675, when the Mahratta princes superseded them, and ruled till they were superseded by the British Government.

The Chólan rulers seem to have done most good for the country by elaborating the extensive system of irrigation, to which the present Government has added little but restorative, conservative and regulating works, of the greatest value no doubt, but no fresh channels have been made. They also built many of the great Hindu Temples, of which there are no less than 3,000 in Tanjore, and their endowments still remain, but the management of many of these is in a deplorable state of neglect, and the temples fast going to ruin. Witness Tirupálturai, Gangaikandapuram, Mannárguḍi and others.

The Nayakan rulers also have left their mark on the country in the numerous Mandapams (open temple halls), Chattrams, (native alms, and rest-houses) and many other buildings, showing their peculiar Indo-Moorish style of architecture, having vaulted roofs and pointed arches, the best specimen of which that I have seen is the palace of Tirumala Nayak at Madura, built about 1650.

A very noticeable fact in the Tanjore delta is the comparative scarcity of forts and fortified towns. The inhabitants appear to me to be unusually and seriously industrious, and to have a smaller admixture of the warlike classes than any of the South-Indian districts I have passed through. They have been habituated to agriculture for so long that the vice of war has died out, and the people seem too busy and well off to revive it.

The Nayaks do not seem to have introduced many immigrants of Telugu race ; the neighbouring warlike tribes of Kallans and Maravans are also absent from the deltaic part of the country, and the pastoral tribes are only found in the more forested tracts beyond the delta.

It is stated that with the exception of a short experience of Muhammadan rule under Haidar 'Ali (in 1780), there is no record of the country having suffered from famine, although food prices have risen very high during the prevalence of famine in adjacent districts.

There is one patent reason for the country not having been harassed by fire and sword, which is, that it was impassable for troops, or could be easily made so, for half the year or more, and *that* in the cool and fine season of autumn and winter, when the rice-fields are all under water. Besides this, there were no made roads in the delta fit for wheeled traffic, except in the dry season. Pack cattle are much used even now.

The irrigated part of the country is now well supplied with raised roads, but even these for the most part are almost useless for any large amount of wheel traffic in the wet season, because they are unmetalled, or only metalled with the ordinary river sand from the channels : and it appears marvellous how a thriving population can be content to pass several months confined to their villages as it were in islands, surrounded by a sea of deep mud, with only doubtful pathways for communication along the narrow and irregular banks dividing the rice-fields. The river channels, when in flood, are not commonly used for communication or traffic. The British Government made some of the channels navigable by means of locks &c., but these have become completely disused, and replaced by railways.

The climate of the Kávéri delta is mild and moist, compared with that of the adjacent districts, due no doubt to its situation on the coast and the great spread of irrigation water. The annual course of the weather is somewhat thus :—

During January the weather is cool and fine with fresh north-east breezes.

In February the wind is lighter and more easterly. Heavy fogs are common night and morning, succeeded by hot days. The rice crop is cut and the country quickly drains dry.

In March, April and May the wind is variable. Near the coast, land and sea-breezes prevail. The hot weather sets in, fields become bare and parched, and the heat increases greatly. Latterly, southerly and south-westerly winds set in, and occasional thunder-storms occur to clear and cool the air, and an occasional partial 'fresh' comes down the Kávéri channels.

In June, strong westerly winds prevail with much dust and dry heat.

In July, August and September, the river channels fill from the south-west monsoon rain on the western ghâts, also from occasional local falls of rain. Early rice cultivation begins, and the westerly winds gradually fall, to be succeeded by calms and variable winds.

In October and November, the wind sets in from the north-east, and heavy falls of rain occur, the temperature falls considerably, and rice cultivation is carried on to the utmost extent.

In December, the weather becomes fine and the wind more steady from the north-east.

The population of Tanjore is dense, being nearly 2,000,000 for an area of 3,700 square miles, giving an average of 540 per square mile, but it amounts, in the richer parts, to 1,000 per square mile. It is composed chiefly (two thirds) of Hinduized local tribes and one third of settlers.

Gross Number.		Caste or Race.	No.	Employment.
1,804,000	1,200,000 Hindus of local descent.	Vanniyan (Kallar ?).	574,000	Labourers.
		Paraiyan (Pallar ? &c.)	350,000	Menials.
		Sambadavan.	118,000	Fishermen.
		Idaiyans, Sánán, &c.	158,000	Herdsmen, potters, washers, &c.
	604,000 Immigrants.	Vellálan.	348,000	Cultivators.
		Brahman.	127,000	Land and house-owners, scholars, idlers, &c.
		Chetti, &c.	129,000	Weavers, artificers, merchants, &c.
103,000	Muhammadans, principally Labbé.			Trade, horticulture, &c.
66,000	Christians.			
1,000	Others.			
Total, 1,974,000				

There are said to be no wild or aboriginal tribes in the district.

Although the famine was scarcely over, in the beginning of 1878 there were no signs of distress visible, but all the people seemed well off. On the contrary, the upper classes seemed to be all the wealthier. Bricks were being made and burnt everywhere. New houses and buildings were being erected, and the effect of the famine appears only to have enriched the dwellers in this land of rice-fields. The labouring population being paid in grain as usual, the high prices prevailing elsewhere did not affect them.

XVI.—*On the proper relative Sectional Areas for Copper and Iron Lightning Rods.—By* R. S. Brough.

So far as mere conductivity is concerned, a comparatively thin wire of either copper or iron would suffice for the loftiest building ; but such a thin conductor would be dangerous, because it would be fused by a heavy discharge of lightning.

Now the problem is to determine what relative sectional areas should be given to copper and iron rods, in order that neither should be more liable to fusion than the other.

The usual answer given, is, that an iron rod should have 4 times the sectional area of a copper rod.* This result is, I suppose, arrived at in the following way. The conductivity of copper is about 6 times as great as that of iron, but the melting point of iron is about 50 per cent. higher than that of copper, therefore $\frac{6 \cdot 0}{1 \cdot 5} = 4$, is the ratio for the sectional area of iron to copper.

This simple treatment of the problem, however, is incomplete, because it neglects to take three most important factors into consideration, namely, (1) the influence of the rise of temperature in increasing the electrical resistance of the metal, (2) the difference between the "thermal capacity" or "specific heat" of copper and iron, and (3) the fact that the iron rod being made several times more massive than the copper rod, it will require a proportionately greater quantity of heat to increase its temperature. These omissions introduce an enormous error in the result.

The effect of the passage of a discharge of lightning through the rod will be to raise its temperature.

The temperature (T) to which a given length of the rod will be raised will depend on

(1) The quantity of heat developed by the discharge.

(2) The mass of the rod.

(3) The "Specific heat" σ of the metal composing the rod.

This may be expressed mathematically as follows :

$$T = \text{Const.} \frac{H}{\sigma \, m}$$

where m is the mass of the unit length of the rod, which we shall assume to be uniform in sectional area throughout its length, and H is the quantity of heat developed by the discharge.

* War Office Memorandum by Sir Fred. Chapman, R. E.

We may take $\sigma = 0{\cdot}1013$ for copper, and $= 0{\cdot}1218$ for iron. These figures were only verified by Dulong and Petit up to 300° C. It is probable, however, that their ratio, with which we are only here concerned, would not greatly alter at higher temperatures. At any rate, comparing the specific heat between 0° and 100° C, with that between 0° and 300° C, we infer that any alteration would be in favour of iron, *i. e.*, that the specific heat of iron would increase in a quicker ratio than that of copper.

Adopting the centimetre as the unit of length, the mass of one centimetre of the rod $= \rho$ a, where a is the sectional area of the rod in square centimetres, and $\rho = 8{\cdot}9$ for copper and $= 7{\cdot}8$ for iron.

Further, assuming the quantity and duration of the discharge to be constants, $H = \text{Const.} \times R$, where R is the resistance of the unit length of the conductor.

But $R = \frac{\lambda}{a}$, where λ is the specific resistance of the metal per cubic centimetre at its temperature of fusion.

We may take the melting point of copper as 1400° C, and that of wrought iron as 2000° C* ; and, in order to find λ assume that Dr. William Siemens's formula, which he verified to 1000° C, holds good,† viz.—

$$\left.\begin{array}{l} \lambda\, t = \lambda_0\,(0{\cdot}026577\, t^{\frac{1}{2}} + 0{\cdot}0031443\, t - 0{\cdot}29751) \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{for copper} \\ \lambda\, t = \lambda_0\,(0{\cdot}072545\, t^{\frac{1}{2}} + 0{\cdot}0138133\, t - 1{\cdot}23971) \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{for iron} \end{array}\right\}$$

The temperature t in these formulæ is to be measured from the absolute zero, so that we have $t = 1673$ for copper, and $t = 2273$ for iron.

The value of λ_0 per cubic centimetre of copper is 1·652 Microhms, and per cubic centimetre of iron is 9·827 Microhms.‡

Thus the value of $\lambda\, t$ per cubic centimetre of copper becomes 10 Microhms at 1673° C, and per cubic centimetre of iron becomes 107 Microhms at 2273° C.

$$\left.\begin{array}{ll} \text{Hence } H = \text{Const. } \dfrac{10}{a} \text{ for copper} \\ \text{and} \quad H = \text{Const. } \dfrac{107}{A} \text{ for iron} \end{array}\right\}$$

* Rankine's Tables.

† Bakerian Lecture, 1871.

‡ Jenkin's Cantor Lectures, from Mathiessen's experiments.

Therefore $T = \text{Const.}\ \dfrac{10}{0{\cdot}1013 \times 8{\cdot}9 \times a^2}$ for copper

and $T = \text{Const.}\ \dfrac{107}{0{\cdot}1218 \times 7{\cdot}8 \times A^2}$ for iron

Thus $T = \text{Const.}\ \dfrac{11{\cdot}09}{a^2}$ for copper

and $T = \text{Const.}\ \dfrac{112{\cdot}63}{A^2}$ for iron

Now putting T = the temperature of fusion in each case

$$1400 = \text{Const.}\ \frac{11{\cdot}09}{a^2} \text{ for copper}$$

$$2000 = \text{Const.}\ \frac{112{\cdot}63}{A^2} \text{ for iron}$$

$$\text{Therefore } \left(\frac{A}{a}\right)^2 = \frac{1400}{2000} \cdot \frac{112{\cdot}63}{11{\cdot}09}$$

$$= 0{\cdot}7 \times 10{\cdot}16$$

$$= 7{\cdot}112$$

Whence $A = 2{\cdot}7a$ about

$$= \frac{8}{3}\, a \text{ about}$$

or the sectional area of an iron rod should be to the sectional area of a copper rod in the ratio of 8 to 3.

XVII.—*Description of a New Homopterous Insect belonging to the Genus* Cosmoscarta.—*By* W. L. Distant. *Communicated by* J. Wood-Mason.

Cosmoscarta masoni, n. sp.

Pronotum stramineous, with a quadrate black spot on anterior margin; head luteous; tegmina, pectus, legs and abdomen shining black. Prosternum with lateral borders stramineous.

Face robustly tumid, transversely strigose, with a central impunctate longitudinal impression; eyes prominent, luteous; ocelli distinct, shining, situated at about an equal distance from each other as from eyes; basal portion of the head somewhat pitchy. Pronotum thickly and finely punctured, with the lateral margins dilated and strongly reflexed, the lateral angles produced prominently outwards, and the posterior margin rounded, the disc is prominently raised and convex, across the centre of which is a faint impunctate central longitudinal line. The frontal quadrate black patch contains a deep, angular, linear impression on each side behind the eyes, and two small rounded impressions on the posterior border.

Tegmina obscurely and finely punctured; wings dark fuscous with the nervures black. Hind tibiæ with a small spine towards apex.

♀. Long. ex. tegm. 17 mill. Exp. tegm. 45 mill.

Greatest long. pronot. $7\frac{1}{2}$ mill. Exp. lat. ang. pronot. 11 mill.

Habitat, Taoo, Tenasserim. Alt. 3—5000 ft.

The distinct colouration and more especially the peculiar structure of the pronotum, will serve to distinguish this fine species from any other of the genus. In the last respect its nearest allied form will be the *C. costalis*, Walk.*

This insect was contained in a collection of Tenasserim *Rhynchota* entrusted to me by Prof. Wood-Mason for determination. It is too soon to speak of their geographical affinities as a whole, but the genus *Cosmoscarta*, which was represented by two other species (*C. megamera* and *C. basinotata*), exhibits affinities which I believe will be shared by the other *Rhynchota* of this collection. *C. basinotata* has hitherto only been recorded from Borneo, and *C. megamera*, although found in N. India, has still been also received from Penang, Laos, and Hong-Kong.

* Stäl no doubt correctly places this form as only a variety of *C. proserpina*, White, a species I do not possess in its typical form.

XVIII.—*On the Indian Species of the Genus* Erinaceus.—*By* J. Anderson, M. D., *Supdt. Indian Museum, and Professor of Comparative Anatomy, Medical College.*

(Read 4th December, 1878.)

(With Plates III, IV, V and Va.)

Dr. Jerdon* recognized only two species of Indian Hedgehog, *viz.*, *Erinaceus collaris*, Gray, and *Erinaceus micropus*, Blyth, distinguishing the former as the North Indian and the latter as the South Indian hedgehog. But besides these, the following supposed species had either been described or indicated as belonging to the Indian and Himalayan fauna, before the publication of Jerdon's work. They were as follows, according to priority, *viz.*, *E. spatangus*, Bennett,† *E. grayi*, Bennett‡ *E. mentalis*, Gray§ (not described) and finally *E. nudiventris*, Horsfield.‖ The two first of these were stated by Bennett to be from the Himalayas, while Gray recorded *E. mentalis* from India, and Horsfield *E. nudiventris* from Madras.

Dr. Jerdon doubtfully considered *E. grayi* as identical with *E. collaris*, and *E. spatangus* as the young of *E. grayi*, but he did not pass any opinion on the undescribed *E. mentalis*. In 1841, Wagner described a hedgehog under the name of *E. albiventris*,¶ and considered it as probably of Indian origin. On the strength of this opinion Jerdon was disposed to regard it as possibly *E. micropus*. Dr. Peters, however, very kindly arranged with the authorities of the Museum at Munich that the type of *E. albiventer* should be sent to him for comparison with a specimen forwarded to him by me, and which I then believed to be *E. micropus*, but which now proves to be a nearly allied species named by Stoliczka *E. pictus*.** This latter species, however, is so closely allied to *E. micropus*, in the structure of its feet, that the comparison instituted between its feet and those of *E. albiventer*, conclusively proves that the latter is a perfectly distinct form from both, as it only possesses 4 toes in the hind feet, whereas *E. micropus* and *E. pictus*, like all the other Indian species of hedgehogs, have 5 toes in the hind feet. Dr. Peters is of the opinion that *E. albiventer*, is probably the young of *E. heterodactylus*, Sundvl. from Africa.

* Mammals of India, 1867, p. 62.

† Proc. Zool. Soc. Lond. 1832, p. 123.

‡ l. c. p. 124.

§ List. Mamm. B. M. 1851, p. 81.

‖ Cat. Mamm. East. Ind. Co. Mus. 1851, p. 136.

¶ Schreber, Säugeth. Vol. (Supp.) 11, 1841, p. 22.

** Stoliczka, Journ. As. Soc. Beng., Vol. XLI, 1872, p. 223.

From the facts to be hereafter stated there can be no doubt but that these two species, *E. micropus* and *E. pictus* are perfectly distinct from each other, and from any other species of Indian hedgehog ever described.

It would also appear from what I have stated under *E. grayi*, that it is a well-defined species, and that it is probably the hedgehog which was figured by Gray from the Doab as *E. collaris*, but which was never described, and also that Dr. Jerdon was correct in regarding *E. spatangus* as the young of *E. grayi*, the latter term being the one that should be accepted for the species.

Dr. Gunther, to whom I am indebted for comparing the hedgehogs in the British Museum with certain specimens forwarded from the Indian Museum, informed me that the true relations of *E. mentalis* cannot be properly determined. I regret, however, that having mislaid Dr. Gunther's notes, I am unable to give the details of his comparisons.

I have personally examined the type of *E. nudiventris* which is a very young example of *E. micropus*.

Besides these three species, *E. micropus*, *E. pictus*, and *E. grayi*, the materials which have passed under my observation* have yielded two other apparently distinct species of hedgehog from Western India, and which I propose to name respectively *E. jerdoni*, and *E. blanfordi*, the distinctive characters of which are indicated hereafter. We have thus five species of hedgehog in India, three of which are forms which were unknown when Fitzinger† published his compilation on the *Erinaceidæ* in which he recognized *E. grayi*, *E. collaris*, *E. spatangus*, *E. mentalis*, *E. nudiventris* and *E. micropus*, referring them all to a trivial sub-genus *Hemiechinus*.

The hedgehogs of India are referable to two distinct groups, based on the characters of the dentition. *E. micropus* and *E. pictus* resemble each other in the following dental detail, wherein they differ from the other Indian hedgehogs, but whether any of the African forms are like them in this respect I am unable to say. The character I refer to is this, that the second upper premolar has a simple crown and only one fang, whereas *E. grayi*, *E. jerdoni*, *E. blanfordi*, *E. macracanthus*, *E. niger*,‡ *E. megalotis*, *E. auritus*, *E. albubus*, and *E. europæus*, have the same tooth large with a compound crown and with 3 fangs. In both the species, the second upper premolar is very small and somewhat external to the line of the other teeth. In *E. pictus*, the tooth would appear to be generally present throughout life, and it is larger than in *E. micropus*, in which it seems to be generally lost at an early age. In hedgehogs with a compound second premolar, the tooth is

* I am specially indebted to Mr. W. T. Blanford for his having placed his fine series of Indian hedgehogs, preserved in alcohol, at my disposal for examination.

† Sitzgsber. Ak. Wiss. Wien. LVI. 1867, pp. 844, 890.

‡ For description of this species see following pages (p. 212).

always in the line of the other teeth and always large and is never prematurely shed.

The first premolar also of the lower jaw is relatively smaller than in the species just enumerated, and it is smaller in *E. micropus* than in *E. pictus*.

There is a remarkable circumstance connected with *E. micropus*. In examining the different species of Indian hedgehogs, I was in the habit of having their skulls removed and cleaned for examination, and in having this done with *E. micropus* I was always disappointed on receiving back the skulls from the osteologist to find what I supposed was a broken zygomatic arch, owing to careless manipulation. The Museum osteologist, however, persisting in asserting that he was most careful in preparing the skulls, and that he had not injured them, I had a careful dissection made from without inwards on to the zygomatic arch, and I was astonished to find that there was no trace of a malar bone in any specimens of *E. micropus* examined by me, 4 in all. This fresh dissection showed that the interval between the zygomatic process of the squamous and the malar process of the maxillary is bridged over by tendon, and that therefore this South Indian hedgehog stands alone in this remarkable feature. Such a variation on the normal structure of the skull of a hedgehog was not to be anticipated, as there is no weakening of the zygomatic arch in any of the other species. Even in the allied species *E. pictus*, the malar is strongly developed. An examination of the free ends of the process of the maxillæ and squamous shews that this observation is perfectly accurate, as there is no indication whatever of any specialized surface on which a malar could rest, and which is always easily observable in skulls of other species in which the malar has been lost.

Notwithstanding this anomalous character, I am disposed to attach more weight to the character of the second upper premolar in this species than to the absence of its malar, which is an intense specific variation, whereas the other which is common to two species very closely allied in other details of their structure would seem to be almost entitled to sub-generic rank.

These two forms, *E. micropus* and *E. pictus*, notwithstanding the foregoing difference in the skulls, are externally so alike that they might be mistaken for one another. Not only is their coloration almost identical, but the form of their heads is much the same; and more important, their fore feet more especially differ essentially in shape from the fore feet of all the other Asiatic species of hedgehogs (see figs. *e* and *f*, Pl. III, and compare with fig. *f*, Pl. IV). Both of these species are characterized by their feet being short, club-shaped, and tubercular on the soles, whereas in such forms as *E. grayi* and the other Asiatic hedgehogs, the feet are not club-shaped and tubercular, but moderately elongated with well-developed toes and generally long claws.

The feet of hedgehogs would appear to be the subject of considerable variation, as some have only 4 toes on the hind feet, (*Peröechinus* Fitzinger), and moreover the central pad of the hind feet would appear to be rudimentary in some species and to be present in others, while, as has just been shown, some of them have tubercular soles. It appears to me therefore that reliable specific characters are to be observed in the feet of the members of this genus, but I do not consider any of the variations to be of sub-generic value. As an illustration of the differences that subsist in this respect, it will be observed that the species *E. grayi* does not possess any true central pad on the hind foot, a structure which is largely developed in *E. jerdoni*, but nearly absent in *E. blanfordi*, which, as was to be expected from this circumstance, is closely allied to *E. grayi*.

Another feature in the structure of Indian hedgehogs is deserving of attention, and that is the presence on the vertex, in some species, of a considerable nude area quite devoid of spines, and even of the most rudimentary hairs. This naked area reaches forwards to where the spines arise on the forehead, dividing those on this region into two sets, one on either side of the head. It occurs in all the Indian species with the exception of *E. grayi* and *E. blanfordi*, and it is present also in *E. niger* and *E. macracanthus*, whereas it does not appear to exist in the European hedgehog and I have not observed it in any of the following species, *viz.*, *E. auritus*, *E. albulus*, and *E. megalotis*, all of which, however, like the Indian species, whether with or without this area, agree in having fine soft almost silky hair, very distinct from the long bristly hair that clothes the body of the European species.

In the Zoology of Persia* a small hedgehog is figured along with the type of *E. macracanthus*. Both of the specimens which yielded the figures are now in the Indian Museum and the latter is distinguished (*E. macracanthus*,) by this nude area and black spines with two white rings, and the former, which Blanford considered as a young specimen of the species, by the entire absence of the bare area and by yellowish spines of which the tips are white, followed by a narrow black ring succeeded by a white and this again by a short brown space. This small hedgehog in the character of its spines and in the absence of the bare area on the vertex resembles *E. megalotis*, but it does not appear to be that species. I am disposed to conclude that this bare area is of too great structural importance to be present or absent among members of a species and to consider it as of specific significance. With regard to the disposition of the spines it would appear that

* Zool. of Persia, Blanford, 1876, Pl. 1.

their relative positions to each other depend greatly on the condition of the *panniculus carnosus*, and that the spines only become irregularly intermixed through contractions of this muscle which, when relaxed, permits the spines to lie flat and regularly.

On the label of an example of *E. albulus*, collected by Stoliczka, he has written, "outer edge of nostrils ciliated." On looking at the nostril in all the Indian species of hedgehog, I find that the outer edge, more especially the upper crescentic half, is provided with a papillary valve which serves to close the orifice. In *E. grayi*, it forms a distinct fringe of 12 papillæ.

The spines of the Indian and Western Asiatic hedgehogs are grooved and ridged, the ridges being covered with fine tubercles. The numbers of the ridges on the spines of the same animal are subject to considerable variation, and the degree to which the tubercles are developed appears to vary, so that stable specific characters are not yielded by these structures.

The foregoing characters, therefore, permit of the Indian hedgehogs being resolved into the following groups, and of the species being recognized by the characters under which they are grouped.

A. Second upper premolar simple, one-fanged.

a. Feet club-shaped, soles tubercular.

I. A division or bare area on the vertex.

No malar bone: a prominent dark brown band through the eyes on to the neck. A white frontal band. Spines orange with apices white, succeeded by a narrow dark brown band. Ears moderate. Fur below white, limbs brown, ... *E. micropus.*

A perfect malar bone: a brown band through the eyes and only very rarely prolonged on to the neck, stopping at the angle of the mouth. Spines broadly white at apex, succeeding brown band rather pale: no orange tint on spines. Ears round and not large, but larger than in the preceding species. Limbs pale brown, under-surface white, ... *E. pictus.*

B. Second upper premolar compound, three-fanged.

b. Feet well developed and broad.

II. No division or bare area on the vertex.

No large mesial pad on the hind foot. Head elongated and muzzle long. Ears large, high and pointed. General colour dark brown,... *E. grayi.*

Mesial pad on the hind foot very feeble. Head short, muzzle not elongated. Ears moderately large, not high and not pointed. General colour black above, fuliginous-brown below, ... *E. blanfordi.*

III. A division on the vertex, separating the spines into two groups. Hind foot with a large prominent mesial pad. Muzzle moderately long. Ears large, rounded at the tip and broad at the base. Spines long with 2 white and 3 black bands in the adult. General colour black above and below, ... *E. jerdoni*.

The following is a description of these species in detail:

Erinaceus micropus. Plate V4.

Erinaceus auritus, Pearson, Journ. As. Soc. Bengal, Vol. V, 1836, p. 191.

Erinaceus collaris, Gray. List. Mam. B. M. 1843, p. 81, *partim*.

Erinaceus micropus, Blyth, Journal Asiatic Soc. Bengal, Vol. XV, 1846, p. 170, *partim*; *id. op. cit.* Vol. XXII, 1853, p. 582; *id.* Cat. Mam. Mus. As. Soc. Bengal, 1863, p. 80: Wagner, Schreber, Säugeth, Suppl. V, 1855, p. 591; Stoliczka, Journal Asiatic Soc. Bengal, Vol. XLI, 1872, p. 225.

Erinaceus nudiventris, Horsfield, Cat. Mam. East Ind. As. Mus., 1851, p. 136.

Erinaceus (Hemiechinus) micropus, Fitzinger, Sitzungbte. der K. Akad. Wissensch. Wien, Vol. LX, Pl. 1, 1867, p. 875, *partim*.

Head rather short, and broader than *E. pictus*, and slightly concave from the forehead to the tip of the snout. Ears moderately large and rounded at the tip, directed forwards and outwards, and slightly smaller than the ears of *E. pictus*. Feet well developed, but small, short and broad, with short toes and short claws: feet being somewhat larger than those of *E. pictus*. The first toe of the hind foot small, but claw strong. The soles of the hind feet more or less tubercular. When the muscle is not contracted over the forehead, the spines do not reach anterior to the front margin of the ears. There is a broad bare space passing backwards from the forehead for about one inch and a quarter, with a nearly uniform breadth of half an inch, and this bare area would appear to exist in both sexes of the species. The tail is short, and there is a semicircular bare area above it. The ears are moderately but sparingly clad with short whitish hairs, and the tail with longish dark brown hairs. The anterior third of the head, up to half way between the nose, the eye, and the chin appear to be nude, but they are very sparsely covered with minute white hairs. The middle third of the head is covered more profusely with longer hairs, and the posterior third, to between the ears, densely with moderately long hairs, increasing in length from before backwards. The upper surfaces of the feet are well clad with short flattened brown hairs. The bare surfaces on the head and above the tail are perfectly devoid of hairs. The under surface is not very thickly clad and the insides of the limbs are still less so. The spines are rather fine, about 0·83 of an inch long, very sharp and marked with from 17 to 22 ridges and furrows, the former generally broader than the latter, and covered with minute shining tubercles. The apex of each spine is white and is succeeded by a narrow dark brown band which gives a brown and white speckled appearance to the animal. The remainder of each spine is yellow or orange yellow. The seminude skin of the anterior third of the head is leaden-coloured, a hue that extends on to the chin. The hairs on the second or middle third of the head form a broad brown band which embraces the eye, passes backwards behind the angle of the mouth, over the under surface of the neck as a dark brown collar. A brown spot at the upper angle of the ear. A broad white band behind the brown band and the spines of the forehead, passing downwards before the ears on to the sides of the neck and throat, behind the brown band, and continuous with the white of the under parts; chin and whiskers white, and sides of chin brownish. The lower halves of the limbs clad with brown hairs, also the tail. The inguinal region and lower abdomen clad with brown hairs with an intermixture of white.

The leading features of this species are its short snout and head, short club-shaped feet as compared with *E. grayi*, *E. blanfordi*, and *E. jerdoni;* its slightly longer feet as compared with *E. pictus*, which are, however, of the same type; its not long ears, slightly shorter than in the latter; its white and brown tipped spines, orange or yellow; and a brown collar over the forehead, between the eyes, behind the angle of the mouth and across the throat.

The skull is distinguished by its short broad character, but in this respect it is much narrower than the skull of *E. pictus*. In the former, the breadth across the zygomata falls short considerably of two thirds of the length, whereas in *E. pictus*, breadth and sharpness are marked features of the skull, combined with a greater post-orbital contraction than in *E. micropus*, and, in the adult male, the breadth generally equals two thirds of the length. The complete absence of the malar bone is another character which separates it from *E. pictus*, from which it is also distinguished by the small size of its 2 upper premolars.

The following are some measurements of *E. micropus*.

	♂	♂	♂
Length of body and head, ...	6″ 65	6″ 05	5″ 90
,, of tail, ...	0″ 45	0″ 53	0″ 57
Height of ear,............................	1″ 15	1″ 05	1″ 02
Breadth of ear, ...	0″ 80	0″ 78	0″ 76
Snout to eye, ...	1″ 00	0″ 94	0″ 94
Eye to ear, ...	0″ 40	0″ 31	0″ 38
Length of hind foot without claw, ...	1″ 15	1″ 13	1″ 15
Breadth at 5th toe,........................	0″ 36	0″ 40	0″ 30

Blyth, in 1846,* in treating of the hedgehogs collected by Hutton near the Sutlej, pointed out that the third specimen described by Hutton,† with some doubt, under the name of *E. collaris*, Gray, was apparently distinct from that species. Blyth was disposed to regard it as identical with a hedgehog in the Asiatic Society's Museum, the locality of which he then stated was unknown, but which he afterwards considered‡ to have been received from the Nilgiris from Mr. Smoult and to be the specimen mentioned by Pearson as *E. auritus.* This latter specimen Blyth regarded as specifically identical with hedgehogs sent him from Southern India by Sir Walter Elliot, and with the hedgehog from Southern India in the British Museum grouped by Gray under *E. collaris.* He compared the skull of an adult specimen sent from Southern India by Sir Walter Elliot with the skull of Mr. Smoult's hedgehog and found them exactly to correspond, and these specimens he named *E. micropus*, the last mentioned being the type of the species. The skull, however, of Capt. Hutton's third specimen he goes on to remark "presents some differences; the general form is rather shorter and broader, it is more constricted between the orbits and the zygomæ are considerably more projecting; the small upper premolar anterior to the incisor teeth is less minute; and in the lower jaw, the second lateral pair of incisors from the front are much smaller, as indeed are also the next or last pair of the true incisors." From the description of this specimen which was obtained by Hutton§ in the neighbourhood of Shah Färíd on the left bank of the Sutlej, and from the details regarding the points wherein its skull differs from the skull of the Southern Indian hedgehog, I am disposed to consider, that Hutton's third specimen was an example of *E. pictus.* In 1853|| Blyth was still doubtful regarding the specific identity of Hutton's third specimen with *E. micropus.*

The next species, the cranial characters of which had been so well indicated by Blyth in 1846 and which entitle it to recognition, was described in 1872 by Stoliczka as *E. pictus*, but no reference was made to Blyth's observations, nor to the cranial and dental features of the animal. The characters selected by Dr. Stoliczka were exclusively external, and were derived from supposed differences existing between its spines and those of *E. micropus*, but after a very careful consideration of a large series of spines of both forms under the microscope, it appears to me that much importance cannot be attached to these structures as guides to species.

* Journ. As. Soc. Bengal, Vol. XV, p. 170; *op. cit.*, Vol. V, 1836, p. 191.

† *op. cit.*, Vol. XIV, p. 351.

‡ *op. cit.*, Vol. XXII, 1853, p. 582.

§ *op. cit.*, Vol. XIV, p. 351.

|| *op. cit.* Vol. XXII, 1853, p. 582.

Gray in his List of Mammalia* confounded this species with his *E. collaris*, = *E. grayi*.

E. micropus appears to be confined to Southern India, where it occurs in the low lying country and not on the mountains. Col. Beddome informs me that no hedgehog is found on the Nilgiris. The limits, however, of its northern and western distribution have yet to be ascertained.

ERINACEUS PICTUS. Plate III.

? *Erinaceus indicus*, Royle, Ill. Ind. Zool. 1839, p. 6, not described.

Erinaceus collaris ? Hutton, Journ. Asiatic Soc. Bengal, Vol. XIV, 1845, p. 351, 3rd specimen, *partim ;* Blyth, *l. c.* p. 352, foot note, *id. op. cit.*, Vol. XXII, 1853, p. 582, *partim.*

Erinaceus micropus, Blyth, Journ. Asiatic Soc. Vol. XV, 1846, p. 170, *partim.*

Erinaceus (*Hemiechinus*) *micropus*, Fitzinger, Sitzungsbte. der K. Akad. Wissensch. Wien, Vol. LVI, Pt. 1, 1867, p. 875, *partim.*

Erinaceus (*Hemiechinus*) *pictus*, Stoliczka, Journal Asiatic Soc. Bengal, Vol. XLI, 1872, p. 223.

Head (fig. *d*) the same as in *E. micropus*, but the ears (fig. *g*) somewhat larger, and the feet (*c* to *f*) narrower and not quite so long : the tail (fig. *h*) also is the same as in that species. The spines have the same characters as in *E. micropus*, but their tips are more broadly white and the brown bands below are not so dark. The result is that the latter are nearly obscured by the former. The remaining spines are pale yellowish, nearly white and not orange. There is no continuation of the brown band of the forehead lower than the angle of the mouth, except as a very rare circumstance, and in animals from the region of Central India, where the species probably meets the Southern *E. micropus*, but the colours in all other respects are alike. The dimensions of the species are these :

	♂	♂	♀	♀	♀
Length of head and body, ...	6″ 70	6″ 00	5″ 85	5″ 90	4″ 73
„ „ tail, ...	0″ 68	0″ 68	0″ 55	0″ 53	0″ 58
Height of ear, ...	1″ 33	1″ 23	1″ 03	1″ 21	0″ 85
Breadth of ear, ...	0″ 86	0″ 88	0″ 70	0″ 81	0″ 61
Snout to eye, ...	0″ 88	0″ 80	0″ 88	0″ 95	0″ 73
Eye to ear, ...	0″ 39	0″ 35	0″ 30	0″ 30	0″ 25
Length of hind foot without claw, ...	1″ 10	1″ 12	1″ 10	1″ 10	0″ 95
Breadth across 5th toe, ...	0″ 35	0″ 30	0″ 25	0″ 35	0″ 30

The skull (figs. *a* to *c*) is distinguished by its shortness and great zygomatic breadth, in which respects it differs from the skulls of all other Asia-

* List of Mamm. B. M., 1843, p. 81.

tic hedgehogs, and, as already stated, by its one-fanged simple second premolar placed out of the line of the teeth, and by the rather marked post-orbital contraction. The teeth are large and about the same size as in *E. micropus*, only the second premolar of the latter is excessively minute. The other characters wherein it differs from *E. micropus*, have been already indicated under that species.

As already remarked, this form was first described by Hutton as a probable variety of certain hedgehogs which he doubtfully regarded as *E. collaris*, which two of them appear to have been, but this third specimen, however, was undoubtedly *E. pictus*. *E. micropus* has diverged from the ordinary character of the genus more than any other Indian hedgehog, as is evinced by the absence of the malar, and in the excessively rudimentary character of its second premolar, and these modifications occurring in the most southern outlier of a Palæarctic type are noteworthy.

A hedgehog obtained at Guna by Dr. A. Barclay would seem to indicate that the two species may possibly interbreed, as I have experienced some difficulty, judging by external characters only, in saying to which it should be properly referred. The coloration of its spines is more like that of *E. pictus*, than *E. micropus*, as the tips are broadly white, but, unlike any other example of *E. pictus* that has come under my observation, the brown band from the forehead is prolonged beyond the angle of the mouth across the throat. In all other respects, the coloration is alike to that of *E. micropus*. The ears also are somewhat larger than in *E. pictus*. The affinities, however, of this hedgehog as manifested by its teeth and the form of its skull are towards *E. pictus*.

Besides occurring at Gúna, the most southern locality from which I have obtained it, I have received it also from Ulwar, from Major T. Cadell, V. C.; and the Indian Museum also came into the possession of a large number of specimens from Agra through Mr. A. E. Carlleyl. An example from Karachi has been received by exchange with the Municipal Museum, through the valued assistance of Mr. J. A. Murray. This latter specimen agrees with one in Mr. W. T. Blanford's possession from the same locality. He also possesses an adult male from Jeysulmere, the dimensions of which are given in the first column of the foregoing measurements.

It is probable that E. *indicus* was applied by Royle to the hedgehog which occurs about Delhi, and which appears to be this species.

Erinaceus grayi. Plate IV.

Erinaceus collaris, Gray, Ill. Ind. Zool, Vol. I, 1872, Plate VIII, (not described): *id.* List. Mamm. B. M. 1843, p. 81, *partim*: Hutton, Journ. As. Soc. Bengal, Vol. XIV, 1845, p. 351, (first two specimens only);

Blyth, *op. cit.*, Vol. XV, 1846, p. 170 : *id. op. cit.*, Vol. XXII, 1853, p. 582, *partim ;* Wagner, Schreber, Säugeth. Suppl., Vol. V, 1856, p. 590 : Stoliczka, Journ. As. Soc., Vol. XLI, 1872, p. 225.

Erinaceus grayi, Bennett, Proc. Zool. Soc. 1832, p. 124 ; Gray List Mamm. B. M. 1843, p. 81 : Wagner, Schreber, Säugeth., Suppl. Vol. II, 1841, p. 28 ; *id. op. cit.*, Suppl. Vol. V, 1856, p. 590 ; Fitzinger, Sitsungsbte. der K. Akad. Wien, Vol. LVI, Pt. 1, 1867, p. 870, *partim ;* Stoliczka, Journ. As. Soc. Beng, Vol. XLI, 1842, p. 225.

Erinaceus spatangus, Bennett, Proc. Zoo. Soc. 1832, p. 124, *juv ;* Ogilby, Royle's Ill. Ind. Himal. Botany, 1839, p. 62 ; Blyth, Journ. As. Soc. Bengal, Vol. XV, 1846, p. 170 ; Gray, Mamm. B. M,. 1843, p. 82 ; Wagner, Schreber, Säugeth., Suppl. Vol. II, 1841, p. 27 ; *id. op. cit.* Suppl. Vol. V, 1856, p. 590 ; Stoliczka, Journ. As. Soc. Bengal, Vol. XLI, 1872, p. 225.

Hemiechinus grayi, Fitzinger, Sitzungsbte. der K. Akad. Wien, Vol. LVI, Pt. 1, 1867, p. 870.

Hemiechinus collaris, Fitzinger, Sitzungsbte. der K. Akad. Wien, Vol. LVI, Pt. 1, 1867, p. 872.

Hemiechinus spatangus, Fitzinger, Sitzungsbte. der K. Akad. Wien, Vol. LVI, Pt. 1, 1867, p. 873,

Facial portion of head pointed and rather long (fig. *d*). Ears (fig. *g*) large, full, long and somewhat pointed. Feet (figs. *e* and *g*) large, the fore feet rather broad and somewhat truncated, with moderately long toes and powerful claws. The proximal palmar pads forming a pair, and not very prominent. The hind feet with the toes turned inwards, the fingers moderately long and with strong claws. The proximal pad of the sole internal to the first toe, and which is strongly developed as a large mesial pad in *E. jerdoni*, is practically absent in this species, so little is it developed.* The tail (fig. *h*) is moderately long and shortly haired ; no bare space on the vertex. The spines begin slightly behind the anterior margin of the ear, and they are generally about 0″75 long. The longitudinal grooves are numerous and shallow, but broader than the ridges which are 25 to 26 in number and studded with small tubercles. The spines are very narrowly tipped with black, and below this there is a very narrow yellowish band, succeeded by a broad dark-brown, almost black band, the remainder of each spine being yellow, except at its extreme base which is dusky. The broad dark-brown band below the yellow subapical band is so strongly developed, that when the animal is viewed from the side, with the spines directed outwards, it has a black appearance. There is, however, considerable variation in the intensity to which the yellow sub-apical band is developed, and some animals are

* The artist has not well represented this feature on the plate.

therefore much lighter coloured than others, as the brown band succeeding the latter is also much paler in some individuals than in others.

This species, besides the almost entire absence of the proximal mesial pad of the sole, is at once distinguished by the complete absence of the bare space that occurs in E. *pictus*, and E. *micropus*, among the spines of the vertex. From the two last named species which have no large proximal pad on the sole, it is recognised by its large feet, well developed toes, powerful claws, and by the turning in of the hind feet, as well as by its different coloration. There is a considerable naked space over the sacrum, and on the dorsum of the tail as in other species. The snout is seminude, being sparsely covered with very minute hairs. Behind the whiskers, the hairs become much more numerous and longer, and the area below the eye, and the forehead are well clad. The greater part of the front of the ear is nude, but there is a sprinkling of short white hairs internal to and along its margins. The chin and below the lower lips are almost naked, and, immediately behind the chin, the hairs are few. The under parts are well clad, but not densely so, and the limbs are thinly clad, more especially the feet on which the hairs are very few and short. The tail also is only sparsely clothed.

The general colour of the animal is blackish-brown or brown, the spinous portion of the body being darkest; but the colour is variable owing to the reasons already mentioned.

The front of the face from the nose backwards to the spines, the limbs and all the under parts with the exception of the chin and a line from it upwards to the ear which are white, are generally dark-brown or fuliginous-brown, blackish on the face, on which there is occasionally a considerable intermixture of white hairs. The hairs which clothe the ears, and a tuft of hairs at the base of the anterior margin of the ears, are white. The white on the chin is more prolonged upwards to the ears in some specimens than in others, giving rise to a kind of white collar which is much exaggerated in the figure of *E. collaris*. The claws are horny yellow.

The following are the measurements of this species:

	♂	♀	☿
Length of body and head, ...	6″85	6″70	6″70
,, of tail, ...	0″96	1″30	1″02
Height of ear, ...	1″45	1″52	1″38
Breadth of ear, ...	0″97	0″97	1″00
Snout to eye, ...	1″00	0″49	0″62
Eye to ear, ...	0″52	0″49	0″62
Length of hind foot without claw, ...	1″45	1″45	1″50
Breadth of hind foot, ...	0″49	0″45	0″38

The skull of this species (figs. *a* to *b*) is distinguished from that of *E. pictus*, and the skull of *E. micropus*, by its large second premolar with three fangs, and from the other two species by its great zygomatic breadth. In this latter respect, it resembles *E. pictus*, but the skull has a considerably longer muzzle than in that species, and, as a whole, is not so broad and round. It is considerably broader than *E. blanfordi*, with more marked post-orbital contraction, and from *E. jerdoni* it is still more markedly separated by its relatively much greater breadth across the zygomatic, and more especially across the base of the muzzle, at the third premolar. The skull is undoubtedly most nearly allied to that of *E. blanfordi*, to which it presents a very close resemblance when the adolescent skull is compared with the adolescent skull of the type of that species. But the latter is narrower across the zygomæ, and has less post-orbital contraction, as already stated. It is further separated from the skull of *E. jerdoni* by its larger teeth, and by the different form of the canine. This tooth in *E. blanfordi*, as well as in this species, is less triangular and more sharply pointed than in *E. jerdoni*, *E. niger*, *E. pictus*, and *E. micropus*, and in this respect differs more in appearance from the first premolar than it does in these last-named species. All of these species are characterized by the presence of two sharp cusps to the canine section of the third premolar, while in *E. niger* described by Blanford, the posterior of these two cusps is entirely absent and its last molar presents only one eminence, while in all the others this tooth has two cusps the inner of which is always the larger.

The figure in the Illustrations of Indian Zoology was copied from one of General Hardwicke's drawings, and on the plate it is stated that the hedgehog was a species found in the Doab. There are many tracts of country in North-Western India named Doab, but General Hardwicke appears from his paper on *Mus giganteus*,* in using the term Doab, to have had in view the country lying between the Jumna and Ganges, in which the military Station of Fatehgarh is situated, and where he appears to have been stationed. There he had drawings made of the species of hedgehog which is there common, also of *Mus giganteus*, and of *M.* (*Nesokia*) *hardwickii* = *Arvicola indica*, Gray.

I am indebted to the late Mr. Andrew Anderson for many living examples of the hedgehog that occurs about Fatehgarh, and which appears to me to agree with the figure of *E. collaris*, from the Doab. As in the figure, the chin of these hedgehogs was more or less white, and, in some, the white extended up towards the ear as a kind of collar which, however, is exaggerated in the drawing of *E. collaris*, in which the contrast between the colours is too marked, and the animal altogether represented too dark. Notwithstand-

* Trans. Journ. Linn. Soc. Vol. VII, 1804, p. 308.

ing, I think there can be but little doubt, that the Fatehgarh hedgehog which is very common in the district is the *E. collaris*, Gray.

The specimens from Madras in the British Museum referred to this species are, as already mentioned, examples of *E. micropus*, Blyth.

This species has been also obtained at Ajmír in Rájpútána by Mr. Blanford, and if I am correct in referring to it Hutton's two specimens, it extends west to the Sutlej. There Hutton obtained it in separate holes, " beneath a thorny bush called ' Jhund' in the desert tracts of shifting sand between Sundah Badairah and Hasilpoor," on the left bank of the Sutlej, and apparently in close proximity to *Erinaceus pictus*.

Erinaceus blanfordi, n. s., Plate V.

Muzzle rather short (fig. *d*) and not much pointed; ears moderately large (fig. *g*), but broader than long and rounded at the tips, which are not accuminate as in *E. grayi*. The length of the anterior margin is equivalent to the breadth of the ear at its base. The feet (figs. *e* and *f*) are large and the hind foot resembles that of *E. grayi*, with the first toe well developed and there is the absence of any well developed median pad. The feet are also larger and broader than in *E. jerdoni*, and the first toe is more largely developed as in *E. grayi*. The claws are long and curved, especially those of the fore foot. The tail (fig. *h*) is short. The spines meet in a point on the forehead and do not reach quite so far forwards as the base of the upper border of the ear, and there is no bare patch in the midst of them, on the vertex. They are moderately long with 24 to 28 concentric ridges and furrows, the former finely tubercular. The general colour of the spiny portion of the animal is deep black, when the spines are looked at directly on end and when they are at rest, but when raised or seen sideways, the mesial yellow band becomes visible. The apex of each spine is broadly tipped with deep black, and this is succeeded by a very broad yellow mesial band, the base of each spine being dusky brown. The fur generally is deep brown and moderately long and soft. A few white hairs occur on the chin, and there is a tuft of white hairs at the anterior angle of the ear, and the latter anteriorly and posteriorly is sparsely covered with white hairs.

The skin of the back of the ear is blackish, also the margins of the ears anteriorly, but the centre of the ear is white. The claws are yellowish.

Measurements of *E. blanfordi*.

	♂
Length of body and head, ...	5′ 36
„ of tail,...	0 91
„ of hind foot without claw, ...	1″ 32
Height of ear, ...	1″ 10

Breadth of ear, ...	0″ 85
Nose to eye, ...	0″ 72
Eye to ear, ...	0″ 35

The skull (figs. *a* to *c*) of this species is distinguished from that of *E. grayi*, by its much less zygomatic breadth and by the less protuberant character of the supra post-orbital region. The teeth in both these species have much the same general characters. It is undoubtedly very closely allied to *E. grayi*, which it resembles in the absence of a bare area over the vertex, in its large feet with its hind toes somewhat turned inwards, and strong and long claws, and in the almost complete absence of a mesial pad on the hind foot, but it differs from it externally in its shorter muzzle, much shorter and more rounded ears, and in its darker coloration, and smaller size.

This species is known only from one specimen procured by Mr. W. T. Blanford at Rohri in Sind, where it is apparently associated with *E. jerdoni*, and I have named the species after its discoverer.

Erinaceus jerdoni, n. s., Plate V*A*.

Muzzle moderately long and pointed. Ears large, rounded at the tips and broad at the base. Feet large, more especially the fore feet which are broad and powerful, with strong claws. The hind feet well developed, but proportionally not so large as the fore feet. A large well developed pad on the under aspect of the hind foot. Claws strong. The tail moderately long. The spines begin on a line with the anterior margins of the ear, divided on the vertex by a large nude area as in *E. micropus* and *E. pictus*. The spines are not very thick and they are marked generally with 19 grooves and 19 ridges, the latter exceeding the breadth of the former and being very sharp, with the tubercles passing down on their sides, almost into the hollow of the furrow. The animal is black when the spines lie flat, but when they are partially erected, the white bands show, and a variegated appearance is produced. In the adult with the spines 2″·15 in length, there are two white and three dark bands. The apical band is broad and deep shining black, and it is succeeded by a white band nearly of the same breadth, which is followed by a brown band with a white band below it, and then a dusky basal band. These are the characters of two females from Karachi, but in the younger of the two, the spines are 0″·97 in length and the basal band is hardly developed. In an adolescent male from Rájanpur, which I refer to this species, there is generally only one white central band to each spine, the apical and basal bands being black. In a few, however, measuring 0″·75 in length, there are two white and three apical bands as in the type, and it is probable that in this adolescent male as it reached maturity and its spines grew, the coloration of the type would be attained. In a still younger female from Rohri, Sind, and for the privilege of examining which I am indebted to Mr. W. T. Blanford, the spines are fine and rather soft, and the majority of them do not exceed 0″·80, but yet they have only one white band prominently developed, although the basal white band is more or less indicated.

The hair generally is dusky brown, with an intermixture of grey hairs on the head and on the chin and throat, the fur behind the latter area and on the sides of the neck being paler brown than on the limbs and on the sides. A patch of white hairs occurs at the base of the anterior angle of the ear, and the inner surface of the ear is clad with short white hairs and the apical third of the back of the organ with similar hairs. The moustaches are brown and reach behind the ear. The claws are yellow.

Measurements of *E. jerdoni.*

	Adult. ♀	Adolescent. ♂
Length of body and head, ...	7″45	5″85
,, of tail, ...	1″25	0″91
,, of hind foot without claw, ...	1″48	1′ 40
Height of ear, ...	1″40	1″35
Breadth of ear, ...	0″76	0″80

The skull of the female in its general characters is allied to the skull of *E. macracanthus*, Blanford, but is considerably less, with smaller teeth, the upper dental line of the latter measuring 1″·03 to 0″·97 in this species, which is a considerable difference in such small skulls. The skull also of *E. macracanthus* is characterised by a considerable concavity on the mesial line in the fronto-parietal area, which does not exist in this species. The skull has also a very strong resemblance to the skull of *E. niger*, but it is a relatively broader skull than the latter, which has an attenuated facial region, less post-orbital breadth and less temporal contraction, a smaller brain case, and only one internal cusp developed on the third premolar. It is distinguished from the skull of *E. blanfordi* by its more slightly elongated character, by its greater post-orbital breadth and swelling, by its relatively longer and less expanded zygomatic arch, more produced muzzle and by its teeth. It is markedly distinct from the short but especially broad skull of *E. grayi*, and it has much smaller teeth than that species.

The external features which appear to me to entitle this form to recognition as a species distinct from *E. blanfordi*, are the very prominent character of the mesial pad on the hind foot, its larger ears and the presence of a large nude area on the vertex, as in *E. micropus* and *E. pictus*, this latter character along with those already indicated separating it from *E. grayi*.

It resembles *E. niger*, in having a bare mesial area on the vertex, but is distinguished from that form by its smaller fore feet and smaller ear, and by its cranial characters as well.

There can be little doubt, however, but that *E. macracanthus*, and *E. jerdoni*, are very closely allied forms, but I believe that the characters I have indicated will be found persistent and reliable guides to enable them to be distinguished the one from the other.

This species occurs at Karachi, from whence I have received it from Mr. J. A. Murray, the Curator of the Karachi Museum, and from Rájanpur from Dr. E. Sanders. Mr. Blanford has also obtained it at Rohri, in Sind.

Description of Plates.

Plate III. Details of structure of *Erinaceus pictus*, Stoliczka. *a.* upper view of skull : *b.* side view of skull : *c.* skull seen from below : *d.* side view of head : *e.* upper and under aspects of hind foot : *f.* fore foot seen from above and from below : *g.* side view of ear : *h.* side view of tail. All drawn natural size.

Plate IV. Details of structure of *Erinaceus grayi*, Bennett. *a.* upper view of skull : *b.* side view of skull : *c.* skull seen from below : *d.* side view of head : *e.* upper and under aspects of hind foot : *f.* fore foot seen from above and from below : *g.* side view of ear : *h.* side view of tail. All drawn natural size.

Plate V. Details of structure of *Erinaceus blanfordi*, n.s. *a.* upper view of skull : *b.* side view of skull : *c.* skull seen from below : *d.* side view of head : *e.* upper and under aspects of hind foot : *f.* fore foot seen from above and from below : *g.* side view of ear : *h.* side view of tail. All drawn natural size.

Plate V A. Skull of *Erinaceus micropus*, Blyth. *a.* upper view : *b.* side view : *c.* skull seen from below : Natural size. *d.* teeth of upper and lower jaws enlarged 2 diameters.

Skull of *Erinaceus jerdoni*, n.s. *e.* upper view of skull : *f.* side view : *g.* skull seen from below : Natural size. *h.* teeth of upper and lower jaws enlarged 2 diameters.

XIX.—*Description of a supposed new Hedgehog from Muscat in Arabia.*—*By* W. T. Blanford, F. R. S., &c.

(Received and read Dec. 4th 1878.)

(With Plate IX.)

Amongst a collection of small mammals, birds and reptiles, sent to me some time since by Colonel Miles, the Political Agent at Muscat, are two specimens, one preserved in spirit, the other a skin, of a species of hedgehog which appears to me undescribed. It is somewhat intermediate in characters between the Indian *E. collaris*, and the Persian and Baluchistan *E. macracanthus*, and *E. megalotis*, being larger than the former and having longer spines, whilst it is inferior in both respects to the two latter. The following is a description of the new form.

Erinaceus niger, sp. nov.

E. supra niger, subtus nigrescenti-fuscus, auriculis longiusculis, pilis sparsis griseis indutis, aculeis longiusculis, apices versus nigris, in medio albis, ad basin fuscis. Long. tota 6—7, *auriculi* 1·6, *plantæ* 1·25 *poll. angl.*

Hab. Juxta Muscat in Arabia.

The description is chiefly taken from the specimen in spirit, a female. The size is moderate, exceeding that of *E. collaris*, but apparently inferior to *E. europæus*. The colour is black above, the white ring on the spines being very inconspicuous, the face is sooty black with a few gray hairs interspersed, the ears are grey. On the lower parts and limbs all the hairs are sooty or blackish brown.

The feet are of moderate size, not so broad as in *E. grayi*, nor short as in *E. micropus*, but resembling those of *E. collaris* in form, and thinly clad with hair above. Five claws on all feet, the inner claw on the hind feet much smaller than the others.

The ears are long, not very broad, rounded at the end, thinly clad outside and near the margin inside with short whitish hairs: there are longer white hairs at the base of the anterior inner margin, and longer blackish hair near the base in front and behind.

Spines long, one inch to one and a quarter in length on the hinder part of the back. In the spirit specimen, a female, none exceed 1·1 inches; in the dried skin some are nearly $1\frac{1}{4}$ inches long. The spines commence on the forehead inside of each ear, leaving a space free from spines in the middle, running back for about an inch. All are black at the points for half an inch, then white for about $\frac{1}{5}$ inch, then dusky to near the base where they are rather paler. Each spine is surrounded by about 24 to 28 longitudinal grooves, the ridges between the grooves being closely tuberculate.

The following are measurements of the specimen in spirit, an adult female. Males are probably rather larger. The length, owing to contraction, is somewhat less than that of a fresh specimen would be—

Length from nose to anus, ...	5·5
Ditto of tail, ...	0·9
Total,	6·4
Length of ear from orifice, ...	1·6
Ditto ditto outside, ...	1·35
Breadth of ear, ...	0·9
Length of palma without claws, ...	0·9
Ditto planta ditto, ...	1·25

The skull of the same specimen is rather narrower than that of *E. collaris*, and has a longer muzzle. The following are measurements:

	in
Length from occipital plane to end of premaxillaries, ...	1·9
Ditto from lower margin of *foramen magnum* to ditto, ...	1·78
Ditto of bony palate from opening of posterior nares, ...	1·05
Breadth across zygomatic arches,...	0·98
Breadth of frontal region between orbits, ...	0·45
Ditto nasal bones, ...	0·13
Length of nasal suture,...	0·56
Ditto of mandible, ...	1·42
Height of ditto about, ...	0·65

Description of Plate.

Fig. 1. Head of *Erinaceus niger*.
2. Fore foot of ditto.
3. Hind foot of ditto.
4, 5, 6. Skull of ditto.

XX.—*On* Arvicola indica, *Gray, and its relations to the Sub-Genus* Nesokia, *with a description of the species of* Nesokia.—*By* J. ANDERSON, M. D., *Superintendent of the Indian Museum, and Professor of Comparative Anatomy, Medical College.*

(Read 4th Dec. 1878.)

(With Plates XIII and XIV.)

In Gray and Hardwicke's Illustrations of Indian Zoology there is a representation of a rodent,* "The Indian Field-Mouse," *Arvicola indica*, Gray, bearing the date 1st May, 1829. This drawing is unaccompanied by any information regarding the locality from whence the animal was obtained. It represents a rat with a short bluff head; with moderately-sized, semi-nude ears; sparsely clad feet with rather long claws, and a naked tail shorter than the length of the body and head. The eye is figured large. The general colour is a pale sandy brown, with interspersed longer hairs.

In the Proceedings of the Zoological Society for 1835, p. 108, it is recorded that Dr. Gray on exhibiting some rats and mice collected by Mr., now Sir Walter, Elliot, in the Southern Mahratta country, took occasion to point out that the so-called *Arvicola indica* was really a true *Mus*. In 1837† Dr. Gray in referring to the Genus *Mus*, as understood by him, stated that "the *Mus giganteus*, Hardwicke, may be regarded as the type, to which may be added the two following new Indian species which have the tail shorter than the body and the fur with scattered bristles," and these species were *Mus rufescens*, Gray, (House-rat), and *Mus kok*. The latter he considered to be identical with *Arvicola indica*. Dr. Gray, holding this view regarding the identity of the animal figured in the Ill. Ind. Zool. with that of the rat sent by Elliot from Madras, under the Canarese name of *Kok*, re-named it, adopting the native name, *kok*, for the species. The *Mus kok*, afterwards described by Elliot as *Mus providens*, appears to me, however, to be distinct from the animal originally figured as *A. indica*.

In the same contribution, Dr. Gray described a rodent with "the cutting teeth, large, smooth, yellow and flat in front" under the name of *Mus hardwickii*. He compared it to *Mus kok*, that is, to the Madras rat which, he stated, it very much resembled, "but the skull is much wider and stronger and rather larger, and the cutting teeth are nearly twice as wide and are flat in front. The grinders are very little larger than those of that species."

* Vol. I, Plate XI, Mamm. 1832.

† Mag. Nat. Hist. (Charlesworth) Vol. I, 1837, p. 585.

In 1842,* Dr. Gray, selecting *Mus hardwickii* as his type, described the genus *Nesokia*, characterizing it thus, " cutting teeth very large, flat in front and smooth; grinders 3·3; front upper large with three cross ridges; the middle oblong, and the hinder much narrowed behind, each with two cross ridges; the front lower grinder larger, narrowed in front with three cross ridges; hinder each with two ridges, the hindermost smallest, rather narrowed behind: tail short, thick, with whorls of scales and scattered bristles: toes 4—5, moderate, the three middle sub-equal, long, the outer moderate: claws small, compressed: front thumb tubercular, with a rudimentary claw: ears moderate, naked." " This genus," Dr. Gray states, " is easily known from the rats *(Mus)* by the large size of the cutting teeth and the shortness of the tail: it appears," he continues, " to be intermediate between the Rats and *Rhizomys*."

In 1839,† Sir Walter Elliot described the afore-mentioned rat from Southern India under the name of *Mus (Neotoma) providens*, identifying it with the *Mus indicus*, Geoff. and the *Arvicola indica*, Gray, mentioning its Canarese name *Kok* or *Koku*, but his identification of it with *M. indicus* Geoff. was erroneous, as *Mus providens* is undoubtedly a *Nesokia*. Prof. A. Milne-Edwards, who has kindly examined for me the type specimen of *M. indicus*, Geoff. in the Paris Museum, informs me that it is very nearly allied to *Mus decumanus*, and that, although it is a little smaller, its teeth have the same conformation; and he further observes that *Mus indicus* is perfectly different from the animal figured by Peters under the name of *Spalacomys indicus*. *Mus providens*, however, has a skull like that of *S. indicus*, as I have satisfied myself by the examination of the skulls of two of Sir Walter Elliot's specimens.

Sir W. Elliot, in considering *Mus providens* as identical with *Arvicola indica*, Gray, lends the weight of his authority to the view that I have been led to adopt regarding *Arvicola indica*, because there can be no doubt that they both belong to one sub-generic type of *Mus*.

On referring to the list of Mammalia in the British Museum, published in 1848, three specimens of a rat are mentioned under the name of *Mus kok*‡ from Madras, and presented to the British Museum by Sir W. Elliot, and in the Introduction to his List of Mammalia§ 1843, Dr. Gray states that the *Mus kok* and some other species of rats (*Mus rufescens*, &c.) described in the Magazine|| of Natural History, 1837, were founded on specimens sent by Sir Walter Elliot, and that they were au-

* Ann. and Mag. Nat. Hist., Vol. X, 1842, p. 264.

† Madr. Journ. Lit. and Sc., Vol. X, 1839, p. 209.

‡ *l. c.*, p. 110.

§ *Op. cit.*, 1843, p. vii.

|| *l. c.*

thentic specimens of the species described by Elliot in the Madras Journal of Literature and Science.* There can therefore be no doubt of the identity of *Mus kok* with *Mus providens*, and that the types, as stated in the 'List of Mammalia,' on the authority of Elliot, were from cultivated plains in the Madras Presidency, and from Madras itself. The figure of *Arvicola indica*, fortunately bearing the date, 1st May 1829, renders it impossible that any of Elliot's specimens could have contributed the type of that species, and, moreover, in the Proceedings of the Zoological Society of 1835, it is stated that it was figured from General Hardwicke's drawings.

In the 'List of Mammalia,' there is no specimen under *M. kok*, of which *Arvicola indica* was regarded by Dr. Gray as a synonym, that could have formed the type of the latter, as all the specimens of *M. kok* that have been mentioned were, with one exception, received from Sir W. Elliot. The exception is described as (*e*) "a small rat with a very long tail: India: from Dr. Smut's Collection." A very long tail would seem to be sufficient evidence that this was neither *M. kok* nor *Arvicola indica*. On again turning to the 'List of Mammalia,' we find that the type of *Nesokia hardwickii* was presented by General Hardwicke, and in connection with this it is noteworthy that animals from the North-West Provinces of India corresponding to the description of that species are remarkably like the drawing of *Arvicola indica*. Moreover, Blyth states that there is no rat in Bengal, nor apparently in Madras, corresponding to that figure, and by extensive research, I can confirm this statement.

In the Catalogue of the Specimens and Drawings of Mammalia and Birds of Nepal and Tibet, presented by B. H. Hodgson to the British Museum (1846), the *Kok*, *M. providens*, is assigned to *Nesokia*, a course which Blyth himself followed in his Memoir on the Rats and Mice of India and in his Catalogue of Mammals.

In 1842, Sir Walter Elliot presented two stuffed specimens of *Mus providens* = *M. kok*, Gray, to the Museum of the Asiatic Society of Bengal and these specimens still exist in the Indian Museum. They apparently belong to the variety found in the red soil, and which Elliot says is much redder than the common *Koku* of the black land, and they are quite distinct from *M. (N.) hardwickii*.

On a review of these circumstances, I am disposed to make the suggestion that the rat figured as *Arvicola indica*, and which Gray considered to be the *Mus indicus* of Geoffroy, is in reality the rat described by him, first under the name of *Mus hardwickii*, and afterwards as *Nesokia hardwickii*; and in connection with this view of the question, it is important to bear in mind that the figure of *Arvicola indica* was received from

* *l. c.*

General Hardwicke who afterwards, in presenting to the British Museum the type of Gray's *Mus (Nesokia) hardwickii*, presented a rat agreeing with the figure of *Arvicola indica.* The type of *Mus indicus* with which Gray believed his *Arvicola indica* to be specifically identical was from Pondicherry, and as has already been stated, it is a true rat allied to *M. decumanus*, and perfectly distinct from the animal figured under the name of *A. indica*, but, moreover, no rat has been obtained at Pondicherry at all corresponding specifically to the *Mus (Nesokia) hardwickii* with which the figure of *Arvicola indica* agrees.

The specimens of *Mus providens* in the Calcutta Museum are distinguished from *Mus (Nesokia) hardwickii* by their much narrower incisors, smaller molars, and by a long but narrow anterior palatine foramen, an opening which is very short in *Mus (Nesokia) hardwickii*, as is seen in Peters' characteristic figure of the so-called *Spalacomys indicus*,* but the form of the skull is the same, both differing in the same respects from *Mus.* I have had the Madras rat alive† and have observed that it has the deep and rather short muzzle of *Nesokia*, with incisors broader than those of ordinary rats, and with the molars, when worn down, having the general characters of *Nesokia.* These rats, coming as they do from Southern India, agree externally with the types of *M. providens*, and have similar short *Nesokian* skulls.

In Lower Bengal, there is a burrowing rat, a great pest in gardens, in which it constructs numerous tortuous passages, some comparatively superficial, and others at times very deep, and throws up heaps resembling mole hills. It is closely allied to *Mus providens*, but differs from it in its somewhat greater size, and in other slight details, afterwards to be noticed. This is the rat which Blyth incorrectly identified with *Mus indicus*, Geoff., and with which he also wrongly identified *Arvicola indica, Mus huttoni*, Blyth, *M. rattoides*, Hodgson, *Mus pyctoris*, Hodgson, and *Mus dubius*, Kelaart, but which is perfectly distinct from *Mus (Nesokia) hardwickii* which also differs from *M. huttoni.* It appears probable that this is the rat also figured in the Ill. Ind. Zool. Vol. II, pl. 21, under the name of *Arvicola bengalensis*, but which was never described. This being the case, the Bengal form must be named, whilst *Mus (N.) hardwickii* will stand for the rat originally described as *Arvicola indica*, and afterwards as *Nesokia hardwickii ;* the original of the figure of *A. indica* being probably the type itself of *Mus hardwickii*, whereas *M. (N.) providens* will stand for the Southern form first described by Gray under the barbarous name of *M. kok.* In the Indian Museum, there are many rats in alcohol from Fateh-

* Abhand. der K. Akad. Wissensch. zu Berlin, 1840, p. 143, Taf. II, fig. 1.

† I may take the opportunity to record here that males and females of this rat escaped from confinement in the Calcutta Museum.

garh, presented by the late Mr. Andrew Anderson, which yield skulls the exact counterpart of the skull figured by Peters as *Spalacomys indicus,* and these rats agree with the figure of *A. indica,* and with the description of *Nesokia hardwickii.* Hodgson described, in 1846, a rat from Nepal which he called *Mus hydrophilus** and which Gray first regarded as an *Arvicola,* and afterwards as a *Nesokia.* He described it as characterised by its small ears, hardly above one-third the length of the head, also by its short tail "and by its fine and short pelage: the head he described as larger and the muzzle thicker than in the common land rats; 'above dusky brown; below and the limbs nearly white. Long piles inconspicuous. Snout to vent $3\frac{1}{2}$ inches; tail $2\frac{3}{4}$; head $1\frac{1}{4}$; ears $\frac{9}{16}$; palm $\frac{1}{2}$; planta $\frac{7}{8}$.' These characters would seem to indicate a rat allied to the so-called *Nesokia* or *Spalacomys,* Peters, but I hesitate to pronounce any decided opinion on the species. In connection with the name of *hydrophilus* given by Hodgson to this rat, I have observed that the common *Nesokia* of Lower Bengal, which I propose to name *Mus (N.) blythianus* after Blyth, who did so much to forward the progress of Natural History in India and to enlarge our knowledge of this group, manifests a remarkable capacity, for a rat of its type, to take to water, when hard-pressed. Its burrows are frequently constructed on the banks of tanks in Lower Bengal, and when the rats are being dug out, they will freely take to the water, if that is their only way of escape, and swim considerable distances. To test this aquatic power, I had two rats placed in a large wire bird-cage, and the cage partially submerged. If the rats, when in those circumstances, were much annoyed, they immediately dived to the bottom of the cage, where they could be observed running about under water. I also had them removed from the cage, and let loose in the large sheet of water in the Zoological Gardens, between the two iron bridges. When let loose at the bank, and an attempt was made to catch them, they immediately dived, and the stronger of the two did not appear at the surface for some time, when it was observed at a considerable distance from the bank, making for the opposite side.

I have already referred to the name given by Elliot to the allied form from Madras, viz., *M. providens.* He records of it that it stores up large quantities of grain during harvest. The natives of Bengal ascribe a similar habit to *M.* (*N.*) *blythianus,* and it has been stated to me that sometimes considerable quantities of grain may be found in a burrow, and that the natives being aware of this habit make raids on these murine granaries.

With reference to the characters of the genus *Nesokia,* Gray, the examination of a large series of skulls of *M. hardwickii* and of the other species shows that the dental features selected by Gray are essentially

* Ann. and Mag. Nat. Hist. Vol. XV, 1845, p. 267; Cat. Sp. and Draw. Mamm. &c. Hodgson, Nepal, Coll. Brit. Museum, 1846, p. 19; *l. c.* 1863, new ed., p. 10.

those of worn teeth, and that they do not contain the characters of the dentition as seen in the teeth before they are worn. In the latter condition, each of the three laminæ of the first upper molar presents a large central cusp, and a much smaller or even minute cusp on either of its sides, resulting as it were from the sinuous characters of each lamina of the tooth. In true mice and ordinary rats, the laminæ are transversely more sinuous and smaller, whereas in *Nesokia* they are large and transverse without any marked sinuosity, in the more typical forms. In the second upper molar, there are only two laminæ, the first being abortive and only represented by a small isolated cusp attached to the anterior face of the inner cusp or fold of the first of the two laminæ, which is exactly the same arrangement as in *Mus*. The last molar, except in having its laminæ more regularly transverse than in *Mus*, resembles the same tooth in this latter genus. In the lower jaw, there is the same regularly transverse character in the larger laminæ as compared with *Mus*, but all the cusps are the same. In the large rats of the type of *M. giganteus*, Hardwicke, the teeth conform more to the type characteristic of the ordinary rats and mice, the laminæ, however, being relatively larger than in *Mus* and less sinuous, but taking the dentition as a whole, in connection with the form of the skull, these large rats are more closely allied to *Nesokia* than to the true rats, an opinion which was first held by Sir Walter Elliot.*

The incisor teeth of a *Nesokia* are always broader than those of an ordinary rat, and in this respect are more chisel-shaped, but the incisor teeth of the large rats such as *M. giganteus* are also proportionally broader than those of ordinary rats.

In the adult animal, such as that figured by Prof. Peters, the laminæ are very regularly transversely oblong without any trace of such cusps as those I have described; and in old individuals of the larger rats, such as *M. giganteus*, the teeth I have observed to be worn down, much in the same way as in the so-called *Nesokia* = *Spalacomys*. Considering these facts, it does not appear that the genus *Nesokia* has any ground to recognition on characters derived from the dentition. The points in which the skulls of rats referable to the type of *M. (Nesokia) hardwickii*, Gray, (*Spalacomys indica*, Peters,) differ from those of the ordinary rats and mice are, on the other hand, much more pronounced than any difference in their dentition. The skull of *Nesokia* is a much broader and shorter skull with a short stout muzzle and expanded zygomata. The brain case is much shorter and broader than that of any member of the genus *Mus*. The temporo-parietal ridges also are proportionally nearer each other than in *Mus*, and the upper surface of the parietals is more flattened. The anterior palatine foramina are much

* Madr. Journ. Lit. and Sc., Vol. X, p. 209. Sir W. Elliot erroneously regarded *M. providens* and *M. giganteus* as belonging to the genus *Neotoma*.

more closed than in ordinary rats and mice, and in some of the more typical *Nesokiæ*, such as *M. (N.) hardwickii*, they are almost closed. There is also this further difference, that the palate of *Mus-Nesokia* contracts more anteriorly than in *Mus*, and is always proportionally narrower, with a much shorter edentulous interspace behind the last molar than in *Mus*. In the larger rats, such as *M. giganteus*, the posterior portion of the palate, in this respect, corresponds to *Mus-Nesokia*, and the features of the palate generally are more *Mus-Nesokian*, than those of true *Mus*. The palate also of *Mus-Nesokia* is marked by two somewhat pronounced longitudinal furrows which are the backward prolongations of the anterior palatine foramina. These grooves, near their hinder extremities, have the posterior palatine foramina lying in their course, and beyond them they are prolonged over the posterior margin of the palatines where they nearly constitute a closed canal by the inward projection of the inner palatine border of the maxilla and the somewhat thickened and anteriorly recurved posterior margin of the palatines. This arrangement is seen to occur only in a very feeble degree in ordinary rats and mice which, however, have not, as a rule, any thickening of the hinder margin of the palatines. Like the majority of thoroughly burrowing rodents, the tympanics are relatively much larger than in the ordinary rats. The large rats (*M. giganteus*) have the palatine features and the tympanics of *Mus-Nesokia*. These giant rats have rather more elongated skulls than the more typical Nesokians and, in this respect, they serve to connect the latter with the generality of mice and rats, but in their other features they more resemble *Mus-Nesokia* than *Mus*. I would therefore regard them as constituting a section of the sub-genus *Nesokia*. This view was first put forward by Sir Walter Elliot, so long ago as 1839, and Blyth agreed with him in regarding the affinities manifested by the great bandicoot rats as thoroughly *Nesokian*, and in the propriety of separating all of these *Nesokian* species from the typical forms of mice.

After a careful consideration of the characters which these various species display, it appears that this sub-genus of *Mus* may be conveniently divided into three sections ; 1st, one section containing such forms as *Mus* (*Nesokia*) *hardwickii*, *M. (N.) huttoni*, *M. (N.) scullyi*, the more typical species of *Nesokia*, all characterised by broad incisors regularly laminated, large molars and small anterior palatine foramina, with tails considerably shorter than the body ; and the females possessing only 4 pairs of mammary teats, two inguinal, one axillary and one pectoral : 2nd, another section comprising *M.* (*N.*) *providens*, *M.* (*N.*) *blythianus* (*n. s.*) and *M.* (*N.*) *barclayanus* (*n. s.*), distinguished by somewhat narrower incisors, smaller and less regularly tranversely laminated molars, more open anterior palatine foramina and longer tails ; with the females possessing as many as even 7 to 9 pairs of mammary teats* : and, lastly, a third division containing *M.* (*N.*) *giganteus* and *M.* (*N.*) *elliotanus*, (*n.s.*) the so-called bandicoot rats, with longer skulls, broad incisors, with molars of the type of the second section, but proportionally somewhat larger with less wavy laminæ, longer anterior palatine foramina and tails nearly equalling the length of the body and head. I have largely collected rats for the Indian Museum from all parts of India, and out of the materials brought together I am enabled to determine the following species belonging to the sub-genus *Nesokia.*

1st Section.

MUS. (NESOKIA) HARDWICKII, Gray.

? *Arvicola indica*, Gray, Gray and Hardw., Ill. Ind. Zool., Vol. I, 1832, Pl. XI.

Mus. hardwickii, Gray, Mag. Nat. Hist. (Charlesworth), Vol. 1, 1837, p. 585.

Nesokia hardwickii, Gray, Ann. and Mag. Nat. Hist., Vol. X, 1842, p. 265, List Mamm. of 1843, p. 113 ; Jerdon, Mamm. Ind. 1867, p. 190.

? *Mus hydrophilus*, Hodgson, Ann. and Mag. Nat. Hist., Vol. XV, 1843, p. 267.

? *Mus pyctoris*, Hodgson, Ann. and Mag. Nat. Hist., Vol. XV, 1845, p. 267.

Nesokia griffithii, Horsfd., Cat. Mamm. East Ind. As. Mus., 1851, p. 145.

Spalacomys indica, Peters, Abhand. der K. Akad. Wissensch. zu Berlin, 1860, p. 143, Taf. IV, fig. 1.

The head short and bluff, much shorter and broader than in *M.* (*N.*) *providens* and *M.* (*N.*) *blythianus ;* the muzzle broad and deep, and in these respects it resembles (*N.*) *huttoni.* The eye moderately large and situated about half way between the ear and the end of the muzzle. Ears not large, smaller than in these other two species, rounded, seminude, but clad with minute hairs. Tail variable, but much shorter than in *M.* (*N.*) *providens*, and *M.* (*N*) *blythianus*, seldom exceeding the distance between the vent and the middle of the neck, but shorter than in *M.* (*N.*) *huttoni :* ringed, nearly nude, less clad than in *M.* (*N.*) *providens* and *M.* (*N.*) *blythianus*, with minute hairs. Feet well developed, smaller than in *M.* (*N.*) *huttoni ;* claws moderately long ; the upper surface of the feet sparsely clad.

The fur is generally soft and moderately long, but not so silky as *M.* (*N.*) *huttoni :* it varies however in this respect and is sometimes somewhat

* Hodgson described a rat, as *M. plurimammis* from Nepal and the Terai, which, from the description and the proportional length of its tail appears to be an allied species.

harsh. The pelage, as in the other species, consists of three kinds of hairs, short under-lying fur, and ordinary hairs, intermixed among which, especially on the dorsal and sacral regions, are numerous long black hairs which project a long way beyond the fur, as in *M.* (*N.*) *blythianus*,* but not to the same extent. The general colour of the animal on the upper parts is sandy brown or fawn, paler on the sides, and dusky grey with a tinge of yellowish rufous on the under-surface. The muzzle, feet and tail are flesh-coloured, and the ears are of the same colour but somewhat darker.

Mr. Blanford† has pointed out that *M.* (*N.*) *hardwickii* is a much larger animal than *M.* (*N.*) *huttoni*. The measurements of the largest male, *M.* (*N.*) *huttoni*, mentioned by him are as follows, taken from the fresh animal, *viz.* :—

Length of body and head,..................................	7″
Length of tail, ...	4″ 6
Length of hind foot, ...	1″·6

whereas the largest male, out of an extensive series of this rat in alcohol, collected by the late Mr. Andrew Anderson at Fatehgarh, gives the following dimensions :

Length of body and head, ...	7″·85
„ of tail,...	4″·60
„ of hind foot, ...	1″·27

Besides differing in size these species would appear also to differ in the relative proportions of the tail and the feet, the latter being somewhat larger in *M.* (*N.*) *huttoni*, than in *M.* (*N.*) *hardwickii*. The *M.* (*N.*) *griffithi* of Horsfield in its proportion agrees with this species. If two female examples of the two species from the same localities are compared, we have similar results, thus—

	M. (*N.*) *huttoni*. ♀	*M.* (*N.*) *hardwickii*. ♀
Length of body and head, ...	6·50	6″·45
„ of tail, ...	4·55	4″.15
„ of hind foot, ...	1·43	1″·25

I am indebted to Dr. Dobson for having compared the foregoing male specimen from Fatehgarh with the type in the British Museum, with which he pronounces it to agree.

The skulls, however, are remarkably alike and the only differences I can detect are, that the molar teeth of animals by their other characters referable to *M.* (*N.*) *huttoni*, are somewhat larger than those of *M.* (*N.*) *hardwickii*, the anterior palatine foramina of the latter being a little shorter

* These piles are not shown in the figure of the species in the Zoology of Persia.

† Zool. of Persia, p. 59.

than that of the former, but in both they are much closed and their characters are well shewn in the female skull of this species figured by Prof. Peters. This foramen, however, is subject to a slight variation in the degree to which it is closed. The skulls of both species agree in having an expanded surface to the malar process of the maxillary.

Mr. Andrew Anderson forwarded to the Indian Museum from Fatehgarh specimens agreeing with the example that has been compared with the type of the species and which also conforms to Hodgson's description of *Mus. pyctoris*, the type of which, however, Dr. Dobson informs me, he has not been able to find either in the British Museum or in the India Museum.

This species in the proportion of its tail, in the colour of its pelage, in the flesh-coloured character of its several parts, such as its feet and tail, and in the form of its head so closely approaches the figure of the animal depicted as *Arvicola indica,* that I hesitate only with a meagre doubt to regard it as identical with the animal figured under that name. The only dubiety I have in expressing this opinion arises from the affinity that exists between *M. (N.) hardwickii*, and the burrowing rodent described by Blyth as *M.* (*N.*) *huttoni.*

This species is very prevalent about Fatehgarh in the North-Western Provinces of India, and if *M. griffithi* is correctly identified with it, the species would appear to extend into Afghanistan, to the district about Quettah.

Mus (Nesokia) huttoni.

Mus huttoni, Blyth, Jour. As. Soc. Beng., Vol. XV., 1846, p. 139.

Nesokia indica, Blyth, Jour. As. Soc. Bengal, Vol. XXXII, 1863, p. 328, *partim : id.* Cat. Mamm. As. Soc. Mus., 1863, p. 112, *partim.*

Nesokia huttoni, Blanford, Zool. of Persia, 1876, p. 59, P. VI, fig. 1, et cranium, figs. 1 and 2, p. 60.

Head and general form of the animal the same as in *M.* (*N.*) *hardwickii*, but with larger feet and a somewhat longer tail. Fur also as in that species, but more soft and silky and paler fawn-coloured, the under parts being pale hoary, sometimes tinged with yellowish and ferruginous. The ears are round and about the same dimensions as in *M.* (*N.*) *hardwickii*, and very sparsely clad with minute hairs. The feet sparsely covered with short whitish hairs and the tail also almost nude. The nose and feet are flesh-coloured, but the tail and ears are darker and brownish.

	♂	♀
Length of body and head,*	7″.	6″·7
„ of tail, ...	4″·6	4″·9
„ of hind feet, ...	1″·6	1″·5

* These measurements are taken from Mr. Blanford's "Persia," and are those of fresh specimens.

The general characters of the skull I have already indicated under *M.* (*N.*) *hardwickii.*

Mr. Blanford states that this field-rat has only 3 pairs of mammæ, but in a female collected by him at Kalagán, Balúchistán, I observe that it has the same number of mammæ as the female of *M.* (*N.*) *hardwickii*, *viz.*, 8, two inguinal pairs, one axillary pair, and one pectoral pair as in that species. Mr. Blanford probably overlooked the axillary mammæ which occur also in *M.* (*N.*) *providens*, and *M.* (*N.*) *blythianus*, and in the ordinary rats, such as *M. decumanus.*

The Indian Museum has received this species from Umballa, where it was obtained by the late Lieut.-Col. Tytler; from Kalagán in Balúchistán from Mr. Blanford, who has also presented examples from Sháhbandar and Khipra, Sind; and from Karachi examples have been received from Mr. J. A. Murray of the Municipal Museum of that town.

Examples have also been quite recently sent to the Indian Museum from Dakka, Afghanistan, by that observant naturalist Dr. Arthur Barclay. He states "that this species occurs in large numbers all about that Fort, which is at a low elevation, being only a little above Peshawar. The soil is loose and very fine, almost like exceedingly fine sand. The holes of this rat do not run deep but ramify horizontally, just below the surface of the ground. It throws out a mound of earth at the exit of the hole. I have never seen these rats out of their dens during the day, but frequently during my evening walk I have watched them throwing out earth. The mouth of the hole is usually kept shut up with earth."

M. (Nesokia) scullyi.

Nesokia scullyi, J. Wood-Mason, Proc. As. Soc. Beng., 1876, p. 80.

Form of body and head the same as in *M.* (*N.*) *hardwickii*, but distinguished from it and from *M.* (*N.*) *huttoni*, to both of which it is closely allied, by its much larger feet, the hinder pair of which in an animal with the body and head 6″·6 long, the hind foot and claws measure 1″·72, whereas in *M.* (*N.*) *hardwickii* and *M.* (*N.*) *huttoni*, in animals of the same dimension the feet measure respectively 1″·26 and 1″·43. The tail is longer than in *M.* (*N.*) *hardwickii*, and in its proportions it more resembles the tail of *M.* (*N.*) *huttoni*. The fur also is longer and more silky than the fur of the two foregoing species, but in this respect it is approached by *M.* (*N.*) *huttoni*. The tail is stated by Mr. Wood-Mason to be without a single hair, but in the type I observe that it is very sparsely covered with hairs, to the tip. The feet are clad with short brown hairs, but to a less extent than in any of the other species.

The fur is a slightly paler fawn than that of *M.* (*N.*) *huttoni*, the long piles being white tipped. The sides are still paler, and the under surface is a pale grey, tinged with yellowish. The whiskers are black, tipped with white. The ears are short, scarcely appearing above the fur, and they are almost nude, but sparsely clad as in the other species. The feet and claws flesh-coloured.

The skull has a broader muzzle than the skull of *M.* (*N.*) *huttoni*, than which it is somewhat larger, exceeding also the size of the skull of *M.* (*N.*) *hardwickii.* It also differs from the skull of *M.* (*N*) *huttoni*, in its greater supraorbital breadth and less expanded zygomatic. It has the expanded malar process of the maxillary as in *M.* (*N.*) *hardwickii* and *M.* (*N.*) *huttoni*, but to less extent than in the latter species, than which the lachrymal foramen is much smaller. Its molar teeth are also larger than in *M.* (*N.*) *huttoni*, and its anterior palatine foramina are more open. Dr. Scully gives the dimensions as follows: total length 11″·8, tail 5″·2, and the weight as 5·6 oz. The irides he states are dark brown.

This species was obtained by Dr. Scully at Sanju in Kashgaria and presented by him to the Indian Museum.

The Indian Museum has received from Muscat, Arabia, a young rat belonging to this sub-genus, of the following dimensions. Length of body and head 3″·35, tail 2″·30, hind foot 0″·93. Its ears are small and rounded, its tail is rather densely clad with short hairs. It is too young to indicate its species, but it is quite distinct from any of the field rats described in this article.

2nd Section.

Mus (Nesokia) providens.

Mus kok, Gray, Mag. Nat. Hist. (Charlesworth's), Vol. I, 1837, p. 585, *partim*, nec *Arvicola indica*, Gray; *id.* List of Mamm. B. M. 1843, *partim;* Kelaart, Prod. Faun. Zeyl. 1832, p. 66.

Mus (*Neotoma*) *providens*, Elliot, Mad. Jour. Lit. &c., Vol. X, 1839, p. 209, *partim*, nec *Mus indicus*, Geoff. St. Hil., nec *Arvicola indica*, Gray.

Mus (Nesokia) indicus, Blyth, Cat. Mamm. As. Soc. Mus., 1863, p. 112, *partim*, nec *Arvicola indica*, Gray, nec *M. huttoni.*

Nesokia indica, Blyth, Journ. As. Soc. Bengal, Vol. XXXII, 1863, p. 329, *partim*, nec *M. hardwickii*, nec *Mus indicus*, Geoff., St. Hil.; Jerdon Mammal of Ind. 1867, *partim.*

Mus hardwickii, Kelaart, Prod. Faun. *Zeylanicæ*, 1852, p. 65.

The head short and truncated, with a deep muzzle; the ears nearly round, the height equalling the distance between the tip of the muzzle and the eye, nearly nude, but sparsely covered with minute hairs. Eye moderately large, occupying about the middle of the interval between the tip of the snout and the ear. Feet well developed. Claws short and stout. The tail nearly equals the length of the trunk and head, and is thus longer than in *M.* (*N.*) *blythianus*, seminude, ringed and with short brown bristly hairs around the margin of the annuli. Whiskers full and long.

The fur is rather harsh and long and consists as in the other species of three kinds, but the long piles are not numerous.

The general colour of the upper parts is brown, paler than in *M.* (*N.*) *blythianus*, with an intermixture of yellowish or fawn-coloured hairs as in that species, producing a varied hue of brown and yellow: the under parts are whitish with a yellowish tinge, and there are no brown or long hairs intermixed. There is a variety occurring in the red soil and which Elliot says is much redder* in colour than the common *Koku* of the dark land. The nose, ears and feet are dark flesh-coloured or brownish, and the feet are covered with short brown hairs. The claws are yellowish. The whiskers are black.

Sir Walter Elliot gives the following measurements of an old male: length of body 7 inches; of tail $6\frac{1}{2}$; total $13\frac{1}{2}$; of head $1\frac{8}{10}$; of ear $\frac{9}{10}$; of fore palm $\frac{4}{10}$; of hind palm $1\frac{1}{4}$; weight 6 oz. 5 drs "†

The skull is considerably smaller than that of *M.* (*N.*) *blythianus*, of the same age, from which it is also distinguished by its more outwardly arched malar process of the maxillary; by its considerably smaller teeth, and long, but less open, anterior palatine foramina. The brain case also is relatively shorter and more globular than that of *M.* (*N.*) *blythianus*. The total lengths of two female skulls of the same age of these species stand in the following relations to each other. *M.* (*N.*) *providens*, 1″·45. *M.* (*N.*) *blythianus*, 1″·67. Molar line in the former 0″·30, in the latter 0″·33. The upper surface of the skull in the fronto-nasal region is less arched in *M.* (*N.*) *providens*, than in *M.* (*N.*) *blythianus*. The incisors are brilliant orange, more so than in *M.* (*N.*) *blythianus*, but this is a variable character.

The external features which distinguish this from the nearly allied *M.* (*N.*) *blythianus* are its smaller size and slightly shorter head and muzzle, and somewhat smaller ears and longer tail, associated with a paler brown fur and fewer long piles.

This animal occurs in southern Western India and also in Ceylon. In the Indian Museum, there is one of Kelaart's specimens of *Mus dubius*, and which he afterwards considered to be *Nesokia hardwickii*, but its skull and features generally are those of this species.

This species produces from 8 to 10‡ at a birth. Elliot relates that this burrowing field-rat is largely eaten by the Wuddurs, or tank-diggers, who also

* It is a curious circumstance that the pelage of *M.* (*N.*) *blythianus*, becomes quite rufous in alcohol, and that stuffed specimens long exposed to light, change to the same hue, as do also stuffed examples of *M.* (*N.*) *providens*.

† *l. c.*, p. 210.

‡ *l. c.*, p. 210.

plunder its burrows for the grain that is stored up for its winter consumption, and he mentions that in favourable localities the Wuddurs find the grain in such quantities as to subsist almost entirely upon it, during that season of the year! Sir Walter Elliot has also described the burrows of this species, which apparently closely correspond to those of *M.* (*N.*) *blythianus*, and he states that a variety is said to frequent the banks of nullahs and to take to the water when pursued, but that these differ in no respect from the common kind—an exact parallel to what occurs also with the allied form *M.* (*N.*) *blythianus* found in Bengal.

Mus (Nesokia) blythianus, n. s.

? *Arvicola bengalensis*, Gray and Hardw., Ill. Ind. Zool., Vol. II, 1833-34, pl. 21, not described.

Mus (Nesokia) indicus, Blyth, Cat. Mamm. As. Soc. Mus, 1863, p. 112 *partim*, nec *M. indicus*, Geoffroy St. Hil.

Nesokia indica, Blyth, Journ. As. Soc. Beng., Vol. XXXII, 1863, p. 329, *partim*, nec *Mus indicus*, Geoffroy St. Hil.; Jerdon, Mamm. Ind. 1867 p. 187, *partim*, nec *M. indicus*, Geoffroy St. Hil.

Head moderately large, but the muzzle broad and deep compared with *Mus decumanus*. Ears rounded; about one half the length of the interval between their base anteriorly and the tip of the snout nearly nude, but sparsely covered with minute hairs. Eye moderately large, placed a little nearer the ear than towards the tip of the snout. Feet well developed, moderately large. Claws short and stout. The length of the tail somewhat variable, but rarely exceeding the length of the trunk, exclusive of the head. It is ringed and sparsely covered with short bristly hairs at the margins of the rings.

The fur is rather coarse and the piles are profusely intermixed among the pelage and project a long way beyond it. These long hairs are most numerous on the lumbar and sacral regions.

The general colour of the animal is dark brown with fleshy-coloured nose, ears and feet, the under-surface having a somewhat greyish tint approaching to hoary. Intermixed among the generally brown hairs of the upper parts, are numerous yellowish hairs producing a speckled appearance, and these yellow hairs give rise to a somewhat rufous tint in the brown colour. The under-surface is without any intermixture of brown and yellow hairs. The ears and upper surface of the feet and the tail are clad with short brown hairs. The whiskers are black.

Measurements in the flesh, of male and female.

	♂	♀
Length of body and head,	8″·20	6″·05
„ „ tail,	6″·45	5″·55
Total length,	14″·65	11″ 60
Length of hind foot,	1″.30	1″·30
Height of ear,	0″·83	0″·75
Breadth of ear,	0″·75	0″·65

The females are distinguished by the presence of 8 pairs of mammary teats. Two in the inguinal region, four on the sides, one pair in the axilla and one pectoral pair.

The skull is distinguished from the skull of the nearly allied form *M. (N.) providens* by the characters already stated, and from the skull of *M. hardwickii* it differs in its considerably narrower incisors and smaller and more irregularly laminated molars, and by its long and open anterior palatine foramina. It is also a more arched skull. The incisor teeth are orange, occasionally brilliantly so, but generally white towards their tips, whilst in some these teeth are nearly white in both sexes, but the teeth of the males are usually the most coloured.

The nasals vary considerably in length and breadth. Compared with the skulls of ordinary mice, shortness of muzzle is one of its most distinguishing features, associated with expansion of the zygomata and general rotundity. The skull of the male is always considerably larger than that of the female. Among males found among the native huts, I have observed two types of skull, one larger than the typical form, but the animals in other respects were identical with other males conforming to the ordinary type of skull. I have never observed these more elongated skulls in females, but if they do occur I would be disposed to attribute the variation to inter-breeding with *Mus decumanus*.

The adult rat, in its external appearance, has a strong resemblance to *M. decumanus*, when the depth of its muzzle and longer tail are overlooked, and a superficial observer at first sight would be disposed to regard them as one and the same species.

It is distinguished from *M. (N.) hardwickii*, by its much longer tail, by its coarser and much darker pelage, narrower incisors and larger ears, and these features and its much smaller feet distinguish it from *M. (N.) scullyi*.

It is a larger animal than *M. (N.) providens*, than which it has somewhat larger ears, a larger head, and broader incisors.

The Indian Museum possesses examples of this species from Gházipur in the North-West of India, from Dacca, Cachar and Midnapore, and numerous specimens from Calcutta and its neighbourhood.

In Cachar specimens, the colour is somewhat darker.

This rat is very generally distributed over Lower Bengal, and from its abundance it becomes a nuisance in gardens, owing to the tortuous character of its burrows, and from the circumstance that they are generally only a few inches below ground, unless the animal happens to burrow on the bank of a tank when the burrow usually runs horizontally inwards. A burrow consists of a great number of short passages which run a short way and then stop, but I have been unable to detect that they are generally constructed on one plan. There is, of course, a continuous but tortuous principal passage from which the offshoots are given off, and the termination of the former, or it may be the end of one of the short passages, may be enlarged and contain a nest of leaves and grass. Other burrows are much simpler, consisting of only a few passages with one principal passage running right inwards for a long way, and these are generally constructed on the banks of tanks. From a nest such as that described I have removed as many as 10 young rats. Like *M.* (*N.*) *providens*, it is of a fierce disposition and utters a peculiar aspirant sound, grinding and rather knocking its teeth together at the same time, and erecting all its fur, more especially the long piles, and contracting its ears which, like the ears of rats generally, are capable of a folded contraction, about the middle of the conch.

I have already mentioned its aquatic habit and that of storing grain.

The Indian Museum, some years ago, received from Moulmein, through the late Captain Hood, a nearly albino adolescent female *Nesokia* closely allied to this species and to *M. (N.) providens*, but as it is immature, and abnormal in colour, I hesitate to name it specifically. The following are its measurements:

Length of body and head, ...	6″·70
„ of tail, ...	5″·26
Total length, ...	11″·96
Length of hind foot,..	1″·32
Height of ear, ...	0″·75

The skull has the ordinary characters of this section of the Sub-genus, and manifests some affinities to *M.* (*N.*) *providens*, more especially in its anterior palatine foramina, which are narrower than in *M.* (*N.*) *blythianus*.

Hodgson has described a rat which is closely allied to this species, *viz.*, *M.* (*N.*) *plurimammis*.

Mus (Nesokia) barclayanus, n. s.

Dr. Arthur Barclay of the Bengal Medical Service, obtained at Gúna, Central India, an adult male field rat which appeared at first sight to be a new generic type, judging from its external appearance only. Whilst it had the general form of *Nesokia* there was this remarkable feature that its ears were nude and only projecting a very short way above the fur, while a broad white band ran from above the nose, through the eye, to the ear. I had the animal figured and afterwards killed, and on examining the skull there could be no doubt regarding the animal's affinities, and that it was closely allied to *Mus (Nesokia) blythianus*, having the same narrow incisors, compared with *M.* (*N.*) *hardwickii*, and the same small molars, with wide anterior palatine foramina.

The ears were nearly symmetrical on either side and, as already stated projected only a little above the fur. It seemed to me, however, that their short character was due to their having been artificially cut, as the margin of each ear was rounded and unhaired. I was therefore disposed to conclude that this rat must have been once in confinement, probably on account of the curious sport of a white band from the nose through the eye, and that either to mark the animal so that it could always be recognised, or perhaps with the object of enhancing its value to the uninitiated, its ears had been cut. There could be no doubt but that it was a *Nesokia* allied to, but probably distinct from, *Mus* (*N.*) *blythianus.*

I was so convinced of this that I sent to the North-West for more specimens of these field rats, and to Mr. Whitwell of the Opium Department, Gházipur, I am indebted for a female field rat which appears to be a normal example of a species which was first made known by the sport which I have described.

The following is a description of this species :

Muzzle short and bluff, less so than in *M.* (*N.*) *hardwickii*, and slightly shorter than in *M.* (*N.*) *blythianus*. Ears moderately large and rounded. Forehead slightly arched. Tail exceeding the length of the trunk, but not equalling the length of the combined body and head : ringed and sparsely clad. Hind foot well developed. Piles moderately long. Fur not very soft, much coarser than in *M.* (*N.*) *huttoni*. General colour of upper parts brown or brownish, tending to silvery grey on the under surface. Feet and muzzle flesh-coloured ; hair brownish. Tail nearly black. Claws horny white.

Dimensions of male and female.

	♂	♀
Length of body and head, ...	8″·70	7″.75
,, of tail, ...	7″·20	7″·00
,, of hind foot, ...	1″·39	1″·33

The skull is considerably larger than that of *Mus* (*N.*) *blythianus*, relatively longer and more arched. There is not, however, very great difference in size between the teeth of this form and that of *M.* (*N.*) *blythianus*, and the anterior palatine foramina are much the same in both. The nasals are considerably relatively broader and larger than those of *Mus* (*N.*)

blythianus, but these bones appear to be subject to considerable variation in this group, and, in the female skull, they are much narrower than in the skull of the male.

In Sind, there is a field rat which corresponds in its general character to this species. The skull of a female from Khípra, Thar and Párkar District, Sind, has all the characters of the female from Gházipur with exactly similar nasals.

A very closely allied, if not identical rat to this, is found at Srinagar, Kashmir, and of which the Indian Museum has one example collected by Dr. Stoliczka.

Its skull exactly agrees with the skull of the male (see figure), except that its nasals are a little narrower. This Kashmir rat is a dark sandy brown above, with long black piles, especially on the lower portion of the back; the under surface of the animal being yellowish with an intermixture of dusky. The fur is coarse, resembling that of this species, of which the Kashmir rat is probably a local race.

This rat appears also to occur in the Purneah District, and in the Indian Museum there is a skull of a rat, marked Cachár, seemingly closely allied to this form.

3rd Section

Mus (Nesokia) elliotanus, n. s.

Head short and deep; muzzle deep and broad; eye half way between ear and nose, moderately large; ears not large, rounded sparsely covered with short hairs. Feet large and well developed with strong claws and sparsely clad. Tail sparsely covered with short bristles on the margins of the annuli, and nearly equalling the length of the body and head.

Pelage coarse, with moderately long piles, most numerous on the back and over the rump. Vibrissæ moderately long.

General colour above, brown with intermixed yellowish or pale brown hairs, producing much the same colour as in *M.* (*N.*) *blythianus*, paler on the sides and passing into greyish on the under parts. Nose and feet flesh-coloured. Ears dark brown, tail blackish.

Measurements of 4 specimens.

	Calcutta. ♂	Purneah. ♂	Calcutta. ♀ juv.	Purneah. ♀ juv.
Length of body and head,...	10″·50	9″·85	8″·25	6″·95
„ of tail, ...	5″·80*	9″·70	7″·40	6″·90
„ of hind foot, ...	2″·28	2″·28	2″·04	1″·83
Height of ear, ...	1″·12	1″·08	0″·95	1″·03

The skull of this species approaches in size the dimensions of the skull of such rats as *M.* (*N.*) *giganteus*, but in form it resembles the skull of

* Imperfect.

M. (*N.*) *blythianus* more than that of the former, being less elongated and with a shorter muzzle, with less breadth between the lachrymal foramina. The teeth have the same characters as in *M.* (*N.*) *blythianus*, but, of course, are very much larger. The nasals are moderately short and very different from the broad nasals of *M.* (*N.*) *giganteus.*

The total length of the skull of the largest male is 2·20 from the upper border of the foramen magnum to the end of the premaxillaries, with a maximum breadth of 1·27 across the zygomatic.

Mr. S. E. Peal has presented to the Indian Museum from Sibságar, Assam, a rat distinctly referable to this species, and I am indebted to Mr. W. T. Blanford for the opportunity to examine another example of this species from the Khási Hills.

In all of these skulls, the female as well as the male, the incisors are bright orange, but in the female somewhat paler, due to her youth or, it may be, sex, and with white tips as in the male Assam skull.

I obtained this rat first at Purneah and afterwards two specimens at Calcutta. The adult male of these two I obtained from a native who asserted that he found it in a palm tree, which I discredit. It is evidently a burrowing rat closely allied to *M.* (*N.*) *blythianus.* It would appear to be very rare about Calcutta, for I have not succeeded in obtaining more than two specimens, notwithstanding that I have made special efforts to obtain others. In all probability, the rats mentioned by Hardwicke as Calcutta bandicoots were large examples of *Mus decumanus*, which occasionally attains to a great size.

Blyth, in his Memoir on the Rats and Mice of India, remarked that *Nesokia indica (=Mus blythianus)* had not been seen from the eastward of the Bay of Bengal, though it was likely enough to occur in the dry climate of the region of the Upper Irawadi. Mr. Theobald in 1866*, in confirmation of this supposition of Blyth's, recorded the occurrence at Tonghoo, on the Sittang, of a rat which he referred to this sub-genus. The dimensions indicate an animal of about the same size as *M.* (*N.) elliotanus*, but distinguished from it at once by the different proportions of its tail and trunk. It is in all probability a new species.

Mus (Nesokia) giganteus.

Mus giganteus, Hardwicke, Trans. Journ. Linn. Soc., Vol. VII, 1804, p. 306, Pl. 18; Desm. Mamm. 1822, p. 298; Brantz, Muizen, 1827, p. 101; Gray, Proc. Zoo. Soc. 1832, p. 40; Kelaart, Faunæ Zeylanicæ, 1852, p. 58.

Mus (*Neotoma*) *giganteus*, Elliot, Madr. Journ. Lit. and Sc., Vol. X, 1839, p. 209.

* Proc. As. Soc. Beng. p. 239.

Mus bandicota, Blyth, Cat. Mamm. As. Soc. Mus., 1863, p. 112; *id.* Journ. As. Soc. Bengal, Vol. XXXII, 1863, p. 333.

Pandi Koku, Telegu = Pig-rat, according to Elliot, *l. c.*, p. 209.

Nose somewhat pointed; muzzle moderately long and rather deep; eye considerably nearer to the ear than to the nose, moderately large. Ears somewhat large and rounded, nearly nude, but sparsely clad with short brown hairs. Tail broadly ringed, sparsely clad with short hairs and nearly equalling the length of the body and head. Feet well developed, sparsely clad on their upper surfaces with short hairs; claws not strong. Vibrissæ long, some of those of the moustache passing behind the ear.

Pelage coarse, consisting of three kinds of hairs, *viz.*, the underlying fur, the bristly hairs of the general pelage and the long coarse piles which are intermixed in great profusion among the fur of the back. These long piles are especially abundant on the lumbar and dorsal regions where they are very long, and being so numerous hide the general pelage lying below them and project out a long way beyond it. The piles are almost entirely absent from the sides of the animal and from the head and neck, but, beyond the latter region they rapidly increase in numbers and length. In the living animal, these piles are always as a rule erect.

The general colour of the animal is earthy brown with intermixed yellow hairs, paler on the sides, where the yellowish or grey hairs are more numerous, owing to the absence of the piles. The piles are so numerous on the back that that region is uniform dark brown, and this colour is prolonged along the back to the head. The under surface is dusky brown with a greyish tint. The limbs are brownish, and the nose, inside of the ear and the feet are flesh-coloured, the upper surface of the latter being sparsely covered with dark brown hairs. The tail is black.

This animal attains to a great size; the type having measured 13·25 inches in the length of its body and head, with a tail 13 inches long; but adult males are even larger than this.

The skull of this rat is much more elongated than the skull of *M.* (*N.*) *providens*, but it, as already stated, belongs to the same group, but is, of course, immensely larger, measuring 2″·66 in length by 1″·35 in maximum breadth across the zygomatic. It differs from the skull of the allied species from Lower Bengal and Assam in its slightly more elongated muzzle and very much larger nasals. The female has 12 mammæ.

This species occurs in great numbers in the district around Gúna and, like its congener *M.* (*N.*) *blythianus*, it has the reputation of being a water rat. In the Manbhúm District it is not uncommon, but two specimens in the Indian Museum are much greyer than those from Bhádrachellum, south of the Godávari, presented by Mr. W. T. Blanford, and which nearly resemble the bandicoot of Ceylon. The Manbhúm rats have many greyish piles interspersed among the dark brown hairs, but this seems to be only a local variation of no importance. Their skulls agree with the skulls of the bandicoots from Gúna, for which I am indebted to Dr. A. Barclay, and are not separable specifically from them. Although these Gúna rats and also the bandicoots from the south of the Godávari are the exact counterparts in external appearance of the Ceylon rats, the skulls of the latter have remarkably different nasals from the rats of Gúna and Manbhúm, being much narrower and more posteriorly pointed, and moreover the muzzle of the skull is narrower and not so long. Allowance, however, must be made for variation, especially in insular examples of a species, and I am, therefore, disposed to regard the foregoing differences observable in the species of the Ceylon bandicoots in this light.

Description of Plates.

Plate XIII, *Mus (N.) blythianus : a*, upper view of skull of a ♂ ; nat. size : *b*, under view of same skull : *c*, side view of same skull : *d*, teeth of right upper jaw and teeth of right lower jaw, enlarged

Mus (N.) providens : e, upper view of skull of *M. N. providens*, nat. size : *f*, under view of same skull : *g*, side view of same skull : *h*, teeth of right upper and lower jaws, enlarged.

Mus (N.) barclayanus : i, upper view of skull : *j*, under view of skull : *k*, side view of skull : *l*, teeth of right upper and lower jaws, enlarged.

Plate XIV, *Mus (N.) giganteus : a*, upper view of skull : *b*, under view of skull : *c*, side view of skull : *d*, 1, teeth of right upper jaw, enlarged : *d*, 2, teeth of right lower jaw, enlarged.

Mus (N.) elliotanus : e, upper view of skull : *f*, under view of skull : *g*, side view of skull : *h*, right upper and lower teeth, enlarged.

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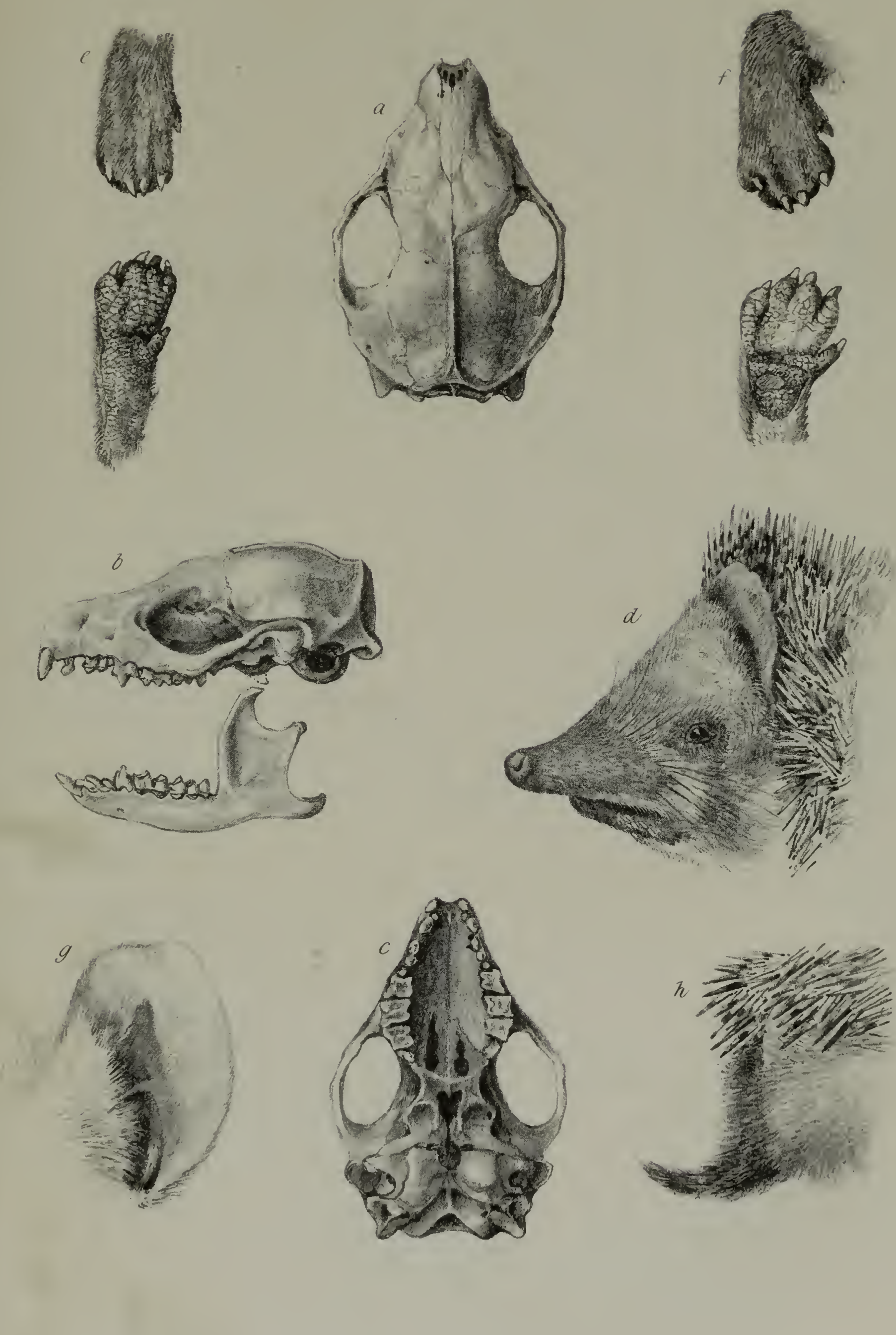
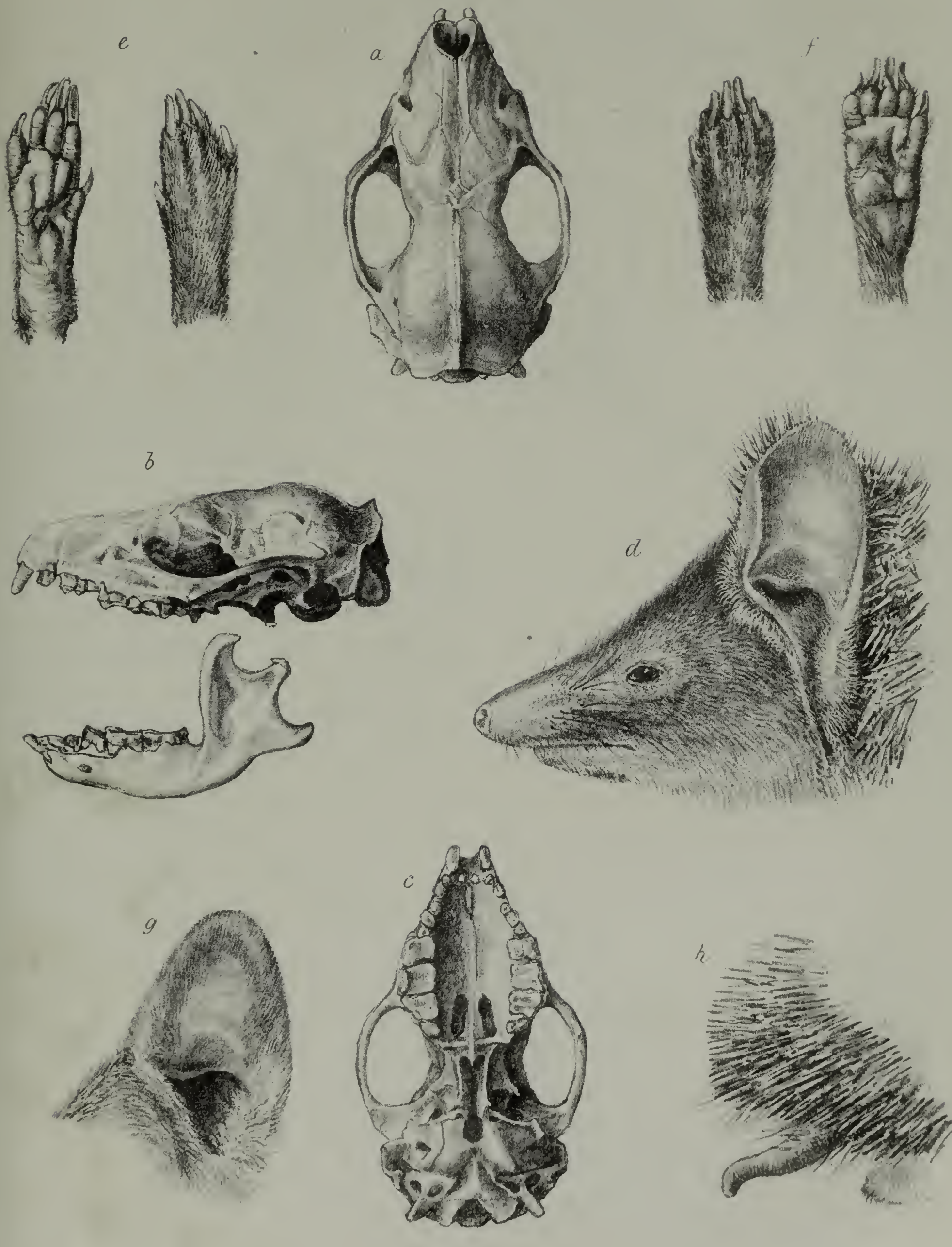
☞ Names of new genera and species have an asterisk (*) prefixed.



Kaliludin Amed, del.
H.H. Godwin-Austen. Lith.

Maclure & Macdonald, imp.

J.ANDERSON. Journ: Asiat: Soc: Bengal. Vol XLVII. Pt II. 1878. PLATE.IV.



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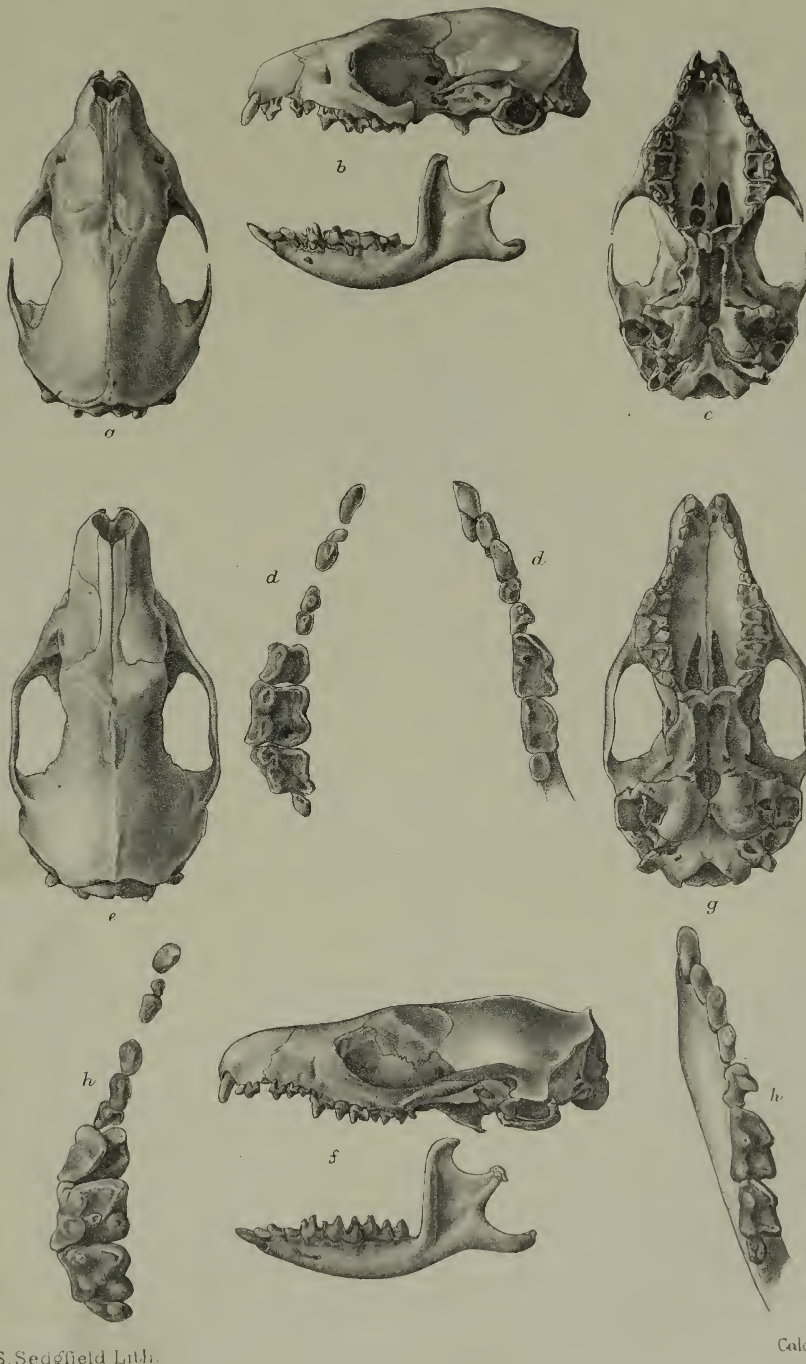
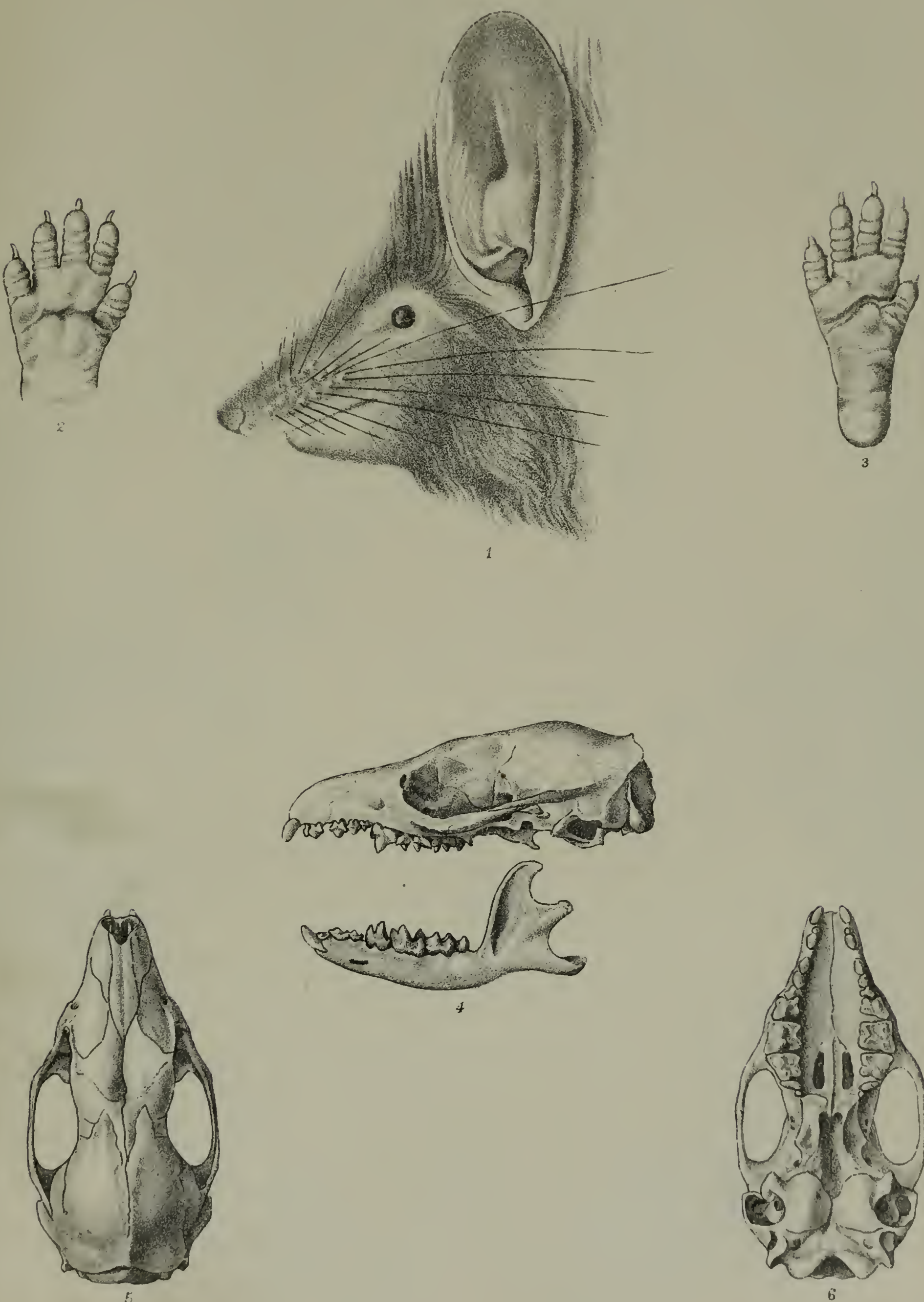


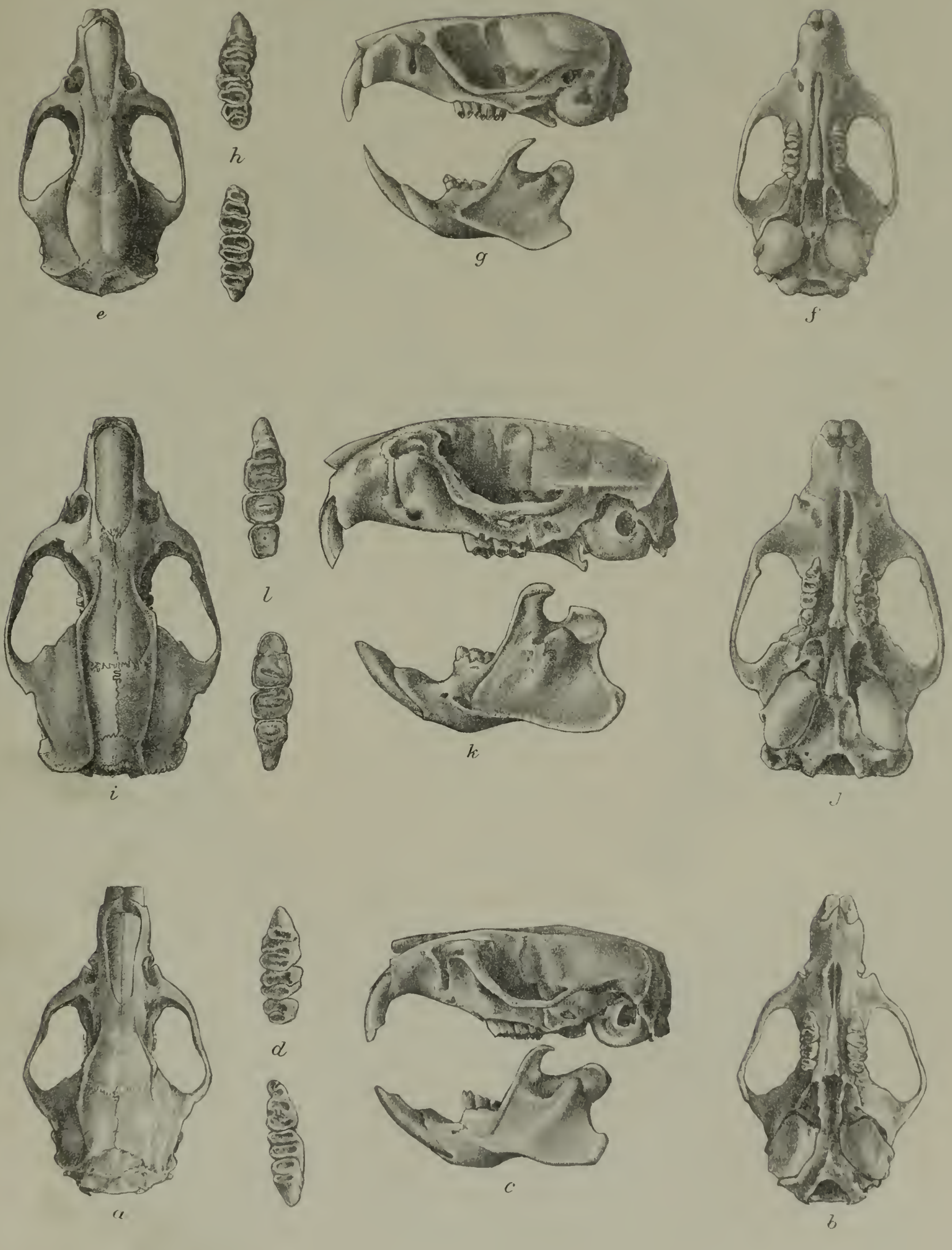
S. Sedgfield Lith. Calcutta



ERINACEUS NIGER.

Mintern Bros imp.

THAUMANTIS LOUISA.



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S. Sedgfield. Lith. Calcutta

S. Sedgfield Lith:

Behari Lall Dass del:

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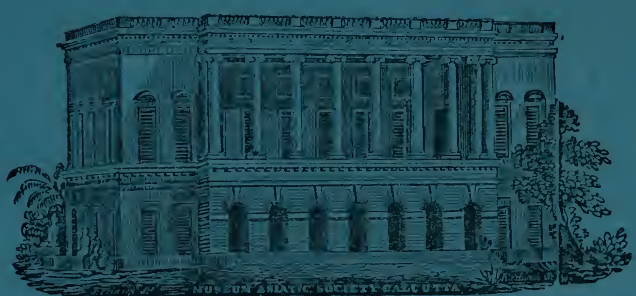

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