TRANSACTIONS

OF

THE ZOOLOGICAL SOCIETY
OF LONDON.

VOLUME XV.

LONDON:
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TRANSACTIONS

OF

THE ZOOLOGICAL SOCIETY OF LONDON.

I. *Report on the Collection of Fishes made by Mr. J. E. S. Moore in Lake Tanganyika during his Expedition*, 1895–96. *By* G. A. Boulenger, *F.R.S.*, *F.Z.S.* *With an Appendix by* J. E. S. Moore, *A.R.C.S.*

Received and read June 21, 1898.

[Plates I.–VIII.]

THE examination of the collection of fishes brought home from Lake Tanganyika by Mr. Moore, and with which I have been entrusted by him, has not yielded any such startling results as have already been announced after study of the Invertebrates[1]. Of the two series in the fauna of Tanganyika, distinguished by its explorer as the normal freshwater and the halolimnic groups[2], the latter is unrepresented in the collection. This may be due either to the origin of the present fish-fauna not reaching so far back in time as that of the Mollusca and other Invertebrates, or to the incompleteness of the series brought home. The latter explanation may be the correct one, since, owing to the lack of suitable dredging-apparatus, and to the difficulties of preserving, to which Mr. Moore has alluded[3], only a small proportion of the fishes of the Lake could be collected, mostly littoral forms found about the rocks; of the deeper-water fishes, which were observed to be abundant both in species and in individuals, we are still almost entirely ignorant; it is therefore to be expected that further collections,

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[1] J. E. S. Moore, "On the Zoological Evidence for the Connection of Lake Tanganyika with the Sea," Proc. R. Soc. lxii. 1898, pp. 451–458.

[2] J. E. S. Moore, "The Molluscs of the Great African Lakes," Q. Journ. Micr. Sci. 1898, pp. 159–204.

[3] *L. c.* See also "The Physiographical Features of the Nyasa and Tanganyika Districts," Geogr. Journ 1897.

made under more favourable circumstances, would considerably modify our views on the general character of this most important section of the fauna.

How incomplete the collection is may be partly realized from the fact that, of the six species previously described from Tanganyika, only one was rediscovered by Mr. Moore. His series of sketches executed from fresh specimens, free use of which he has kindly given me, thus enabling me to represent some of the new species in their natural colours, also indicate the existence of several fishes which are unrepresented in the collection. Large fishes, owing to the impossibility of preserving them, had to be left behind, and the difficulties of transport by carriers resulted in the loss of several jars containing spirit-specimens. Nevertheless, small as it is, and though deficient in any but typically African freshwater forms, the collection is of great interest, and Mr. Moore well deserves the thanks of all zoologists for the manner in which, amid so many difficulties, he has succeeded in affording us a first glimpse at a fish-fauna which has so long remained a mystery.

A study of the freshwater fishes of Africa has hitherto led to the assumption that the bulk of the fauna originated in the region of the great lakes, whence they have radiated towards the Mediterranean and the Atlantic and Indian Oceans—a view based on the close affinity, often amounting to specific identity, of the fishes of the Nile, the Niger, the Congo, and the Zambesi. The homogeneity of the fauna is absolutely opposed to the conception of the great watersheds having been stocked from the sea, within the geological period of which these fishes are representative, this being evident even in the case of such forms as *Lates* and *Tilapia*, which are known to enter salt water. Nothing contrary to this theory is brought to light by an examination of the fishes obtained by Mr. Moore in Lake Tanganyika. The striking character of the Tanganyika fish-fauna, as revealed by Mr. Moore's collection, is the extraordinary variety of the *Cichlidæ*[1]. This is a natural group distributed all over Africa, including Madagascar, but, although rich in species, nowhere else showing within a limited area anything like the modifications of structure described in this report, which have necessitated the establishment of nearly as many new genera as were previously known from the whole of Africa. The generalized characters of some of the *Cichlidæ* occurring in Lake Tanganyika, regarding as indicative of generalization the greater development of the anal fin, consistently with the system followed in classifying their more primitive allies the *Centrarchidæ*[2], and the extent of the lateral lines, both of which are complete in some of the newly-discovered forms[3], afford further support to the

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[1] See P. Z. S. 1898, p. 132.

[2] Cat. Fish. 2nd ed. i. p. 2 (1895).

[3] The lateral line has usually been described as "interrupted" in the *Cichlidæ* and other groups in which it has a similar disposition. This expression conveys a serious misconception, and I have replaced it in the diagnoses of the *Cichlidæ* and the *Serranidæ* allied to *Plesiops* by "lateral lines two," the necessity for this change being particularly obvious in the case of some of the species described in this report. Fishes had no doubt originally a greater number of lines of sense-organs along the body, as we may still observe in many of

proposition enunciated above. Lake Tanganyika might be regarded as the centre of origin of all the African genera of *Cichlidæ*.

Unfortunately, nothing reliable is yet known of this family in a fossil condition, with the exception of a few American Tertiary types, which do not differ materially from those inhabiting the same part of the world at the present time. There is no reason for referring to it the Cretaceous fishes from Mount Lebanon described as "Chromides" by Heckel[1] and by Davis[2]. All we can gather from Heckel's description is that *Pycnosterynx* is based on some "Pharyngognath Acanthopterygian," and that it does *not* belong to the *Cichlidæ* is conclusively proved by his statement: "Rippen kurz, dünn, die hinteren auf langen Querfortsätzen ansitzend," a sentence that has been translated by Davis as "Ribs short and slender, the posterior ones supporting long transverse apophyses"[3]. An examination of some of the specimens of *Pycnosterynx* exhibited in the British Museum suggests to me special relation to the *Berycidæ*, with which they are provisionally associated by Mr. Smith Woodward, and certainly no affinity to the *Cichlidæ*. Considering that coalesced lower pharyngeal bones occur at the present day in such widely different groups as the *Serranidæ*, *Gerridæ*, *Sciænidæ*, *Cichlidæ*, *Pomacentridæ*, *Embiotocidæ*, *Labridæ*, *Scaridæ*, *Pleuronectidæ*, and *Scombresocidæ*, this character, if correctly ascertained by Heckel, would in itself be no serious objection to the allocation of *Pycnosterynx* among the *Berycidæ*. Günther[4] also doubts the correctness of Heckel's determination when he states that "the position of *Pycnosterynx* is uncertain," but we are not enlightened as to its affinities by the further remark that "it approaches certain Pharyngognaths." It appears certain that true Perciform fishes, to which large group the *Cichlidæ* belong, have not yet been described from pre-Tertiary beds.

In order to show what is now known of the fish-faunas of the great lakes, lists are appended of the fishes of Lakes Nyassa, Tanganyika, Victoria Nyanza, and Rudolf. These lists must of course be taken as giving a very inadequate idea of the fauna, owing to the incompleteness of the collections on which they are based; but, imperfect as they are, they nevertheless will prove useful as a basis from which to judge of the relation existing between the piscine inhabitants of these lakes. Of the other lakes, unfortunately, nothing can be said at present, the occurrence of an undetermined species of *Haplochilus* in the Albert Nyanza being all the information we possess.

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the lower forms. In the Teleosteans, as a general rule, the lateral lines are reduced to one on each side, extending uninterrupted from the head to the root of the caudal fin, although among this order there is hardly a single large group that does not offer exceptions such as are shown in the *Cichlidæ*. In these, both upper and lower lateral lines may be complete; or the upper may be complete and the lower reduced, or the reverse; or the upper may be incomplete posteriorly and the lower anteriorly, which latter disposition has led to the misconception involved in the term "interrupted."

[1] Abbild. u. Beschr. n. Thier. Syrien, p. 235 (1843).

[2] Tr. R. Dublin Soc. (2) iii. 1888, p. 531.

[3] *L. c.* p. 532.

[4] 'Study of Fishes,' p. 200 (1880).

I. *Lake Nyassa*[1].

CICHLIDÆ.

1. *Paratilapia robusta* Gthr.
2. „ *afra* Gthr.
3. „ *modesta* Gthr.
4. „ *livingstonii* Gthr.
5. „ *intermedia* Gthr.
6. „ *dimidiata* Gthr.
7. „ *longiceps* Gthr.
8. *Corematodus shiranus* Blgr.
9. *Tilapia shirana* Blgr.
10. „ *mossambica* Ptrs.
11. „ *kirkii* Gthr.
12. „ *squamipinnis* Gthr.
13. „ *rendalli* Blgr.
14. „ *lateristriga* Gthr.
15. „ *subocularis* Gthr.
16. „ *johnstoni* Gthr.
17. „ *lethrinus* Gthr.
18. „ *tetrastigma* Gthr.
19. „ *callipterus* Gthr.
20. „ *williamsi* Gthr.
21. „ *aurata* Blgr.
22. *Docimodus johnstoni* Blgr.

MASTACEMBELIDÆ.

23. *Mastacembelus shiranus* Gthr.

SILURIDÆ.

24. *Bagrus meridionalis* Gthr.
25. *Anoplopterus platychir* Gthr.
26. *Synodontis zambesensis* Gthr.

CYPRINIDÆ.

27. *Labeo mesops* Gthr.
28. *Barbus trimaculatus* Ptrs.
29. *Barilius guentheri* Blgr.
30. *Engraulicypris pinguis* Gthr.
31. *Pelotrophus microlepis* Gthr.
32. „ *microcephalus* Gthr.

CHARACINIDÆ.

33. *Alestes imberi* Ptrs.

CYPRINODONTIDÆ.

34. *Haplochilus johnstoni* Gthr.

MORMYRIDÆ.

35. *Mormyrus discorhynchus* Ptrs.
36. „ *catostoma* Gthr.
37. *Mormyrops zambanenje* Ptrs.

II. *Lake Tanganyika*[2].

SERRANIDÆ.

1. *Lates microlepis* Blgr.

CICHLIDÆ.

2. *Lamprologus fasciatus* Blgr.
3. „ *compressiceps* Blgr.
4. „ *moorii* Blgr.
5. „ *modestus* Blgr.
6. „ *elongatus* Blgr.
7. „ *furcifer* Blgr.
8. *Telmatochromis vittatus* Blgr.
9. *Telmatochromis temporalis* Blgr.
10. *Julidochromis ornatus* Blgr.
11. *Paratilapia pfefferi* Blgr.
12. „ *macrops* Blgr.
13. „ *ventralis* Blgr.
14. „ *furcifer* Blgr.
15. „ *leptosoma* Blgr.
16. *Ectodus descampsii* Blgr.
17. „ *melanogenys* Blgr.
18. *Bathybates ferox* Blgr.
19. *Eretmodus cyanostictus* Blgr.

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[1] *Cf.* Günther, P. Z. S. 1864, p. 307, 1893, p. 616, and Ann. & Mag. N. H. (6) xvii. 1896, p. 397; Boulenger P. Z. S. 1896, p. 915, and Ann. & Mag. N. H. (6) xix. 1897, p. 155, and (7) i. 1898, p. 254.

[2] *Cf.* Günther, P. Z. S. 1893, p. 628.

Cichlidæ (*continued*).

20. *Tilapia tanganicæ* Gthr.
21. ,, *burtoni* Gthr.
22. ,, *labiata* Blgr.
23. *Tropheus moorii* Blgr.
24. *Simochromis diagramma* Gthr.
25. *Petrochromis polyodon* Blgr.
26. *Perissodus microlepis* Blgr.
27. *Plecodus paradoxus* Blgr.

Mastacembelidæ.

28. *Mastacembelus moorii* Blgr.
29. ,, *tanganicæ* Gthr.
30. ,, *ophidium* Gthr.

Siluridæ.

31. *Clarias anguillaris* L.
32. ,, *liocephalus* Blgr.
33. *Anoplopterus platychir* Gthr.
34. *Auchenaspis biscutata* Geoffr.
35. *Synodontis multipunctatus* Blgr.
36. *Malapterurus electricus* Gm.

Cyprinidæ.

37. *Labeo*, sp.

Characinidæ.

38. *Alestes macrolepidotus* C. & V.
39. ,, *macrophthalmus* Gthr.
40. *Hydrocyon forskalii* Cuv.

Cyprinodontidæ.

41. *Haplochilus tanganicanus* Blgr.

Polypteridæ.

42. *Polypterus bichir* Geoffr. (?).

Lepidosirenidæ.

43. *Protopterus annectens* Ow. ? [1].

III. *Lake Victoria Nyanza* [2].

Cichlidæ.

1. *Paratilapia longirostris* Hilg.
2. ,, *cavifrons* Hilg.
3. ,, *retrodens* Hilg.
4. *Tilapia nilotica* Cuv.
5. ,, *nuchisquamulata* Hilg.
6. ,, *sauvagii* Pfeff.
7. ,, *obliquidens* Hilg.

Mastacembelidæ.

8. *Mastacembelus*, sp.

Siluridæ.

9. *Clarias*, sp.
10. *Synodontis afrofischeri* Hilg.

Cyprinidæ.

11. *Labeo forskalii* Rüpp.
12. *Labeo rueppellii* Pfeff.
13. *Barbus pagenstecheri* Fisch.
14. ,, *trimaculatus* Ptrs.

Characinidæ.

15. *Alestes rueppellii* Gthr.

Cyprinodontidæ.

16. *Fundulus tæniopygus* Hilg.

Mormyridæ.

17. *Mormyrus oxyrhynchus* Geoffr.
18. ,, *longibarbis* Hilg.

Lepidosirenidæ.

19. *Protopterus annectens* Ow.

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[1] Reported from Lake Tanganyika by Sir H. H. Johnston, Brit. C. Afr. p. 362 (1897).

[2] Hilgendorf, Sitzb. Ges. naturf. Fr. Berl. 1888, p. 75; Pfeffer, Thierw. O.-Afr., Fische (1896); Günther, Ann. & Mag. N. H. (6) xvii. 1896, p. 397.

IV. *Lake Rudolf*[1].

CICHLIDÆ.

1. *Tilapia nilotica* Cuv.
2. „ *tristrami* Gthr.

SILURIDÆ.

3. *Synodontis schal* Bl. Schn.
4. „ *smithii* Gthr.

CYPRINIDÆ.

5. *Barbus*, sp.

CHARACINIDÆ.

6. *Citharinus geoffroyi* Cuv.
7. *Alestes rueppellii* Gthr.
8. *Distichodus rudolphi* Gthr.

POLYPTERIDÆ.

9. *Polypterus senegalus* Cuv.

The fishes of Lake Nyassa are, with two exceptions, specifically distinct from those of the Nile, as pointed out by Dr. Günther[2], while seven out of forty-three species represented in Lake Tanganyika occur both in the Nile and in the rivers flowing into the Atlantic. And as the *Mormyridæ*, which furnish the two species common to Nyassa and the Nile[3], have not yet been recorded from Tanganyika, while, with the exception of a small stream-Siluroid, not one of the species described from the former lake has been rediscovered in the latter, it follows that, although similar in general character, the fish-fauna of the two lakes shows no trace of community so far as specific forms are concerned, as might have been expected from the absence of direct communication between them.

Before concluding these prefatory remarks, I wish to express my thanks to Messrs. J. H. Gardiner and J. Green for their kind assistance in supplying me with sciagraphs of the new fishes, which, supplementing the skeletons prepared by Mr. Groenvold, have enabled me to add some notes on the osteological characters of the genera described as new.

SERRANIDÆ.

1. LATES MICROLEPIS, sp. n. (Plate I. fig. 1.)

Body elongate, its depth $3\frac{1}{2}$ times in the total length. Length of head 3 times in total length; upper profile nearly straight; diameter of eye equal to length of snout, $3\frac{3}{4}$ times in length of head; lower jaw projecting; maxillary extending to below centre of eye, the width of its distal extremity not quite half diameter of eye; præ- and suborbitals finely serrated; cheeks, opercles, and occiput covered with small scales; præopercular border forming nearly a right angle, finely toothed on its vertical limb, with two or three widely-separated spines on its lower limb, and with one or two very

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[1] Günther, P. Z. S. 1896, p. 217.

[2] 'Study of Fishes,' p. 230.

[3] If, as seems probable, the distinction between *Mormyrops zambanenje* and *M. anguilloides* should not be maintained. On the other hand, the Nilotic specimens referred to *Mormyrus discorhynchus* may prove to be specifically separable. Lake Tanganyika might thus ultimately possess no species of fish in common with the Nile.

strong spines at the angle; opercular spine as much developed as the latter; clavicle with a group of 3 or 4 strong spines. 16 gill-rakers on lower part of anterior arch. Dorsal VII, II 11; first and second spines short, third very strong, longest, $\frac{2}{3}$ length of head; longest soft rays $\frac{2}{5}$ length of head. Pectoral $\frac{1}{2}$ length of head. Anal III 8; spines short, second and third equal. Caudal truncate. Caudal peduncle twice as long as deep. Scales 100–110 $\frac{12-13}{29-30}$. Body silvery, spotted and marbled with brown; dorsals spotted with brown; caudal with irregular brown bars.

Total length 155 millim.

Two young specimens from Kinyamkolo.

This species is closely allied to the widely-distributed *Lates niloticus* Hasselq. Compared to young specimens of the latter, it differs in the smaller scales, the higher spinous dorsal, the longer caudal peduncle, and the shape of the caudal fin, which is truncate instead of rounded.

CICHLIDÆ.

2. LAMPROLOGUS FASCIATUS, sp. n. (Plate I. fig. 2.)

A few moderately large curved canine teeth in front of each jaw, followed by a narrow band of minute teeth; lateral teeth very small. Depth of body 4 times in total length, length of head 3. Snout as long as the diameter of the eye, which is 3 times in length of head and equals $1\frac{1}{2}$ interorbital width; maxillary extending to below anterior border of eye; cheeks naked; opercles and occiput scaled. Gill-rakers short, 12 on lower part of anterior arch. Dorsal XIX 8; spines increasing in length to the last, which measures $\frac{2}{5}$ length of head and nearly equals longest soft rays. Pectoral $\frac{1}{2}$ length of head. Ventral reaching vent. Anal X 6; spines increasing in length to the last, which slightly exceeds longest dorsal. Caudal rounded. Caudal peduncle as long as deep. Scales 46 $\frac{5}{10}$; lat. l. $\frac{24-26}{23-26}$. Yellowish, with 11 dark brown bars, the first across the vertex; fins greyish, dorsal and anal edged with blackish.

Total length 70 millim.

A single specimen from Kinyamkolo.

3. LAMPROLOGUS COMPRESSICEPS, sp. n. (Plate I. fig. 3.)

A few moderately large curved canine teeth in front of each jaw, followed by a narrow band of minute teeth; lateral teeth very small, curved. Depth of body $2\frac{1}{2}$ to $2\frac{3}{5}$ times in total length, length of head $2\frac{3}{5}$ to $2\frac{3}{4}$. Head very strongly compressed, with concave upper profile; snout a little longer than diameter of eye, which is 4 times in length of head and equals $1\frac{1}{2}$ interorbital width; maxillary extending to below anterior border of eye; cheeks naked; opercles and occiput with small scales. Gill-rakers moderately long, 15 on lower part of anterior arch. Dorsal XX–XXI 6;

spines increasing in length to the sixth, which measures half length of head, the posterior a little shorter; longest soft rays a little longer than longest spines. Pectoral $\frac{1}{2}$ to $\frac{3}{5}$ length of head. Ventral produced into a filament. Anal X 5; spines increasing in length to the last, which equals the last dorsal; longest soft rays $\frac{3}{5}$ length of head. Caudal rounded. Caudal peduncle as long as deep. Scales 32–33 $\frac{5}{12}$; lat. l. $\frac{22-23}{9-10}$. Brown, with indistinct traces of five darker vertical bars; pectoral bright yellow, other fins blackish towards the border.

Total length 83 millim.

Two specimens from Kinyamkolo.

4. Lamprologus moorii, sp. n. (Plate I. fig. 4.)

9 or 10 equal, moderately large conical teeth in front of each jaw, followed by a narrow band of minute teeth; lateral teeth very small. Depth of body $2\frac{1}{2}$ times in total length, length of head 3 to $3\frac{1}{5}$. Snout as long as diameter of eye, which is 3 to $3\frac{1}{3}$ times in length of head and equals interorbital width; maxillary extending to below anterior border of eye; cheeks with small, deciduous scales; opercles and occiput scaled. Gill-rakers short, 9 or 10 on lower part of anterior arch. Dorsal XIX–XX 8–9; spines slightly increasing in length to the last, which measures nearly half length of head; middle soft rays prolonged, at least $\frac{3}{4}$ length of head. Pectoral $\frac{3}{4}$ to $\frac{4}{5}$ length of head. Ventral prolonged into a long filament. Anal VII–VIII 6–7; spines increasing in length to the last, which is a little longer than the longest dorsal; middle soft rays prolonged into filaments. Caudal rounded. Caudal peduncle as long as deep. Scales 33–35 $\frac{5-7}{11-12}$; lat. l. $\frac{24-28}{9-13}$. Dark brown; fins blackish.

Total length 93 millim.

Several specimens from Mbity Rocks and Kinyamkolo.

5. Lamprologus modestus, sp. n. (Plate I. fig. 5.)

A few large curved canine teeth, tipped with brown, in front of each jaw, followed by a band of minute teeth; lateral teeth very small. Depth of body $3\frac{1}{3}$ to $3\frac{2}{5}$ times in total length, length of head 3 to $3\frac{1}{3}$. Snout a little longer than diameter of eye, which is $3\frac{1}{2}$ to 4 times in length of head and equals interorbital width; maxillary extending to below anterior border of eye; cheeks naked; opercles and occiput scaled. Gill-rakers very short, 7 on lower part of anterior arch. Dorsal XX 8–9; spines increasing in length to the last, which is not quite half length of head; middle soft rays prolonged, $\frac{2}{3}$ to $\frac{3}{4}$ length of head. Pectoral about $\frac{2}{3}$ length of head. Ventral prolonged into a short filament. Anal V 6–7; spines increasing in length to the last, which is as long as middle dorsals; middle soft rays prolonged, like the dorsals. Caudal truncate. Caudal peduncle as long as deep. Scales 36–40 $\frac{5-6}{12-14}$; lat. l. $\frac{24-25}{7-11}$.

Uniform brown; soft dorsal and caudal fins with round black spots between the rays.

Total length 75 millim.

A single specimen from Mbity Rocks, and another from Kinyamkolo.

6. Lamprologus elongatus, sp. n. (Plate I. fig. 6.)

6 to 8 large canine teeth in front of each jaw, followed by a broad band of minute villiform teeth; lateral teeth very small. Depth of body 4 times in total length, length of head $2\frac{3}{4}$ to $2\frac{4}{5}$. Snout twice as long as diameter of eye, which is 5 times in length of head and equals interorbital width; maxillary extending to below anterior border of eye; cheeks naked; opercles and occiput scaled. Gill-rakers moderately long, 12 on lower part of anterior arch. Dorsal XVIII 10–11; spines slightly increasing in length to the last, which measures $\frac{1}{3}$ length of head; longest soft rays half length of head. Pectoral half length of head. Ventral reaching vent. Anal V 8; spines increasing in length to the last, which equals longest dorsal. Caudal truncate. Caudal peduncle $1\frac{1}{2}$ as long as deep. Scales 90–95 $\frac{10}{22\text{–}28}$; lat. l. $\frac{44\text{–}56}{20\text{–}30}$. Brown, with darker spots having a tendency to form cross-bars; caudal fin with round dark spots between the rays.

Total length 113 millim.

One specimen from Mbity Rocks, and one from Kinyamkolo.

7. Lamprologus furcifer, sp. n. (Plate II. fig. 1.)

A few large curved canine teeth in front of each jaw, followed by a moderately broad band of minute villiform teeth; lateral teeth very small. Depth of body 4 to $4\frac{1}{4}$ times in total length, length of head $2\frac{4}{5}$ to 3. Snout as long as or a little longer than diameter of eye, which is $3\frac{1}{2}$ to $3\frac{2}{3}$ times in length of head and exceeds interorbital width; maxillary extending to below anterior fourth of eye; cheeks and opercles with deciduous scales. Gill-rakers short, 16 on lower part of anterior arch. Dorsal XX–XXI 7–8; spines increasing in length to the last, which measures $\frac{2}{5}$ length of head; middle soft rays produced, $\frac{2}{3}$ to $\frac{3}{4}$ length of head. Pectoral $\frac{3}{4}$ length of head. Ventral reaching vent or origin of anal. Anal VI–VII 6; spines increasing in length, the last nearly as long as last dorsal; middle soft rays produced. Caudal deeply notched, crescentic. Caudal peduncle $1\frac{1}{2}$ as long as deep. Scales 50–54 $\frac{6\text{–}7}{16\text{–}17}$; lat. l. $\frac{32\text{–}34}{22\text{–}31}$; lower lateral line often nearly complete. Dark brown, with very indistinct blackish bars on the body; dorsal and caudal with round black spots between the rays; tips of the caudal lobes whitish.

Total length 125 millim.

Three specimens from Kinyamkolo, and one from Mbity Rocks.

The genus *Lamprologus* was known from a single species *L. congoensis* Schilthuis, discovered a few years ago in the Congo. The species now described raise the number to 7, distinguishable by means of the following key:—

I. Caudal rounded or truncate.
  A. Anal with 10 spines.
D. XIX 8; Sc. 46 $\frac{5}{10}$; depth of body 4 times in total length . . . . . . 1. *L. fasciatus.*
D. XX–XXI 6; Sc. 32–33 $\frac{5}{12}$; depth of body $2\frac{3}{5}$ to $2\frac{3}{4}$ times in total length. 2. *L. compressiceps.*
  B. Anal with 6 to 8 spines.
D. XIX–XX 8–9; Sc. 33–35 $\frac{5\text{–}7}{11\text{–}12}$; depth of body $2\frac{1}{2}$ times in total length . 3. *L. moorii.*
D. XVIII–XIX 8–10; Sc. 42–53 $\frac{6\text{–}7}{14\text{–}15}$; depth of body $3\frac{3}{4}$ to 4 times in total length.
4. *L. congoensis.*
  C. Anal with 5 spines.
D. XX 8–9; Sc. 36–40 $\frac{5\text{–}6}{11\text{–}14}$; depth of body $3\frac{1}{3}$ to $3\frac{2}{5}$ times in total length . 5. *L. modestus.*
D. XVIII 10–11; Sc. 90–95 $\frac{16}{22\text{–}28}$; depth of body 4 times in total length . 6. *L. elongatus.*
II. Caudal deeply notched, crescentic.
D. XX–XXI 7–8; A. VI–VII 6; Sc. 50–54 $\frac{6\text{–}7}{16\text{–}17}$ . . . . 7. *L. furcifer.*

TELMATOCHROMIS, g. n.

Body more or less elongate; scales ctenoid. Jaws with a series of conical teeth, followed by a broad band of minute tricuspid teeth; lateral teeth small, conical. Maxillary exposed. Dorsal with 20 to 22 spines, anal with 6 or 7. Vertebræ 33 (16+17).

This genus is closely allied to *Lamprologus*, differing in the small teeth forming a band behind the outer row being tricuspid instead of conical. It therefore stands somewhat in the same relation to *Lamprologus* as *Tilapia* does to *Paratilapia.*

8. TELMATOCHROMIS VITTATUS, sp. n. (Plate II. fig. 2.)

12 to 16 enlarged conical teeth, tipped with brown, in the outer row in each jaw. Depth of body $4\frac{1}{2}$ to $4\frac{2}{3}$ times in total length, length of head 4. Snout descending in a strong curve, as long as or a little longer than the diameter of the eye, which is $3\frac{2}{3}$ to 4 times in length of head and equals interorbital width; maxillary extending to below the nostril; head naked, opercle with a few deciduous scales. Gill-rakers very short and few. Dorsal XXI–XXII 8; spines increasing in length to the last, which equals $\frac{1}{2}$ length of head; soft rays a little longer. Pectoral $\frac{3}{4}$ length of head. Ventral produced into a short filament, reaching origin of anal. Anal VII 5–6; spines increasing in length to the last, which equals last dorsal. Caudal rounded. Caudal peduncle as long as deep. Scales 45–52 $\frac{6}{16}$; lat. l. $\frac{25\text{–}29}{13\text{–}15}$. Yellowish, with a dark

brown lateral stripe from the upper lip, through the eye, to the base of the caudal, where it expands into a spot; another dark brown stripe from the vertex along the base of the dorsal; a few brown spots on the dorsal; anal edged with dark brown; a black bar at the base of the pectoral, which is white.

Total length 78 millim.

Two specimens from Mbity Rocks.

9. TELMATOCHROMIS TEMPORALIS, sp. n. (Plate II. fig. 3.)

8 to 12 enlarged conical teeth, tipped with brown, in the outer row in each jaw. Depth of body $3\frac{1}{4}$ to $3\frac{1}{2}$ times in total length; length of head 3 to $3\frac{1}{4}$. Snout descending in a strong curve, $1\frac{1}{2}$ as long as the diameter of the eye, which is $4\frac{1}{2}$ times in length of head and a little less than interorbital width; maxillary extending to below anterior border of eye; head naked, or with a few deciduous scales on the opercles. Gill-rakers very short and few. Dorsal XX–XXI 6–7; spines increasing in length to the last, which equals $\frac{1}{3}$ to $\frac{1}{2}$ length of head; middle soft rays produced, $\frac{2}{3}$ to $\frac{3}{4}$ length of head. Pectoral $\frac{2}{3}$ length of head. Ventral produced into a filament, extending beyond origin of anal. Anal VI–VII 6–7; spines increasing in length to the last, which equals or slightly exceeds last dorsal; soft rays produced, like the dorsals. Caudal rounded. Caudal peduncle as long as deep. Scales 43–46 $\frac{6}{12}$; lat. l. $\frac{25}{9\text{–}17}$. Brown, with small round darker spots between the dorsal, anal, and caudal rays; a dark horizontal streak behind the eye; a dark bar at base of pectoral.

Total length 85 millim.

Three specimens from Kinyamkolo, and one from Mbity Rocks.

The deep anterior groove of the skull, in which the ascending processes of the præmaxillaries are received, extends to the anterior third of the orbits, and the strong occipital crest is prolonged forward to it; parietal crests are entirely absent; the chain of suborbital bones is very slender. None of the ribs are sessile, being inserted on a step at the back of the transverse processes of the vertebræ at a short distance from the centre; all bear epipleurals; only the last præcaudal vertebra has a hæmal bridge.

JULIDOCHROMIS, g. n.

Body elongate; scales ctenoid. Jaws very narrow, with a few curved canines in front, the outer of which are very large and tusk-like, followed on the sides and behind by minute conical teeth forming a narrow band. Maxillary exposed. Dorsal with 22 to 24 spines, anal with 8 or 9. Vertebræ 34 (17+17).

This genus represents an exaggerated type of *Lamprologus*. The very specialized dentition and the general aspect remind one of the Julidine *Labridæ*, whence the name proposed.

10. Julidochromis ornatus, sp. n. (Plate II. fig. 4.)

4 or 6 canines in each jaw, tipped with brown. Depth of body 4 to $4\frac{1}{2}$ times in total length, length of head $3\frac{1}{3}$ to $3\frac{1}{2}$. Snout $1\frac{1}{2}$ to twice as long as diameter of eye, which is $4\frac{1}{2}$ to 5 times in length of head and $1\frac{1}{2}$ in interorbital width; maxillary extending to below nostril; cheeks naked; opercles scaled. Gill-rakers very short and few. Dorsal XXII–XXIV 5; spines equal from the eighth or tenth, $\frac{1}{3}$ length of head; longest soft rays $\frac{1}{2}$ to $\frac{2}{3}$ length of head. Pectoral about $\frac{2}{3}$ length of head. Ventral produced in a filament, reaching origin of anal. Anal VIII–IX 4–6; spines increasing in length to the last, which equals $\frac{2}{5}$ length of head. Caudal rounded. Caudal peduncle as long as deep. Scales 45-50 $\frac{6–7}{12–13}$; lat. l. $\frac{26–29}{10–15}$. Yellowish, with three dark brown stripes on each side, the lower from the end of the snout to the base of the caudal, the upper along the base of the dorsal; a large round dark-brown spot on the base of the caudal; a small black spot at the base of the pectoral; anal edged with brown; caudal brown.

Total length 85 millim.

Five specimens from Mbity Rocks.

The præmaxillary groove is deep and extends to the anterior third of the orbits; the occipital crest is low and continued forward to the præmaxillary groove; parietal crests are present, but very feeble; the chain of suborbital bones is replaced by a ligament; the mandible is very massive, the lower surface flat, projecting as a keel on the sides. The ribs are inserted on a step of the transverse processes, at a short distance from the centre; all bear epipleurals; only the last præcaudal vertebra has a hæmal bridge.

11. Paratilapia pfefferi, sp. n. (Plate III. fig. 1.)

Teeth small, in 3 series in each jaw, forming a narrow band, outer largest. Depth of body equal to length of head, $2\frac{2}{3}$ times in total length. Snout with straight upper profile, as long as eye, the diameter of which is $3\frac{1}{3}$ times in length of head and equals $1\frac{1}{2}$ interorbital width; maxillary extending to below anterior border of eye; 3 series of scales on the cheek; large scales on the opercle. Gill-rakers rather long, 11 on lower part of anterior arch, the larger spatulate. Dorsal XVI 8; spines increasing in length to the sixth, which measures a little less than $\frac{1}{2}$ length of head and nearly equals longest soft rays. Pectoral $\frac{4}{5}$ length of head. Ventral reaching origin of anal. Anal III 7; third spine longest, as long as longest dorsal. Caudal feebly emarginate. Caudal peduncle $1\frac{1}{2}$ as long as deep. Scales very finely denticulate on the edge, 33 $\frac{3}{9}$; lat. l. $\frac{21–22}{12–13}$. Pale olive above, silvery beneath, with seven darker vertical bars; fins greyish brown.

Total length 76 millim.

A single specimen from Kinyamkolo.

This species, which I have much pleasure in naming after the distinguished zoologist of Hamburg, Dr. G. Pfeffer, who has much contributed to our knowledge of East African ichthyology, is nearest allied to *P. intermedia* Gthr., from Nyassa.

12. Paratilapia macrops, sp. n. (Plate III. fig. 2.)

Teeth small, in 3 series in each jaw, forming a narrow band, outer largest. Depth of body three times in total length; length of head $2\frac{2}{3}$ to 3. Snout with straight upper profile, a little shorter than the eye, the diameter of which is $2\frac{3}{4}$ times in length of head and exceeds interorbital width; maxillary extending to below anterior border of eye; 2 or 3 series of scales on the cheek; large scales on the opercle. Gill-rakers short, 11 on lower part of anterior arch. Dorsal XVI 10–12; spines increasing in length to the sixth, which measures a little less than $\frac{1}{2}$ length of head and equals longest soft rays. Pectoral as long as head. Ventral extending a little beyond origin of anal. Anal III 6–7; third spine longest, a little shorter than longest dorsal. Caudal with crescentic emargination. Caudal peduncle as long as deep. Scales very finely denticulate on the edge, 33–34 $\frac{3}{10}$; lat. l. $\frac{33}{15-17}$; upper lateral line complete, extending to base of caudal. Pale brownish above, silvery beneath; a series of five indistinct dark blotches on each side of the body; spinous dorsal edged with brown above.

Total length 70 millim.

Two specimens from Kinyamkolo, and one from Mbity Rocks.

Closely allied to the preceding species; distinguished by the larger eye, the complete upper lateral line, the longer pectoral, and the more strongly emarginate caudal. Connects the preceding species with the following, which represents a more aberrant type.

13. Paratilapia ventralis, sp. n. (Plate III. fig. 3.)

Teeth very small, in 2 series in both jaws, the outer larger and tipped with brown. Depth of body $2\frac{2}{3}$ to 3 times in total length, length of head 3. Snout with curved upper profile, a little shorter than the eye, the diameter of which is $2\frac{2}{3}$ to $2\frac{3}{4}$ times in length of head and exceeds interorbital width; maxillary extending to below anterior fourth of eye; 2 or 3 series of scales on the cheek; large scales on the opercle. Gill-rakers rather long, lanceolate, 17 to 19 on lower part of anterior arch. Dorsal XII–XIII 13–14; spines increasing in length to the eighth or ninth, which measures nearly $\frac{1}{2}$ length of head and $\frac{3}{4}$ or $\frac{4}{5}$ longest soft rays. Pectoral a little longer than head. Ventral much produced, extending far beyond the origin of the anal, especially in the males, in which it may reach the end of the caudal. Anal III 9–10; third spine longest, about $\frac{2}{5}$ length of head; middle soft rays produced, nearly as long as head. Caudal deeply emarginate, crescentic. Caudal peduncle $1\frac{1}{2}$ as long as deep.

Scales finely denticulate on the edge, 34–36 $\frac{4}{13\text{–}14}$; lat. l. $\frac{30\text{–}36}{10\text{–}16}$; upper lateral line complete or nearly so, usually reaching base of caudal. Grey-brown above, with or without irregular darker spots, silvery below; fins grey-brown, the ends of the ventral filaments white.

Total length 92 millim.

8 specimens from Kinyamkolo, and one from Mbity Rocks.

This species is remarkable among its congeners from continental Africa for the low number of its dorsal spines combined with the large eye, the crescentic caudal, the extremely produced ventrals, and the upper lateral line extending on the caudal peduncle.

14. PARATILAPIA FURCIFER, sp. n. (Plate IV. fig. 1.)

Teeth very small, in 3 series in both jaws, the outer largest and tipped with brown. Depth of body equal to length of head, 3 times in total length. Snout with curved upper profile, a little shorter than the eye, the diameter of which is $2\frac{2}{3}$ to $2\frac{3}{4}$ times in length of head and slightly exceeds interorbital width; maxillary extending to below anterior border of eye; 2 or 3 series of scales on the cheek; large scales on the opercle. Gill-rakers rather long, lanceolate, 15 or 16 on lower part of anterior arch. Dorsal XIII 13–14; spines increasing in length to the ninth, which measures a little less than $\frac{1}{2}$ length of head; some of the soft rays produced, nearly as long as head. Pectoral a little longer than head. Ventral much produced, extending nearly to caudal. Anal III 9; third spine longest, $\frac{2}{5}$ length of head; middle soft rays produced, like the dorsals. Caudal deeply emarginate, crescentic, the rays at the angles produced. Caudal peduncle $1\frac{1}{2}$ as long as deep. Scales finely denticulate on the edge, 60–63 $\frac{4\text{–}5}{16\text{–}17}$; lat. l. $\frac{54\text{–}55}{28\text{–}32}$; upper lateral line nearly complete, extending on the caudal peduncle. Bluish above, white beneath; a few ill-defined yellow streaks along the body; some yellow marblings on the postocular part of the head; fins white, with some yellow streaks on the dorsal and anal and between the ventral and caudal rays (according to a sketch by Mr. Moore).

Total length 110 millim.

Two specimens from Kinyamkolo.

Closely allied to the preceding; distinguished by much smaller scales.

15. PARATILAPIA LEPTOSOMA, sp. n. (Plate III. fig. 4.)

Teeth small, in 3 series in the upper jaw, in 4 in the lower, outer largest. Depth of body 4 to $4\frac{1}{3}$ times in total length; length of head 3. Snout with straight upper profile, as long as or a little longer than the eye, the diameter of which is $3\frac{1}{2}$ to $3\frac{2}{3}$ times in length of head, and equals interorbital width; maxillary extending to below anterior border of eye or not quite so far; 2 series of scales on the cheek; opercle covered with scales. Gill-rakers long, slender, and close-set, 20 on lower part of anterior arch. Dorsal XII 14–15; spines increasing in length to the last, which measures $\frac{2}{5}$ length of head, and is nearly as long as the soft rays. Pectoral $\frac{3}{4}$ length of head. Ventral reaching origin of anal. Anal III 10–12; third spine longest, a little shorter than longest dorsal. Caudal feebly emarginate. Caudal peduncle twice as long as deep. Scales very finely denticulate on the edge, 39–40 $\frac{2\text{–}3}{11}$; lat. l. $\frac{27\text{–}31}{11\text{–}13}$. Brown, lighter beneath; dorsal and anal with or without brown longitudinal streaks; caudal spotted with brown or black at the base.

Total length 87 millim.

Two specimens from Kinyamkolo, and two from Mbity Rocks.

Approaches *P. longiceps* Gthr. in the elongate body, but differs greatly in the dentition, the shape of the snout, and the fin-formula. Only the Malagassy species of the genus *Paratilapia* were known to have fewer than 13 spines in the dorsal fin; but one of the species described above (*P. ventralis*) has only 12 or 13.

BATHYBATES, g. n.

Body elongate; scales cycloid, small and irregular. Several rows of large fang-like teeth in the jaws. Maxillary exposed. Dorsal with 14 spines, anal with 3. Vertebræ 36 (17+19).

This genus is closely related to *Paratilapia*, with which it is to a certain extent connected by *P. longiceps* Gthr., from Nyassa. However, the more formidable dentition, coupled with the character of the scales on the body, appear sufficient to warrant the establishment of a new genus. The unique species appears in most respects more specialized than *Paratilapia longiceps*, although more primitive than any known species of that genus in the longer anal fin and the complete upper lateral line.

16. BATHYBATES FEROX, sp. n. (Plate IV. fig. 2.)

Teeth long and sharp, fang-like, wide apart, in 4 series in the upper jaw, in 3 in the lower. Depth of body 4 times in total length, length of head 3 times. Snout long and strongly compressed, with convex upper profile; eye large, its diameter $1\frac{2}{5}$ times in length of snout, $3\frac{1}{2}$ in length of head, and a little greater than interorbital width; maxillary not quite reaching to below anterior border of eye; 5 series of small scales on the cheek; large scales on the opercle. Gill-rakers moderately long and slender, 13 on lower part of anterior arch. Dorsal XIV 16; spines rather feeble, slender, subequal from the fifth, which measures $\frac{2}{7}$ length of head; longest soft rays $\frac{1}{3}$ length of head. Pectoral $\frac{3}{4}$ length of head. Ventral not reaching vent. Anal III 16; spines short and feeble. Caudal deeply forked, middle rays not half as long as outer. Caudal peduncle nearly twice as long as deep. Scales small and irregular, especially below the lateral lines, 78 $\frac{7}{38}$; lat. l. $\frac{78}{44}$; the upper extending from the opercle to the caudal, the lower from below the last dorsal spines to the caudal. Pale bluish green, iridescent above, white below; dorsal and anal bluish grey; ventrals and caudal yellowish; pectorals yellow; two dark streaks on the dorsal.

Total length 275 millim.

A single specimen from Kinyamkolo, taken at a depth of 400 feet. The specimen is a female with ripe ova; these are of large size, measuring $3\frac{1}{2}$ millim. in diameter. The stomach contains a small, partially-digested fish of the genus *Paratilapia*, as first ascertained by a sciagraph kindly prepared by Messrs. Gardiner and Green, which has enabled me to compare the structure of the vertebral column with that of other members of the family *Cichlidæ*. The insertion of the ribs is typical, viz., sessile, except on the last three præcaudal vertebræ; the transverse processes are short and in front of the ribs. The number of vertebræ agrees with that of the more elongate species of *Paratilapia*.

ERETMODUS, g. n.

Body moderately elongate; scales ctenoid. Jaws with rather large spatulate teeth with truncated crowns disposed in oblique transverse rows of two or three. Lips much developed; maxillary entirely concealed when the mouth is closed. Dorsal with 23 to 25 spines; soft rays reduced to 3 to 5; anal with 3 spines. Vertebræ 30 (15+15).

A strongly aberrant form, remarkable for its dentition and the structure of the dorsal, formed almost entirely of spines.

17. ERETMODUS CYANOSTICTUS, sp. n. (Plate III. fig. 5.)

8 or 10 transverse series of teeth in each jaw, the crowns reddish brown. Depth of body equal to length of head, 3 times in total length. Profile of snout curved; length of snout $1\frac{1}{2}$ to twice diameter of eye, which is $4\frac{1}{3}$ to 5 times in length of head, and a little less than interorbital width; mouth extending to below nostril; cheeks and opercles naked. Gill-rakers short, 9 or 10 on lower part of anterior arch. Dorsal XXIII–XXV 3–5; spines subequal from the sixth, $\frac{1}{3}$ length of head, a little shorter than soft rays. Pectoral $\frac{3}{4}$ length of head. Ventral reaching vent. Anal III 6–7; third spine longest, a little longer than dorsals; soft rays about $\frac{2}{3}$ length of head. Caudal rounded. Caudal peduncle deeper than long. Scales 32–35 $\frac{3}{11\text{–}12}$; lat. l. $\frac{22\text{–}23}{6\text{–}9}$. Blackish brown, with scattered pale blue dots; belly yellowish.

Total length 75 millim.

Five specimens from Mbity Rocks, and three from Kinyamkolo.

The toothed portions of the præmaxillary and mandible are much developed in depth, in a manner suggestive of the *Sparidæ* and *Scaridæ*, and the teeth are implanted in sockets. The deep triangular groove for the reception of the præmaxillaries extends to between the orbits, and the occipital crest is prolonged to it; the parietal crests are produced on the frontals; the præorbital is large, and the chain of suborbitals very slender. The pharyngeal teeth have long slender shafts and conical brown cusps. The ribs are attached to the back of short transverse processes; all but the last one support epipleurals; the last four præcaudal vertebræ have a hæmal bridge.

18. TILAPIA LABIATA, sp. n. (Plate V. fig. 1.)

Outer teeth rather large, feebly notched; inner teeth very small, tricuspid, in 3 or 4 series. Depth of body equal to length of head, $2\frac{2}{3}$ to $2\frac{3}{4}$ times in total length. Snout with straight upper profile, $1\frac{1}{4}$ to $1\frac{3}{4}$ diameter of eye, which is $3\frac{1}{2}$ to $4\frac{1}{2}$ times in length of head and equals interorbital width; maxillary not extending to below anterior border of eye; 3 or 4 series of scales on the cheek; large scales on the opercle; lips very strongly developed, both produced into a large triangular lobe in front. Gill-rakers moderate, 15 on lower part of anterior arch. Dorsal XVIII 10; middle dorsal spines longest, about $\frac{2}{5}$ length of head, and a little shorter than longest soft rays. Pectoral $\frac{3}{4}$ to $\frac{4}{5}$ length of head. Ventral reaching origin of anal. Anal III 6–7; third spine longest, as long as longest dorsals, slightly shorter than longest soft rays. Caudal truncate. Caudal peduncle slightly longer than deep. Scales finely denticulate on the border, 33–35 $\frac{5\text{–}6}{12\text{–}13}$; lat. l. $\frac{22\text{–}25}{13\text{–}15}$. Pale olive, with 10 more or less distinct darker cross-bars; fins greyish-brown; dorsal sometimes with oblique dark and light streaks; caudal with numerous round dark spots between the rays.

Total length 170 millim.

Four specimens from Kinyamkolo.

This species is easily recognizable by the extraordinary development of the lips, which bears a curious resemblance to that observed in the Central American *Heros labiatus*[1]. It appears to be nearest allied to *Ctenochromis nuchisquamulatus* Hilg., and *C. sauvagii* Pfeffer, from the Victoria Nyanza.

TROPHEUS, g. n.

Body moderately elongate; scales ctenoid. Jaws angularly bent at the sides, with bands of minute tricuspid teeth, an outer row of bicuspid teeth, and enlarged conical teeth at the sides of the præmaxillary; mouth transversely linear when closed; maxillary concealed under the præorbital. Dorsal with 21 spines, anal with 6. Vertebræ 33 (17+16).

This genus differs from *Tilapia* in the angularly-broken præmaxilla armed with enlarged conical teeth at the sides, and the higher number of anal spines.

The name proposed (τροφεύς, one who rears, brings up, educates) refers to the peculiar mode of nursing the eggs described hereafter.

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[1] Günther, P. Z. S. 1864, pl. iv. fig. 1.

19. TROPHEUS MOORII, sp. n. (Plate V. fig. 2.)

Teeth minute, those of the outer series tipped with brown and numbering about 50. Depth of body $2\frac{1}{2}$ to $2\frac{2}{3}$ times in total length, length of head $3\frac{1}{4}$ to $3\frac{1}{2}$. Snout descending in a strong curve, as long as or a little longer than the diameter of the eye, which is $3\frac{1}{2}$ to 4 times in length of head, and equals $\frac{2}{3}$ to $\frac{3}{4}$ interorbital width; mouth extending to below anterior border of eye; 4 series of scales on the cheek; large scales on the opercle. Gill-rakers short, 11 or 12 on lower part of anterior arch. Dorsal XXI 5–6; spines increasing in length to the sixth, which measures not quite half length of head; longest soft rays $\frac{2}{3}$ to $\frac{3}{4}$ length of head. Pectoral as long as head. Ventral produced into a short filament, reaching beyond origin of anal. Anal VI 5–6; spines increasing in length to the last, which slightly exceeds longest dorsal. Caudal slightly notched. Caudal peduncle as long as deep. Scales 30–32 $\frac{3}{12}$; lat. l. $\frac{22\text{–}25}{11\text{–}12}$. Dark brown; a large bluish-white blotch on each side; belly reddish brown; fins blackish.

Total length 110 millim.

Five specimens from Kinyamkolo.

The occipital crest is very strong and the parietal crests are produced on the frontals. The insertion of the ribs is as described in the preceding genera *Telmatochromis* and *Eretmodus*.

The mouth and pharynx of one of the specimens contains four eggs of very large size, the vitelline sphere measuring 4 millimetres in diameter, with an embryo in an advanced stage of development. The egg of the Fifteen-spined Stickleback (*Gasterosteus spinachia*), hitherto regarded as the largest Teleostean egg in proportion to the size of the animal, measures only 3 millimetres in diameter[1]. Besides the Siluroids of the genera *Arius* and *Galeichthys*, which have very large eggs, at least two species of *Tilapia* were known to give shelter to their eggs in the manner noticed above, viz., *T. simonis* Gthr. (*Chromis paterfamilias* Lortet), as observed by Prof. Lortet in Lake Tiberias, and *T. nilotica* Cuv., as noticed by me in a specimen collected by Canon Tristram in the same lake. But these eggs, produced by fishes of the size of our common Perch, are very numerous, and measure only about 2 millim. in diameter. It has besides been observed in these *Tilapiæ*, as well as in the Siluroids, that the function of protecting the eggs devolves on the male sex, while, to my surprise, the Tanganyika fish proved on autopsy to be a female. Whether this is constantly so, or whether either parent takes to the nursing duties, remains to be ascertained by examination of a larger number of specimens. I am all the more disposed to think the latter possibility will be confirmed, from the fact that a specimen of *Tilapia nilotica*

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[1] The absolutely largest known Teleostean egg is that of the Siluroid *Arius commersonii*, which measures 17 millim. in diameter. The size of the *Arius*-egg is much underrated by Günther ('Study of Fishes,' p. 160) and by McIntosh and Masterman ('British Marine Food Fishes,' p. 12), who ascribe to it a maximum of 10 millim

with the pharynx filled with embryos belongs to the female sex, while Dr. Lortet's observations on *T. simonis* had led to the belief that specimens carrying eggs in that manner are invariably males.

It is here necessary to recall the observation contained in Livingstone's 'Last Journals,' vol. ii. p. 17, that the "Dagala" or "Nsipé," of Lake Tanganyika, a small fish 2 or 3 inches long, and very like Whitebait, is said to emit eggs by the mouth. The comparison of this fish to Whitebait excludes the possibility of the one here described being the "Dagala" or "Nsipé," which will probably prove to be a Cyprinodont, if not actually the *Haplochilus tanganicanus* described below.

SIMOCHROMIS, g. n.

Body moderately elongate; scales ctenoid. Jaws with broad bands of minute tricuspid teeth, with an outer series of larger bicuspid teeth, and a single series of conical teeth at the sides of the præmaxillary; maxillary concealed under the præorbital. Dorsal with 17 or 18 spines, anal with 3. Vertebræ 31–32 (15+16–17).

The type species differs from the other members of the genus to which it was originally referred in the differentiation of the teeth at the sides of the præmaxillary, a character in which it agrees with the genus *Tropheus*.

20. SIMOCHROMIS DIAGRAMMA Gthr.

Chromis diagramma Günth. Proc. Zool. Soc. 1893, p. 632, pl. lviii. fig. 3.

The bands of teeth in both jaws consisting of 8 to 10 series, gradually decreasing in size from the outer border. Depth of body $2\frac{1}{2}$ to $2\frac{2}{3}$ times in total length, length of head $3\frac{1}{4}$ to $3\frac{1}{2}$. Snout descending in a strong curve; diameter of eye 3 to $3\frac{1}{2}$ times in length of head, $1\frac{1}{2}$ in interorbital width; mouth extending to below anterior border of eye; 4 series of scales on the cheek; large scales on the opercle. Gill-rakers short, 12 or 13 on lower part of anterior arch. Dorsal XVII–XVIII 9–10; spines increasing in length to the sixth, which measures $\frac{2}{5}$ to $\frac{1}{2}$ length of head; longest soft rays about $\frac{2}{3}$ length of head. Pectoral as long as head. Ventral reaching vent or origin of anal. Anal III 7–8; third spine longest, as long as longest dorsal. Caudal truncate. Caudal peduncle as long as deep. Scales 31–33 $\frac{3}{10}$; lat. l. $\frac{20\text{–}23}{10\text{–}14}$. Olive, whitish beneath; young with 9 rather indistinct vertical bars; gill-membrane sometimes with dark brown spots; fins greyish; a dark brown stripe may be present along the spinous dorsal, which has a black edge.

Total length 105 millim.

Four specimens from Kinyamkolo.

PETROCHROMIS, g. n.

Body moderately elongate; scales ctenoid. Jaws with very broad bands of minute, bristle-like teeth, with incurved bi- or tricuspid crowns; maxillary concealed under the præorbital. Dorsal with 17 or 18 spines, anal with 3. Vertebræ 32 (16+16).

Distinguished from *Tilapia* by the very broad bands of minute teeth with incurved crowns, from *Simochromis* by the absence of conical teeth in the præmaxillary.

21. PETROCHROMIS POLYODON, sp. n. (Plate VI. fig. 1.)

Crowns of teeth brown. Depth of body $2\frac{1}{2}$ to $2\frac{2}{3}$ times in total length, length of head $2\frac{3}{4}$ to 3 times. Snout with convex upper profile, $1\frac{1}{2}$ to $1\frac{2}{3}$ diameter of eye, which is 4 to $4\frac{1}{2}$ times in length of head and $1\frac{1}{2}$ in interorbital width; mouth hardly extending to below anterior border of eye; 4 or 5 series of scales on the cheek; large scales on the opercle. Gill-rakers very short, 12 or 13 on lower part of anterior arch. Dorsal XVII–XVIII 8–9; spines increasing in length to the sixth or seventh, which measures about $\frac{2}{5}$ length of head; longest soft rays $\frac{3}{5}$ to $\frac{2}{3}$ length of head. Pectoral nearly as long as head. Ventral reaching vent or origin of anal. Anal III 7–8; third spine longest, as long as longest dorsal. Caudal truncate. Caudal peduncle as long as deep. Scales 32–34 $\frac{3\text{–}4}{12\text{–}13}$; lat. l. $\frac{22\text{–}24}{13\text{–}17}$. Olive-brown, whitish beneath; fins grey or blackish.

Total length 135 millim.

Two specimens from Kinyamkolo, and two from Mbity Rocks.

The præmaxillary and mandibular bones are very massive, and the maxillary is much reduced in size; the ascending processes of the præmaxillaries extend to between the anterior borders of the orbits and are received in a deep excavation, to which the strong occipital crest extends; the parietal crests are produced forwards as far as the frontals; the præorbital is large, and the chain of suborbitals very slender. Only the first rib is absolutely sessile, the following being attached to the back of the transverse processes at a short distance from the centre; the epipleurals extend to the twelfth rib; the last two præcaudal vertebræ form a hæmal bridge.

PERISSODUS, g. n.

Body elongate; scales cycloid. Teeth rather large, unequal in size, few, with swollen bases and low slightly-notched crowns, compressed transversely to the axis of the jaws, disposed in a single series; maxillary exposed. Dorsal with 18 spines, anal with 3. Vertebræ 35 (17+18).

The extraordinary dentition which characterizes this new genus may be looked upon as an extreme specialization of that exhibited by *Tilapia*, a specialization in an opposite direction from that attained by *Petrochromis*.

22. PERISSODUS MICROLEPIS, sp. n. (Plate VI. fig. 2.)

10 teeth on each side of the præmaxillary, 9 on each side of the mandible. Depth of body 3$\frac{2}{3}$ times in total length, length of head 3$\frac{1}{4}$. Snout a little longer than diameter of eye, which is 4 times in length of head, and almost equals interorbital width; lower jaw projecting; maxillary extending to below anterior border of eye; 3 series of scales on the cheek; large scales on the opercle. Gill-rakers rather long, 14 on lower part of anterior arch. Dorsal XVIII 10; spines increasing in length to the last, which measures $\frac{2}{5}$ length of head; longest soft rays $\frac{2}{3}$ length of head. Pectoral $\frac{3}{4}$ length of head. Ventral not reaching vent. Anal III 8; third spine longest, nearly as long as longest dorsal; longest soft rays half length of head. Caudal truncate. Caudal peduncle 1$\frac{1}{2}$ as long as deep. Scales 65 $\frac{5}{20}$; lat. l. $\frac{44}{30\text{–}31}$. Uniform dark reddish brown; a blackish opercular spot.

Total length 100 millim.

A single specimen from Mbity Rocks[1].

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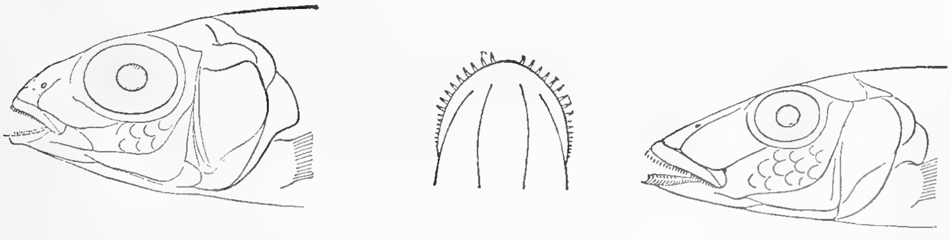
[1] I think it desirable to allude here briefly to two remarkable genera of *Cichlidæ* from Lake Tanganyika, which I have founded on specimens obtained by Capt. Descamps and sent to me for study by the Administration of the Congo Free State. The specimens are in so bad a condition that it will never be possible to draw up from them complete definitions of the species, but their dentitions, which indicate remarkable new genera, are well preserved, and I am sure the annexed figures together with the short notes here given will be sufficient to ensure their future recognition:—

ECTODUS, g. n.—Teeth very small, conical, in two series in both jaws, the outer larger; outer mandibular teeth pointing outward, perpendicular to the others; maxillary concealed under the præorbital when the mouth is closed. Scales rather large, ctenoid. Dorsal with 14 spines, anal with 3.

Ectodus descampsi, sp. n. (Fig. 1, *a*.)—D. XIV 14; A. III 8. Depth of body 3$\frac{4}{5}$ times in total length, length of head 3. Eye very large, 2$\frac{4}{5}$ in length of head, 1$\frac{3}{4}$ interorbital width. Two series of scales on the cheek. Sc. 34 $\frac{3}{10}$; lat. l. $\frac{28}{15}$. Total length 95 millim.

Ectodus melanogenys, sp. n. (Fig. 1, *b*.)—D. XIV 16; A. III 13. Depth of body 5 times in total length, length of head 3$\frac{1}{3}$. Eye 4 times in length of head, 1$\frac{1}{2}$ in length of snout, 1$\frac{1}{4}$ interorbital width. Three series of scales on the cheek. About 35 scales in a longitudinal series. A black spot on the chin. Total length 95 millim.

Fig. 1.



a. *b'*. *b*.

MASTACEMBELIDÆ.

23. MASTACEMBELUS MOORII, sp. n. (Plate VII. fig. 1.)

Depth of body 14 times in total length, length of head (without rostral appendage) $6\frac{1}{3}$ times; vent equally distant from end of snout and base of caudal; length of head $2\frac{1}{2}$ to 3 times in its distance from vent, and $\frac{1}{2}$ in its distance from first dorsal spine. Snout 3 times as long as eye, ending in a trifid dermal appendage which is a little longer than eye; cleft of mouth extending to below centre of eye; no præopercular spines. Vertical fins united with the rounded caudal. Dorsal XXV–XXVII 70–80; spines very short. Anal II 70–80. Pectoral $\frac{1}{4}$ length of head. Scales very small, 30–35 between origin of soft dorsal and lateral line. Brown, tail with a wide-meshed blackish network; dorsal and anal whitish, with a vertical series of blackish spots or vertical bars; anal and caudal edged with blackish.

Total length 440 millim.

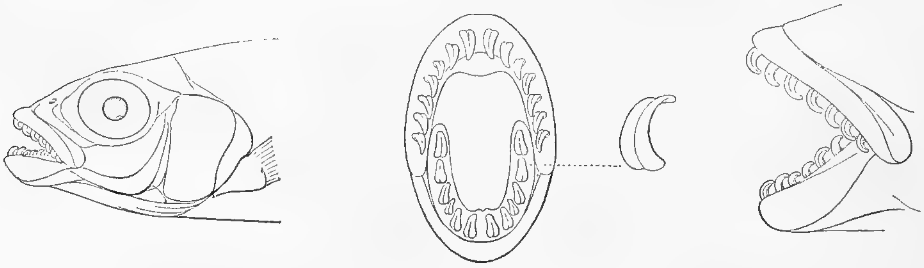
Two specimens from Mbity Rocks.

This species has been compared with *M. marmoratus*, Perugia, from the Congo, which differs in the more slender body (its depth contained 20 times in the total length) with larger scales, the shorter tail, the longer rostral appendage (measuring twice the diameter of the eye), and the higher number (30) of dorsal spines.

I think as many as 13 African species of *Mastacembelus* may be distinguished, as shown in the following synopsis:—

PLECODUS, g. n.—Teeth large and few, in a single series, dilated at the base, truncated at the end, compressed, slightly grooved in front, curved and directed backwards; 14 teeth in the upper jaw, 12 in the lower; maxillary exposed. Scales moderate, cycloid. Dorsal with 19 spines, anal with 3.

Fig. 2.



Plecodus paradoxus, sp. n. (Fig. 2.)—D. XIX 14; anal III 12. Depth of body 4 times in total length, length of head $4\frac{1}{2}$. Eye large, longer than snout, $\frac{1}{3}$ length of head, $1\frac{1}{4}$ interorbital width; maxillary extending to below anterior third of eye; 3 series of scales on the cheek. Sc. 65 $\frac{6}{17}$; lat. l. $\frac{50}{40}$. Total length 90 millim.

I. Vent nearly equally distant from the end of the snout and the base of the caudal fin.

A. Two strong præopercular spines.

D. XXIII–XXIV 75; A. II 75–76; length of head (measured to extremity of opercle and without rostral appendage) hardly twice in its distance from vent and 6 times as great as its distance from the first dorsal spine . . . . 1. *M. marchii* Sauv.

D. XXIV 100; A. II 100; length of head $3\frac{1}{2}$ times in its distance from vent, equal to its distance from the first dorsal spine . . . . 2. *M. cryptacanthus* Gthr.

D. XXVII 85; A. III 92; length of head $2\frac{1}{2}$ in its distance from vent, 3 times as great as its distance from first dorsal spine . . . . 3. *M. congicus* Blgr.[1]

D. XXVI–XXX 80; A. II 80 . . . . 4. *M. liberiensis* Blgr.[2]

D. XXIX–XXX 117–130; A. II 117–127; length of head nearly 4 times in its distance from vent, and nearly twice as great as its distance from the first dorsal spine.

5. *M. loennbergii* Blgr.[3]

B. Præopercular spines minute (young) or absent.

D. XXVII–XXVIII 70–80; A. II 80–90; length of head 3 to 4 times in its distance from vent, equal to or a little less than its distance from the first dorsal spine.

6. *M. flavomarginatus* Blgr.[4]

D. XXVII 80–82; A. II 60–65; length of head equal to its distance from the first dorsal spine.

7. *M. niger* Sauv.

D. XXVII–XXIX 65–70; A. II 68–75; length of head $2\frac{1}{2}$ to 3 times in its distance from the vent, and $\frac{1}{2}$ in its distance from the first dorsal spine . . . 8. *M. shiranus* Gthr.

D. XXIX 95; A. II 85; length of head 3 times in its distance from the vent, and $\frac{1}{3}$ in its distance from the first dorsal spine . . . . 9. *M. nigromarginatus* Blgr.[5]

D. XXV–XXVII 70–80; A. II 70–80; length of head twice in its distance from the vent, and nearly $\frac{1}{3}$ in its distance from the first dorsal spine . . . . 10. *M. moorii* Blgr.

II. Vent much nearer the caudal fin than the end of the snout; one or two præopercular spines.

D. XXX 85; A. II 70 . . . . 11. *M. marmoratus* Perugia.[6]

D. XXXIII–XXXV 50–60; A. II 50–60 . . . . 12. *M. tanganicæ* Gthr.

III. Vent much nearer the end of the snout than the caudal fin.

D. XXXI–XXXII 103; A. I 116 . . . . 13. *M. ophidium* Gthr.

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[1] A species from the Upper Congo founded on a single specimen with mutilated tail and regenerated caudal fin. I have now a perfect specimen.

[2] *M. marchii* Steind. *nec* Sauv.—Liberia.

[3] *M. cryptacanthus* Loennberg *nec* Gthr.—Cameroon.

[4] A new species founded on specimens from the Gaboon previously referred to *M. cryptacanthus*.

[5] A new species founded on a single specimen from Ashantee.

[6] Type examined.—Vent equally distant from the head and from the caudal; head once and a half as long as its distance from the first dorsal spine; 17 scales between origin of soft dorsal and lateral line.

SILURIDÆ.

24. CLARIAS ANGUILLARIS L.

This species occurs in the Nile as well as in the Niger and the Ogowe. It is one of those Siluroids which are known to live a considerable time out of water and to make excursions on dry land after the manner of Eels.

25. CLARIAS LIOCEPHALUS, sp. n. (Plate VII. fig. 2.)

Vomerine teeth in a narrow band, without posterior process. Depth of body $5\frac{1}{2}$ times in total length, length of head 5 times. Head smooth, covered with soft skin, slightly longer than broad; occipital process very short, angular; diameter of eye 3 times in length of snout, 6 times in interorbital width; maxillary barbel as long as the head, nasal barbel a little shorter; inner mandibular barbel $\frac{3}{5}$ length of head. Dorsal 70. Anal 50. Caudal free. Pectoral $\frac{1}{2}$ length of head, not extending to the vertical of origin of dorsal fin. Uniform blackish brown.

Total length 80 millim.

A single specimen from Kinyamkolo.

26. ANOPLOPTERUS PLATYCHIR Gthr.

Two specimens from marshes near Mbity.

I have recently recorded the occurrence of this species in Lake Nyassa, and it has also been described by Vaillant as *Chimarrhoglanis leroyi*, from Mrogoro torrent, Urugaru Mountains, East Africa.

27. AUCHENASPIS BISCUTATA Geoffr.

Known from the Nile and the Senegal.

28. SYNODONTIS MULTIPUNCTATUS, sp. n. (Plate VIII.)

Præmaxillary teeth in 5 or 6 irregular transverse series; mandibular teeth in a single series of 16, feebly curved, simple, measuring hardly $\frac{1}{3}$ diameter of eye. Depth of body $3\frac{1}{4}$ times in total length, length of head $3\frac{2}{3}$. Head scarcely longer than broad, slightly convex on the crown; snout rounded, less than half length of head, twice as long as eye; eye supero-lateral, well visible from above, its diameter $4\frac{1}{2}$ times in length of head, twice in interorbital width. Gill-cleft very narrow, not extending below base of pectoral. Maxillary barbel simple, reaching a little beyond anterior third of pectoral spine; mandibular barbels strongly fringed, outer a little more than twice as long as inner, and half as long as maxillaries. Dorsal II 7; spine strong, a little shorter than the head, strongly serrated behind in its distal half. Adipose fin low, a little shorter than the head, twice as long as its distance from the dorsal. Humeral process simply granulate, sharply pointed, not extending quite so far as the occipito-nuchal shield, which is $1\frac{1}{2}$ as long as broad and reaches the first soft ray of the dorsal. Anal III 7. Caudal deeply bifurcate. Skin smooth. Pale reddish brown above, with very numerous blackish-brown round spots, which are smallest on the head and nape; lower parts and barbels white, unspotted; ventrals yellow; dorsal and caudal broadly edged with yellow.

Total length 240 millim.

A single specimen from Sumbu.

29. Malapterurus electricus Gm.

The Electric Cat-fish is widely distributed, being on record from the Nile, the Niger, the Ogowe, and the Congo.

CYPRINIDÆ.

30. Labeo, sp. inc.

An unmistakable figure of a *Labeo* is among Mr. Moore's sketches, and although the specimen is not represented in the collection entrusted to me for description, I have included the fish as being the only representative of the Cyprinoids yet found in Tanganyika. The specimen from which the drawing was made was of large size, and therefore could not be preserved under the difficult circumstances to which allusion has been made in the introduction to this memoir.

CHARACINIDÆ.

31. Alestes macrolepidotus C. & V.

Occurs in the Nile, the Senegal, the Niger, and the Congo.

32. Alestes macrophthalmus Gthr.

This fish was known only from the Ogowe.

33. Hydrocyon forskali Cuv.

Occurs in the Nile, the Senegal, and the Niger.

CYPRINODONTIDÆ.

34. Haplochilus tanganicanus, sp. n. (Plate VI. fig. 3.)

Body compressed, its depth 4 times in total length; length of head $4\frac{1}{3}$ times. Snout depressed; lower jaw projecting beyond the upper; eye a little longer than snout, a little shorter than interorbital width, 3 times in length of head. Dorsal 13, originating at equal distance from the head and the caudal fin; the first ray corresponds to the 18th scale of the lateral line; posterior rays longest, $\frac{2}{3}$ length of head. Anal 28, ariginating below extremity of pectoral. Pectoral $\frac{4}{5}$ length of head, extending far beyond root of ventral. Caudal feebly emarginate. Caudal peduncle twice as long as deep. Scales 42 in a longitudinal line, 11 in a transverse line. Silvery, with a darker lateral stripe; dorsal and anal with greyish horizontal streaks.

Total length 80 millim.

A single specimen from Mbity Rocks.

POLYPTERIDÆ.

35. POLYPTERUS BICHIR Geoffr. (?).

Mr. Moore informs me that a *Polypterus* occurs in moderate abundance in the lake, and although he did not bring home specimens, he feels tolerably confident, from his recollection of them, that the fish belongs to the typical *P. bichir*, which occurs in the Nile, the Niger, and the Congo, and not to any of the closely-allied species that are often confounded with it.

APPENDIX. By J. E. S. MOORE.

In the foregoing description of the fishes which I succeeded in bringing through from Tanganyika to the coast, Mr. Boulenger has already alluded to the difficulties that were experienced in transporting them in spirit, through several hundred miles of often trackless, always scorching, forest, and of the inevitable losses which this entailed. The difficulties of transport, however, were by no means all. It must be nearly impossible for anyone who has not visited the African lakes to realize their huge size and oceanic character.

One must be as heavily equipped for dredging in these waters as would be required for effective operations in the open sea. It will easily be understood, therefore, how incomplete our knowledge of the deep-water fauna of these lakes must be considered, when it is remembered that on Tanganyika I was of necessity forced to work with native dug-out boats, and with nothing better than the natives themselves as motive power.

In the case of the fishes, moreover, there are no sources of collateral evidence from which we may obtain any insight into the nature of the deep-water forms, for dead fishes, unlike molluscs, leave no shells behind them, to be thrown upon the beaches of the lake, whereby, in the case of the molluscs, we gain some knowledge of the existence of forms which have not been seen alive; nor can we make use of the knowledge of the inhabitants in this matter, for the best of the Tanganyika natives are but wretched fishermen, merely using either surface traps, or light and inefficient drag-nets, which are thrown out a short distance from the shore and then hauled in to the land. Such nets are necessarily used only on smooth sandy beaches, and consequently the fishes caught in them are only of those species which inhabit places of this description, and although they are numerically abundant, they belong to half a dozen species at the most.

Nearly all the new forms which I obtained were killed by dynamite from the craggy ledges of the west coast of the lake, where the water was deep enough, about 20–35 feet, but not too deep for my men to dive and procure the greater number of the fishes, which, after every shot, were invariably found on the bottom. The number of fishes in such situations is really surprising, and on several occasions, after firing a single cartridge, I obtained more than two tall negroes could well carry, when slung in a bag between them on a pole.

Only one fish was obtained from anything approaching to the deeper water of Tanganyika, about 400 feet, which was accidentally entangled in a basket dredge, and this was the specimen of the new species *Bathybates ferox* described on p. 15.

Of the fishes which exist on the great mud-plains, which are to be found about 1000 feet below the surface in many portions of the lake, or of those which may occur in the vastly deeper portions, absolutely nothing is known.

The fishes which have been collected, moreover, were obtained almost exclusively from the south-western extremity of Tanganyika, and to suppose that the fishes which occur in this locality are in any way representative of the fishes, even in similar situations, throughout the whole lake, would be as absurd as if we were to suppose that the shoal-water fish of the whole English Channel could be obtained from a few miles of rocky beach about the Needles and the Isle of Wight. That the fishes differ in different portions of the lake I have myself observed, and it has also been shown in a most striking manner by the fact that of the six species previously described from Tanganyika, which were collected by Captain Hore near Ujiji, I have only rediscovered one.

The fishes which have been already obtained in Tanganyika, or in Nyassa for that matter, must therefore be regarded as merely the surface skimmings of these lakes, and as in no sense representing the whole fish-fauna they may contain.

Really deep water, 300 fathoms and upwards, is to be found over large areas in Nyassa, and to what depth the water in Tanganyika may reach no one knows; but it is obvious that where water of such depth exists, if the lakes in which it is contained have been permanent for any great length of time, there ought to be modified forms of the freshwater fishes to suit such depths, and, with the exception of *Bathybates ferox*, these have not yet been obtained.

In the case of Tanganyika, the interest which attaches to the future exploration of its deeper water is particularly great, since I have elsewhere shown that the majority of the Halolimnic animals, most of the molluscs, sponges, and so forth, are exclusively deep-water forms. In fact, it was only when my dredging capacities, so to speak, were giving out, that the more interesting of these forms, the genera *Typhobia*, *Bathanalia*, and the like, were beginning to come in.

That there are no Halolimnic representatives among the fishes which have hitherto been obtained is no evidence that other fishes of a widely different and possibly of a Halolimnic type may not in future be secured. On the other hand, the fact that the Teleostean fishes now existing in Lake Tanganyika should not correspond with the Molluscan section of the Halolimnic group is really what one would expect; for, as I have recently shown[1], the facies of the Molluscan section of the Halolimnic group is almost, if not quite, indistinguishable from that of the Jurassic seas. Except the Herring-like *Leptolepidœ*, few, if any, Teleostean fishes are represented in Jurassic beds, and we should therefore expect the piscine accompaniments of the Halolimnic molluscs to be entirely composed of Ganoids and the like. I found a species of *Polypterus*, which I took to be *P. bichir*, abundant on the southern shores of Lake Tanganyika, and it is quite possible that some of the active carnivorous fishes which inhabit the open water may be Ganoids too. What the fish is that so much surprised Glaive, when he crossed the lake, by attacking the paddles of his boat, is quite unknown, but I myself saw these same fishes attack the paddles of my own boat, not 20 miles from the spot where Glaive described them, on the west coast of the lake.

Judging, therefore, from the incomplete character of our knowledge of the fish-fauna of Lake Tanganyika, and from the vast antiquity of the lake, as evidenced by the Jurassic facies of its molluscan shells, it is only natural to expect that future exploration may reveal, among these fishes, forms that are of the highest scientific interest from a morphological point of view. I mean that Tanganyika and its neighbourhood present one of those few localities where it is legitimate to expect that we may discover many forms that in most places have become extinct.

Our very slight acquaintance with the surface-forms existing in Nyassa and Tanganyika, and the complete absence of all knowledge of the contents of the deep waters of these lakes, unfortunately by no means exhausts the sum of our present ignorance of these matters. We have no real knowledge of the extent of the Halolimnic fauna, beyond the lake in which it was originally discovered. I have shown only that this fauna is not present in Nyassa nor in Shirwa, nor yet even in the little lake Kela, not more than 20 miles from the Tanganyika shore, and that it is extremely probable that it does not extend to Mwero and Lake Bangweolo to the west. But for anything that can actually be shown to the contrary, it may be present in Lake Rukwa to the east, and in the Albert and Albert Edward Nyanzas to the north, and it is perhaps almost to be expected that some representatives of this stock should be found in Lake Kivu, which lies in the same great valley not more than 50 miles to the north of Tanganyika. But what is the relation of this lake, the effluent of which flows south into Tanganyika, to the Albert and Albert Edward Nyanzas, with effluents flowing into the Nile, towards the north? All that

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[1] "On the Hypothesis that Lake Tanganyika represents an old Jurassic Sea," Quart. Journ. Microsc. Sci. xli. no. 162, June 1898.

we know at present is that the watershed between these lakes is situated in their common valley, and that the whole series of lakes, from Tanganyika in the south to the Albert Edward in the north, appears to lie in one continuous valley-system, which owes its origin to a single geological movement, that has affected, although it may be at very different times, an immense area of ground, and reaches at the present time actually to the shores of the Red Sea.

The lakes which lie in these valleys immediately to the north of Tanganyika are therefore of especial zoological interest, for it may be that in these isolated sheets of water there exist animals analogous to those which constitute the Jurassic Halolimnic fauna of Tanganyika itself. The similarity of the Halolimnic gastropods to those of the Jurassic seas is, as I have insisted elsewhere, so complete and so remarkable that no effort should be spared which may throw light on the real nature and origin of these forms.

The only geographical fact which is at present available is this, that there exists a certain similarity in the fish-fauna of Tanganyika to that of the lower Nile, and it may be that this is an indication that at some time the Nile watershed was further south, and drained out of Tanganyika to the north, in which case Halolimnic animals will without doubt be found among the lakes towards the north. All this is, however, little more than mere conjecture, but it will help my present purpose if it renders more apparent the extreme desirability of becoming better acquainted with the zoology of the lakes in the Rift valleys immediately to the north of Tanganyika.

The presence of a Halolimnic fauna in Lake Tanganyika, as something superadded to the normal freshwater stock of the lake, is at present the central fact, and if the expectations which the morphological characters of those Halolimnic animals already known have raised should be fulfilled, we have something here which may completely change our views respecting the past history of the continent, and provide morphology with some most unique and valuable comparative material.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. *Lates microlepis*, p. 6.
Fig. 2. *Lamprologus fasciatus*, p. 7.
Fig. 3. ,, *compressiceps*, p. 7.
Fig. 4. ,, *moorii*, p. 8.
Fig. 5. ,, *modestus*, p. 8.
Fig. 6. ,, *elongatus*, p. 9.

PLATE II.

Fig. 1. *Lamprologus furcifer*, p. 9.
Fig. 2. *Telmatochromis vittatus*, p. 10.

Fig. 3. *Telmatochromis temporalis*, p. 11.
Fig. 3 *a*. ,, ,, dentition.
Fig. 3 *b*. ,, ,, skeleton.
Fig. 4. *Julidochromis ornatus*, p. 12.
Fig. 4 *a*. ,, ,, dentition.
Fig. 4 *b*. ,, ,, skeleton.

PLATE III.

Fig. 1. *Paratilapia pfefferi*, p. 12.
Fig. 2. ,, *macrops*, p. 13.
Fig. 3. ,, *ventralis*, p. 13.
Fig. 4. ,, *leptosoma*, p. 14.
Fig. 5. *Eretmodus cyanostictus*, p. 16.
Fig. 5 *a*. ,, ,, dentition.
Fig. 5 *b*. ,, ,, skeleton.

PLATE IV.

Fig. 1. *Paratilapia furcifer*, p. 14.
Fig. 2. *Bathybates ferox*, p. 15.
Fig. 2 *a*. ,, ,, dentition.

PLATE V.

Fig. 1. *Tilapia labiata*, p. 17.
Fig. 2. *Tropheus moorii*, p. 18.
Fig. 2 *a*. ,, ,, dentition.
Fig. 2 *b*. ,, ,, skeleton.

PLATE VI.

Fig. 1. *Petrochromis polyodon*, p. 20.
Fig. 1 *a*. ,, ,, dentition.
Fig. 1 *b*. ,, ,, skeleton.
Fig. 2. *Perissodus microlepis*, p. 21.
Fig. 2 *a*. ,, ,, dentition.
Fig. 3. *Haplochilus tanganicanus*, p. 25.

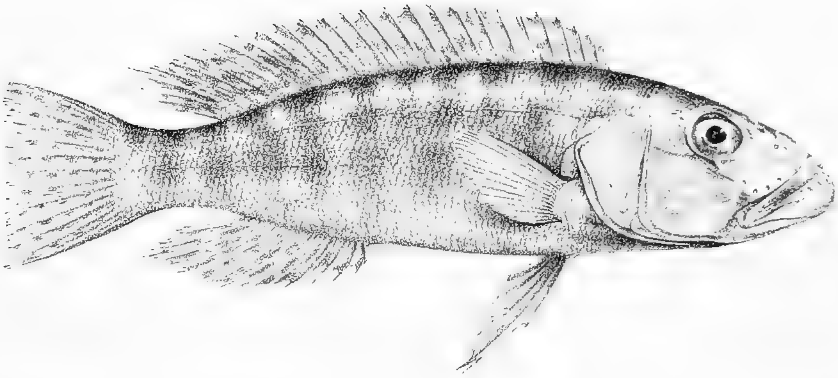
PLATE VII.

Fig. 1. *Mastacembelus moorii*, p. 22.
Fig. 2. *Clarias liocephalus*, p. 24.
Fig. 2 *a*. ,, ,, upper view of head and nape. Magnified (×3).

PLATE VIII.

Synodontis multipunctatus, p. 24, with lower view of head.

Trans. Zool. Soc. Vol. XV. Pl. I.



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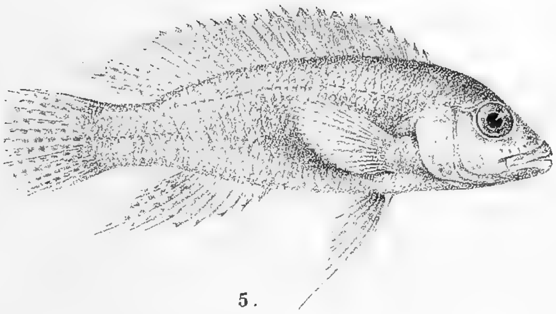

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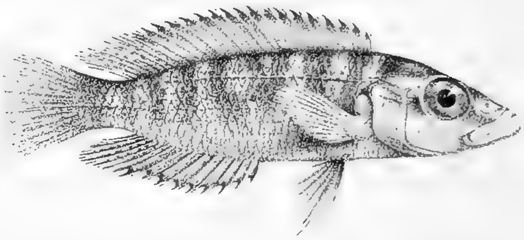

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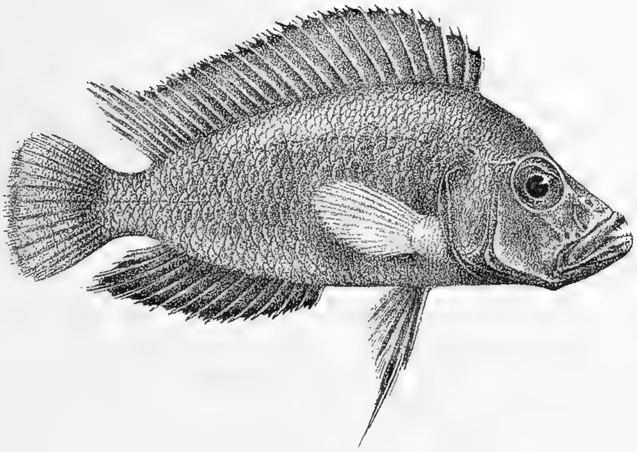

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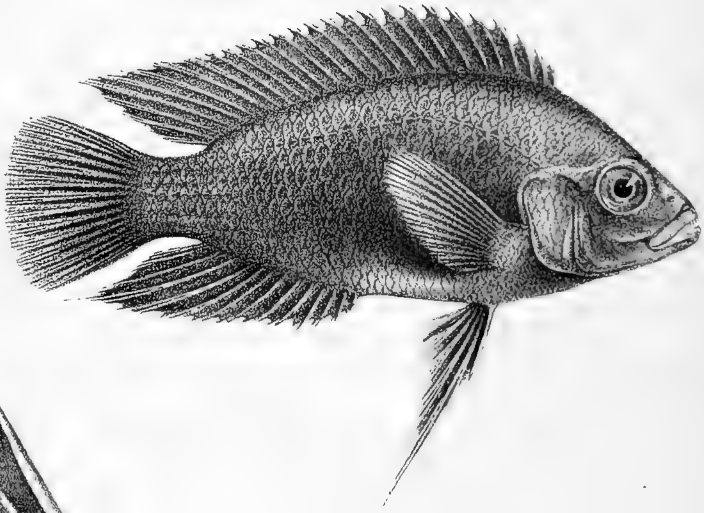

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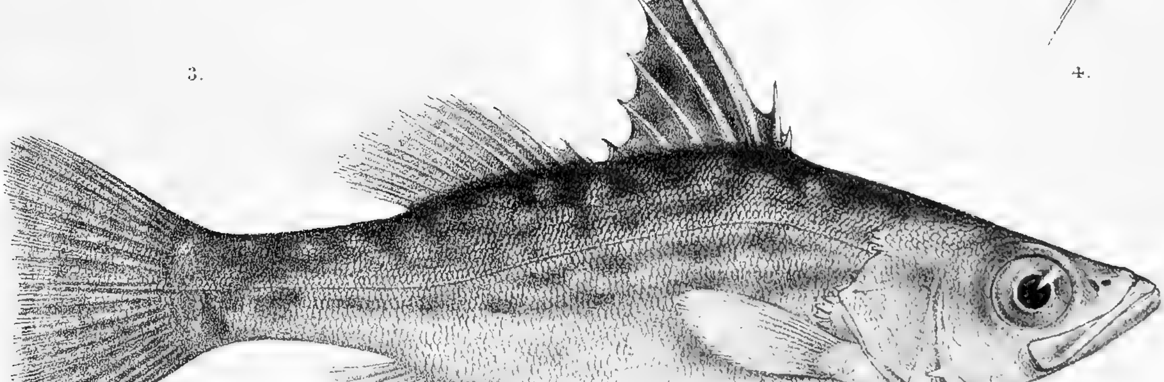
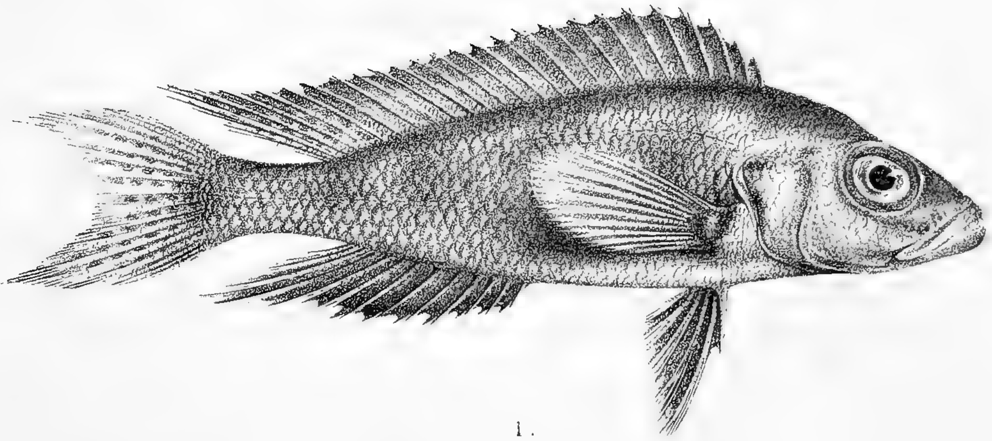


1.

J. Green del. et lith.

Mintern Bros. imp.

1. LATES MICROLEPIS. 2. LAMPROLOGUS FASCIATUS. 3. LAMPROLOGUS COMPRESSICEPS.
4. LAMPROLOGUS MOORII. 5. LAMPROLOGUS MODESTUS. 6. LAMPROLOGUS ELONGATUS.



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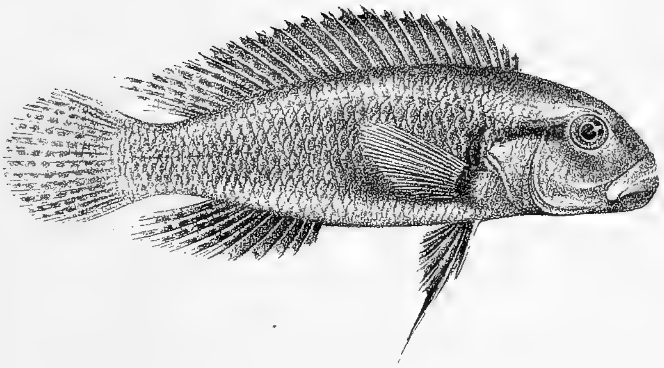

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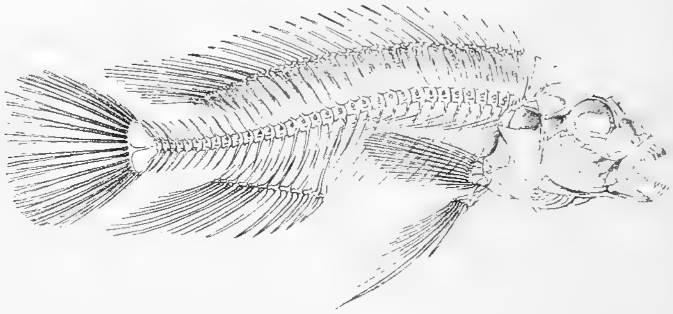

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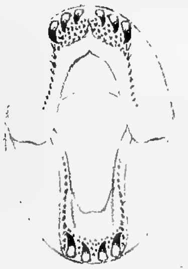
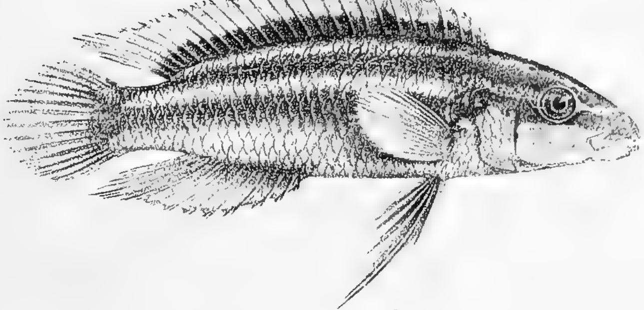


4a.

2.

3a.



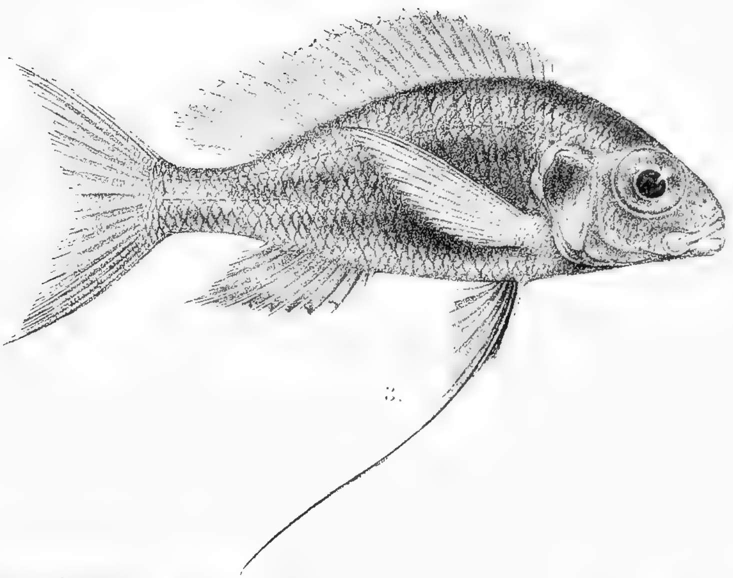
4.

4b.

J. Green del. et lith.

Mintern Bros imp.

1. LAMPROLOGUS FURCIFER.
3. TELMATOCHROMIS TEMPORALIS.
2. TELMATOCHROMIS VITTATUS.
4. JULIDOCHROMIS ORNATUS.



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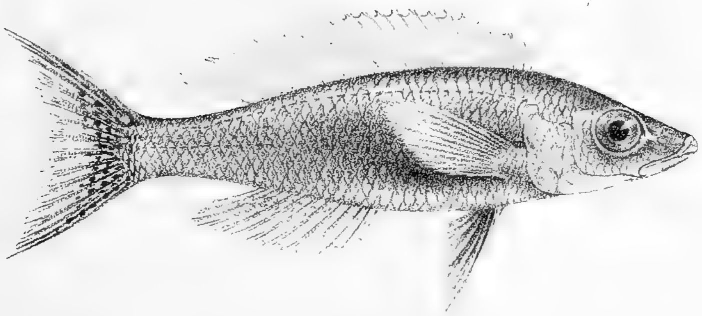

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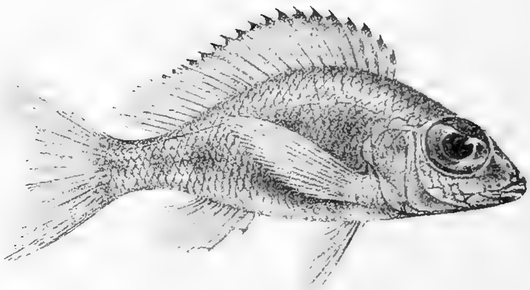

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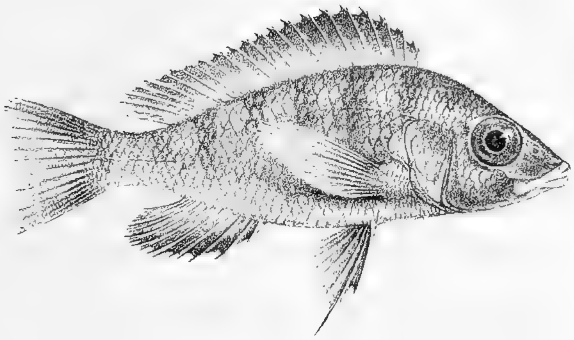

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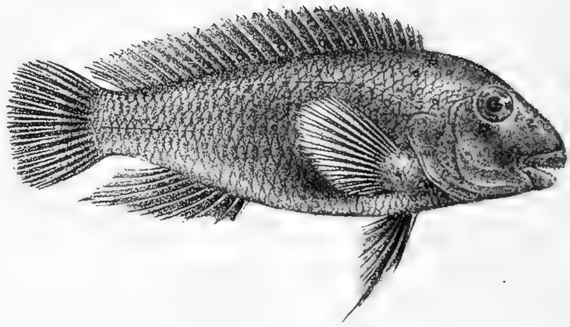


5.

5a

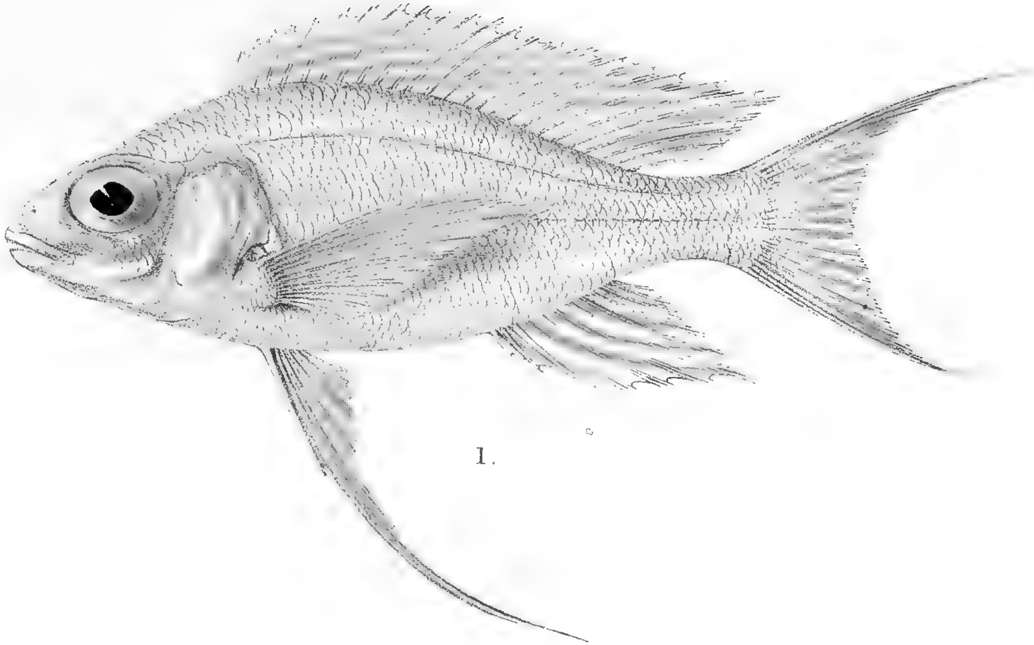
5b.

J. Green del. et lith.

Mintern Bros. imp.

1. PARATILAPIA PFEFFERI. 2. PARATILAPIA MACROPS. 3. PARATILAPIA VENTRALIS
4. PARATILAPIA LEPTOSOMA. 5. ERETMODUS CYANOSTICTUS.

2a.



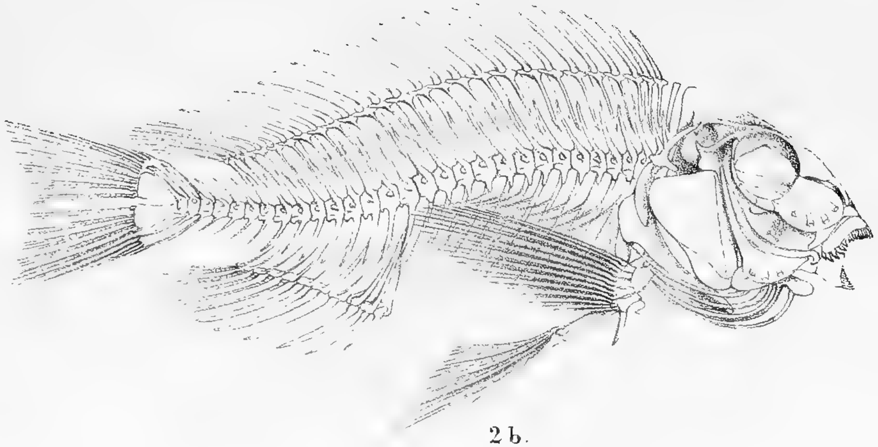
1.

2

J Green del et lith.

Mintern Bros. Chromo.

1 PARATILAPIA FURCIFER. 2 BATHYBATES FEROX.



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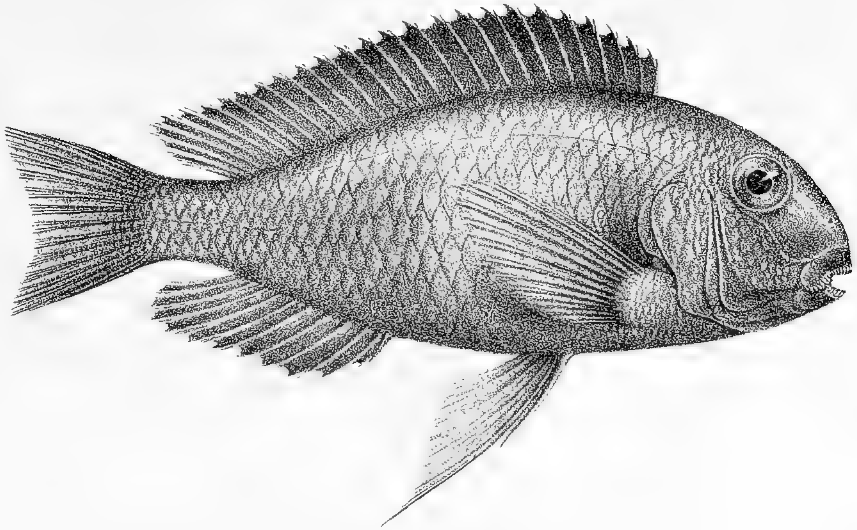

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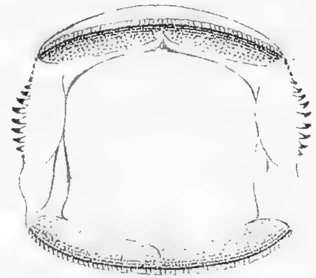

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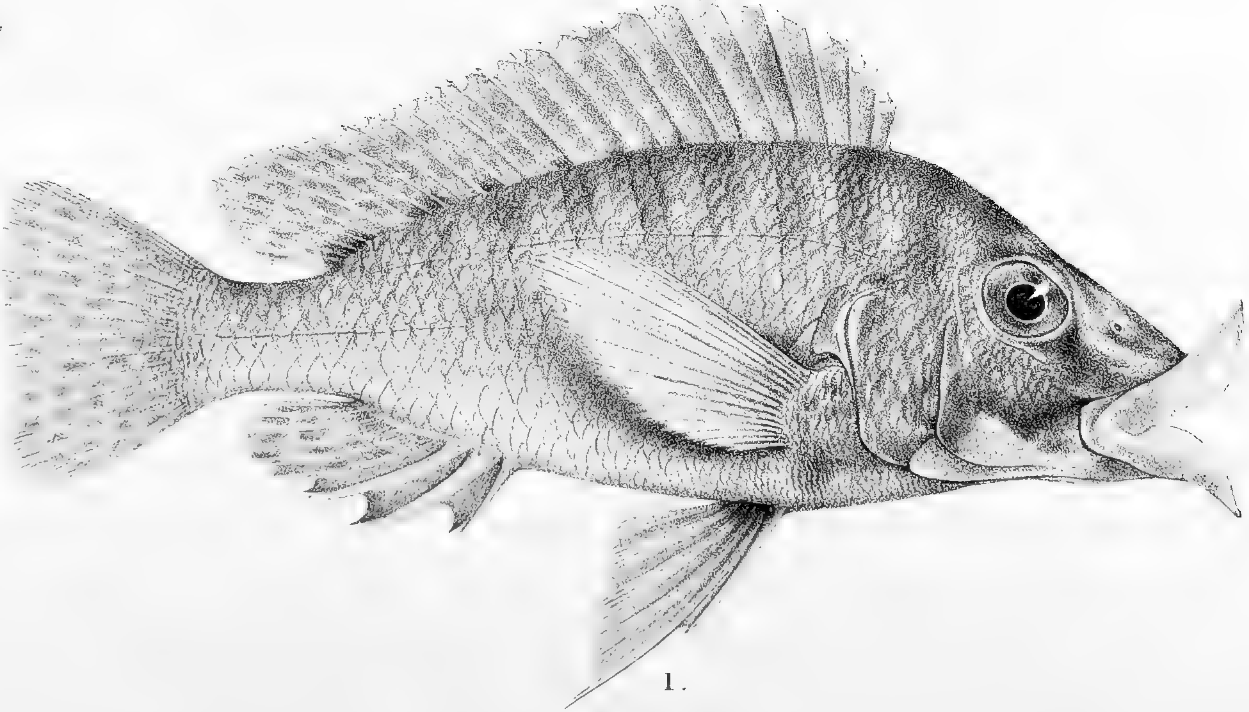
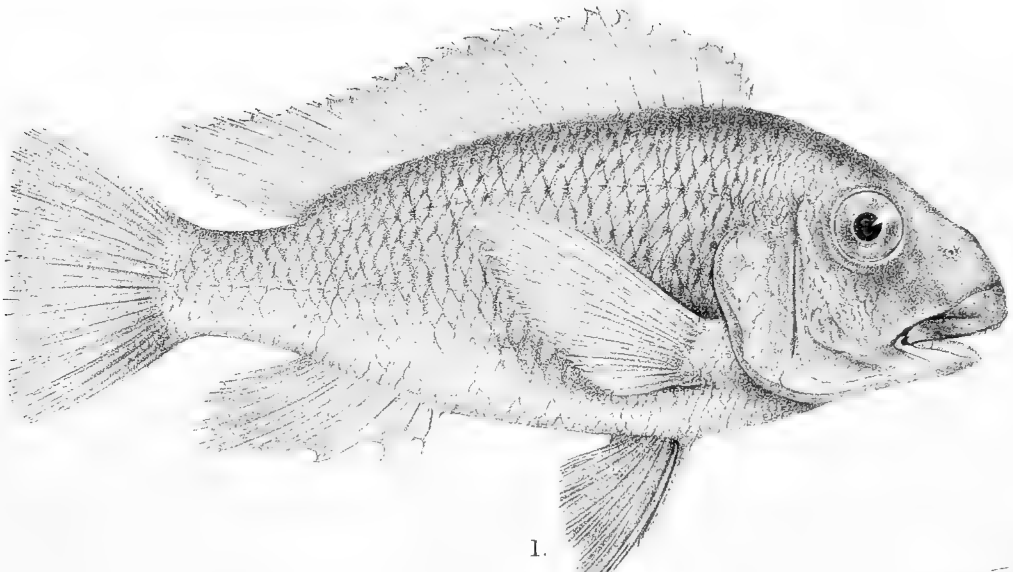


1.

J. Green del. et lith.

Mintern Bros. imp.

1. TILAPIA LABIATA. 2. TROPHEUS MOORII.



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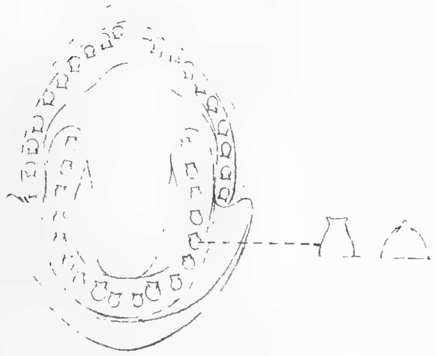

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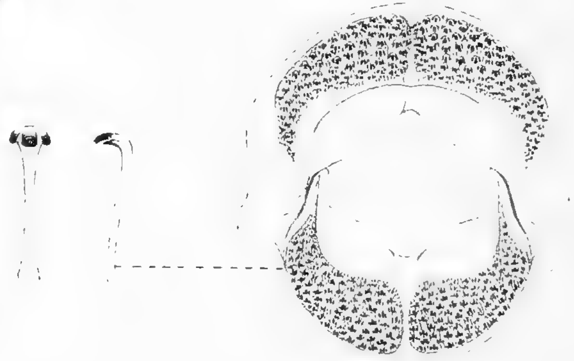

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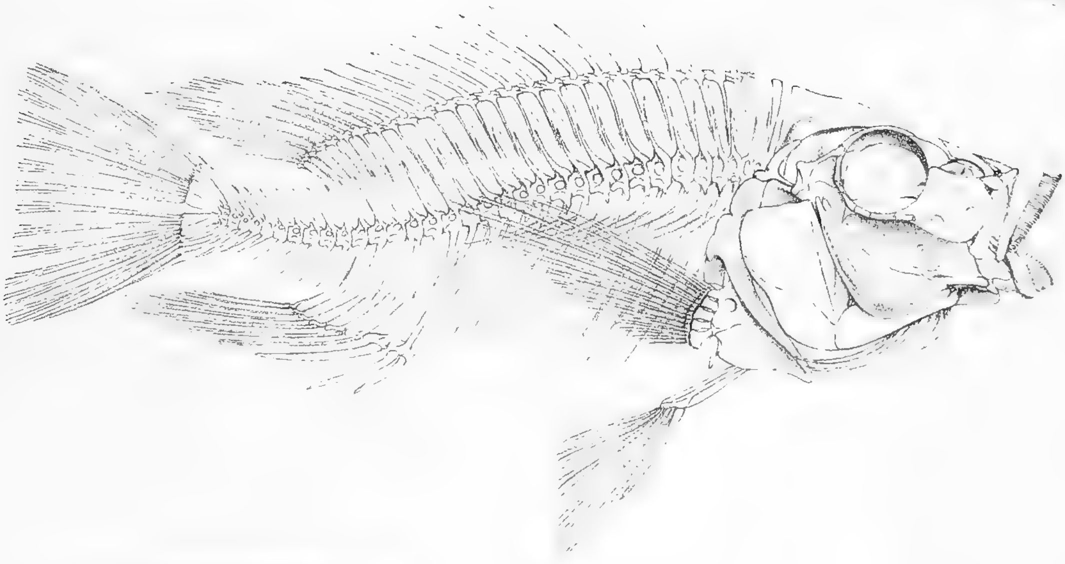

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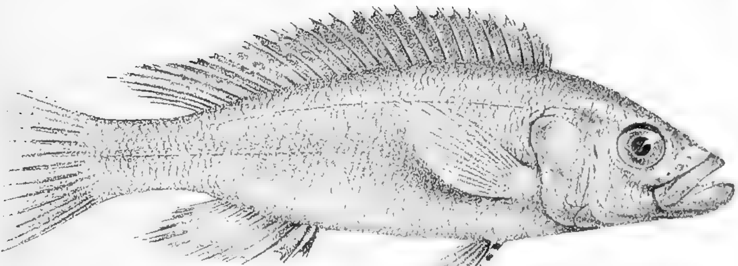

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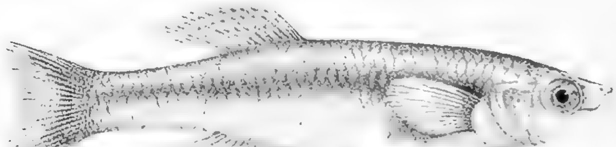
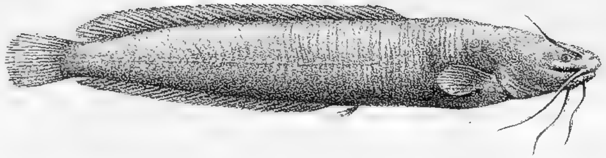


3.

J Green del et lith.

Mintern Bros imp.

1. PETROCHROMIS POLYODON. 2. PERISSODUS MICROLEPIS. 3. HAPLOCHILUS TANGANICANUS.



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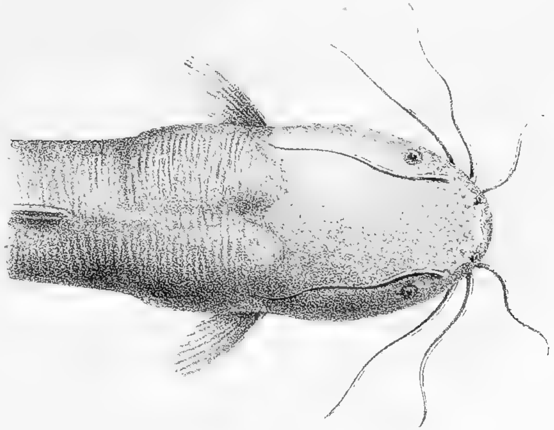

2a.

1.

J. Green del. et lith.

Mintern Bros imp.

1. MASTACEMBELUS MOORII. 2. CLARIAS LIOCEPHALUS.

J. Green del et lith.

Mintern Bros. Chromo

SYNODONTIS MULTIPUNCTATUS.

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December 1898.

P. L. SCLATER,
Secretary.

TRANSACTIONS

OF

THE ZOOLOGICAL SOCIETY OF LONDON.

VOL. XV.—PART 2.

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August 1899.

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Continued on page 3 of Wrapper.

II. *On the Marine Copepoda of New Zealand.*

By G. Stewardson Brady, *M.D., D.Sc., LL.D., F.R.S., C.M.Z.S.*

Received February 9, 1899, read March 21, 1899.

[Plates IX.–XIII.]

In this paper I complete, so far as possible, an account of two collections of New Zealand Entomostraca submitted to me by Mr. G. M. Thomson of Dunedin, and Drs. Meinert and H. J. Hansen of Copenhagen. A former contribution (already published in the 'Transactions' of this Society, vol. xiv. p. 429) deals with the Ostracoda; the present paper refers to the Copepoda. It is rather remarkable that no Cladocera were noticed in any of the numerous gatherings represented in these collections, and it is also unfortunate that of some of the most interesting species only one or two imperfect examples were found,—in some cases so extremely imperfect that I have made no attempt to describe or figure them. In some other cases of specimens preserved in picric acid, the opacity and extreme brittleness of the subjects made dissection very difficult, and recognition of anything beyond the coarser external features quite impossible. The collections were made for the most part by means of the tow-net at the surface and down to a depth of 6–8 fathoms; a few were from littoral algæ. Not much systematic investigation of the marine microzoa of New Zealand appears hitherto to have been made; for the work already done we are indebted chiefly to Mr. G. M. Thomson, who has published papers on the Ostracoda and Copepoda in the 'Transactions' of the New Zealand Institute. There can be no doubt that a rich harvest awaits any observer who may be able to devote time and labour to the task.

The memoirs quoted in this paper are as follows. They are indicated in the synonymy by the numbers assigned to them in the list:—

Boeck, Axel. (1).—Oversigt over de ved Norges Kyster iagttagne Copepoder henhörende til Calanidernes, Cyclopidernes og Harpactidernes Familier. (Vidensk.-Selskabs Forhandlinger, 1864.)

Brady, G. S. (1).—A Monograph of the free and semi-parasitic Copepoda of the British Islands. (Ray Society, 1878–80.)

" (2).—Report on the Copepoda collected by H.M.S. 'Challenger' during the years 1873–76. (1883.)

" (3).—Description of a new Species of *Cyclops*. (Sixth Annual Report of the Fishery Board for Scotland.) 1888.

" (4).—A Revision of the British Species of Freshwater Cyclopidæ and Calanidæ. (Natural History Transactions of Northumberland, Durham, and Newcastle-upon-Tyne, vol. xi.) 1891.

Claus, C. (1).—Die frei lebenden Copepoden, mit besonderer Berücksichtigung der Fauna Deutschlands, der Nordsee und des Mittelmeeres. Leipzig, 1863.

Dana, J. D. (1).—American Journal of Science, vol. viii. (1849).

„ (2).—Crustacea of the United States Exploring Expedition (1852).

Giesbrecht, W. (1).—Systematik und Faunistik der pelagischen Copepoden des Golfes von Neapel und der angrenzenden Meeres-abschnitte. Berlin, 1892.

Krämer, A. (1).—On the most frequent Pelagic Copepoda and Cladocera of the Hauraki Gulf. (Transactions and Proceedings of the New Zealand Institute, 1894, vol. xxvii.)

Lubbock, J. (1).—On two new Subgenera of Calanidæ. (Annals & Magazine of Natural History, March, 1853.)

Scott, Thomas (1).—Report on Entomostraca from the Gulf of Guinea, collected by John Rattray, B.Sc. (Transactions of the Linnean Society of London, 2nd ser. Zool. vol. vi. January, 1894.)

Thomson, G. M. (1).—On the New Zealand Copepoda. (Transactions and Proceedings of the New Zealand Institute, vol. xv.) 1882.

Section I. *GNATHOSTOMA* Thorell.

Family CALANIDÆ.

Genus Calanus Leach.

1. Calanus finmarchicus (Günner).

Taken in the surface-net, Otago Harbour.

Genus Paracalanus Boeck.

1. Paracalanus parvus (Claus). (Plate IX. figs. 1, 2.)

In the surface-net, Otago Harbour and Port Chalmers; Hauraki Gulf (*Dr. Krämer*).

Genus Clausocalanus Giesbrecht.

1. Clausocalanus arcuicornis (Dana).

1849. *Calanus arcuicornis* Dana (1).
1852. *Calanus arcuicornis* Dana (2), p. 1056, pl. lxxii. figs. 7 *a*, *b*.
1892. *Clausocalanus arcuicornis* Giesbrecht (1), pp. 186, 193, pl. i. fig. 14, pl. x. figs. 1–19, pl. xxxvi. figs. 29–31.
1894. *Clausocalanus arcuicornis* Scott (1), p. 73, pl. viii. figs. 38–47.

Taken in the surface-net, Port Chalmers. Recorded also by Dr. Krämer from the Hauraki Gulf.

This species has been sufficiently figured by Giesbrecht and Scott (*loc. cit.*).

2. Clausocalanus furcatus (G. S. Brady). (Plate IX. figs. 3–7.)

1883. *Drepanopus furcatus* G. S. Brady (2), p. 77, pl. iv. figs. 1, 2, pl. xxiv. figs. 12–15.
1892. *Clausocalanus furcatus* Giesbrecht (1), p. 194, pl. xxxvi. figs. 32, 33, 35.

The genus *Drepanopus* which, as proposed by the present writer, included two species, *D. furcatus* and *D. pectinatus*, has been divided by Dr. Giesbrecht into two genera—*Drepanopus* and *Clausocalanus*, to the latter of which *D. furcatus* is transferred. The original description dealt with females only, no males having been observed in the 'Challenger' collections. I therefore give here figures of some of the more important diagnostic structures. In some of the New Zealand gatherings both of these species occur together, and when associated with *C. arcuicornis* and *Paracalanus parvus* in various stages of growth it becomes by no means an easy matter to separate them. The most conspicuous characters are to be found in the fusions of the antennal joints, the relative lengths of the abdominal segments, and in the structure of the fifth pair of feet in both sexes.

The anterior antennæ of the female in *C. furcatus* reach somewhat beyond the extremity of the cephalothorax and are 24-jointed, having all the joints perfectly distinct; in the male (fig. 5) the first and second joints are coalescent, so also are the eighth, ninth, and tenth; all the rest are distinct. The fifth pair of feet in the female (fig. 4) are very short, two-jointed and alike on both sides; in the male (fig. 7) the foot of the right side is five-jointed, and about half as long as the abdomen (considerably shorter than in *C. arcuicornis*), that of the left side is two-jointed and only as long as the first joint of the right foot. The abdomen is four-jointed in both sexes (figs. 3, 7), the first segment being very short, the remaining segments nearly equal in the female, while in the male the third is rather reduced and the fourth rather increased in length.

Hab. Taken plentifully in the surface-net in Otago Harbour and at Port Chalmers, and in the net at 7 fathoms off Gisborne.

Genus Acartia Dana.

1. Acartia ensifera, sp. nov. (Plate IX. figs. 8–15.)

Female.—Seen from above (fig. 8) the cephalothorax is elongated, slightly narrowed towards the front, which is rounded but obscurely angulated in the middle, posterior angles rounded off and entirely without spines; rostrum obtuse, not furcate; abdomen about one-third as long as the cephalothorax (fig. 9), composed of three segments, first segment very wide in the adult and equal to the united lengths of the second and third segments; caudal stylets slender, more than twice as long as broad, longer than either of the two preceding segments. The antennules reach slightly beyond the posterior extremity of the cephalothorax. Fifth pair of feet (fig. 10) two-jointed, basal joint broad, quadrate, its outer margin prominent and mucronate in the middle, whence arises a single very long seta; second joint bulbous at the base and tapering to a long setiform apex. Terminal spines of the swimming-feet (fig. 11) very slender and sword-shaped, with finely pectinate margins. Length 1·2 millim.

Male.—Abdomen composed of four segments (fig. 14), the first very short, second twice as long, third and fourth rather shorter; caudal stylets rather longer than the preceding segment. Antennules more nodose than in the female owing to the distal dilatation of many of the joints (figs. 12, 13), some of which are more or less distinctly coalescent. The fifth foot of the right side is longer than that of the left (fig. 15); the inner margins of the first and second joints have large lobose protuberances, and the last joint is bent upon itself at a right angle, ending in a sharp point; on the left side the first joint is broad and quadrangular and has a long seta attached to its angulated outer margin; second joint rather longer and narrower, third dilated at the base and bearing on the inner margin of the narrowed distal extremity three small setiform laminæ.

Hab. Plentiful in surface gatherings from Otago Harbour, Port Chalmers, Bay of Islands, and Napier; also in the net at a depth of 7 fathoms off Gisborne. These gatherings consisted almost entirely of females, males being extremely rare; almost all had attached spermatophores.

A form described in the 'Challenger' Report under the name of *Acartia denticornis* is very nearly allied to this species, but the antennules of *A. ensifera* possess no well-marked teeth, though these are constantly present in both sexes of *A. denticornis.* The antennules in *A. denticornis* are fully as long as the animal itself, while in *A. ensifera* they reach scarcely further than the extremity of the cephalothorax. The peculiar enlargement of the first segment of the abdomen in the female *A. ensifera* is likewise characteristic.

Genus TEMORA Baird.

1. TEMORA TENUICAUDA, sp. nov. (Plate IX. figs. 16–23.)

Female.—Cephalothorax robust, width great in proportion to the length (fig. 16), broadly rounded in front, abruptly narrowed behind; angles of the posterior extremity rounded off, not at all produced or spinous. Abdomen short, four-jointed, first segment about twice as long as either of the following three, and in the adult having a pouch-like process on the ventral surface; caudal stylets cylindrical, extremely long and slender, from eight to ten times as long as broad, bearing one small seta on the outer margin beyond the middle, and three at the apex, one of which is spathulate at its base and nearly as wide as the stylet itself (fig. 18). Antennules sparingly clothed with extremely short setæ, 24-jointed, slender, about as long as the cephalothorax (figs. 16, 17). Feet of the fifth pair (fig. 19) simple, rudimentary, three-jointed, the last joint nearly twice as long as either of the preceding two and ending in three small claw-like setæ. Terminal spines of the outer branch of the swimming-feet (fig. 20) well-developed and stout, the principal one strongly serrated with about fourteen teeth on its inner margin. Length 1·75 millim.

Male.—Cephalothorax and abdomen as in the female except that the abdomen is five-jointed; none of the caudal setæ have dilated bases (fig. 23). Eighteenth joint of the right antennule (fig. 21) very faintly serrulated. Fifth foot (fig. 22) of the right side strongly prehensile, basal joint large, subquadrate, and produced into a long curved claw which opposes the three-jointed outer ramus; first joint of the outer ramus about twice as long as broad, second and third not much longer than broad and bearing respectively one and two short marginal spines; fifth foot of the left side short, simple, three-jointed, last joint forming a short curved unguis.

Hab. Taken plentifully in the surface-net in the Bay of Islands and Otago Harbour, also at a depth of 6 fathoms in Auckland Harbour.

Of all the specimens examined not one was found in perfect condition, and all were very brittle and opaque owing to the action of picric acid preservative. The species is very closely allied to the well-known *T. longicornis* of European seas, but there is no serration of the right male antennule, except on the eighteenth joint; the widely-dilated tail-seta of the female is characteristic, and the serratures of the spines of the swimming-feet are much fewer and larger than in *T. longicornis.*

Genus CENTROPAGES Kröyer.

1. CENTROPAGES DISCAUDATUS, sp. nov. (Plate X. figs. 1–7.)

? *Centropages typicus* Kröyer, var. *aucklandicus* Krämer (I), pl. xv. figs. 1–5, p. 217.

Female.—Antennules very slender, 24-jointed, reaching considerably beyond the posterior end of the cephalothorax. Infero-posteal angle of the cephalothorax produced on each side into a long spine. Abdomen (fig. 6) three-jointed; first joint dilated proximally and bearing on its dorsal margin a slender plumose seta; second joint longer, much dilated proximally; third very short, constricted proximally; furcal joints short, not much longer than broad, almost square as seen from above (fig. 7), distally truncated and bearing five rather short terminal setæ, three of which are bulbously dilated at the base. Outer branch of the fifth pair of feet (fig. 5) having its second joint produced inwardly into a very stout and long spine.

Male.—Infero-posteal angles of the cephalothorax spinous, but not so strongly as in the female; abdomen four-jointed, all the joints subcylindrical (fig. 1), furcal joints cylindrical, about twice as long as broad, terminal setæ not swollen at the base; the first abdominal segment short, the following three nearly equal, not very much longer than broad and altogether devoid of spines. Basal joints of the antennules (fig. 1) almost devoid of marginal processes or teeth; joints from the 13th to the 18th much swollen, the 15th and 16th each bearing a strong marginal spine; the three following joints densely pectinated with fine setæ (figs. 2, 3), which, at the base of the 17th joint, are replaced by a series of small squared tubercles. Outer branch of the fifth pair of feet of the right side (fig. 4) terminating in a chelate joint, the blades of which are long, slender, only moderately curved, and not at all crenulated, the outer blade having a markedly constricted median neck; outer branch of the left foot devoid of marginal setæ, simple, and terminating in two very small apical setæ. Length 1·6 millim.

Hab. Taken in the surface-net at Port Chalmers and in Otago Harbour.

This may perhaps be the form referred to by Dr. Krämer as *Centropages typicus*, var. *aucklandicus*, though in some respects it does not agree accurately with his figures and description. It cannot, I think, be properly referred to any variety of *C. typicus*, though the pectinated armature of the male right antennule agrees exactly with that species. To make my meaning clearer I give some of the more important characters of the two species in a tabular form.

It is, however, very closely allied to *C. brachiatus* (Dana), and the females of the two species may not be easily distinguishable, but the armature of the antennule, together with the structure of the fifth pair of feet in the male, presents very sufficient distinctive characters.

	C. typicus.	*C. discaudatus.*
Basal joints of the antennules...	First, second, and fifth joints in both sexes have strong marginal spines.	No well-developed spines on the basal joints in either sex.
15th and 16th joints of the right male antennule.	Sixteenth joint has a strong spine.[1]	A strong spine on both joints.
First abdominal somite in female.	Two slender spine-like setæ on ventral and a shorter one on dorsal aspect.	One dorsal seta.
Caudal segments in female......	Twice as long as broad; setæ not swollen at base.	Scarcely longer than broad; setæ swollen at base.
Prehensile branch of right fifth foot in male.	Inner claw slightly pectinated; outer not distinctly constricted in middle.	Inner claw not pectinated; outer distinctly constricted.

2. Centropages pectinatus, sp. nov. (Plate IX. figs. 24–27.)

Female.—Abdomen slender, four-jointed (figs. 26, 27), the first joint wider than the rest, bearing on its dorsal surface a brush of several fine hairs and at the posterior angle a single slender spine; caudal segments about thrice as long as broad, two or three of the principal terminal setæ dilated basally (fig. 27 *b*). Lateral spines of the outer branches of the swimming-feet lancet-shaped, with very finely pectinated margins; median joint of the outer branch of the fifth pair (fig. 25) produced internally into a

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[1] Giesbrecht figures a rather feeble spine also on the fifteenth joint, but I have not been able to find it in any of my specimens.

long falcate spine, the concave margin of which is distinctly pectinated; the basal joint of the fourth (?) pair of feet bears also a very long falcate spine (fig. 24). Male unknown.

This description is extremely imperfect, being based upon only two battered specimens which were taken—one off Napier in the net at a depth of 8 fathoms, the other at the surface in Otago Harbour.

The characters seem clearly to distinguish this from any described species.

Subfamily PONTELLINÆ.

Genus LABIDOCERA Lubbock.

1. LABIDOCERA CERVI Krämer. (Plate X. figs. 8–14.)

Labidocera cervi Krämer (1), p. 218, pl. xvi. figs. 6, 7.

Female.—Cephalothorax subtruncate posteriorly, the ventral angles produced and mucronate (fig. 9). Abdomen four-jointed, the first, second, and third segments about equal, fourth about half as long as the preceding; caudal laminæ rather longer than broad, obliquely quadrate (figs. 9, 13); terminal setæ scarcely as long as the abdomen. Antennules reaching to the posterior extremity of the cephalothorax. Fifth pair of feet (fig. 10) alike on both sides, two-branched, the internal branch composed of one small joint, the outer of one much larger joint which bears three moderately large lateral teeth and two smaller and much more slender ones at the apex. In the immature condition, however (fig. 11), the outer branch consists first of three and afterwards of two joints. Length 2·3 millim.

Male.—The infero-posteal angles of the cephalothorax (fig. 13) are not quite so strongly spined as in the female; the abdomen five-jointed (fig. 13). The armature of the right antennule consists of a fine pectination of the seventeenth and eighteenth and of the coalescent nineteenth, twentieth, and twenty-first joints: the twenty-second joint is prolonged internally, forming a sharp process which extends beyond the apex of the penultimate joint. The right foot of the fifth pair (fig. 14) is strongly prehensile, the basal joint simple, second joint attached near the middle by a hinge-articulation, its outer portion forming a slender flexuous process, its inner portion forming a broad lamina and giving attachment at its apex to a long and slender falcate joint which opposes the outer process of the second joint; the foot of the left side is simple, slender, three-jointed, nearly as long as that of the right side, its terminal joint having a few short apical teeth and near the distal extremity a diffuse pubescent patch. Length 2·8 millim.

Hab. In the surface-net, from Otago and Akaroa.

Though my observations differ in some respects from those of Dr. Krämer, I have no doubt that this is the species named by him *Labidocera cervi*. Dr. Krämer says that the abdomen of the female is two-jointed, and in some specimens I have found the abdominal segments so interfused that it is difficult to make out the number: there may, indeed, be no visible separation, but in some there are distinctly four segments. In the allocation of joints to the right male antennule, I have followed Dr. Giesbrecht (*Labidocera nerii*, &c.), not having myself been able to make them out distinctly in the New Zealand specimens.

Family CYCLOPIDÆ.

Genus Cyclops (O. F. Müller).

1. Cyclops ewarti G. S. Brady. (Plate X. figs. 15–17.)

1888. *Cyclops ewarti* G. S. Brady (3), pl. viii. figs. 1–6.
1891. „ „ idem (4) pl. vii. figs. 4–7.

One specimen of a *Cyclops* which I cannot in any way distinguish from *C. ewarti* was found in a surface-net gathering from Otago Harbour.

This capture is peculiarly interesting, inasmuch as the species was originally described from specimens taken in the Firth of Forth, and it seemed doubtful whether they might not have made their way thither from some neighbouring freshwater habitat. No other instance is on record, so far as I know, of a true *Cyclops* having been found living in the sea, and it is very remarkable that this New Zealand example, of the purely pelagic character of which there can be no doubt, should belong to the same species.

I have thought it well to figure here some of the parts of the Otago specimen. The only difference between it and the Scottish examples is the greater width of the abdomen, which may, however, be accounted for by pressure. An interesting peculiarity of the species, in which both northern and southern forms agree, is the bipectinate character of the terminal spine of the inner branch of the fourth pair of feet (Pl. II. fig. 17 *a*). In all other species these pectinations are represented by very fine setæ.

Genus Oithona Baird.

1. Oithona spinifrons Boeck.

Oithona spinifrons Boeck (1), p. 25.
„ „ G. S. Brady (2), p. 90, pl. xiv. figs. 1–9, pl. xxiv A. figs. 1, 2.

Frequent in surface gatherings from Otago Harbour, and in the tow-net at 7 fathoms off Gisborne.

I cannot distinguish these specimens from those which I have already (*loc. cit.*) described and figured under the above name. Dr. Giesbrecht disagrees with my reference and thinks that they belong to *O. spinifrons* Claus, but in the length of the antennules and some other characters they seem to me to agree more closely with Boeck's species.

Family HARPACTICIDÆ.

Subfamily LONGIPEDIINÆ.

Genus ECTINOSOMA Boeck.

1. **ECTINOSOMA AUSTRALE**, sp. nov. (Plate X. figs. 18–25.)

Antennules seven-jointed (?); first three joints stout and short, the succeeding joints much more slender (fig. 18); antennæ (fig. 19) nearly as long as the antennules, three-jointed, secondary branch three-jointed, the second joint very short. Mandibles (fig. 20) with one large terminal tooth and four short spinules; palp long, two-jointed, and bearing on the first joint a minute two-jointed branchlet. The mouth-organs (figs. 21, 22) and swimming-feet (fig. 23) present no special features. Feet of the fifth pair (fig. 24) much subdivided; inner segment digitiform and bearing two apical spine-like setæ, one of which is long, the other very short; outer segment laciniated, its inner lobe bearing, like the neighbouring segment, two unequal setæ, external to which are three short processes bearing single apical setæ, the first and third short, the second long and slender. Caudal laminæ (fig. 25) very short and wide; setæ slender, non-plumose, the central one about twice as long as the two principal laterals. Length ·66 millim.

Hab. Otago Harbour, between tide-marks.

The distinctions between many so-called species of *Ectinosoma* are extremely slight, and in this case the fifth foot is the only member which presents very definite characters. In the present state of our knowledge it seems very doubtful whether this, as well as some others, should not rank rather as varieties than as distinct species.

Subfamily TACHIDIINÆ.

Genus EUTERPE Claus.

1. **EUTERPE GRACILIS** Claus.

1863. *Euterpe gracilis* Claus (1), p. 110, pl. xiv. figs. 1–13.
1880. „ „ G. S. Brady (1), p. 22, pl. xl. figs. 1–16.
1892. „ *acutifrons* Giesbrecht (1), p. 555, pl. xliv.
1852. ? *Harpacticus acutifrons* Dana (2), p. 1192, pl. lxxxiii. figs. 11 *a*, *b*.

This species was found plentifully in most of the gatherings. In the surface-net from Otago Harbour and Port Chalmers; in the net at 6 fathoms, Auckland Harbour; 7 fathoms, off Gisborne; 8 fathoms, off Napier.

Subfamily Amymoninæ.

Genus Amymone Claus.

1. Amymone clausii Thomson.

1882. *Amymone clausii* Thomson (1), p. 98, pl. v. figs. 1–8.

Taken in the surface-net, Bay of Islands.

Subfamily Canthocamptinæ.

Genus Laophonte Philippi.

1. Laophonte serrata (Claus).

1863. *Cleta serrata* Claus (1), p. 123, pl. xv. figs. 13–20.
1880. *Laophonte serrata* G. S. Brady (1), vol. ii. p. 71, pl. lxxiii. figs. 1–14.

Hab. On algæ in Lyttelton Harbour.

2. Laophonte meinerti, sp. nov. (Plate XI. figs. 1–10.)

Antennules of the *female* short, seven-jointed (fig. 2); the comparative lengths of the joints as in the following formula: $\frac{1\,.\,2\,.\,3\,.\,4\,.\,5\,.\,6\,.\,7}{6\quad 13\quad 9\quad 3\quad 4\quad 3\quad 5}$. Posterior foot-jaws (fig. 4) slender; hand narrow, its external margin obscurely angulated near the middle; terminal unguis slender, slightly curved, rather longer than the hand. First pair of feet (fig. 5) very slender; outer branch three-jointed, scarcely more than one-third as long as the inner branch, exclusive of the terminal unguis; inner branch much elongated, destitute of setæ, with a long and slender apical unguis. Swimming-feet (fig. 6) small and slender. Feet of the fifth pair (fig. 8) small, foliaceous, each joint bearing several marginal setæ, one of which is much longer than the rest. Length ·75 millim.

Second joint of the *male* antennule produced posteriorly into a short conical spine; fourth joint very much enlarged and forming a quadrate vesiculiform swelling, from the anterior border of which arises a stout curved sensory filament (fig. 3).

Hab. On algæ in Lyttelton Harbour. Two specimens.

Two further specimens, which may perhaps belong to this species, were found in a gathering from between tide-marks in Otago Harbour. Figures of the posterior foot-jaws and of the first and fifth feet of these specimens are given in Plate XI. figs. 9, 10. These do not altogether correspond with similar parts of *L. meinerti*, but the differences may possibly be varietal only.

Subfamily HARPACTICINÆ.

Genus DACTYLOPUS Claus.

1. DACTYLOPUS TISBOIDES Claus.

1863. *Dactylopus tisboides* Claus (I), p. 127, pl. xvi. figs. 24–28.
1880. „ „ G. S. Brady (I), p. 106, pl. liv. figs. 1–16.

Hab. Between tide-marks, Otago Harbour.

2. DACTYLOPUS HANSENI, sp. nov. (Plate XI. figs. 11–18.)

Very similar to *D. tisboides* in general appearance (fig. 11), but rather larger. Antennules of the *female* (fig. 12) eight-jointed, rather densely setiferous; fourth joint bearing a stout sensory filament. Posterior foot-jaw (fig. 14 *a*) slender; hand bearing on each margin a single seta and a fringe of minute cilia; terminal claw slender, about as long as the hand itself. Terminal claws of the first pair of feet (fig. 15) long and slender, as are also the spines of the outer branch; penultimate joint of the inner branch bearing near the distal extremity a single small plumose seta. Fifth pair of feet of the *female* (fig. 18) large, the inner lamina considerably shorter than the outer one; apex finely ciliated, subtruncated, and bearing two long and two short setæ; distal extremity of the outer lamina bearing six setæ of various lengths and widely separated, the lateral margins ciliated; no cilia between the large setæ. Length ·85 millim.

Male.—The antennule (fig. 13) is geniculated, but none of the joints are very tumid; terminal joint of the inner branch of the second pair of feet (fig. 16) forming two curved finger-like processes, from near the base of which spring two long plumose setæ: fifth pair small (fig. 17); inner lamina shorter than the outer, with two short spine-like apical setæ; outer bearing six setæ, the two apical ones much longer than the rest.

Hab. Lyttelton Harbour: on algæ, 1 specimen; tow-net at 6 fathoms, 1 specimen.

The nearest allies of this species seem to be *D. cinctus* (Claus) and *D. strömii* Baird, but both of them differ distinctly in minor points.

Genus FLAVIA, gen. nov.

Like *Dactylopus*, except that the inner branch of the second pair of feet consists of one greatly elongated joint, and is entirely destitute of spines or claws (Plate X. fig. 30). Anterior and posterior foot-jaws simple, prehensile, with long terminal ungues.

1. FLAVIA CRASSICORNIS, sp. nov. (Plate X. figs. 26–31.)

Antennules very short and stout, two-jointed, moderately setiferous (fig. 26). Feet of the first pair as in *Dactylopus*, the terminal ungues thick and hook-like (fig. 29): inner branch of the second pair (fig. 30) longer than the outer branch, very slender, with truncate unarmed apex; near the base there is on each margin an angular prominence, from which springs a minute seta, and near the distal extremity on the outer margin a rounded non-setiferous tubercle, nearly opposite to which, from the inner margin, arise two long and delicate plumose setæ. Anterior foot-jaw simple, elongated, with a slightly curved terminal unguis (fig. 27); posterior somewhat similar, the hand armed with a long slender marginal spine and a strong curved terminal unguis (fig. 28).

A single specimen of this species occurred in a gathering from among algæ in Lyttelton Harbour. The posterior antennæ, mandibles, and maxillæ were not seen distinctly enough to permit of their being figured, but in general conformation are similar to those of most Harpacticidæ.

Genus PHROSO, gen. nov.

Body slender; in general appearance like *Canthocamptus*. First four pairs of feet with both branches three-jointed; feet of fifth pair foliaceous, unbranched. Internal branch of antennæ two-jointed. Mandible strongly toothed, palp two-branched. Anterior and posterior foot-jaws simple, with large terminal ungues and no palp.

1. PHROSO GRACILIS, sp. nov. (Plate XI. figs. 19–27.)

Female.—Antennules eight-jointed, rather densely setiferous; first four joints stout, last three much more slender (fig. 20): lengths of the joints as in the following formula: $\frac{1\,.\,2\,.\,3\,.\,4\,.\,5\,.\,6\,.\,7\,.\,8}{12\ 12\ \ 8\ \ 5\ \ 5\ \ 2\ \ 4\ \ 5}$; from the fifth joint arises a stout sensory filament. Antennæ (fig. 21) nearly as large as the antennules, three-jointed; to the basal joint is attached a two-jointed internal branch. Mandibles well developed (fig. 22), with sharp slender teeth and a palp composed of a large basal joint and two single-jointed branches. Maxillæ (fig. 23) small, lobose (imperfectly seen). Anterior foot-jaw (fig. 24) slender, simple, geniculated, with a stout terminal unguis and three plumose setæ attached to the second joint. Posterior foot-jaw (fig. 25) larger than the anterior, composed of a single stout joint which bears a long falcate, terminal unguis. Basal joint of the fifth pair of feet (fig. 27) short and broad, and bearing on each lateral angle a long seta; terminal joint subovate, twice as long as broad; apex narrow and truncate; external margin ciliated above, and below the middle having two long widely separated setæ. Length 1·3 millim. Male unknown.

Hab. One specimen taken in the surface-net, Port Chalmers.

Genus THALESTRIS Claus.

1. THALESTRIS FORFICULA Claus.

1863. *Thalestris forficula* Claus (I), p. 131, pl. xvii. figs. 7–11.
„ „ Thomson (I), p. 104, pl. x. figs. 16–21.

Otago Harbour, between tide-marks; "dredged abundantly in Dunedin Harbour" (*Thomson*).

2. THALESTRIS CILIATA, sp. nov. (Plate XI. figs. 28–33.)

Robust; lateral margins of the abdominal segments clothed with short setæ (fig. 33). Antennules nine-jointed (fig. 28); joints subequal, the length represented by the following formula: $\frac{1 . 2 . 3 . 4 . 5 . 6 . 7 . 8 . 9}{8\ \ 8\ \ 6\ \ 6\ \ 4\ \ 6\ \ 3\ \ 3\ \ 4}$. Posterior foot-jaw forming a subovate, elongated hand, the anterior margin of which bears a continuous fringe of short, closely-set setæ; terminal unguis stout, falcate, more than half as long as the hand (fig. 29). Outer branch of the first pair of feet (fig. 30) with densely pectinated margin: one long and stout spine at the apex of the first and one on the middle of the second joint; the last joint has two fine marginal setæ and one very long, slender seta at the apex, between which are two stout falcate claws with hook-like projections at their bases: the outer branch has a single seta near the distal extremity of the first joint, and at its apex are two ungues, one large and one small. The marginal spines of the swimming-feet (fig. 31) are long and slender, and the outer edges of the joints of both branches are ciliated. The two laminæ of the fifth pair of feet (fig. 32) are of equal length; the outer lamina ovate, with finely ciliated margins, four long setæ at the apex and two on the outer edge; the inner lamina has five principal setæ, two marginal and three apical, the intervals between which are ciliated. Male unknown.

Hab. Akaroa Harbour. One specimen only.

3. THALESTRIS AUSTRALIS, sp. nov. (Plate XII. figs. 1–5.)

Antennules nine-jointed, slender, the comparative lengths of the joints as in the following formula: $\frac{1 . 2 . 3 . 4 . 5 . 6 . 7 . 8 . 9}{8\ \ 10\ \ 7\ \ 8\ \ 6\ \ 6\ \ 4\ \ 4\ \ 6}$ (fig. 1). Hand of the posterior foot-jaw (fig. 2) subovate, bearing near the middle of the anterior margin a single spine-like seta, terminal unguis moderately stout and reaching a little beyond the middle of the hand. Outer branch of the first pair of feet (fig. 3) shorter than the inner, stout, its inner margin bearing rather in front of the middle a stout plumose seta, outer margin a large median spine and four apical ungues which successively increase in length from first to last; the inner branch has a long, slender, apical unguis and a much shorter seta; anterior margins of the larger ungues of both branches finely pectinated. Marginal spines of the swimming-feet (fig. 4) long and slender, with blunt apices; external margins of all the joints ciliated. Laminæ of the fifth pair of feet (fig. 5) broad, subovate, nearly equal in length; margins of the external lamina finely ciliated, and bearing six subequal apical setæ; inner lamina with five setæ on its subtruncate apical margin. Abdominal segments slightly overlapping each other, but altogether devoid of setæ or serrulations. Male unknown.

Hab. Otago Harbour, between tide-marks. One specimen only.

Genus HARPACTICUS Milne-Edwards.

1. HARPACTICUS GLABER, sp. nov. (Plate XII. figs. 6–11.)

Female.—In general appearance like *H. chelifer*. Antennules (fig. 6) slender, moderately setiferous, eight-jointed; lengths of the joints as in the following formula: $\begin{array}{cccccccc} 1\,. & 2\,. & 3\,. & 4\,. & 5\,. & 6\,. & 7\,. & 8 \\ \hline 10 & 11 & 11 & 8 & 4 & 4 & 3 & 1 \end{array}$. Antennæ (fig. 7) stout, nearly as long as the antennules, bearing a small two-jointed branch, extremity of the last joint abruptly truncated and bearing two long, rigid, finely pectinated spines and four slender geniculated setæ; posterior foot-jaw (fig. 8) almost exactly similar to that of *H. chelifer*. Outer branch of the first pair of feet elongated, two-jointed, terminating in three subequal, blunt, slightly curved and very finely pectinated claws; outer margins very sparingly ciliated; each joint bearing within a short distance of its distal end a single short marginal seta: inner branch terminating in a strong slightly curved claw; the long first joint slightly ciliated and having near its apex a slender seta. Feet of the fifth pair two-jointed (fig. 10), basal joint wide, its inner portion distally produced and giving attachment to three long setæ; terminal joint much narrower, margins ciliated, with three long setæ at the apex and one on the outer edge. The spines of the swimming-feet, like those of the first pair and of the antennæ, are minutely pectinated. The margins of the abdominal segments (fig. 11) are smooth except for a few minute hairs at the lateral angles and on the caudal laminæ; principal tail-setæ very long.

Hab. Otago Harbour. One specimen taken in the surface-net.

From *H. chelifer* this species may be distinguished by the number and comparative lengths of the joints of the antennules, by the armature of the antennæ, the non-spinous margins of the first pair of feet, the different build of the fifth pair, and the almost smooth margins of the abdominal somites. There seem to be points of difference also in the mandibles and maxillæ, but these I have not clearly made out.

Genus PELTIDIUM Philippi.

1. PELTIDIUM NOVÆ-ZEALANDIÆ, sp. nov. (Plate IX. figs. 28, 29; Plate XII. figs. 12–15.)

This is in general build and appearance exactly like the common European species *P. interruptum*, Goodsir, the only important differences being found in the posterior foot-jaw and fifth pair of feet. The manus of the second pair of foot-jaws (Pl. IX. fig. 29) is ovate, elongated, the anterior margin fringed with a continuous series of short setæ; terminal unguis long and slender. Feet of the fifth pair (Pl. XII. fig. 14) stout, simple, with truncate apex, which bears three short, stout, and very blunt spines, the outermost of which is attached at a little distance from the apex: the inner margin bears beyond the middle a single seta; the outer margin has also a single seta much nearer the base, and is slightly pubescent between that point and the apex. The shell is extremely hard and thick, and closely beset with small circular puncta. Colour dark brown. Length ·85 millim.

Hab. Taken in the surface-net, Port Chalmers and Otago.

Subfamily IDYINÆ.

Genus IDYA Philippi.

1. IDYA FURCATA (Baird).

Tisbe furcata Claus, Lilljeborg.
Canthocamptus furcatus Baird.
Idya furcata Boeck, Brady, Thomson.

On algæ in Lyttelton Harbour. "Common in shore-kelp and rock-pools near Dunedin; also on kelp in Paterson's Inlet" (*Thomson*).

Genus SCUTELLIDIUM Claus.

1. SCUTELLIDIUM PLUMOSUM, sp. nov. (Plate XII. figs. 16–21, 23–25.)

In general form and appearance indistinguishable from the British *S. tisboides*. The setose investiture of the first foot (fig. 20) is, however, more dense, and the spinous armature of the last joint of the outer branch of the swimming-feet (fig. 21) is also different, there being on the outer margin towards the apex two plumose lancet-shaped spines with intermediate small hairs, while in *S. tisboides* (fig. 22) there are three stout, non-plumose, dagger-shaped spines with no intermediate hairs. Fifth foot in the *female* (fig. 25) elongated, slender, subcrescentic, pointed at the extremity, with setose margins, but not pubescent on the surface; in the *male* (fig. 23) small, subquadrate, with obliquely truncated apex, which bears three long and several shorter setæ. The antennules in the *male* are geniculated (fig. 16): from the second joint springs a small biarticulate peduncle, which bears three stout sensory filaments, and to the antepenultimate joint is attached a much longer and stouter sense-organ. Length ·88 millim.

Hab. This species occurred sparingly in surface gatherings from Otago and Port Chalmers, and in gatherings from seaweeds in Akaroa and Lyttelton Harbours.

The males of *S. plumosum* seem, like those of *S. tisboides*, to be scarce. I have seen only one specimen, some parts of which are here figured. Of *S. tisboides* I have hitherto seen only one imperfect male specimen; and as Dr. Claus has only very partially described or figured it, one may suppose that his experience is similar.

Subfamily PORCELLIDIINÆ.

Genus PORCELLIDIUM Claus.

1. PORCELLIDIUM FULVUM Thomson.

1882. *Porcellidum fulvum* Thomson (1), p. 107, pl. vi. figs. 10, 11, pl. vii. figs. 8–13.

On algæ in Lyttelton Harbour.

Section II. *PŒCILOSTOMA* Thorell.

Family CORYCÆIDÆ Dana.

Genus CORYCÆUS Dana.

1. CORYCÆUS ROBUSTA Dana (?).

Specimens which I refer doubtfully to this species were taken in the surface-net off Port Chalmers and in Otago Harbour.

Genus PAUROCOPE, gen. nov.[1]

Antennules five-jointed; antennæ three-jointed, simple; mandibles simply toothed; posterior foot-jaw forming a prehensile hand with two slender terminal ungues. Two pairs of swimming-feet, each foot consisting of two one-jointed branches.

1. PAUROCOPE ROBUSTA, sp. nov. (Plate XIII. figs. 1–9.)

Antennules (fig. 3) short, five-jointed, sparingly setiferous, joints nearly equal in length. Antennæ nearly as long as the antennules, simple, three-jointed, last joint shorter than the preceding, subquadrate, with six setæ arising from the subtruncate apex, and on the proximal half of the posterior margin a series of about six small, equal, pellucid, lancet-shaped setæ; on the distal half two short and two rather longer, stout, curved, plumose setæ (fig. 4). Trophi very small; mandibles without a palp (?),

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[1] παῦρος, few; κώπη, an oar.

apex broad and bearing an even series of small teeth (fig. 5). Maxillæ composed of four digitiform lobes (fig. 6), which are armed with numerous spine-like divaricate setæ. Anterior foot-jaws laminar, bearing numerous lateral setæ, but not divided into distinct lobes (fig. 7): posterior foot-jaws two-jointed, basal joint short and stout, with three rigid spiniferous setæ at the anterior distal angle; second joint forming a strong subtriangular hand, to the anterior angulated margin of which are attached two long stout setæ, to the narrow distal extremity are hinged two long, biarticulate, slender ungues, which are armed with spine-like marginal setæ (fig. 8). Two pairs of swimming-feet (fig. 9), two-branched, each branch consisting of a single broad lamina; distal and outer margins of the inner branch setiferous; outer branch with four large lancet-shaped spines on the outer margin, at the apex a larger spine, and on the inner margin three long setæ. The cephalothorax is equal in length to the abdomen, and consists of three segments only, the first two being coalescent (figs. 1, 2); the abdomen is two-jointed and suddenly narrower than the cephalothorax: to the posterior angles of the last thoracic segment are attached two small setæ; angles of the first abdominal segments produced backwards, second segment twice as long as the preceding, constricted in front; caudal segments very short. Length ·88 millim.

Hab. Of this very interesting species two specimens were found in a surface-net gathering from Otago Harbour, and one in the net at 7 fathoms from off Gisborne.

The specimen described by Mr. T. Scott under the generic name *Saphirella* seems to be, except as to the mouth-organs, very similar to the present, and I regret that, owing to the *Saphirella* having passed out of Mr. Scott's hands, I have not been able to compare the actual specimens. Mr. Scott's descriptions may be found in his paper on Entomostraca from the Gulf of Guinea (Transactions of the Linnean Society, 2nd ser. Zool. vol. vi. pt. 1, 1894).

[Closely allied to *Paurocope* is a form represented in these gatherings by only two imperfect specimens, which, like *Paurocope*, were taken at the surface in Otago Harbour. I am unable, for want of suitable material, to give a complete account of this species, and it seems not unlikely that it may really represent the male of *Paurocope*, the general resemblance being very close, more especially in the swimming-feet and caudal laminæ. The antennules and antennæ are, however, very different, but this difference, to a lesser extent, is likewise seen in the closely related genera *Sapphirina* and *Corycæus*. A very remarkable character is found in the presence of two simple lenses (ocelli) at the bases of the second pair of foot-jaws. Figures of the animal and some of its appendages are given in Plate XIII. figs. 10–17.

Provisionally I propose the name *Centromma thomsoni* for this species.]

Section III. *SIPHONOSTOMA* Thorell.

Family ENTOMOLEPIDÆ, fam. nov.

Genus Entomolepis [1], gen. nov.

Dorsal surface covered by a thin, oval, scale-like shield, beyond which the extremities of the limbs project only slightly. Antennules slender, simple; antennæ prehensile; swimming-feet two pairs (?). Abdomen short, slender, and, like the cephalothorax, completely covered by the scale-like dorsal investment.

1. **Entomolepis ovalis**, sp. nov. (Plate XIII. figs. 18–21.)

Outline, as seen from above, oval, widest in the middle, width equal to more than half the length (fig. 18). Antennules ten-jointed, slender, the penultimate joint bearing a long and stout sensory filament (fig. 19); the comparative lengths of the joints as in the following formula: $\frac{1\,.\,2\,.\,3\,.\,4\,.\,5\,.\,6\,.\,7\,.\,8\,.\,9\,.\,10}{23\;17\;4\;4\;3\;5\;7\;7\;10\;8}$. Antennæ three-jointed (fig. 20), the basal joint bearing at its apex a minute secondary branch; second joint with a row of fine cilia on its distal half; third joint small and having a stout terminal unguis. Maxilla simple, two-jointed, the second joint pubescent and bearing three long terminal setæ. Two pairs of foot-jaws (figs. 18 *d*, *e*), stout, prehensile, like those of *Dyspontius*. Siphon slender and of moderate length; swimming-feet two pairs (?) two-branched, each branch composed of three joints (fig. 18 *f*). Length 1·3 millim.

One specimen only was found among mud from a depth of 1–5 fathoms in Lyttelton Harbour.

The foregoing description is incomplete, owing to some of the parts having been imperfectly seen, and it is to be hoped that some future observer may be enabled by the help of further specimens to describe more fully what seems to be a very remarkable form.

Family ARTOTROGIDÆ.

Genus Artotrogus Boeck.

1. **Artotrogus ovatus** Thomson.

Artotrogus ovatus Thomson (1), p. 113, pl. xi. figs. 11–14.

In the surface-net off Port Chalmers. One specimen.

2. **Artotrogus brevicaudatus**, sp. nov. (Plate XII. figs. 27–29; Plate XIII. figs. 22–26.)

Cephalothorax much narrowed in front, widest behind the middle; abdomen very short, only about one third as long as the cephalothorax (Plate XIII. fig. 22); siphon

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[1] *ἔντομον*, an insect; *λεπὶς*, a scale.

long and slender (fig. 24). Antennules very short, fourteen-jointed (?) (fig. 23), the basal joints very indistinctly marked; comparative lengths of the joints as in the following formula: $\frac{1\,.\,2\,.\,3\,.\,4\,.\,5\,.\,6\,.\,7\,.\,8\,.\,9\,.\,10\,.\,11\,.\,12\,.\,13\,.\,14}{3\quad 5\quad 2\frac{1}{2}\quad 2\frac{1}{2}\quad 2\frac{1}{2}\quad 2\frac{1}{2}\quad 4\quad 5\quad 4\quad 6\quad 4\quad 5\quad 5\quad 5}$. First segment of the abdomen much longer than the following segments, inclusive of the furca (fig. 26). The mouth-organs and swimming-feet present no distinctive characters. Length 1·1 millim.

Hab. Akaroa Harbour, 6 fathoms.

Genus Caligus.

1. Caligus longicaudatus, sp. nov. (Plate XII. fig. 26.)

A single specimen of a *Caligus*, which seems distinct from any described species, occurred in a surface-net gathering from Port Chalmers. The much elongated abdomen, the abruptly angular carapace, together with the slenderness and length of the last pair of feet, are the chief distinctive characters. Length 5 millim.

EXPLANATION OF THE PLATES.

PLATE IX.

Paracalanus parvus, p. 32.

Fig. 1. Antennule of male, × 140.
Fig. 2. Foot of fifth pair of male, × 210.

Clausocalanus furcatus, p. 32.

Fig. 3. Female, seen from right side, × 84.
Fig. 4. Fifth pair of feet of female, × 250.
Fig. 5. Antennule of male, × 84.
Fig. 6. Fifth pair of feet of male, × 210.
Fig. 7. Abdomen and foot of fifth pair, ♂, seen laterally, × 165.

Acartia ensifera, p. 33.

Fig. 8. Female, seen from above, × 84.
Fig. 9. Abdomen of female, seen from right side, × 110.
Fig. 10. Fifth pair of feet of female, × 210.
Fig. 11. Terminal spine of one of the swimming-feet, × 210.
Fig. 12. Right antennule of male, × 140.
Fig. 13. Left antennule of male, × 140.
Fig. 14. Abdomen of male, × 110.
Fig. 15. Fifth pair of feet of male, × 250.

Temora tenuicauda, p. 34.

Fig. 16. Female, seen from left side, × 50.
Fig. 17. Antennule of female, × 84.
Fig. 18. Abdomen of female, × 84.
Fig. 19. Foot of fifth pair, ♀, × 210.
Fig. 20. Terminal spine of swimming-feet, × 300.
Fig. 21. Right antennule of male, × 84.
Fig. 22. Fifth pair of feet of male, × 110.
Fig. 23. Abdomen of male, seen from front, × 210.

Centropages pectinatus, ♀, p. 36.

Fig. 24. Foot of fourth pair (?), × 84.
Fig. 25. Foot of fifth pair, × 210.
Fig. 26. Abdomen, seen from front, × 84.
Fig. 27. „ „ „ side, × 84.
a. Setæ of first segment, more highly magnified.
b. Setæ of tail, more highly magnified.

Peltidium novæ-zealandiæ, p. 44.

Fig. 28. Antennule of female, × 140.
Fig. 29. Posterior foot-jaw, × 210.

PLATE X.

Centropages discaudatus, p. 35.

Fig. 1. Male, seen from right side, × 65.
Fig. 2. Armature of 17th segment of right antennule, ♂, × 210.
Fig. 3. „ 17th, 18th, and 19th segments of same, × 210.
Fig. 4. Fifth pair of feet of male, × 84.
Fig. 5. „ „ female, × 100.
Fig. 6. Abdomen of female, seen from side, × 100.
Fig. 7. Furca of female, × 100.

Labidocera cervi, p. 37.

Fig. 8. Antennule of female, × 50.
Fig. 9. Abdomen of female, seen from below, × 50.
Fig. 10. Foot of fifth pair, ♀, × 50.
Fig. 11. The same, immature, × 84.
Fig. 12. Right antennule of male, × 50.
Fig. 13. Abdomen of male, × 50.
Fig. 14. Fifth pair of feet of male, × 50.

Cyclops ewarti, p. 38.

Fig. 15. Antennule of female, × 140.
Fig. 16. Abdomen of same, × 84.
Fig. 17. Fourth foot of same, × 140.
a. Terminal spine of inner branch of the same, × 300.

Ectinosoma australe, ♀, p. 39.

Fig. 18. Antennule, × 250.
Fig. 19. Antenna, × 210.
Fig. 20. Mandible, × 250.
Fig. 21. Anterior foot-jaw, × 250.
Fig. 22. Posterior foot-jaw, × 250.
Fig. 23. One of the swimming-feet, × 210.
Fig. 24. Foot of fifth pair, × 210.
Fig. 25. Caudal segments and setæ, × 210.

Flavia crassicornis, ♀, p. 42.

Fig. 26. Antennule, × 250.
Fig. 27. Anterior foot-jaw, × 250.
Fig. 28. Posterior foot-jaw, × 250.
Fig. 29. Foot of first pair, × 210.
Fig. 30. „ second pair, × 210.
Fig. 31. Abdomen, × 100.

PLATE XI.

Laophonte meinerti, p. 40.

Fig. 1. Female, seen from left side, × 84.
Fig. 2. Antennule of female, × 300.
Fig. 3. „ male, × 300.
Fig. 4. Posterior foot-jaw, × 300.
Fig. 5. Foot of first pair, × 210.
Fig. 6. One of the swimming-feet, × 210.
Fig. 7. Inner branch of foot of second pair, ♂, × 300.
Fig. 8. Foot of fifth pair, ♀, × 210.
Fig. 9. „ first pair, × 225.
Fig. 10. „ fifth pair, variety, × 210.

Dactylopus hanseni, p. 41.

Fig. 11. Female, seen from left side, × 100.
Fig. 12. Antennule of female, × 210.
Fig. 13. „ male, × 210.
Fig. 14. Inner branch of antenna, × 210.
Fig. 14 *a*. Posterior foot-jaw, × 280.
Fig. 15. Foot of first pair, × 210
Fig. 16. Inner branch of foot of second pair, ♂, × 300.
Fig. 17. Foot of fifth pair, ♂, × 210.
Fig. 18. „ „ ♀, × 210.

Phroso gracilis, ♀, p. 42.

Fig. 19. Female, seen from right side, × 65.
Fig. 20. Antennule, × 210.
Fig. 21. Antenna, × 210.
Fig. 22. Mandible, × 210.
Fig. 23. Maxilla, × 210.
Fig. 24. Anterior foot-jaw, × 250.
Fig. 25. Posterior foot-jaw, × 250.
Fig. 26. Foot of fourth pair, × 120.
Fig. 27. „ fifth pair, × 210.

Thalestris ciliata, ♀, p. 43.

Fig. 28. Antennule, × 210.
Fig. 29. Posterior foot-jaw, × 260.
Fig. 30. Foot of first pair, × 210.
Fig. 31. „ third pair, × 175.
Fig. 32. „ fifth pair, × 160.
Fig. 33. Abdomen, seen from front, × 84.

PLATE XII.

Thalestris australis, ♀, p. 43.

Fig. 1. Antennule, × 210.
Fig. 2. Posterior foot-jaw, × 210.
Fig. 3. Foot of first pair, × 175.
Fig. 4. One of the swimming-feet, × 175.
Fig. 5. Foot of fifth pair, × 130.

Harpacticus glaber, ♀, p. 44.

Fig. 6. Antennule, × 200.
Fig. 7. Antenna, × 200.
Fig. 8. Posterior foot-jaw, × 210.
Fig. 9. Foot of first pair, × 140.
Fig. 10. ,, fifth pair, × 210.
Fig. 11. Abdomen and caudal setæ, × 84.

Peltidium novæ-zealandiæ, ♀, p. 44.

Fig. 12. Foot of first pair, × 210.
Fig. 13. ,, fourth pair, × 120.
Fig. 14. ,, fifth pair, × 210.
Fig. 15. Abdomen, × 130.

Scutellidium plumosum, p. 45.

Fig. 16. Antennule of male, × 300.
Fig. 17. Antenna of male, × 300.
Fig. 18. Anterior foot-jaw of male, × 210.
Fig. 19. Posterior foot-jaw of male, × 210.
Fig. 20. Foot of first pair of female, × 210.
Fig. 21. Outer branch of one of the swimming-feet, × 300.
Fig. 22. ,, ,, ,, (*D. tisboides*: Irish specimen), × 300.
Fig. 23. Foot of fifth pair of male, × 250.
Fig. 24. First abdominal somite of male, × 210.
Fig. 25. Abdomen and tail of female with fifth pair of feet, × 140.

Caligus longicaudatus, p. 49.

Fig. 26. Female, seen from below, × 16.

Artotrogus brevicaudatus, p. 48.

Fig. 27. Mandible (?), × 120.
Fig. 28. Maxilla, × 210.
Fig. 29. Foot-jaw, × 120.

PLATE XIII.

Paurocope robusta, ♀, p. 46.

Fig. 1. Animal, seen from left side, } × 84.
Fig. 2. ,, ,, above, } × 84.
Fig. 3. Antennule, × 140.

Fig. 4. Antenna, × 210.
Fig. 5. Mandible, × 500.
Fig. 6. Maxilla, × 500.
Fig. 7. Anterior foot-jaw, × 500.
Fig. 8. Posterior foot-jaw, × 210.
Fig. 9. Foot of first pair, × 210.

Centromma thomsoni, p. 47.

Fig. 10. Animal, seen from below, × 140.
Fig. 11. Antennule, × 210.
Fig. 12. Antenna (?), × 210.
Fig. 13. Mandible (?), × 250.
Fig. 14. Anterior foot-jaw, × 210.
Fig. 15. Posterior foot-jaw, × 210.
Fig. 16. Foot of first pair, × 210.
Fig. 17. Abdomen and caudal laminæ, × 210.

Entomolepis ovalis, p. 48.

Fig. 18. Male (?), seen from below, × 84.
a. Siphon; *b.* Antenna; *c.* Mandible-palp?; *d.* Anterior foot-jaw; *e.* Posterior foot-jaw; *f.* Swimming-foot.
Fig. 19. Antennule, × 210.
Fig. 20. Antenna, × 210.
Fig. 21. Mandible-palp (?), × 210.

Artotrogus brevicaudatus, p. 48.

Fig. 22. Outline of animal, seen from below, × 55.
Fig. 23. Antennule, × 210.
Fig. 24. Siphon, × 120.
Fig. 25. Posterior foot-jaw, × 120.
Fig. 26. Abdomen, × 140.

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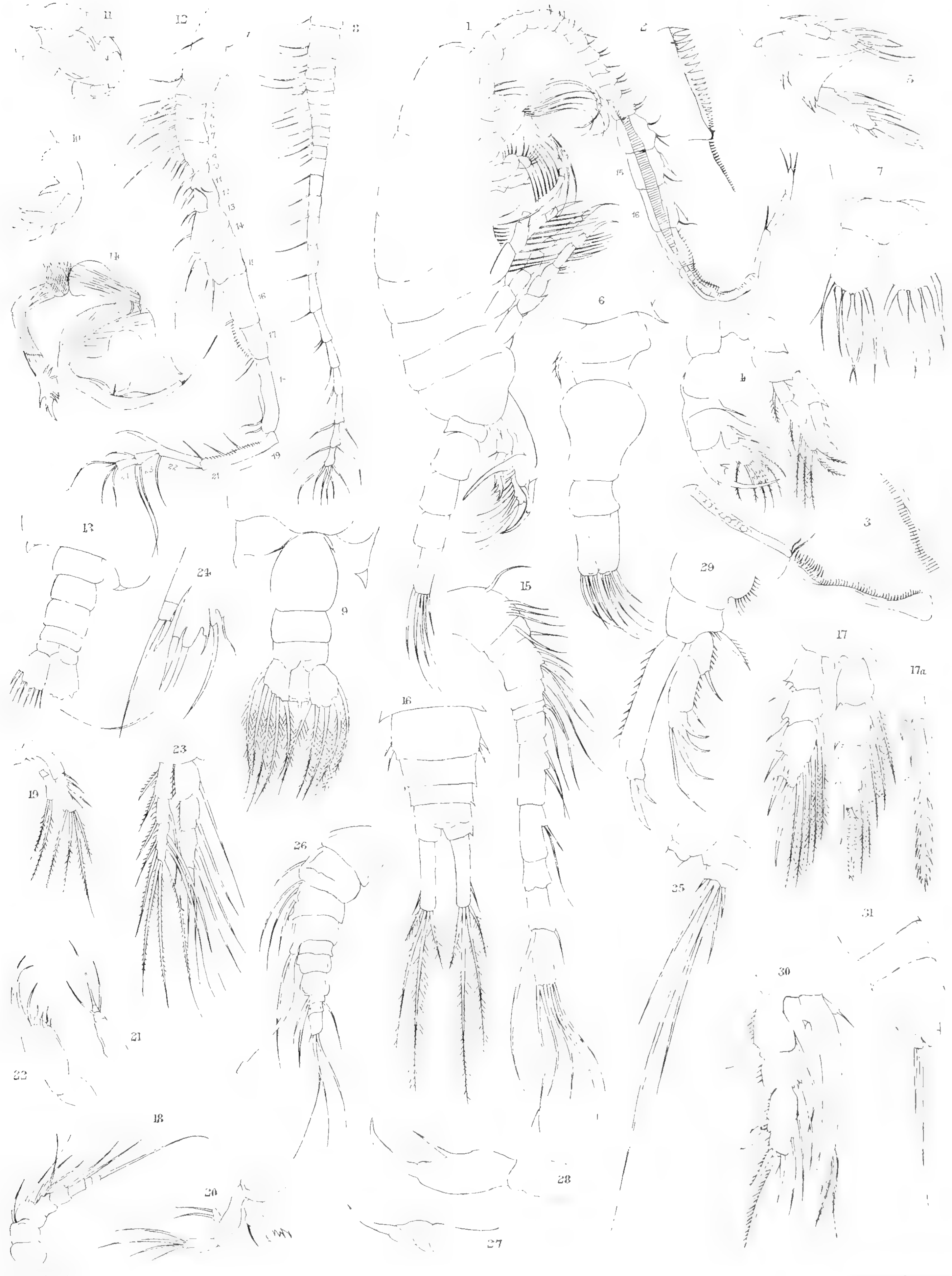

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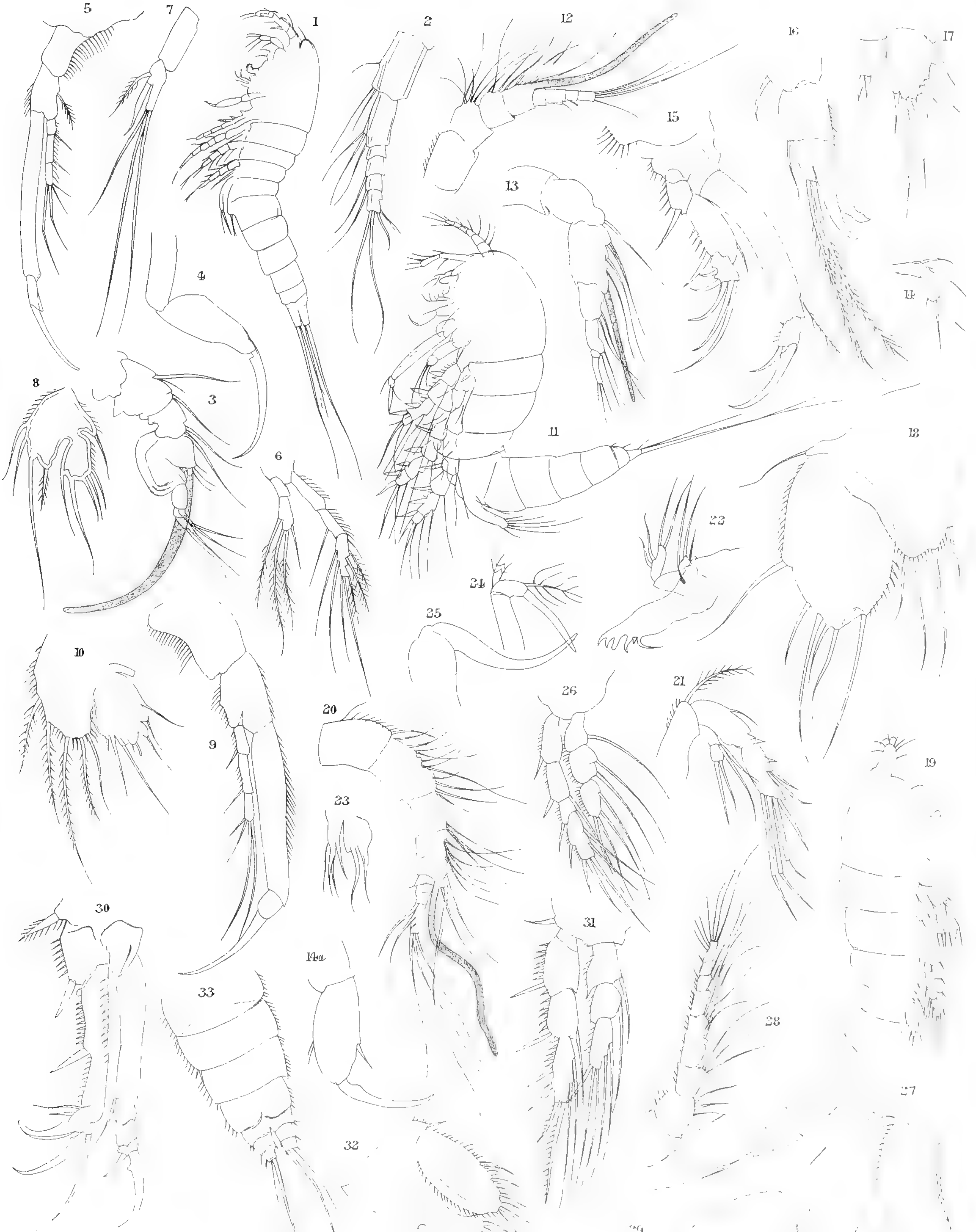

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August 1899.

P. L. SCLATER,
Secretary.

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Continued on page 3 of Wrapper.

III. *On the Extinct Birds of Patagonia.—I. The Skull and Skeleton of* Phororhacos inflatus *Ameghino. By* C. W. ANDREWS, *B.Sc., F.Z.S., Assistant in the British Museum (Natural History).*

Received March 21, read April 18, 1899.

[PLATES XIV.–XVII.]

IN a paper read at the Meeting of the British Association at Ipswich, in 1895, and subsequently published in the 'Ibis'[1], the present writer gave a brief review of a very interesting memoir by Dr. Florentino Ameghino on some remarkable fossil birds from the Tertiary deposits of Patagonia. Since that time, the specimens described by Ameghino have come to the Geological Department of the Natural History Museum, so that an opportunity of examining the bones themselves has arisen; and in the case of the most remarkable of the specimens, the skull and skeleton of *Phororhacos inflatus*, the careful removal of the adherent matrix has revealed for the first time many points of great importance, *e. g.* the structure of the palate. It seems, therefore, desirable to give as complete an account as possible of the osteological characters of this bird, in order, if possible, to arrive at some conclusion as to its precise relationship to recent forms; and although the account given in Ameghino's excellent paper is an accurate one as far as it goes, still it seems best, even at the risk of some repetition, to describe in detail all the parts of the skeleton available, in order to facilitate the comparison of them with recent types.

It may be at once stated that if the remains described by Ameghino really formed parts of one individual skeleton (and there seems to be no reason to doubt this), then this bird presents a most extraordinary combination of characters, to which no close parallel can be found among recent forms. A brief summary of the various opinions that have been expressed relative to the systematic position of the Stereornithes will be found in the above-mentioned review.

The present paper will be confined to a description and comparison of the skeleton of *Phororhacos inflatus* Ameg., that species being represented by much the best series of remains.

SKULL AND SKELETON OF *PHORORHACOS INFLATUS* AMEGHINO.

Of this species there is a fine series of bones, including the skull and mandible, scapula, coracoid, bones of wing, pelvis, and bones of hind limb, as well as some vertebræ: these are said to belong to a single individual. There is also a number of

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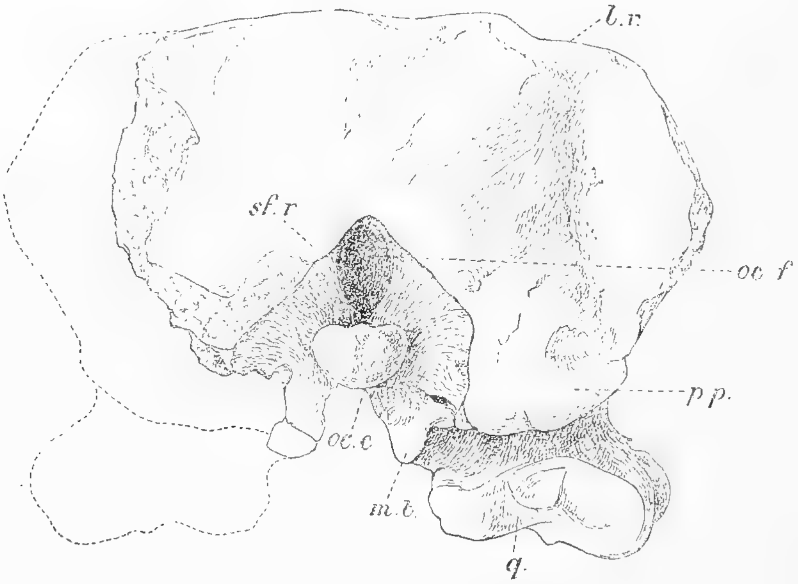
[1] "Remarks on the Stereornithes, a Group of Extinct Birds from Patagonia," Ibis, 1896, p. 1.

odd bones referred to this species, but the following description is founded as far as possible on the associated set, which is the type-specimen.

The Skull and Mandible. (Plates XIV. & XV.)

The skull and mandible are in a wonderfully perfect state of preservation, and, now the matrix has been removed, all the important details of their structure can be made out. The skull has been slightly crushed, so that there is some dislocation of the bones of the roof, and also a slight compression of the beak, but otherwise it retains its original form.

Fig. 1.



Occipital surface of skull of *Phororhacos inflatus* Ameghino. $\frac{3}{4}$ natural size.
l.r., lambdoidal ridge; *m.t.*, mammillary tuberosities; *oc.c.*, occipital condyle; *oc.f.*, occipital foramen; *p.p.*, paroccipital processes; *sf.r.*, supraforaminal ridge; *q.*, quadrate.

The Occipital Region (text-figure, above).—The occipital surface is remarkable for its flatness, its great width from side to side, and the distinctness with which it is marked off from the other regions. This last peculiarity is due to the great development of the lambdoidal ridge (*l.r.*), particularly towards the sides. In its middle portion this ridge merely forms the angle (of about 100°) between the occipital and dorsal regions, but laterally it is produced outward, forming prominent lateral crests which are continuous ventrally with the broad paroccipital processes (*p.p.*). These latter are convex posteriorly, both from above downward and from side to side; their inferior angles extend somewhat below the occipital condyle, and are formed by the ventral prolongations of the very well-marked supraforaminal ridges. These ridges run downward and somewhat outward from the upper border of the *foramen magnum* (*oc.f.*), and form the inner borders of the paroccipital processes, separating them from a depressed area lying between them and the *foramen magnum.* This valley-like depression is closed above by the meeting of the supraforaminal ridges (*sf.r.*), but opens ventrally on either side of the occipital condyle. The inferior angles of the paroccipital processes are united to the mammillary tuberosities (*m.t.*) of the basitemporal platform by prominent buttresses of bone, behind and internal to which the vagus foramina open.

The *foramen magnum* (*oc.f.*) is relatively very small; it is oval in outline, the long axis being vertical. The plane of the opening is inclined backward, making an angle of rather more than 45° with the long axis of the skull. The transverse diameter of the opening is 9 mm., the vertical 16 mm.

The slightly pedunculate occipital condyle (*oc.c.*) is oval, or rather reniform, its upper border being nearly straight, with a vertical groove running down from its middle point nearly to the centre of the condyle. There is a small but deep precondylar fossa (*pc.f.*, Plate XV. fig. 1).

The base of the Skull (Plate XV. fig. 1).—The basitemporal platform (*b.t.*) is a triangular area which is very slightly elevated, and below the level of which the occipital condyle projects. It is concave from side to side, and the postero-lateral angles are produced downward into the very prominent mammillary tuberosities (*m.t.*, fig. 1), which, as mentioned above, are united to the inferior angles of the paroccipitals by buttresses of bone. The posterior margin of the platform is defined by a shallow groove separating it from the occipital region. The lateral borders are thickened ridges, forming anterior prolongations from the mammillary tuberosities (*m.t.*), and converging so that they appear to have met in front in a rounded median angle. This, no doubt, lies immediately below the common opening of the eustachian tubes, which are immediately dorsal to the thickened ridges just described, and open posteriorly by wide apertures into the tympanic cavity. In front of the basitemporal platform the narrow rostrum (*r.*) is seen for a short distance, but it is here badly preserved, and anteriorly is completely invested by the bones of the palate.

On the sides of the basitemporal platform, rather high up and behind its anterior angle, are a pair of basipterygoid facets, with which the pterygoids articulate by means of stout processes borne on their inner surfaces rather behind their middle point (*b.pt.*). Below and behind the articular facets for the pterygoids the basitemporal forms a thin plate of bone (pretemporal wing), which looks outward and downward; the lower edge of this forms the floor of the eustachian canal, while its upper portion is the outer wall of the large pretympanic recess, which opens widely into the tympanic cavity immediately above the posterior aperture of the eustachian tube.

The side of the Skull (Plate XIV.).—The tympanic cavity (*ty.*) is relatively small; posteriorly it is bounded by the concave anterior face of the paroccipital process; the inferior portion of its inner wall is formed by the buttress of bone which joins the paroccipital to the mammillary tuberosity (*m.t.*). Its outer edge is formed by a downwardly-projecting flange of the squamosal, the anterior edge of which runs down between the anterior and posterior quadrate facets. Of these, the antero-external (*o.f.*) is very large, oval in outline, and concave in all directions, but more deeply so from before backward; its outer edge forms a prominent lip on the lower edge of the squamosal prominence. The other facet (*i.f.*) is placed internal and posterior to the last; in form it is a very elongate oval, the long axis being antero-posterior, in which direction it is deeply concave: it looks outward and downward. The opening of a large pneumatic fossa separates it from the downwardly projecting process of the squamosal and also from the anterior facet. Mesiad of the posterior facet, but separated from it by a narrow flat ledge of bone, is a very deep pocket-like depression, into which open numerous foramina. The most posterior of these seems to be the *fenestra ovalis*; the others are probably pneumatic. Ventrally the tympanic cavity communicates by wide openings with the anterior tympanic recess and the eustachian canal.

The squamosal region (Plate XIV., *sq.*) is deeply concave from before backward, and slightly convex from above downward. Posteriorly it forms the anterior face of the prominent lambdoidal crest; ventrally, as already mentioned, it is produced downward into a pointed process, which helps to form the outer boundary of the tympanic cavity. Anteriorly its ventral edge is formed by the prominent outer lip of the anterior quadrate facet (*o.f.*). About 7 mm. above this there is a prominent elongated tuberosity, the long axis of which is directed downward and inward; this I take to be the *zygomatic process* (*zy.*). From its upper end a slight ridge runs upward and backward to the lambdoidal crest (*l.r.*), and forms the lower boundary of the temporal fossa. Internal to the zygomatic process, and connected with it by a short ridge, is another angular projection, the *pretympanic process*; from this also a slight ridge runs upward and backward, but it soon dies away without reaching the main temporal ridge.

As might be expected from the great massiveness of the mandible, the temporal fossæ are very large and deep. Their lower opening is bounded posteriorly by the zygomatic, anteriorly by the postorbital process (*p.orb.p.*), which approach to within 17 mm. of each other. The fossæ are much deeper than broad, and greatly constrict the side of the cranium. Superiorly they are bounded by the temporal ridges, which, as above mentioned, run upward and backward from the zygomatic process till they meet the lambdoidal crest (*l.r.*), with which they are confluent for 28 mm. Leaving the lambdoidal ridge, they sweep forward, first towards the middle line, then outward, terminating anteriorly on the upper surface of the postorbital process. On the roof of the skull the fossæ are separated one from another by an interval of about 12 mm. only.

On the side of the cranium, immediately below the constriction caused by the temporal fossæ, and about on the same level as the quadrate facet, there is a deep infundibuliform depression, at the bottom of which the trigeminal foramen opens. This depression is marked off from the orbit by a ridge which runs upward and outward, terminating above in a prominent cristiform ridge on the ventral surface of the postorbital process.

The *orbits* are very large; they appear to be divided one from another by a complete bony septum (*i.o.s.*), or there was at most a small vacuity in front of the optic foramen. These latter appear to be confluent, and lie on exactly the same level as the trigeminal foramina.

In the upper posterior region of the orbit there is a deep depression, which no doubt lodged a gland; from this a shallow groove runs forward along the upper edge of the interorbital region. This groove marks the course of the olfactory nerve, and immediately above it the great penthouse-like roof of the orbit arises. The whole of the inner and posterior part of this is formed by the orbital plates of the frontals, while externally it is completed by the enormous supraorbital plate of the lachrymal, which in this specimen has been somewhat displaced downward on both sides, so that the skull, seen from above, appears as if it possessed large supraorbital depressions, such as occur in the Petrels, &c.; though, as a matter of fact, no such depressions existed (see Plate XIV. and Plate XV. fig. 2).

The lachrymal (*lac.*), as just mentioned, bears a very large supraorbital plate, which extends nearly to the postorbital process, terminating posteriorly in a blunt rounded angle. Its inner border was closely applied to, if not united with, the outer border of the frontal, and its outer border forms the upper margin of the orbit. Anteriorly its ventral surface is deflected, and the body of the bone turns inward and downward, and is produced ventrally into a nearly vertical bar of bone, which in its ventral portion is flattened laterally to a thin plate, and at its lower extremity articulates with the upper border of the jugal. A little above its middle point this bar has a small backwardly projecting process, but there does not seem to be any trace of a separation into two elements at this point, such as was formerly suggested[1]. The form and relations of this structure are almost precisely the same as in *Serpentarius*, or even more Accipitrine, as in the Eagles, *e. g.* the Harpy Eagle; and I can see no justification for Ameghino's description of the orbit as open anteriorly in *Phororhacos* any more than it is in the birds just mentioned, in which also this process reaches the jugal.

In front of the preorbital process of the lachrymal is the antorbital fossa, which is triangular in outline, its anterior and upper angles being rounded off. Its anterior border seems to be formed by a downgrowth of the nasal meeting an upward process from the maxilla; there are, however, a number of cracks in this region, which render its interpretation difficult, but by comparison of the two sides some degree of certainty can be attained.

The nasals consist of a posterior body, which unites behind with the frontals and supraorbitals; but it cannot be determined whether the two meet in the median

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[1] 'Ibis,' 1896, p. 6.

line or whether they are separated by the facial process of the premaxillæ, the junction with which is quite indistinguishable. It appears very probable that the premaxillæ ran in between the nasals and formed at least the upper portion of the high arch of the culmen between the nostrils, while the upper borders of those openings are formed by processes of the nasals; these bones also send processes downward and forward, forming the posterior border of the nares, and meeting the maxilla below as already mentioned. The angle between the anterior and inferior processes is rounded and has a thickened edge. The form and relations of the nasal are best seen on the left side of the specimen.

Immediately within the anterior border of the antorbital fossa, and united with the inner face of the downward process of the nasal, is the base of a broad band of bone (*eth.*), which runs vertically down the middle of the fossa parallel to the downward process of the lachrymal. The upper end of this band of bone widens out into a fan-shaped expansion, the upper edge of which is slightly overlapped by the anterior margin of the lachrymal. The lower end, also somewhat expanded, is cancellous, and unites with the upturned inner edges of the maxillo-palatine plates, with which the anterior ends of the palatines are indistinguishably fused. The narrowest point of this bar of bone is about its middle, below which it bears a backwardly-directed triangular process. A similar and similarly-situated bar in the ethmoidal region occurs in *Cariama* and also in some Accipitrine birds: *e. g.*, in a modified form, in *Serpentarius*.

The jugal arch is oval in section posteriorly, but in front it is compressed so as to form a broad, thin, vertical bar of bone. On the inner side of its posterior end there is a rounded knob which fits into a corresponding pit on the outer surface of the quadrate. Its anterior end seems to overlap the posterior prolongation of the maxilla. The downward process of the lachrymal articulates with the upper edge of the jugal close to its anterior end.

The form and relations of the *maxilla* to the surrounding bones are very difficult to make out. As just mentioned, its posterior extremity seems to be overlapped by the jugal, and in front of this it no doubt formed the edge of the beak for some distance. On its inner side it widens out suddenly, the expanded portion being directed downward and inward, and forming the large maxillo-palatine plate, with which the anterior end of the palatine unites completely. The maxillo-palatine plates have a thickened hinder border and are highly convex from side to side, and their upturned inner margins unite with the downwardly-directed bar of the ethmoid. The posterior border of each maxillo-palatine plate forms a continuous curve with the lower edge of the jugal arch. On either side of the middle line of the palate they form a long ridge which projects considerably below the tomium; the fused anterior ends of the palatines must also take part in the formation of this ridge. In the middle line they unite for a space of about 3·5 cm., in front of which they are separated by a narrow cleft 2·5 cm. long; how far they extend in front of this cannot be determined, nor is it possible to make out the extent and relations of the facial parts of the maxillæ, and it is therefore uncertain what share, if any, they may take in forming the boundary of the nostrils.

The *premaxillæ* no doubt form the greater part of the enormous beak, but their exact boundaries are not distinct. Superiorly they send out fused nasal processes, which form at least the upper part of the high bar of bone between the nostrils and perhaps extended to the frontals. Anteriorly the bodies of the premaxillæ form the high laterally-compressed anterior section of the beak, the tip of which forms a downwardly-directed hook, about 3·5 cm. long and small compared to the bulk of the whole beak. From the sides of the base of this hook a pair of parallel ridges run back on to the palate; their posterior portion is separated from the tomium by a deep groove, into which the edge of the mandible fits when closed; on their inner side also there is a deep channel, divided by a median ridge, which just behind the decurved hook rises into a prominent tuberosity, at first described as a tooth.

The cutting-edge of the beak forms a double curve; it commence a little behind the point and first forms a strongly convex, prominent edge, sharp in front, but more rounded behind; posteriorly it is very slightly concave, and is a continuation of the line of the lower edge of the jugal arch. The anterior convex portion is no doubt formed by the premaxillæ; the posterior is maxillary. In the premaxillary region the narrow palate is closed, except for a few small median foramina, and is deeply concave from side to side.

The beak, as a whole, is very deep from above downward, strongly compressed laterally, and its whole surface covered with angular and vascular impressions, which indicate that in life it was covered with a very thick horny sheath; the whole must have formed an extremely formidable weapon, whether for attack or defence.

The upper portion of the cranial region of the skull is much flattened (Plate XV. fig. 2). Posteriorly it is greatly constricted by the great temporal fossæ, which are separated in the middle line by an interval of about 12 mm. only. In front of these it widens out and reaches its greatest width at the level of the postorbital processes. In front of these it again narrows, and anteriorly the frontals join the nasals, but their limits are not very clear. The orbital borders of the frontals have thick roughened edges, and probably the great supraorbital plates of the lachrymals, which now lie slightly below the level of the frontals, may, in their normal condition, have united with them throughout their whole extent; but, since their position is symmetrical on the two sides, it is possible they may be in their natural position. As already mentioned, this depression of the supraorbital plates gives the skull, when looked at from above, the appearance of having possessed deep supraorbital fossæ.

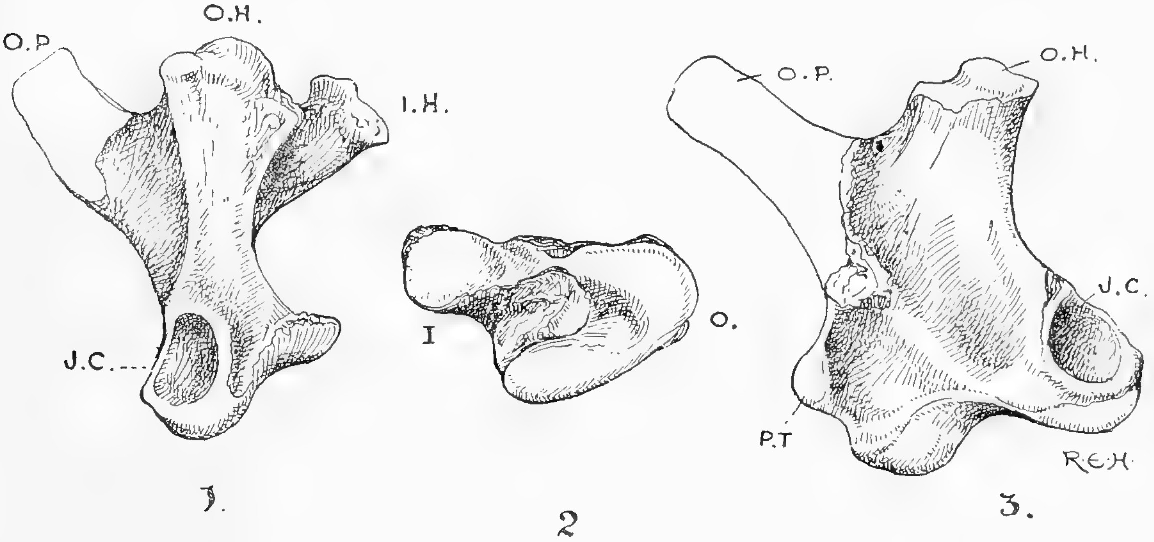
The Palate (Plate XV. fig. 1).—The most important result of the careful removal of the matrix from the skull is that the structure of the palate is completely revealed, the bones being perfect and very little displaced. The taxonomic importance of this region is very great, and examination of it in this bird on the whole tends to support the views previously put forward.

The *pterygoids* (*pt.*) are stout, laterally compressed bones, of considerable depth. At their posterior end they bear a cup-like depression, which receives a corresponding tuberosity on the inner border of the quadrate, and on their upper border, one-third of their length from the posterior end, there is a stout process, oval in section and projecting backward, upward, and inward; it terminates in a facet, which articulates with a corresponding surface on the base of the skull. These upper processes of the pterygoids occupy the position, and perform the function, of the basipterygoid processes of some birds. Anteriorly the pterygoids converge and just meet below the rostrum: their anterior ends are abruptly truncated at right angles to their long axis, and form facets for articulation with the *palatines*; these latter are very large bones; posteriorly they bear short, broad pterygoid processes, which meet in the middle line and articulate with the pterygoid facets just mentioned. The median union of the palatines extends forward about 3 cm., and is marked by a slight ridge: in front of this their median borders diverge and are notched by the hinder borders of the internal narial slits. In the interval between the palatines no trace of the vomer is preserved, except that close to the anterior end, where they join the maxillo-palatine plates, there are traces of a median plate, which is probably a portion of that bone. The body of the palatine is very large, and consists of two lamellæ separated by a deep valley and projecting almost vertically downward. Of these the outer is much the larger, and forms a great ventrally-directed flange. Its inferior border is somewhat thickened, and meets the posterior border, which also is thickened, nearly at right angles. The angle thus formed is slightly everted, and a short distance above it the posterior border slopes gently backward to the pterygoid process. The inner lamella is very small; its ventral border is thickened and is continued backward to meet its fellow on the middle line, forming the median ridge above noticed.

The anterior portion (maxillary process of the palatine is formed by the widening out of the external lamella; this fuses with the maxillo-palatine plates, and together with them forms the prominent longitudinal ridge projecting below the level of the tomium, as before described. The bird in which the palate most nearly resembles the fossil in this respect is *Diomedea*, in which the disposition and relative proportions of these ridges and the form of the cutting-edges of the beak are very similar. Dorsally the palatines send up a thin triangular plate of bone on either side of the rostrum and embracing it.

The *quadrate* (Plates XIV. and XV. fig. 1, also text-figure, p. 63) articulates with the skull by two distinct condyles sharply separated one from another by a deep pit, at the bottom of which is a large pneumatic fossa, hollowed out in the neck of the bone. The antero-external capitulum (O.H.) is much the larger; it is triangular in outline, convex from above downward, and slightly concave from side to side The inner capitulum (I.H.) is borne on a thin, backwardly-directed buttress of bone; it has two facets, one nearly flat, looking upward and inward, the other convex and directed downward. The neck of the bone is deeply excavated by pneumatic fossæ, both on its anterior and posterior face, and also on the inner side at the base of the orbital process (O.P.). This latter is large; its upper and lower borders are nearly parallel, and it terminates in a roughened surface; its length is about 17 mm.

Fig. 2.



Left quadrate of *Phororhacos inflatus* Ameghino.

1. From outer side.
2. Articular surface for mandible.
3. From front.

I.H., inner head; I., inner articular surface for mandible; J.C., cup for end of jugal arch; O., outer articular surface for mandible; O.H., outer head; O.P., orbital process; P.T., tuberosity for articulation with the pterygoid.

The lower end is massive and bears two articular surfaces (I. and O.) for the mandible, which are separated by a shallow groove running outward and forward from the postero-internal border. The form of the facets will be best understood from the figure (fig. 2, above). On the inner border of the bone, just beneath the base of the orbital process, there is an elongated tubercle (P.T.) for union with the hinder end of the pterygoid; and on the outer side, immediately above the surface for the mandible, is the deep circular cup (J.C.) with clearly defined border, which receives the posterior end of the quadrato-jugal.

The *mandible* (Plate XIV.) is specially remarkable for its very massive structure. The relatively narrow symphysis is about 9 cm. long; its ventral border is convex, its dorsal nearly straight, and but slightly upturned at the top. The upper surface is deeply concave from side to side, giving the symphysial region a spout-like form. Behind the convexity of the symphysial region the ventral edge of each ramus is anteriorly slightly concave and posteriorly rather strongly convex. The upper borders of the rami are at first convex and sharp-edged, behind this, as far as the small coronoid process, they are straight and blunt. Behind the coronoid process the edge slopes down to the articular cup for the quadrate. The facets on this are two in number, one external and elongated, one inner and rounded in outline ; both are concave from before backward, and they are separated by a deep fossa, but no pneumatic foramina are present. There is a large and very prominent internal angular process ; the inferior angle is broken away, but it can only have formed merely a slight projection. Just beneath and in front of the coronoid process the mandible is perforated by a very large vacuity.

Comparison of the Skull of Phororhacos *with that of other Birds.*

Comparison of the skull of *Phororhacos* with that of the Struthious birds at once excludes the possibility of any affinity between it and them. The form of the palate, in which, as already described, the palatines and pterygoids both articulate with the rostrum, the reduction or absence of the vomer, and the double head by which the quadrate articulates with the skull, are all points not occurring in any Ratite bird.

It then remains to determine what are the closest allies of *Phororhacos* among the Carinatæ, a question of which any satisfactory solution is very difficult.

Taking the palate first for comparison, we find that it presents in some respects a very remarkable resemblance to that of certain Tubinares, especially the Albatross (*Diomedea*). In this bird, as in *Phororhacos*, the maxillo-palatine plates together with the anterior region of the palatines form on either side a very prominent ridge, projecting considerably below the level of the tomium, the form of which also is very similar in the two birds. The palatines and pterygoids are also similar to those of the fossil in their relations one to another and to the rostrum ; but the palate differs much in form, the internal lamina being much the larger, while in *Phororhacos* the reverse is the case. There are a number of other important differences : thus, in *Diomedea* the palate is schizognathous and the anterior end of the large vomer appears upon it ; there are large supraorbital fossæ. In *Phororhacos* the palate is desmognathous, the vomer is inconspicuous, and there seem to have been no supraorbital fossæ whatever, although slight displacement of the large supraorbital plates of the lachrymal at first sight gives the skull the appearance of having possessed them. Moreover, the form of the antorbital fossa and that of the quadrate are different in many respects. In spite of a certain similarity between the skulls, it does not seem that any close affinity exists between *Phororhacos* and the Tubinares, and in fact, as will be seen below, the structure of the limb-bones and pelvis lends no support whatever to any such relationship.

Comparing the fossil with the skulls of various desmognathous types, one is at once struck with its Accipitrine aspect. This, of course, depends chiefly on the form of the beak, but is heightened by similarity in several points of detail, *e. g.* the form of the lachrymal and of the antorbital fossæ. Closer examination shows, however, that the structure of the palate is very different, particularly in the relations of the anterior end of the palatines to the maxillo-palatine plates; the form of the articulation of the quadrate with the mandible is also widely different. Of the Accipitrine birds, *Serpentarius* approaches the fossil most closely both in structure of the anterior region of the palate and in the existence of an articulation between the pterygoids and the *basis cranii*. In the Storks the palate is in several respects like that of the fossil, particularly in the relations of the palatines to the maxillo-palatine plates; the distal articulation of the quadrate is also similarly constructed, but is relatively much wider from before backward. On the other hand, the lachrymal bears neither a long descending antorbital process nor a large supraorbital plate, and the antorbital fossa is different.

Although the Gruiformes are typically both schizognathous and schizorbinal, it is remarkable that *Cariama* and *Chunga*, which in external appearance and habits so much resemble *Serpentarius*, should have become both desmognathous and holorhinal, like Accipitrine birds. The existence of these characters, therefore, in the skull of *Phororhacos* cannot be regarded as a bar to the relationship between it and the Gruiformes, suggested in a former paper and supported by many structural peculiarities of the pelvis and hind limb. In fact, since the general line of specialization of *Phororhacos* is similar to that which produced the Cariamidæ, the occurrence of these characters might have been expected. In some points, indeed, *e. g.* in the form of the quadrate, *Phororhacos* differs less from the typical Gruiformes than *Cariama* does.

Further discussion of the affinities of this remarkable form is best deferred till after the remainder of the skeleton, as far as we know, has been described.

The dimensions of the skull are:—

	cm.
Length from anterior end of premaxillæ to paroccipital process	33·7
,, ,, ,, to centre of occipital condyle	30·0
Width at paroccipital processes	11·4
,, of cranium at temporal fossæ	7·0
,, at postorbital processes	12·0
,, (least) between temporal fossæ	2·5
,, opposite posterior edge of nostril	3·3
Depth of upper jaw at middle of nostril	11·5
,, ,, at its middle point	11·7
Length of opening of nostril	4·0
Width of upper jaw at middle point	3·8
Height of *foramen magnum*	1·7
Width of distal end of quadrate	3·8

Fig. 3.

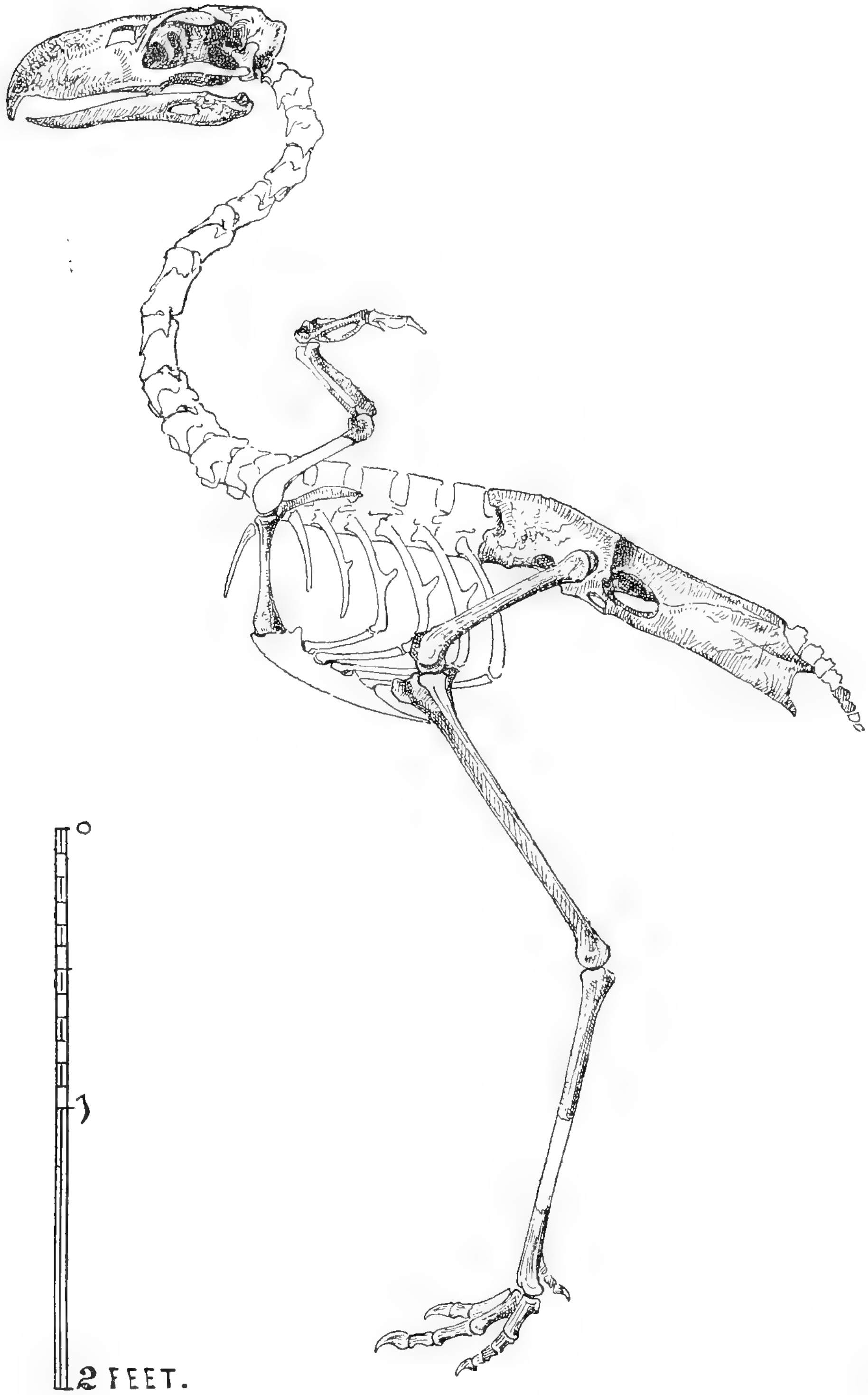


Diagram of skeleton of *Phororhacos inflatus* Ameghino, to show the relative proportions of the bones.

The portions of the skeleton preserved are shaded.

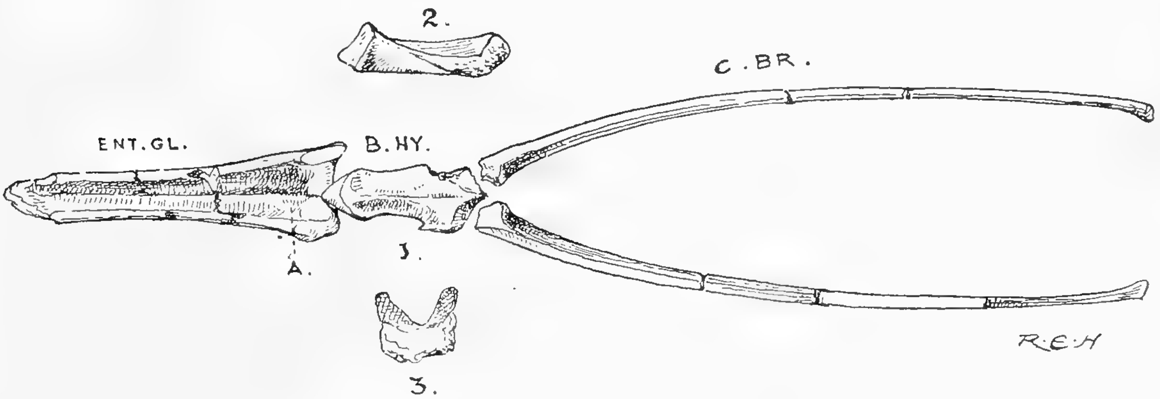
(About $\frac{1}{8}$ natural size.)

The dimensions of the mandible are :—

	cm.
Total length	30·2
Length of symphysis	9·0
Depth of ramus at coracoid process	4·9
Width of articular end	5·5

The hyoid (text-figure, below) is very well preserved, a most exceptional, if not unique, circumstance in a fossil bird. The anterior element, the entoglossal (ENT.GL.), is very large and clearly has originated from the union of two rod-like elements, the ceratohyals, which are united by a thin plate of bone. On the ventral surface the division between the rods is marked by a deep furrow, deepening posteriorly, but the dorsal surface seems to have been regularly convex from side to side. The anterior end is somewhat broken; the posterior is deeply divided by a double articulation for the basihyal (basibranchial 1) (B.HY.), and laterad to this the outer angles are produced into short backwardly-directed processes.

Fig. 4.



Hyoid of *Phororhacos inflatus* Ameghino, slightly reduced.

1. From below.
2. Basihyal from side.
3. Section of entoglossal at point A.

ENT.GL., entoglossal; B.HY., basihyal (first basibranchial); C.BR., ceratobranchial.

The first basibranchial (B.HY.) (basihyal) is a short bar of bone, the thinner lateral borders of which seem to have been broken away. Its dorsal surface is concave from before backward, and on its anterior half from side to side also; ventrally it is convex from before backward. The anterior end bears a double surface for articulation with the entoglossal, separated by a slight ridge, which at its ventral extremity is produced into an anteriorly-projecting prominence. Posteriorly there are two irregular surfaces for the ceratobranchials, meeting at an angle of about 120°. The first basibranchial is not prolonged backward into a urohyal, nor does it, as far as can be seen, bear any surface for the articulation of a distinct median element: if such were present it must have been small and have articulated with the bases of the ceratobranchials (C.BR.). These are thin, slightly curved rods of bone, the anterior ends of which are enlarged and bear the surface for the articulation with the first basibranchial. The posterior ends are also slightly expanded and terminate in convex facets, apparently for union with another element.

In the Albatross the entoglossal is relatively very much smaller, the first basibranchial (basihyal) broad and short, and prolonged backward into a long urohyal, so that the articular surfaces for the ceratobranchials are widely separated.

In *Grus* the entoglossal is very long, slender, and unossified; the first basibranchial (basihyal) is also long and slender, but, as in the fossil, the ceratobranchials articulate with two contiguous surfaces on its hinder end, and the uroglossal is distinct and articulates between the bases of the ceratohyals.

In *Cariama* the two elements forming the *entoglossal* are partly separated by a median foramen and are prolonged into postero-lateral processes behind the articulation with the first basibranchial. This is a short bar of bone terminating in a pair of surfaces for the ceratobranchials. The urohyal is very small and is not in contact with the first basibranchial.

In the Birds of Prey the ossified portion of the entoglossal is, as a rule, deeply bifid anteriorly, the two elements forming it being united for a short distance only. The first basibranchial is somewhat elongate and is prolonged backward into a uroglossal process.

In the Storks the entoglossal is imperfectly ossified, and the first basibranchial is similar to that of the Raptores.

On the whole, the hyoid of *Cariama* approaches the fossil most nearly.

The Coracoid. (Plate XVII. fig. 1.)

The *coracoid* is particularly remarkable for its great length and slenderness, and for the reduction of the acrocoracoid (*ac.*) process.

At the sternal end the bone is almost 32 mm. wide; its anterior face is convex from side to side, and the posterior flat or rather concave. The articular facet for the coracoid groove of the sternum is large and well defined; it extends from side to side of the distal end of the bone both on the anterior and posterior face. At about its middle it is overhung by a very prominent tuberosity, from which a shelf-like projection runs to the inner border of the bone; the union with the sternum must have been very strong.

There is no distinct *processus lateralis* (*p.l.*), its place being occupied by the convex outer border (*p.l.*) of the expanded distal end. On the anterior surface a *linea aspera* runs from the inner angle upward and inward, joining the ridge marking the outer border at about $\frac{1}{3}$ of the length of the bone from its distal end. The shaft towards its upper end is slightly compressed laterally. The total length of the bone is 157 mm.

The proximal end of the bone is peculiar. The acrocoracoid is almost completely absent, the upper end of the bone rising scarcely at all above the scapular surface. From the acrocoracoid region a ridge runs down the antero-internal border of the bone and forms the inner wall of a deep channel, which is bordered externally by the prominence formed by the surface for the scapula and the small procoracoid process. On this descending ridge there is, at some distance from its upper end, an elongate flat facet with which probably the clavicle articulated.

The surface for the scapula is a large, deeply concave area, nearly circular in outline; below its internal border arises a small process or hook of bone (broken in the specimen figured), which overhangs the groove above described and is the procoracoidal process.

The glenoid surface is a smooth, slightly convex area, the lower border of which forms a prominent overhanging lip on the postero-external side.

The coracoid just described is one of the most remarkable bones of the skeleton. Its extreme elongation and the peculiar structure of its upper end, particularly the almost complete suppression of the acrocoracoid, are paralleled, so far as I am aware, only in the coracoid of the flightless *Aptornis*. The coracoid of this bird differs, however, in several important particulars, *e.g.* in the large size of its procoracoidal process, the presence of a supracoracoid foramen, and in the complete fusion of the lower extremity with the sternum.

Fürbringer has regarded the absence of the acrocoracoid as diagnostic of the Ratitæ, and has suggested that the term "Platycoracoideæ" should be used for them in contradistinction to the Acrocoracoideæ, or Carinatæ. The occurrence of this character in two such distinctly Carinate types as *Aptornis* and *Phororhacos*, however, invalidates this distinction, and tends to show that the presence or absence of the acrocoracoid, like that of the keel of the sternum, is in some way dependent on the loss of flight, and probably also on the increase in the bulk of the body.

The articulation with the sternum is particularly well developed, and in no bird could the prominent tubercle and shelf above described be found developed to the same extent. No trace of the sternum is preserved, but, judging from the coracoids, it was probably of considerable size.

Scapula. (Plate XVII. fig. 2.)

Of the *scapula* no perfect specimen is preserved, but the most complete, here figured, wants the distal portion of the blade only. The surface for union with the coracoid is highly convex and roughly circular in outline; it is much roughened, and the union of the two bones must have been a very close one. The glenoid surface, which is slightly convex, is raised on a prominence which projects considerably below the inferior border of the blade. There is a very large acromium process. The portion of the blade preserved is somewhat rounded externally and flat internally.

The width of the proximal end of this bone is 30 mm.

The Bones of the Wing.

The exact length of the wing cannot be determined, owing partly to the incomplete state of the humerus and partly to the absence of the phalanges; but it is certain that, in proportion to the bulk of the bird, it had undergone extreme reduction and must have been entirely useless for purposes of flight. At the same time the stoutness of the bones and the distinctness of the muscle-impressions indicate that it was in some way functional, and the presence of a series of tubercles along the posterior border of the ulna shows that it was provided with a series of large quill-feathers, the remiges. It may have been employed to assist the bird in running, or possibly as a shield, somewhat in the same way as the Secretary-bird is said to use its wings, although for this latter purpose it would appear to have been too small.

Of the *humerus* (Plate XVII. fig. 3) only the distal end is preserved in the type-skeleton. In it the radial (*r.*) and ulnar condyles (*u.*) are of the ordinary avian form, but are less distinctly separated than usual, the intercondylar groove being almost obsolete. The surfaces of the condyles are rough, and probably a considerable pad of cartilage intervened between them and the bones of the forearm. The distal border of the bone is very oblique, owing to the presence on the ulnar side of a pointed process projecting some distance beyond the ulnar condyle (*u.*). The anterior face of the bone above the condyles is deeply concave, and the portion of the concavity close to the ulnar border of the bone contains the well-marked elongated impression of the *brachialis anticus* (*b.a.*). Posteriorly there is a shallow olecranon fossa.

The *ulna* (Plate XVII. fig. 4) is a short, very stout bone; its shaft is slightly curved and triangular in section, the sharpest angle forming its posterior border. At its proximal end the impression of the *brachialis anticus* is not very clearly marked, but the surface for the humero-cubital ligament is very distinct. There is a well-developed olecranon process (*ol.*), the end of which bears a rugose surface for the insertion of the triceps tendon, and from this a slight ridge runs to another rugosity (for the insertion of the long head of the triceps) lying immediately below the edge of the radial glenoidal surface. On the postero-internal border, immediately below the articular surfaces, is a tuberosity for the insertion of the biceps tendon. The sharp posterior border of the bone bears a series of well-marked tubercles, indicating the existence of large quill-feathers (secondary remiges) in the wing: there are about seven of these tubercles.

Towards its distal end the shaft loses its triangular form and becomes circular in section.

The distal articular head is large, and on its outer surface there are impressions marking the origin of various flexor muscles of the digits, and a groove for the passage of tendons. The length of the ulna is approximately 110 mm.

The *radius* (Plate XVII. fig. 5) is represented by the proximal end only.

In the *metacarpus* (Plate XVII. fig. 6) the proximal articular surface is broad and only slightly grooved at its posterior end; there is no fossa into which the cuneiform fits when the manus is flexed upon the forearm; the so-called pisiform process is almost absent. The prominence formed by the fused first metacarpal is stout and short, and terminates in a roughened surface which may possibly have formed the base of a short horny spur or knob. Distally the first metacarpal terminates in a tubercle for articulation with the phalangeal. The second metacarpal (*mc.* 2) is short and thick, compressed laterally and slightly curved. On its upper surface there is a nearly longitudinal, faintly marked groove, and on the anterior surface of the distal end is another short groove for tendons.

The third metacarpal (*mc.* 3) is much more slender than the second; it is strongly curved and so compressed that it forms a mere band of bone. On its ventral surface at the proximal end is a prominent tubercle (*t.*), which will be referred to below; distally it is fused with metacarpal 2 in the usual manner. The distal extremities of the fused metacarpals bear each an articular surface for their phalangeals, as in most birds. The length of the metacarpus is 76 mm.

The reduction that has been undergone by the bones of the wing makes their comparison with those of other birds difficult.

The distal portion of the humerus differs widely from the Albatross, in which the impression of the *brachialis anticus* is in a different position and there is a large ectepicondylar process. In the Birds of Prey the depression on the anterior face above the articular surfaces is always much less than in *Phororhacos*, and the impression of the *brachialis anticus* is more median; in some the distal border is somewhat oblique and there is a trace of the distal process.

In *Ciconia* the distal border is not oblique and the position of the *brachialis* impression is quite different.

In *Grus* the differences are the same as in *Ciconia.*

In both *Cariama* and *Psophia* also the distal border is only slightly oblique (in *Cariama* there is a trace of a blunt distal process on the ulnar side).

The humerus to which I find most resemblance in the form of the distal end is that of *Diaphorapteryx*, the large extinct Rail of the Chatham Islands. In this the distal border is oblique, there is a fairly prominent distal process, and the form and position of the *brachialis anticus* impression is similar. The humerus of *Aptornis* is also somewhat like the fossil, but in it reduction has gone further, the division between the radial and ulnar condyles being still more indistinct and the distal process small.

The short, stout *ulna* is not very much like that of any of the birds referred to in the comparison of the humerus, but approaches that of *Psophia* most nearly.

The proximal end of the right *radius* is preserved. Its articular surface is oval in outline, and the bicipital tuberosity is strongly developed. It is almost identical with the same element in *Cariama*, but the characters of the radius are not sufficiently different in the various groups to be of much importance in determining affinities.

The *metacarpus* differs widely from that of *Diomedea*, *Grus*, and *Ciconia*, and is most like that of *Psophia* and *Cariama*.

In both these birds, as in *Phororhacos*, there is on the ventral edge of the third metacarpal, close to its base, a small process forming a projection (*t.*, fig. 6, Plate XVII.) on the palmar aspect of the manus. I have not observed this in any but these birds, and of them it is most strongly developed in *Cariama*, in which, however, there is a prominent pisiform process.

On the whole, the evidence of the wing-bones seems to point to relationship to the aberrant Gruiform birds *Cariama* and *Psophia*: but in the humerus there is resemblance to such Rails as *Ocydromus*, *Diaphorapteryx*, and *Aptornis*, in which also the wings have undergone more or less reduction; in this case the similarity may merely be due to convergence in degeneration.

Sacrum and Pelvic Girdle. (Plate XVI.)

The vertebræ uniting to form the so-called sacrum (fig. 3) (*synsacrum*, Parker) are about fifteen in number. The most anterior articulated with the last free dorsal by the broad saddle-shaped surface of the centrum and by very large anterior zygapophyses. The neural spine of this vertebra is high and its summit is overlapped by and fused with ossified fasciæ which form a forward extension of the supero-anterior angles of the ilia; looked at from the side a great part of the spine is exposed to view, the anterior borders of the ilia only just overlapping its hinder edge; between the spine and the ilia there is on either side a chink-like ilio-neural canal.

Tubercular and capitular facets for a free rib are present, and both are roughly semicircular, the convexity being directed upward and forward. The capitular facet, borne on a slight parapophysial elevation, is close to the anterior end of the centrum and at the lower end of a ridge which runs upward and backward, bearing near its upper end the tubercular facet. From this a bar of bone, apparently equivalent to the zygapophysial bar of a free vertebra, runs back and unites with the antero-inferior margin of the ilium; from the tubercular facet a metapophysial ridge runs forward on to the zygapophysis. Just behind and above the capitular facet there is a pneumatic fossa of moderate size. The ventral surface of the centrum is pinched up so as to form a sharp median ridge.

In the second vertebra the neural spine is completely concealed by the ilia, and running upward and backward from the anterior end by the centrum there is a thick ridge which, near its lower end, bears a facet for the capitulum of a rib, and at its upper end abuts against the lower border of the ilium; here also there is a median ventral ridge. These vertebræ are probably thoracic.

The centra of the next few vertebræ have been destroyed, but opposite the acetabulum they are again preserved. In this region the median ventral ridge is replaced by a median groove defined by slight ridges, and disappearing opposite on the second of the true sacrals As far as opposite the middle of the acetabulum the vertebræ may be regarded as lumbar; the last of these bears a broad parapophysial process which abuts against the inner border of the ilium. Behind this there seem to be two or three lumbo-sacrals (*Mivart*) in which no parapophyses are present and, except perhaps on the hindermost, no diapophyses, unless these are directed dorsad. In this region the pelvis is very narrow, so that the lateral acetabular or anterior renal fossæ are extremely small.

Behind the lumbo-sacrals are the true sacrals, two in number. Both these possess ventral processes, which, no doubt, are formed by parapophyses + sacral ribs. In the first the process is stout, much expanded at its outer end, and directed outward, upward, and somewhat forward. In the second this process is very slender and quickly fuses with the middle of the upper process (diapophysis), which in this vertebra is stout and directed outward and forward. The diapophysis of the anterior sacral is slightly in front of, and about 1 cm. above, the parapophysis; it is directed backward, outward, and upward. The two diapophyses are separated by a nearly circular space, and their expanded outer ends, together with that of the ventral process of the anterior sacral fuse into a common mass of bone, which abuts against and fuses with the inner surface of the ilium immediately behind the acetabulum.

On the vertebral centra, at the level of the second sacral rib, there is a median hæmal ridge, which is continuous as far as the third of the urosacrals which bear transverse processes.

Behind the last sacral there is an interval in which no transverse processes are present: then they reappear, the first being very slender and directed backward at a very acute angle with the vertebral column; at its distal end it fuses with the succeeding process. This also is directed backward, but is much stouter than the last and greatly expanded at its distal end, where it abuts against the inflected portion of the ilium forming the floor of the pocket-like renal fossa. The next transverse process is very broad, and likewise unites externally with the ilium; it is separated from the processes in front of and behind it by oval foramina. Behind this there are four pairs of similar processes borne by vertebræ with long, narrow centra having a slight hæmal ridge. The free end of the last fused centrum is flat or slightly convex. On the dorsal surface the neural spines of the postacetabular "sacrals" form a prominent median ridge, separated from the ilia, anteriorly at least, by a narrow groove; posteriorly there are several pairs of slit-like interosseous foramina.

The pelvis, seen from above (Plate XVI. fig. 1), appears very long and narrow, the postacetabular region not being expanded to any great extent. Along the middle line runs a prominent ridge, formed in front by the fused upper edges of the ilia and behind by the united neural spines of the postacetabular vertebræ. Opposite the hinder border of the acetabulum is a transverse ridge which, at its outer ends, rises into a pair of very prominent supra-trochanteric crests; these, with the anti-trochanters, form prominent lateral projections. On each side of the median ridge in the post-acetabular region there is a narrow groove separating it from the upper edges of the ilia, and at the bottom of this there are traces of one or two pairs of interosseous foramina. The ilia terminate posteriorly in prominent ilio-caudal processes, which project some distance beyond the last fused caudal. From these processes there runs inward and forward on either side a ridge which, after continuing a short distance parallel to the vertebral axis, runs downward and outward to the upper angle of the ischiadic foramen; this ridge seems to be the hinder part of the ilio-lateral ridge, which is so strongly developed in many birds, *e. g.* Rails. Anterior to it the dorsal surface of the ilia are evenly convex from side to side.

Viewed from the front, the most conspicuous points are (α) the relatively large size of the centra of the sacral vertebræ; (β) the extreme lateral compression, the ilia meeting in the iliac crest at an angle of not more than 10°; (γ) the very narrow slit-like opening of the ilio-neural canals; (δ) the very prominent supra-trochanteric crests which, from this point of view, completely hide the whole of the dorsal surface of the postacetabular region.

In a posterior view the supra-trochanteric crests and anti-trochanters completely conceal the whole pre-acetabular region. Behind them we have first the median ridge of the sacrum, on each side of this a shallow groove, and external to this again the ilia, the regular downward curve of which forms an arc of a circle, and below these the ischia curving outward and diverging one from another. This portion of the pelvis has been crushed laterally, but not to any great extent.

Looking at the pelvis from the side (Plate XVI. fig. 2) it will be seen that the acetabulum is considerably in front of the middle of the pelvis, and measured from the middle of the acetabulum the pre-acetabular portion of the ilium is 140 mm. in length, the postacetabular 265 mm., or roughly as 10 to 19. The acetabulum itself is nearly circular in outline, its antero-posterior diameter being slightly the greater (*acet.*); through it the arches of the lumbo-sacral vertebræ are visible. Its antero-superior border forms a projecting lip, and the anti-trochanter, the lower border of which is excavated by a narrow fossa, is large and very prominent, and, except for a narrow groove, is continuous above with the supra-trochanteric crest. Anterior to the acetabulum is the slightly concave and nearly vertical gluteal fossa of the ilium, below the edge of which the centra of the pre-acetabular sacral vertebræ are visible.

The ischiadic foramen (*is.f.*) is very large and roughly ovoid in outline. Just within its antero-superior angle, and bordered anteriorly by the anti-trochanter and superiorly by the edge of the ilium, there is a pocket-like fossa, which internally is separated by a slight ridge from the mass of bone formed by the fusion of the processes of the true sacrals. The anterior edge of thei schiadic foramen is continued downward as a ridge crossing the shaft of the ischium and terminating below in a prominent process (styliform process), against the inner side of which the pubis was in close contact, thus enclosing an obturator foramen (*o.f.*) which forms a narrow oval opening extending from beneath the posterior half of the acetabulum as far back as the front of the ischiadic foramen.

Posteriorly the pelvis ends in the sharp hinder angle of the ischium, which is separated by a semicircular bay from the ilio-caudal process of the ilium.

Seen from below (Plate XVI. fig. 3) the narrowness of the pelvis is even more noticeable than in the dorsal view. There is practically no internal iliac fossa, the centra of the anterior "sacral" vertebræ being very large and projecting far below the edges of the ilia. The anterior renal fossæ are extremely narrow, and are scarcely visible from this point of view; they are separated by the processes of the two sacrals from the enormous posterior renal fossæ which, as in Rails and some other birds, are prolonged backward into long pocket-like extensions, floored by an ingrowth of the ilium. The only bird in which this ventral ingrowth of the ilium is developed to anything like the length seen in *Phororhacos* is *Fulica*, in which the broad transverse processes of three or four urosacral vertebræ unite with it, while in the fossil there are six or seven such vertebræ.

The Ilium. (Plate XVI., *il.*)

In its pre-acetabular region the dorsal border of the ilium is convex, the ventral concave, and in front the two are united by a nearly straight anterior border which is slightly inclined forward. The ilio-pectineal process is broken, but seems to have been small.

As already mentioned, the postacetabular region is considerably longer than the pre-acetabular, from which it is sharply separated by the supra-trochanteric crest. It is nearly equal in width throughout its length. Posteriorly it terminates in the prominent ilio-caudal process, the lower part of which, however, may be formed by the ischium: from the end of this process runs a ridge which seems to mark the junction of the two bones, and certainly is continuous in front with the suture between them. A second ridge, commencing at the hinder border of the bone close to its sacral border, runs forward and then downward to join that just described close to the ischiadic foramen.

The Ischium. (Plate XVI., *is.*)

The share which this bone takes in the formation of the acetabulum cannot be determined, owing to the complete fusion of the pelvic elements in that region. Beneath the ischiadic foramen it forms a bar of bone 15 mm. wide, which, near its proximal end, bears on its ventral edge a short, stout process which touches the pubis, thus enclosing an obturator foramen. Beneath the ischiadic foramen the ischium expands into a broad plate of bone, the outer surface of which is concave from above downward, and the inner traversed by a prominent rounded ridge marking the prolongation of the axis of the bone. The upper edge unites closely with the ilium, the lower curves downward and outward and terminates posteriorly in an angular process which projects slightly further back than the ilio-caudal process.

The Pubis. (Plate XVI. fig. 2, *pu.*)

The pubis is probably imperfectly preserved; all that now remains is a slender rod of bone arising beneath the middle point of the acetabulum, and running back and terminating against the inner side of the styliform process of the ischium, thus closing an obturator foramen as above mentioned. Whether when complete it extended further back in the usual way cannot be determined.

Comparison with the Pelvis of other Birds.

Comparison of this pelvis with that of the Ratitæ shows at once that *Phororhacos* certainly does not belong to that group, though it may have been, and probably was, "Ratite" in the strict sense of the term. It is true that in its length, narrowness, and the large development of the supra-trochanteric processes there is some similarity to the pelves of *Dromæus* and *Struthio*, a similarity which, no doubt, is merely the consequence of adaptive modification due to a like mode of progression. On the other hand, in essential points of structure, such as the form and relations of the ischia and pubes to each other and to the ilia, the structure of the "synsacrum," particularly in the distinctive form of the two true sacrals and in the form of the renal fossæ, the pelvis in the fossil is very different from that of any Struthious bird. In *Apteryx* alone the sacrum shows slight points of similarity.

Among the Carinate birds the pelves which show most resemblance in general outline to the fossil are those of the Grebes and *Hesperornis*; but in both of these the pre-acetabular portions of the ilia do not unite with the spines of the "sacrals" to form an ilio-neural crest, but remain separated from them by a considerable interval, while, on the other hand, the postacetabular portions approach one another very closely, and may even unite in the middle dorsal line; the exact reverse is the case in *Phororhacos* and most other birds.

To the pelves of the Cranes and Rails the similarity is in many ways remarkable, and probably indicates a real relationship with those birds. The form and character of the renal fossæ, particularly the peculiar pocket-like prolongations of the posterior fossæ, and the general structure of the "synsacrum," especially the distinctness of the true sacrals, are almost identical with those described in the fossil. One difference, however, must be pointed out, viz. that while in *Phororhacos* the postacetabular region is the longer, in nearly all the Gruiformes the reverse is the case. In *Fulica*, however, the post- and pre-acetabular regions are of nearly equal length, and in *Cariama* the postacetabular portion is the longer, as in *Phororhacos.*

The pelvis of *Cariama* is also similar in the form of its posterior border, the presence of prominent supra-trochanteric processes, and, so far as can be ascertained, in the relations of the pubes. It has, however, a well-developed pelvic escutcheon, the whole postacetabular region being relatively wider than in *Phororhacos.* On the whole, so far as the pelvis is concerned, I see no reason for changing the opinion expressed in a former paper [1], that *Cariama* is probably a not very remote modern representative of the extinct type.

From the Birds of Prey the chief points of difference are, that in them the post-acetabular region is very short and is deflected, and there is no ilio-caudal process to the ilium. In *Serpentarius*, however, the first two of these characters are much less marked, and in this respect, therefore, it approaches the fossil, these characters being probably merely correlated with the fact that it is a much better walker than the other Accipitrine birds.

In the Storks the pre-acetabular portions of the ilia meet at a very obtuse angle, the postacetabular region is very wide, and there are no recesses to the post-renal fossæ. In the Herons these fossæ, though present in some, are small, the ilio-neural canals are widely open behind, and the pelvic escutcheon is wide; certain Galliformes, e. g. *Phasianus* and *Francolinus*, in which renal pockets are present, differ from the fossil in much the same respect.

In the account of the skull some points of similarity with that of the Albatross were referred to, but in the pelvis no similarity whatever can be detected. Among the more notable differences may be mentioned the complete absence of pocket-like extensions of the renal fossæ, almost complete absence of supra-trochanteric processes, the backward prolongation of the ischia and their mode of union with the ilia, and the indistinctness of the true sacral vertebræ.

Ameghino, in his manuscript catalogue, distinctly states that this pelvis and other bones were found associated with the skull above described, and formed part of one individual; and if this is the case, as there is no reason to doubt, the structure of the pelvis seems completely to outweigh whatever evidence of relationship with the Albatrosses may be found in the skull.

The dimensions of the pelvis are:—

	cm.
Extreme length	41·5
Length of ilium	41·0
Longitudinal diameter of ischiadic foramen	6·8
Vertical diameter of ischiadic foramen	3·7
Length of obturator foramen	2·5
Greatest height from hæmal ridge of sacrum to top of iliac crest	10·5
Width at anti-trochanters	11·2
„ at supra-trochanteric crests	10·6
„ between upper edges of acetabula	4·5
„ (least) behind supra-trochanteric crests	6·3
„ (least) pre-acetabular region	3·5
„ centrum of first fused "sacral" vertebra	3·3
Length of "synsacrum"	36·5

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[1] 'The Ibis,' 1896, p. 1; see also 'Science Progress,' vol. v. (1896) p. 398.

Vertebræ.

Of the vertebræ, other than those forming the synsacrum, only three are preserved in this specimen. Of these one is the last free dorsal and the others anterior free caudals. The last dorsal has a short centrum, terminated by the usual saddle-shaped articular surfaces, of about equal height and breadth. The ventral portion of the anterior two-thirds of the centrum is pinched up to form a prominent hæmal ridge, the summit of which has been broken away. Laterally the anterior end of the centrum is widened out by stout parapophysial prominences, bearing each an oval cup for the head of the rib. The diapophysis is broken away: immediately beneath its base is a large pneumatic fossa, and another occurs on the side of the centrum. The zygapophyses are of the usual form; the neural spine is very massive, and has its anterior and posterior surfaces roughened for ligamentous union with the spine in front and behind it: its upper portion is broken away.

The caudal vertebræ (Plate XVII. fig. 7) have centra about as long as their anterior face is wide, slightly constricted in the middle, and bearing towards their hinder end a pair of strong, backwardly-directed transverse processes, only the bases of which remain. The anterior articular face is wider than high, the posterior about equal in the two directions; the anterior surface is slightly concave, the posterior convex, but with a median pit, which probably marks the primitive position of the notochord. The neural arch does not extend quite to the hinder end of the centrum, and the neural spine is greatly thickened at its upper end, which forms a flat bilobate surface, which was evidently connected with the vertebræ before and behind by tendons, probably more or less ossified.

The Femur. (Plate XVII. fig. 8.)

The head of the femur rises to a marked degree above the level of the trochanter, the upper portion of the elevation being formed by a large blunt-pointed process, which partly divides the deep pit for the *ligamentum teres* into two parts. Ventrally also the articular surface is divided by a shallow groove into an anterior and a posterior lobe, so that when looked at from the inner side the head appears to be imperfectly trilobate. The neck is much hollowed out on its ventral surface, and the head is clearly pedunculate. The articular surface of the trochanter is continuous with that of the head, at least posteriorly.

On the anterior, and particularly on the outer, face of the trochanter are a number of extremely distinct impressions of muscle-insertions. The shaft is as nearly as possible straight, there being only a slight forward convexity in its lower portion. In the middle it is cylindrical in section, but just above the condyles it is somewhat flattened from before backward. The postero-internal border is defined by an extremely conspicuous *linea aspera*, which, as Ameghino remarks, is a veritable projecting lamina of bone. It runs from end to end of the shaft, terminating below in the upper angle of the inner condyle. The anterior face of the shaft is likewise marked by an intermuscular ridge running obliquely downward and inward from the outer edge of the trochanter: in its lower third it forks, one branch running to the upper anterior angle of each of the condyles; in its upper portion this line no doubt separated the surfaces for the *cruræus* and the *vastus externus.*

There is a deep popliteal fossa, which is separated by a prominent bar of bone from the intercondylar fossa, which is marked by two deep pits for ligaments.

The outer condyle projects considerably below the inner; its fibular ridge is very prominent, and the surface for the fibula slightly concave from side to side. On the lower end of the outer condyle is a very distinct facet for the tendon of the outer head of the *tibialis anticus.* Anteriorly the condyles project considerably, and the rotular channel is comparatively deep.

Comparing the femur of *Diomedea* with the fossil, we find that it differs, among other points, in the shallowness and form of its popliteal fossa and in the great antero-lateral compression of the lower end of the shaft. The head, moreover, is much less distinctly pedunculate.

The femur of *Grus* differs in the somewhat more curved shaft, the elevation of the trochanter above the head, the somewhat shallower popliteal fossa, and the smaller degree of obliquity of the distal articulation.

In *Psophia* the trochanter is high and the popliteal fossa shallower than in the fossil. In *Cariama* the shaft is rather curved and the trochanter is somewhat raised above the head, which is very similar to that of the fossil: the distal end differs only in the somewhat greater shallowness of the popliteal fossa.

In the Rails the shaft of the femur is always much curved, and the trochanter rises considerably above the head.

In the Birds of Prey (including *Serpentarius*) the femur is pneumatic, the trochanter rises above the head, and the neck, as a rule, is very short.

The dimensions of the femur are:—

	mm.
Length	227
Width at proximal end	59
„ at distal end	62
„ of middle of shaft	25
Circumference of middle of shaft	81

The Tibio-tarsus. (Plate XVII. figs. 9 & 10.)

The tibio-tarsus is a comparatively long and slender bone. The shaft is somewhat flattened on its anterior and posterior surfaces, and tapers slightly towards its distal end. It is straight, but the median border near its distal end curves slightly inward, so that the inner condyle projects considerably inward; the outer condyle is in a line with the outer border of the shaft. The anterior surface is bordered internally by a strongly-marked *linea aspera*, which is continuous above with the procnemial crest, and towards the lower end forms the inner border of the very deep groove for the extensor tendons; it terminates at the inner end of the extensor bridge. This latter lies obliquely; near the upper border of its inner end there is a deep pit for the attachment of the oblique ligamentous sling through which the tendon of the *tibialis anticus* passes: the other end of the ligament is inserted lower down on a well-marked tubercle just above the outer condyle; the lower border of the bridge passes externally into a prominent tuberosity, such as occurs in the Storks, &c., and serves for the insertion of the ligament bridging the extensor tendons.

The condyles are about equal in size, and are separated by a deep intercondylar gorge which opens above into a median concavity lying in the middle line immediately below the last-mentioned tuberosity, and, when the leg is flexed, receiving the large intercondylar tuberosity of the metatarsus. Posteriorly the intercondylar groove is short and shallow, but is still sharply defined, being bounded by the prominent posterior projections of the condyles. Looked at from the side the outer condyle is nearly circular in outline, while the inner is much elongated from before backward; both are concave on their outer surfaces.

The upper end of the bone is relatively small, but the pro- and ectocnemial crests are fairly well developed and rise considerably above the proximal articular surface, which slopes upward and forward. The inner glenoid surface is flat or only slightly convex; posteriorly it forms a considerable projection and is separated by a notch from the outer or fibular surface, which is small and very convex in all directions.

There are no pneumatic foramina. The centre of the shaft is occupied by a large smooth-walled cavity, and the thickness of the bone in the middle of the shaft does not exceed 4 mm.

The tibio-tarsus of *Diomedea* differs from that of the fossil in the much greater breadth of the intercondylar fossa, the nearly transverse direction of the extensor bridge and the absence of a tuberosity at its outer end, and in possessing a much larger cnemial crest.

In *Grus* the tibia differs widely in the relatively greater width of the distal articulation, in which the condyles are small and the intercondylar groove broad; on the other hand, there is a median tuberosity.

In *Psophia* the extensor bridge is much more transverse, and the outer condyle considerably the larger, as in Rails.

In *Cariama* the condyles are relatively smaller and the intercondylar groove shallower and broader.

In *Ciconia* the tibia presents considerable resemblance to the fossil, but the articular surfaces for the femur are less distinctly separated, the extensor bridge is less oblique, and the groove for the tendons occupies the whole width of the shaft.

In the Accipitrine birds, including *Serpentarius*, the cnemial crests are very small, the groove for the extensor tendons nearly median, there is no distinct tuberosity at the outer side of the extensor bridge, and the condyles are comparatively small and separated by a broad intercondylar gorge; while, in correlation with the small size of the intercondylar tuberosity of the metacarpus, there is no depression at the upper end of the intercondylar groove, into which it fits when the bones are flexed one upon another.

The dimensions of the tibio-tarsus are:—

	cm.
Length, including cnemial crest	39·5
,, without cnemial crest	37·5
Width at distal end	4·3
Width of shaft at narrowest point, *i. e.* about 3 cm. above extensor bridge.	2·7
Circumference at same point	8·2
Width from front to back at same point	2·0

The Metatarsus. (Plate XVII. figs. 11–17.)

The glenoidal facets for articulation with the tibia are deeply concave; the outer (*o.*) is slightly below the inner, and has a bluntly pointed process on its outer border. There is a prominent rounded intercondylar process (*i.c.*), which on the outer side, at its base, bears a shallow pit for the insertion of the outer semicircular ligament. On the outer side of the bone, immediately below the anterior angle of the outer glenoid facet, is a rough surface for the insertion of the lateral tibio-tarsal ligament. Posteriorly the hypotarsus (*hy.*) forms a broad projecting mass, consisting of an outer broad ridge and a narrow inner one, separated by a shallow groove; the outer and inner surfaces of the hypotarsus are also slightly grooved, but there are no closed or nearly closed channels for tendons. The whole hypotarsus is short, and the two ridges constituting it converge below into a simple median ridge, which soon dies away on the hinder surface of the shaft. In the slight depressions on either side of the hypotarsus are the posterior openings of the interosseous foramina, the inner being slightly higher up than the outer.

The anterior face of the shaft is deeply concave in its upper part, so that the interosseous foramina open anteriorly at the bottom of a deep fossa, the outer a little above the inner. Immediately below these foramina is a pair of oval rugosities, the outer slightly above the inner, for the insertion of the *tibialis anticus.* Internal to these is a deep groove, over which the inner border of the bone forms an overhanging lip; this groove is for the tendon of the *extensor communis digitorum.*

The concavity of the upper portion of the anterior face is continued as a broad channel extending down about the upper half of the shaft; but there is no specimen in which this region is complete, so that the exact length of the bone is unknown.

The posterior surface is occupied at its upper end by a ridge forming a prolongation of the hypotarsus. Lower down the shaft it is narrowed and flattened, its outer border being formed by a prominent ridge, which is continued upward and outward, and terminates above in the process which forms the outer border of the external glenoid fossa; its inner border is formed by a less prominent ridge, which is not, as in *Cariama*, continuous above with the inner ridge of the hypotarsus.

The outer face of the shaft is bordered by the ridges which form the outer edges of the anterior and posterior faces. This surface widens out towards the middle of the bone, and is flat or even slightly concave. The outer surface is slightly convex, and is not very sharply marked off from the posterior surface.

As above mentioned, the shaft is incomplete in both the metatarsi of the type-skeleton, but the distal portion (three or four inches) of the right metatarsus is very well preserved. The upper portion of the shaft preserved in this specimen is very slender and roughly triangular in section, one angle of the triangle being a rugose ridge on the posterior surface. A short distance above the inner trochlea, and at the lower end of the ridge just mentioned, is the surface for the attachment of the hallux (*hal.*). Below this the posterior surface is slightly concave from side to side. The anterior surface has near its outer side a shallow groove deepening distally and having at its lower end the foramen for the tendon of the *adductor digiti externi*. This foramen leads into two channels, one opening between the outer and middle trochlea, the other on the posterior surface of the bone immediately above the trochleæ.

The distal trochleæ are arranged in a slightly curved line (fig. 17). The median trochlea (*tr.* 3) is very large and its articular surface is sharply delimited, both anteriorly and posteriorly; the median groove is much deeper behind than in front. The inner trochlea (*tr.* 2) is relatively small, and is considerably shorter than the middle one. Its articular surface is evenly convex from side to side, except on its posterior side, where it is slightly grooved. It is situated a little posterior to the middle trochlea, behind which it projects considerably. The outer trochlea (*tr.* 4) is rather larger than the inner and is slightly longer; it also projects considerably behind the median, and its articular surface is grooved posteriorly only. The lateral surfaces of all the trochleæ are deeply excavated by pits for the insertion of the ligaments of the toes.

In comparing the metatarsus of *Phororhacos* with that of other birds, it must be remembered that it has probably been profoundly modified in correlation with the loss of the power of flight and the consequently exclusively pedestrian progression of the bird. Among the peculiarities which may probably be thus accounted for are the simple hypotarsus, the relatively great length of the bone, and the disposition of the distal trochleæ.

The metatarsus of *Diomedea* differs in several respects, the chief of which are complete absence of all trace of a hind toe, relatively large size of the articular ends compared with the shaft, breadth and complication of the hypotarsus, and absence of a pit for ligament at the outer side of the base of the intercondylar tuberosity.

In *Grus* the metatarsus differs in the complication of the hypotarsus and the position of the inner (2nd) trochlea, which is high up and much deflected backward.

In *Psophia* there is a close canal in the hypotarsus, otherwise the bone is much like the fossil.

In *Cariama* the metatarsus in most respects closely resembles that of *Phororhacos*, but it is proportionately more slender, and at its distal end the lateral trochleæ (particularly the inner 2nd) are less reduced. The metatarsus of *Ciconia* is similar in many points, but at the proximal end the hypotarsus is longer, its crests much more prominent, and it is situated further below the glenoid surfaces than is the case in *Phororhacos*. At the distal end the chief difference is that the lateral trochleæ are larger in proportion to the median one.

In most Accipitrine birds the metatarsus is widely different, both in the form of the hypotarsus and the deep excavation of the hinder surface of the shaft for the various muscles of the toes and the arrangement of the trochleæ. *Serpentarius*, however, has undergone such modification in correlation with its terrestrial habits that it approaches *Phororhacos* very much more closely than do the rest of the group: this is chiefly the result of the elongation of the shaft and the alterations in the form of the talon and in the arrangement of the trochleæ. Nevertheless, there are several points, such as the almost complete absence of an intercondylar tuberosity, in which it differs widely from the fossil.

The dimensions of the metatarsus are:—

	mm.
Width at proximal end	47
,, at distal end	44
,, of middle trochlea	19

Only one of the phalanges of the hind foot belonging to the skeleton above described is preserved, but there is a nearly complete left pes of another individual of the same species. In this it is seen that the hallux was well developed and terminated in a strong hooked claw: the metatarsal articulates with the tarso-metatarsus by a simple knob, and terminates distally in a trochlear surface with a deep pit for ligament on its outer side. The total length of this toe is about 53 mm. In the second digit there are, as usual, three phalanges, the terminal (3rd) one being sharp-pointed and slightly hooked; the remaining two, though shorter than the phalanges of the middle digit, are nearly as stout. The lengths of the phalanges are: 1st, 31 mm.; 2nd, 32 mm.; 3rd (ungual), 36 mm.; the total length of the toe is about 93 mm. The middle toe consists of four phalanges, the first of which is nearly as long as the two proximal phalanges of the second digit together; both it and the two succeeding digits are somewhat compressed from above downward. The ungual phalangeal is a powerful hooked claw. The lengths of the phalanges are: 1st, 55 mm.; 2nd, 38 mm.; 3rd, 27 mm.; 4th (ungual), 44 mm.

Of the inner toe only the ungual and one of the other phalanges is preserved; the length of the former is about 27 mm.

Concluding Remarks.

In the preceding pages only a few of the types to which the fossils have been compared are mentioned, they being the only types to which any resemblances pointing to possible affinities could be made out. And even among these there are some to which the similarity is so slight that they also might perhaps have been omitted. For instance, in the case of *Diomedea*, it is only in the structure of the palate and one or two other points in the skull that any similarity with *Phororhacos* can be detected, the rest of the skeleton being strongly against any such relationship. In fact, it seems to the writer that the only groups that really come into question are the Falconiformes and aberrant Gruiformes, *Cariama*, *Chunga*, and to a less degree *Psophia*.

It is to a relationship with the former group that the general appearance of the skull and feet of *Phororhacos* seems to point; but, as above shown, the general structure of the skeleton, particularly of the pelvis and hind limb, is opposed to this, while, on the other hand, it is strongly in favour of affinity with the Gruiformes. In this, however, the skull at first sight seems to oppose a number of serious difficulties, differing widely from the skull of the typical Crane both in general appearance and in many points of structure, *e. g.* in its holorhinal nares and desmognathous palate; but it is precisely in these points that the Cariamidæ also differ from the typical members of the group and therefore resemble the fossil. Still the differences between the skull of *Phororhacos* and that of *Cariama* are so great that some explanation of them is necessary if the close affinity of the two forms is to be maintained. This explanation seems to be found in the extraordinary size of the beak in the fossil, a specialization that has led to great modifications in several regions of the skull. Thus the size and weight of the upper jaw have led to changes in the palate in the direction of greater rigidity, resulting in the extensive union in the middle line of the maxillo-palatine plates and their complete fusion with the anterior ends of the palatines (this occurs also in Toucans and Hornbills). Moreover, the development of the peculiar prominent ridges formed by these combined elements, and, as already described, projecting below the tomium on either side the middle line, also tends greatly to increase the rigidity of the beak, and possibly the modes of union of the pterygoids with the *basis cranii* may still further add to it.

Again, with the great massiveness of the mandible is correlated the large size of the temporal fossæ, and the weight of the skull as a whole has led to an increase in the area of the occipital surface by the extension of the lambdoidal and paroccipital crests, to which the muscles supporting the head are attached. The characters thus accounted for give the skull of *Phororhacos* its peculiar form, so different from that of *Cariama,* and would be evidence of a high degree of specialization even if the rest of the skeleton were unknown.

It was no doubt this high degree of specialization that brought about the extinction of this giant bird as soon as the conditions to which it was adapted underwent some change, while the smaller more generalized *Cariama* and *Chunga*, or rather their ancestors, survived. In fact, it appears that *Phororhacos* stands in somewhat the same relation to the Cariamidæ that such forms as *Glyptodon* and *Panochthus* stand to the modern Armadillos.

All the specimens described are from the Santa Cruz Beds of Monte Observacion, Patagonia. The age of these deposits is doubtful, but they probably correspond to some part of the Miocene of the Northern Hemisphere.

EXPLANATION OF THE PLATES.

PLATE XIV.

Skull and mandible of *Phororhacos inflatus* Amegh., p. 56. From side. $\frac{2}{3}$ nat. size.

PLATE XV.

Skull of *Phororhacos inflatus* Amegh., p. 56.

Fig. 1. From below. $\frac{2}{3}$ nat. size. Fig. 2. From above. $\frac{2}{3}$ nat. size.

b.pt.	Process of pterygoid articulating with base of the skull, p. 57.
b.t.	Basitemporal platform, p. 57.
eth.	Ethmoid (?), p. 60.
i.f.	Facet for inner head of quadrate, p. 58.
i.o.s.	Interorbital septum, p. 59.
lac.	Lacrymal, p. 58.
l.r.	Lambdoidal ridge, p. 58.
m.t.	Mammillary tuberosities, p. 57.
max.pal.	Maxillo-palatine plates, p. 62.
n.	Nasals, p. 59.
oc.c.	Occipital condyle, p. 57.
o.f.	Facet for outer head of quadrate, p. 58.
o.q.	Orbital process of quadrate, p. 63.
pal.	Palatine, p. 62.
pc.f.	Precondylar fossa, p. 57.
p.mx.	Premaxilla, p. 61.
p.orb.p.	Postorbital process, p. 58.
pt.	Pterygoid, p. 62.
q.	Quadrate, p. 62.
q.j.	Quadrato-jugal, p. 60.
r.	Rostrum, p. 57.
sq.	Squamosal, p. 58.
sup.o.	Supra-orbital plate, p. 59.
ty.	Tympanic cavity, p. 57.
zy.	Zygomatic process, p. 58.

PLATE XVI.

Pelvis of *Phororhacos inflatus* Amegh., p. 72. $\frac{1}{2}$ nat. size.

Fig. 1. From above. Fig. 2. From side. Fig. 3. From below.

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a.t.	Ante-trochanter, p. 73.
il.	Ilium, p. 75.
is.	Ischium, p. 75.
is.f.	Ischiadic foramen, p. 74.
o.f.	Obturator foramen, p. 74.
p.	Pubis, p. 76.
s.	Sacral vertebræ, p. 72.
u.s.	Urosacral vertebræ, p. 73.

PLATE XVII.

Limb-bones of *Phororhacos inflatus* Amegh. $\frac{2}{3}$ nat. size.

Fig. 1. Right coracoid, anterior surface, p. 68.
Fig. 2. Right scapula, inner surface, p. 69.
Fig. 3. Distal end of left humerus, p. 70.
Fig. 4. Right ulna, olecranon restored from left side, p. 70.
Fig. 5. Right radius, proximal end, p. 70.
Fig. 6. Right metacarpus, palmar surface, p. 70.
Fig. 7. Caudal vertebra, p. 78.
Fig. 8. Left femur, p. 78.
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Fig. 10. ,, ,, distal end, p. 80.
Fig. 11. Left tarso-metatarsus, postero-internal view of proximal end, p. 81.
Fig. 12. ,, ,, antero-external view of proximal end, p. 81.
Fig. 13. ,, ,, anterior view of proximal end, p. 81.
Fig. 14. Right tarso-metatarsus, posterior view of distal end, p. 82.
Fig. 15. ,, ,, anterior view of distal end, p. 82.
Fig. 16. ,, ,, upper articular surface, p. 81.
Fig. 17. ,, ,, lower articular surface, p. 82.

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b.a.	Impression of *brachialis anticus*, p. 70.
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i.c.	Intercondylar tuberosity, p. 81.
in.c.	Inner condyle of tibia, p. 80.
hal.	Surface for hallux, p. 82.
hyp.	Hypotarsus, p. 81.
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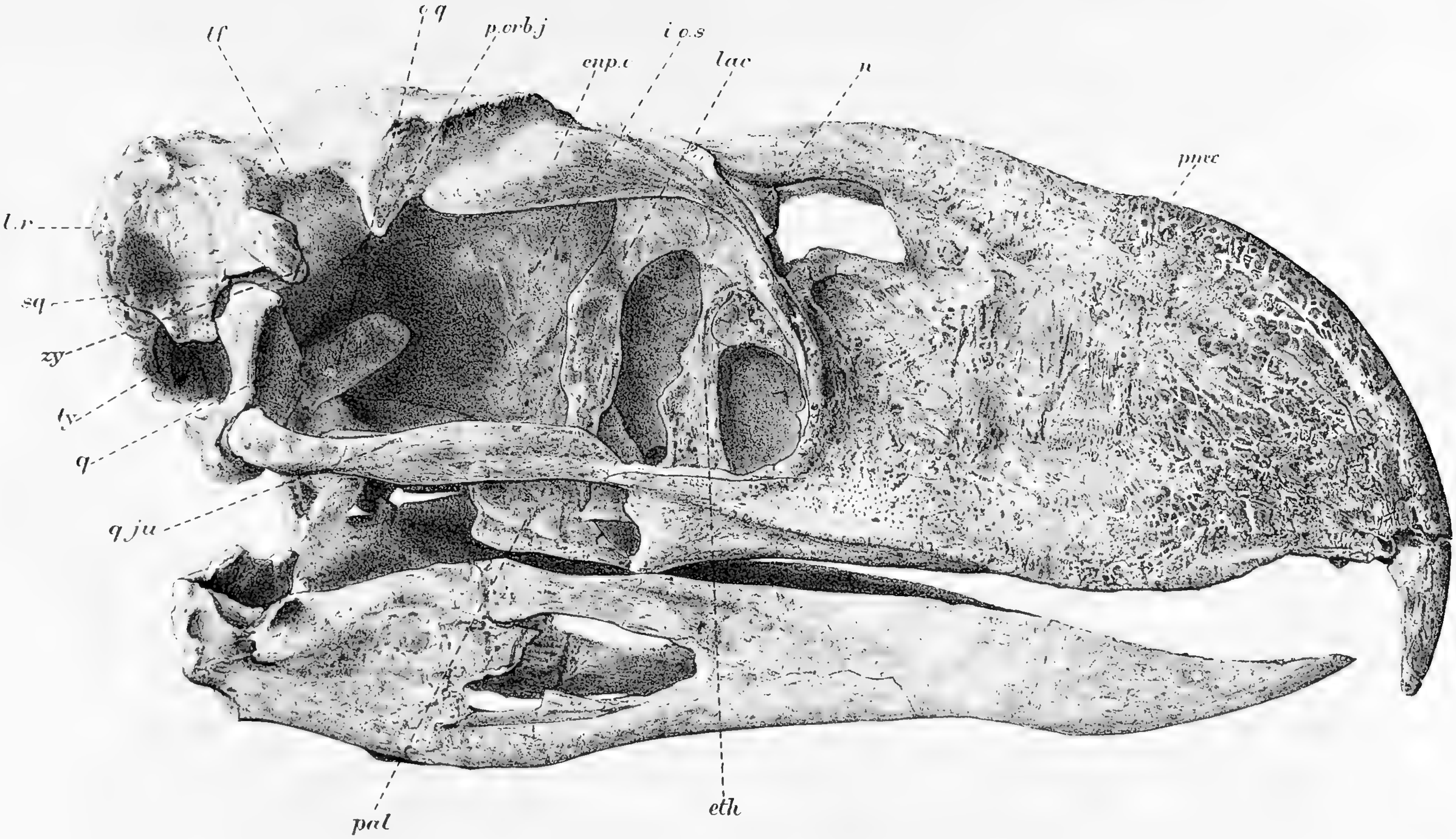
o.	Outer articular surface at proximal end of metatarsus, p. 81.
o.c.	Outer condyle of tibia, p. 80.
ol.	Olecranon process of ulna, p. 70.
p.l.	*Processus lateralis* of coracoid, p. 68.
r.	Radial condyle of humerus, p. 70.
t.	Tuberosity at base of the third metacarpal, p. 71.
*tr.*2, *tr.*3, *tr.*4.	Trochleæ of 2nd, 3rd, and 4th metatarsals, p. 82.
u.	Ulnar condyle of humerus, p. 70.



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PHORORHACOS INFLATUS

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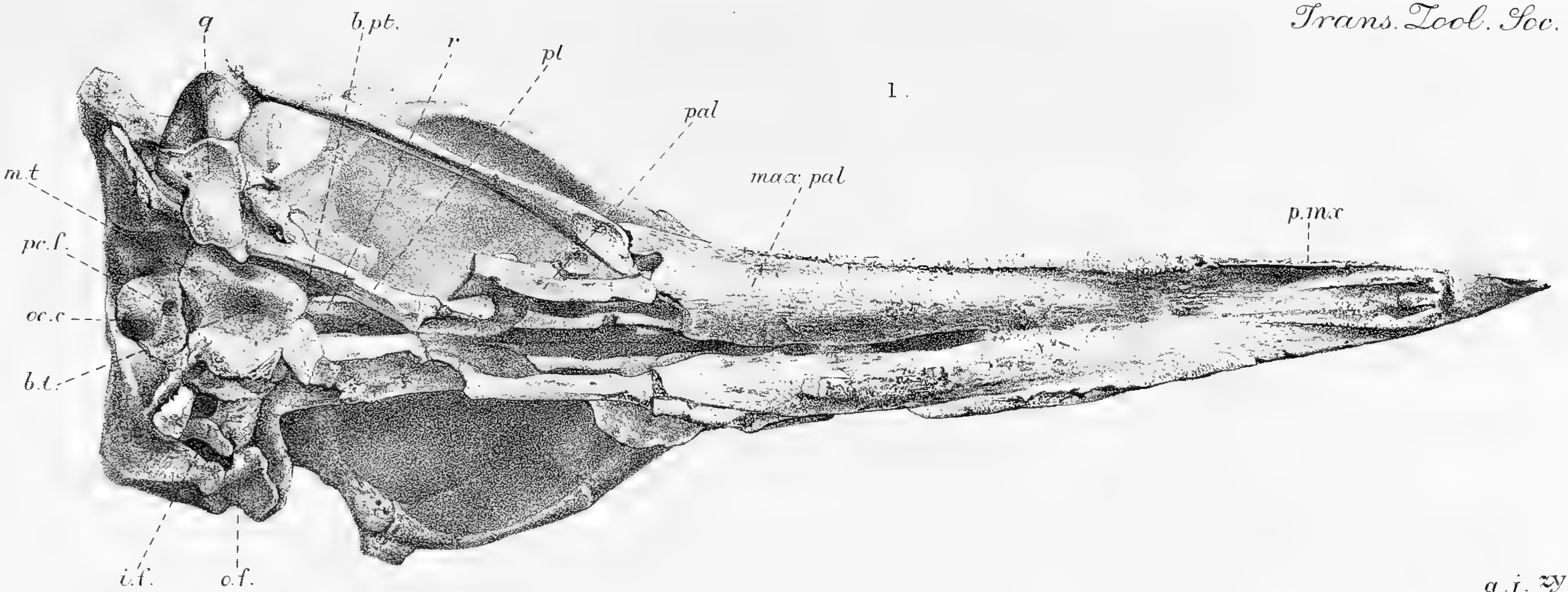

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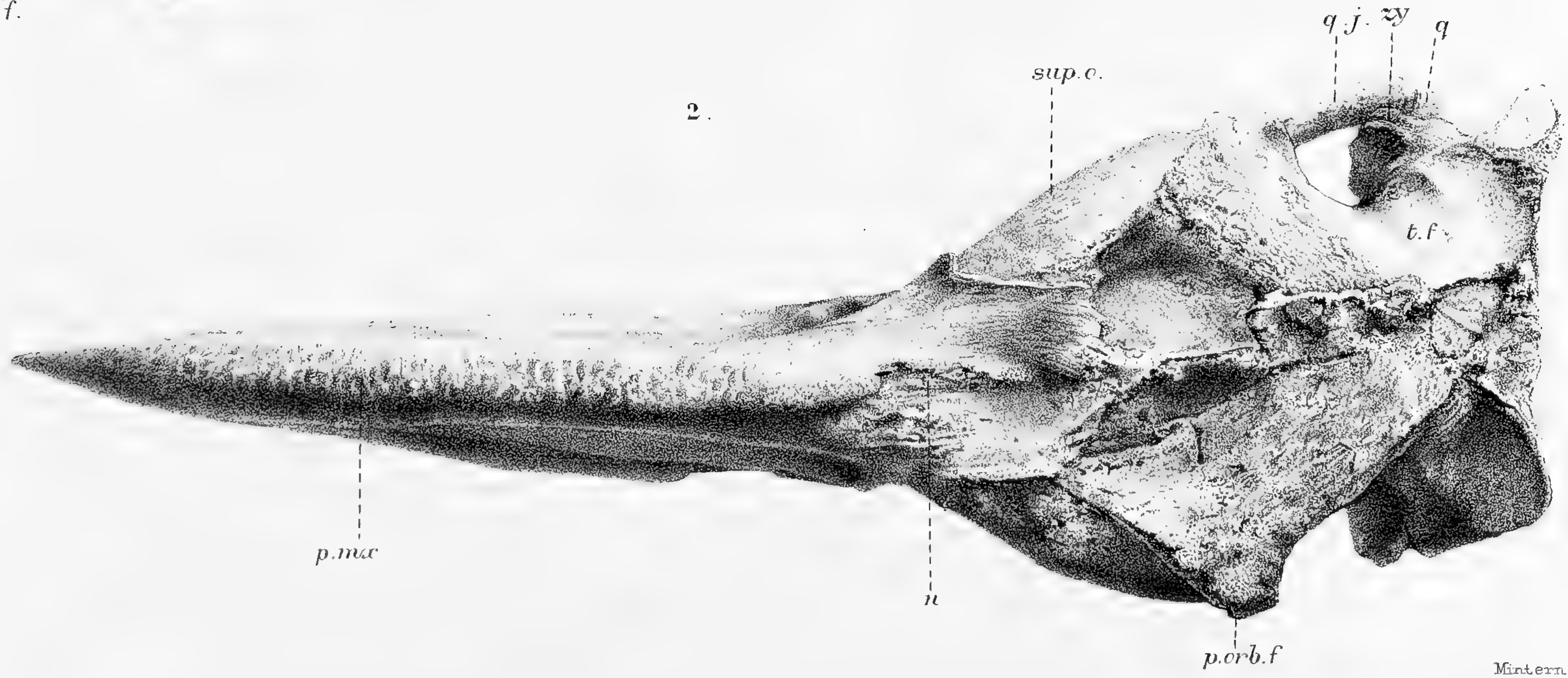

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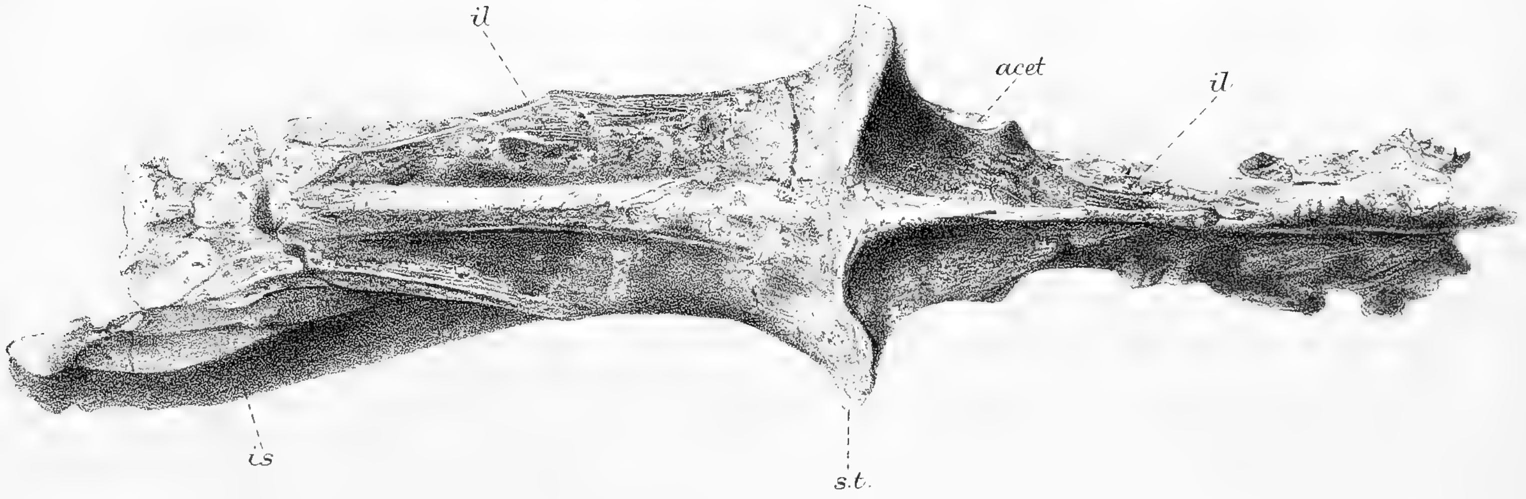

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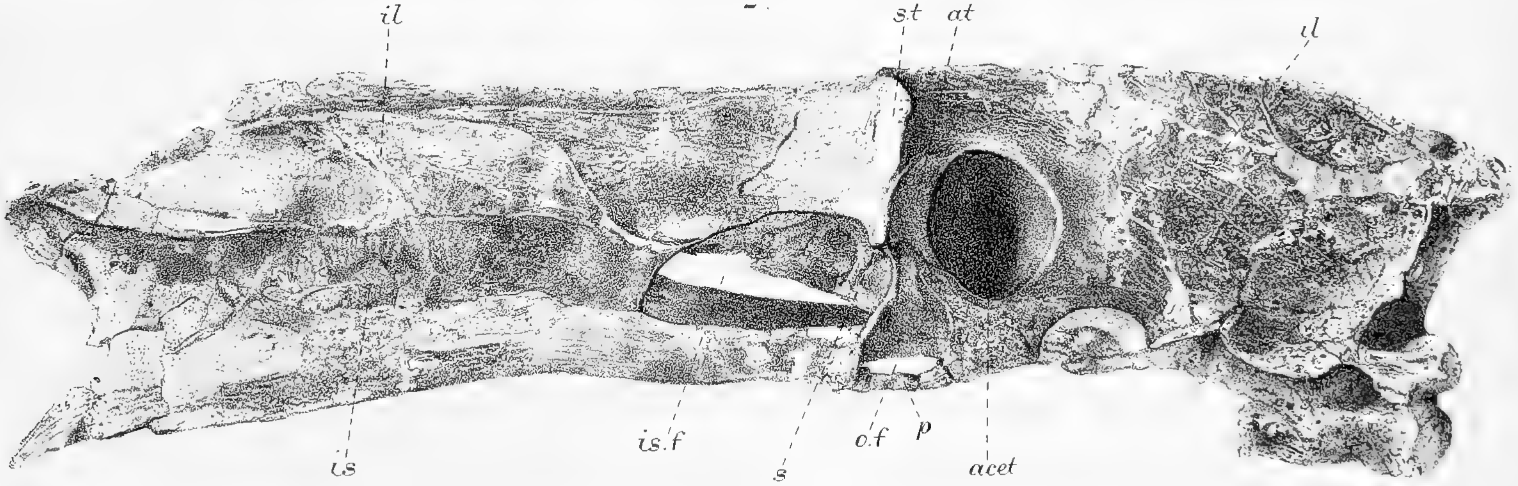

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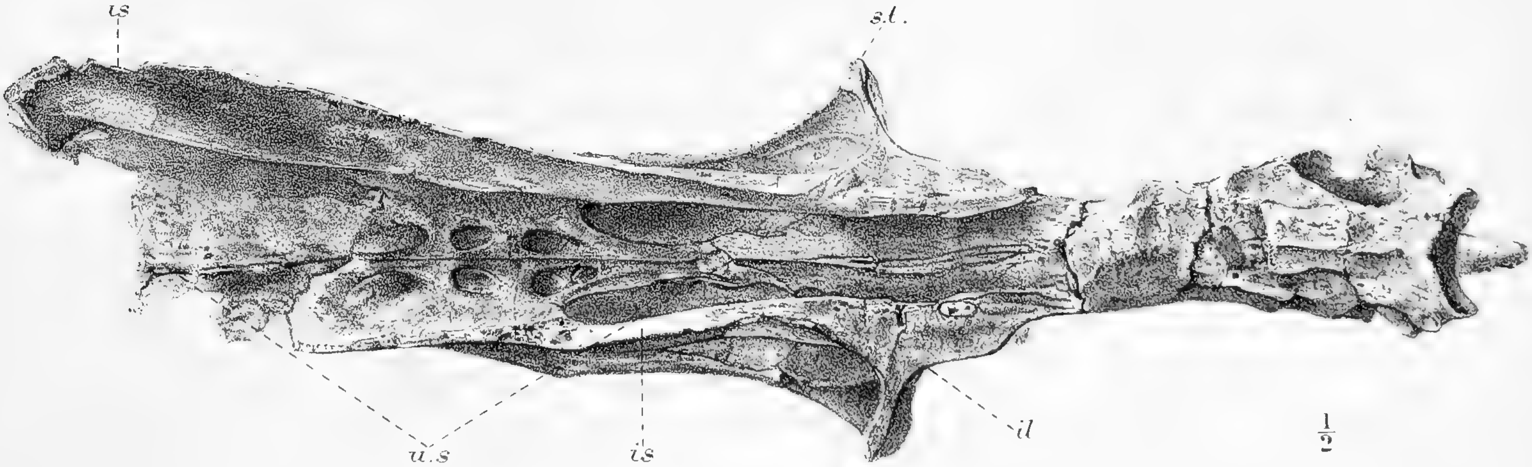

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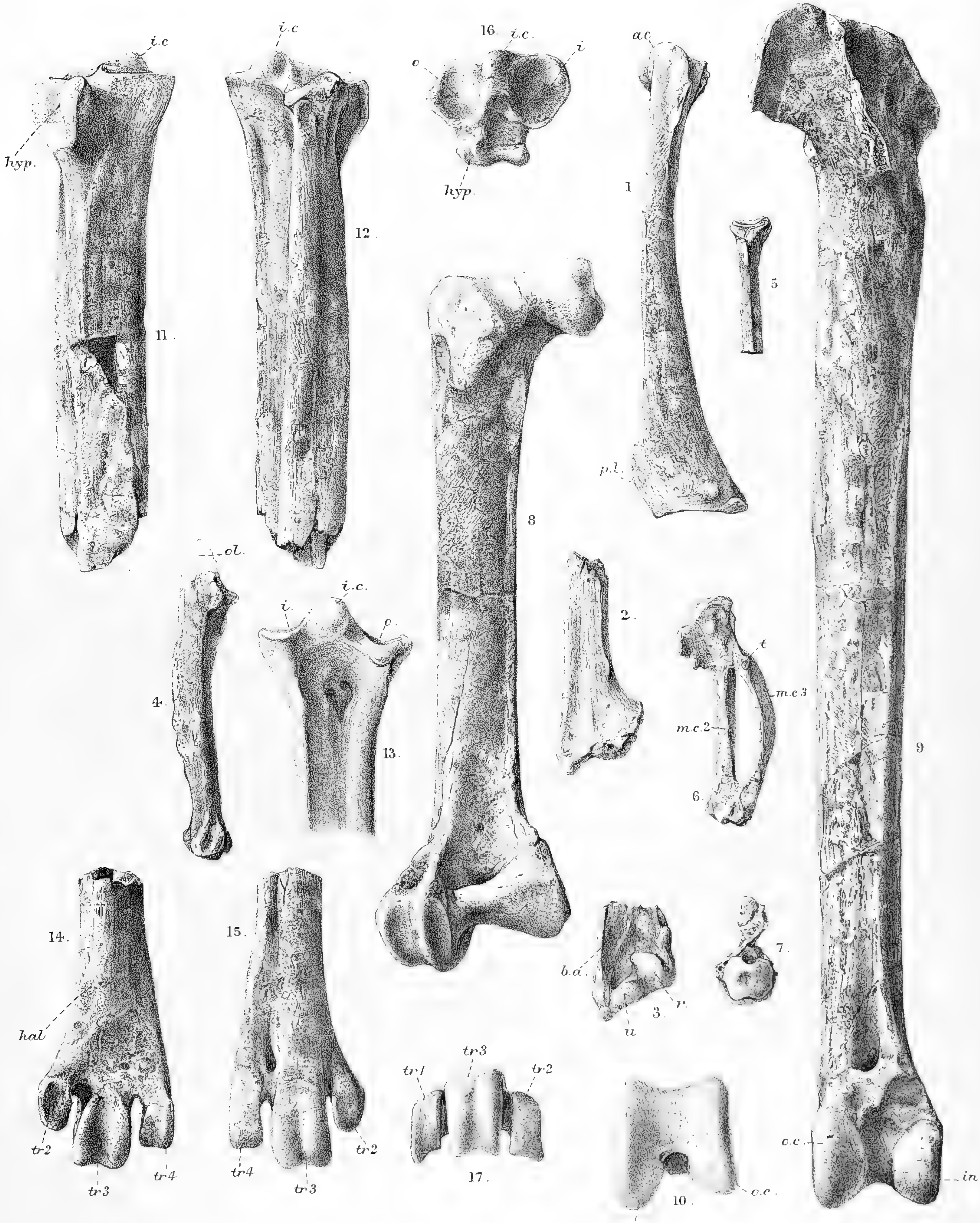

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October 1899.

P. L. SCLATER,
Secretary.

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Continued on page 3 of Wrapper.

IV. *Second Contribution to the Ichthyology of Lake Tanganyika.—On the Fishes obtained by the Congo Free State Expedition under Lieut. Lemaire in* 1898. *By* G. A. Boulenger, *F.R.S.*, *F.Z.S.*

Received May 13, read May 16, 1899.

[Plates XVIII.–XX.]

THE extraordinary richness of Lake Tanganyika in Perciform fishes of the family *Cichlidæ*, first revealed by Mr. Moore's collection, reported upon in these Transactions, vol. xv. 1898, pp. 1–30, pls. i.–viii., is further shown by the collection made in July–August 1898 by the Lemaire Expedition at Moliro, at the southern extremity of the Lake, already explored by Mr. Moore. Although consisting of no more than 34 specimens, the collection entrusted to me for description by the Government of the Congo Free State contains the types of ten new species, three of which warrant the establishment of new genera. These new genera are of further interest in emphasizing a feature of the Tanganyika *Cichlidæ* to which I have drawn special attention in my previous contribution, p. 2, viz. the extent of the lateral lines in many of the forms discovered by Mr. Moore. The knowledge of forms with three lateral lines, a condition previously unrepresented in the *Cichlidæ*, adds force to the remarks I have made with regard to the morphological significance of the so-called "interrupted lateral line."

The Lemaire collection is further valuable for the care with which coloured sketches of most of the fishes have been taken on the spot by M. Dardenne, the excellent artist attached to the expedition. These sketches have enabled me to represent some of the more strikingly coloured forms in chromolithography.

In addition to the definitions of the new species, I am able to draw up descriptions of the two species of *Ectodus* of which very incomplete definitions were given in the previous contribution, owing to the bad condition of the type-specimens. I have also added notes on the known species of which specimens are contained in the Lemaire collection, or of which coloured drawings, accompanied by an indication of the native names, have been supplied by M. Dardenne.

SERRANIDÆ.

1. LATES MICROLEPIS Blgr.

Originally described from young specimens, 155 millim. long. The adult, measuring 800 millim. and weighing 14 lbs., has, as could be expected, very different proportions and is of a uniform dark silvery colour. The eye is contained 9 times in the length of the head, which is $\frac{1}{3}$ of the total; longest dorsal spine $\frac{1}{2}$ length of head. Caudal peduncle and caudal fin as in the young.

Native name: "Sangala."

CICHLIDÆ.

2. LAMPROLOGUS LEMAIRII, sp. n. (Plate XVIII. fig. 1.)

A few moderately large curved canine teeth in front of each jaw, followed by a narrow band of minute teeth; lateral teeth very small. Depth of body $3\frac{1}{2}$ times in total length, length of head $2\frac{3}{4}$. Snout slightly longer than the diameter of the eye, which is $3\frac{1}{3}$ times in length of head and nearly double interorbital width; maxillary extending to slightly beyond vertical of anterior border of eye; cheeks and occiput naked; a few small deciduous scales on the opercles. Gill-rakers short, 9 on lower part of anterior arch. Dorsal XIX 7; spines equal from the fifth, which measures a little more than $\frac{1}{3}$ length of head and $\frac{3}{4}$ longest soft rays. Pectoral $\frac{3}{5}$ length of head. Ventral reaching origin of anal. Anal VIII 5; spines increasing in length to the last, which slightly exceeds longest dorsals. Caudal rounded. Caudal peduncle a little longer than deep. Scales 48 $\frac{10-11}{16}$; lat. l. $\frac{30}{17}$. Pale brown, most of the scales dark-edged; a blackish oblique bar from below the anterior third of the eye to the maxillary; a large blackish opercular spot; three oblique blackish bands, descending forwards, on each side of the back, extending on the base of the dorsal; dorsal and anal tipped with blackish.

Total length 107 millim.

A single specimen.

This species takes its place in the series between *L. moorii* and *L. congoensis*.

3. TELMATOCHROMIS TEMPORALIS Blgr.

Native name: "Muchétila."

4. PARATILAPIA DEWINDTI, sp. n. (Plate XVIII. fig. 2.)

Teeth very small, in 3 or 4 series in both jaws, the outer scarcely larger and not tipped with brown. Depth of body equal to length of head, nearly 3 times in total length. Snout with curved upper profile, shorter than the eye, the diameter of which is $2\frac{2}{3}$ to $2\frac{3}{4}$ in length of head and exceeds interorbital width; maxillary extending to below anterior fourth of eye; 2 or 3 series of scales on the cheek; large scales on the opercle. Gill-rakers rather long, lanceolate, 17 or 18 on lower part of anterior arch. Dorsal XII–XIII 12–13; spines increasing in length to the eighth or ninth, which measures $\frac{2}{5}$ or $\frac{1}{2}$ length of head and $\frac{3}{4}$ longest soft rays. Pectoral a little shorter than head, extending as far as origin of anal. Ventral produced into a long filament, extending beyond origin of anal. Anal III 9; third spine longest, $\frac{2}{5}$ length of head; middle soft rays produced, as long as or a little shorter than head. Caudal deeply emarginate, crescentic. Caudal peduncle $1\frac{1}{3}$ as long as deep. Scales finely denticulate on the edge, $37–38\,\frac{4}{13}$; lat. l. $\frac{29–30}{14–15}$; upper lateral line not reaching base of caudal. Grey above, white beneath; four yellowish stripes along each side; pectorals yellowish; other fins dark grey or blackish.

Total length 100 millim.

Three specimens.—Native name: "Likuko."

This species is named in memory of the distinguished young geologist, Dr. De Windt, attached to Lieut. Lemaire's expedition, who was accidentally drowned in Lake Tanganyika. It is very closely allied to *P. ventralis* Blgr., from which it differs in the dentition and in the shorter pectoral fin.

5. BATHYBATES FEROX Blgr.

Native name: "Musupa."

TREMATOCARA, g. n.

Closely allied to *Paratilapia*, but with the teeth very minute, in a narrow band in both jaws, the maxillary entirely concealed under the præorbital when the mouth is closed, the muciferous cavities of the top and sides of the skull and of the mandible extremely large, as in *Acerina*, and with a single, incomplete, lateral line.

6. TREMATOCARA MARGINATUM, sp. n. (Plate XIX. fig. 1.)

Depth of body $3\frac{1}{2}$ times in total length, length of head $2\frac{2}{3}$ to 3. Snout with curved upper profile, shorter than the eye, which is $2\frac{1}{2}$ in length of head and exceeds interocular width; mouth extending to below anterior border of eye; cheek naked; a few deciduous scales on the opercle; nasal, frontal, præ- and suborbital, præopercular, and mandibular bones with very large and deep cavities separated by narrow septa and covered with a thin skin. Gill-rakers short, 10 on lower part of anterior arch. Dorsal X 11; spines $\frac{2}{5}$ length of head, a little shorter than longest soft rays. Pectoral acutely pointed, as long as head. Ventral reaching origin of anal. Anal III 10; third spine nearly as long as dorsals. Caudal with deep crescentic notch. Caudal peduncle $1\frac{1}{2}$ as long as deep. Scales cycloid, $30\frac{3}{8}$; lateral line reduced to a few (6 or 7) short tubes in the upper series. Pale brownish above, white beneath; a bluish lateral stripe; fins yellowish, dorsal and anal edged with blackish.

Total length 63 millim.

Two specimens.—Native name: "Lilowé."

GRAMMATOTRIA, g. n.

Body elongate; scales ctenoid; three incomplete lateral lines. Jaws narrow, with a band of minute conical teeth and an outer series of rather longer ones; maxillary concealed under the præorbital when the mouth is closed. A large papillose pad on each side of the pharynx, between the gills. Dorsal with 15 spines, anal with 3.

7. GRAMMATOTRIA LEMAIRII, sp. n. (Plate XVIII. fig. 3.)

Depth of body 4 times in total length, length of head 3. Snout with slightly convex upper profile, $1\frac{1}{2}$ diameter of eye, which is $3\frac{2}{3}$ in length of head and equals interocular width; maxillary extending to between nostril and eye; 3 series of scales on the cheek; opercle covered with scales. Gill-rakers short, 12 on lower part of anterior arch. Dorsal XV 14; spines slender, equal from the fifth, which measures nearly $\frac{1}{3}$ length of head; soft rays not longer than the spines. Pectoral acutely pointed, nearly as long as head, extending as far as origin of anal. Ventral reaching vent. Anal III 10; third spine a little stronger and shorter than longest dorsals. Caudal with deep crescentic notch. Caudal peduncle $2\frac{1}{3}$ as long as deep. Scales $55\,\frac{6\text{–}7}{13}$; lat. l. $\frac{48\text{-}52}{\frac{26}{13\text{–}15}}$. Pale brown above, yellowish beneath; a small dark brown opercular spot; a round brown spot on caudal peduncle at root of caudal fin; dorsal fin greyish, the soft portion with round white spots; other fins yellowish.

Total length 175 millim.

A single specimen.—Native name: "Murungi."

8. ECTODUS[1] DESCAMPSI Blgr. (Plate XIX. fig. 2.)

Depth of body $3\frac{1}{2}$ times in total length, length of head 3. Snout short, with curved

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[1] To the generic characters as given in the original description must be added the presence of a large dermal pad in front of the upper part of the gill-arches, same as in *Pelmatochromis* and *Chromidotilapia*.

upper profile, slightly shorter than the eye, the diameter of which is $2\frac{4}{5}$ in length of head and equals $1\frac{1}{2}$ interorbital width; maxillary extending to between nostril and eye; two series of scales on the cheek; opercle naked. Gill-rakers short, 11 on lower part of anterior arch. Dorsal XIII 13; spines slender, increasing in length to the last, which is about $\frac{2}{5}$ length of head and little shorter than the soft rays. Anal III 8; third spine slightly shorter than longest dorsals. Pectoral obtusely pointed, $\frac{2}{3}$ length of head. Ventral reaching vent. Caudal emarginate. Caudal peduncle $1\frac{1}{2}$ a slong as deep. Scales 35 $\frac{3}{11}$; at l. $\frac{27}{14}$. Pale brown above, yellowish beneath; fins yellow; a round blackish spot on the hinder part of the spinous dorsal.

Total length 60 millim.

A single specimen.

9. Ectodus melanogenys Blgr. (Plate XIX. fig. 3.)

Depth of body 5 to $5\frac{1}{4}$ times in total length, length of head $3\frac{1}{2}$. Snout long, with nearly straight upper profile, $1\frac{2}{3}$ diameter of eye, which is 4 times in length of head and equals or slightly exceeds interorbital width; maxillary extending to between nostril and eye; 3 series of scales on the cheek; deciduous scales on the opercle. Gill-rakers short, 12–13 on lower part of anterior arch. Dorsal XIII–XIV 17; spines slender, increasing in length to the last, which is about $\frac{2}{5}$ length of head; last soft rays produced, at least half length of head. Anal III 13; third spine $\frac{1}{3}$ length of head. Pectoral pointed, a little shorter than head. Ventral reaching origin of anal. Caudal deeply emarginate. Caudal peduncle twice as long as deep. Scales 43–44 $\frac{3\text{–}4}{10}$; lat. l. $\frac{30\text{–}31}{14\text{–}16}$. Grey above, white below; dorsal scales with a pale blue central spot; a blackish opercular spot; chin and branchiostegal membrane blackish; dorsal grey, with whitish streaks and spots, and a large oval blackish spot in the middle of the spinous portion; anal grey, streaked with whitish; pectoral and caudal yellowish, the latter with crescentic dark bands; ventral blackish at the end.

Total length 110 millim.

Two specimens.—Native name: "Losorella."

10. Ectodus longianalis, sp. n. (Plate XIX. fig. 4.)

Depth of body 5 times in total length, length of head 3. Snout long, with slightly convex upper profile, $1\frac{1}{2}$ diameter of eye, which is $3\frac{1}{2}$ times in length of head and nearly $1\frac{1}{2}$ interorbital width; maxillary extending to between nostril and eye; 3 series of scales on the cheek; deciduous scales on the opercle. Gill-rakers short, 12 on lower part of anterior arch. Dorsal XV 15; spines slender, increasing in length to the last, which is $\frac{1}{3}$ length of head; soft rays slightly longer, the last not produced. Anal III 17; third spine $\frac{1}{4}$ length of head. Pectoral pointed, $\frac{4}{5}$ length of head. Ventral nearly reaching origin of anal. Caudal deeply emarginate. Caudal peduncle twice as long as deep. Scales $44\frac{3}{9}$; lat. l. $\frac{31}{17\text{–}18}$. Brownish above, whitish beneath; a blackish opercular spot; a lateral series of rather indistinct dark spots; dorsal greyish; other fins yellow.

Total length 97 millim.

A single specimen, with the mouth and pharynx full of advanced embryos.

The characters of the 3 species of *Ectodus* may be contrasted as follows:—

E. descampsi. D. XIII–XIV 13–14. A. III 8. Sq. 34–35 $\frac{3}{10\text{–}11}$; lat. l. $\frac{27\text{–}28}{14\text{–}15}$. Depth of body $3\frac{1}{2}$–$3\frac{4}{5}$ in total length. Snout slightly shorter than eye.

E. melanogenys. D. XIII–XIV 16–17. A. III 13. Sq. 43–44 $\frac{3\text{–}4}{10}$; lat. l. $\frac{30\text{–}31}{14\text{–}16}$. Depth of body 5–$5\frac{1}{4}$ in total length. Snout much longer than eye.

E. longianalis. D. XV 15. A. III 17. Sq. $44\frac{3}{9}$; lat. l. $\frac{31}{17\text{–}18}$. Depth of body 5 in total length. Snout much longer than eye.

XENOTILAPIA, g. n.

Body moderately elongate; scales ctenoid; three lateral lines. Mouth small, very protractile; upper jaw with series of minute conical teeth; two mandibular teeth turned outwards, in a single series; maxillary concealed under the præorbital when the mouth is closed. A large papillose pad on each side of the pharynx, between the gills. Dorsal with 14 or 15 spines, anal with 3.

11. XENOTILAPIA SIMA, sp. n. (Plate XIX. fig. 5.)

Depth of body 4 times in total length, length of head $3\frac{1}{4}$. Snout very short and deep, with very steep convex upper profile; eye very large, oval, its diameter $\frac{2}{5}$ length of head and much greater than interorbital width; mouth nearly straight, horizontal, extending to below anterior border of eye; 3 or 4 series of scales on the cheek; deciduous scales on the opercle. Gill-rakers very short, broad, truncate, 9 on lower part of anterior arch. Dorsal XIV–XV 12; spines subequal from the fifth, $\frac{1}{3}$ length of head; longest soft rays $\frac{2}{5}$ length of head. Pectoral acutely pointed, as long as head. Ventral with the inner ray produced and reaching a little beyond origin of anal. Anal III 11; third spine $\frac{1}{3}$ length of head. Caudal with deep crescentic notch. Caudal peduncle twice as long as deep. Scales strongly ciliated, 40–41 $\frac{3\text{–}4}{10\text{–}11}$; lat. l. $\begin{array}{c}32\text{–}36\\ \hline 21\text{–}22\\ \hline 15\text{–}16\end{array}$.

Pale brownish, with a few round darker spots; a blackish opercular spot; a shining golden spot on the subopercle; dorsal greyish, other fins yellowish.

Total length 105 millim.

Two specimens.—Native name: "Lufuina."

12. Tilapia labiata Blgr.

Native name: "Kobo."

13. Tilapia dardennii, sp. n. (Plate XX. fig. 1.)

Teeth very small, in 4 or 5 series in both jaws, outer bicuspid, separated from the series of smaller tricuspid teeth by a rather wide interspace. Depth of body 3 to $3\frac{1}{3}$ times in total length, length of head $3\frac{1}{3}$ to $3\frac{1}{2}$. Snout with strongly curved upper profile, little longer than the diameter of the eye, which is $3\frac{1}{2}$ times in length of head and equal to or a little less than interorbital width; mouth small, $\frac{3}{5}$ width of head, extending to between nostril and eye; 5 or 6 series of scales on the cheek; large scales on the opercle. Gill-rakers short and thick, 13 on lower part of anterior arch. Dorsal XIX 10; sixth to ninth spines longest, not quite half length of head, a little shorter than longest soft rays. Pectoral acutely pointed, as long as or slightly shorter than the head, not extending to origin of anal. Ventral reaching vent or not quite so far. Anal III 8; third spine as long as and much stronger than longest dorsals. Caudal feebly emarginate. Caudal peduncle $1\frac{2}{3}$ or $1\frac{3}{4}$ as long as deep. Scales mostly ctenoid, 37 $\frac{5}{11}$; lat. l. $\frac{24\text{-}25}{17\text{-}19}$. Yellowish olive above, silvery beneath, with 10 or 11 dark dorsal cross-bars, the first between the eyes; yellowish streaks along the series of scales; fins yellowish, dorsal with some olive marblings, pectoral and anal red at the base.

Total length 155 millim.

Two specimens.—Native name: "Sangani."

14. Tilapia rubropunctata, sp. n. (Plate XX. fig. 2.)

Teeth very small, in 4 or 5 series in both jaws, outer bicuspid, separated from the series of smaller tricuspid teeth by a rather wide interspace. Depth of body 3 times in total length, length of head $2\frac{2}{3}$. Snout with straight upper profile, twice as long as diameter of eye, which is $4\frac{1}{2}$ times in length of head and equals interorbital width; mouth large, $\frac{3}{4}$ width of head, extending to between nostril and eye; a few deciduous scales on the cheek; large scales on the opercle. Gill-rakers short, rather slender, 12 or 13 on lower part of anterior arch. Dorsal XVI 9; spines equal in length from the sixth or seventh, measuring $\frac{1}{3}$ length of head and $\frac{2}{3}$ longest soft rays. Pectoral obtusely pointed, $\frac{2}{3}$ length of head, not extending to origin of anal. Ventral reaching vent. Anal III 7; third spine a little shorter than longest dorsals. Caudal truncate. Caudal peduncle as long as deep. Scales mostly cycloid, a few on the sides of the body below the lateral line finely denticulate, 32–33 $\frac{4\text{–}5}{11\text{–}12}$; lat. l. $\frac{22}{12\text{–}13}$. Olive-brown above, pale yellow beneath; dark cross-bars on the back; each scale of the back and sides with a central vermilion spot; head spotted and marbled with dark purplish brown; lower jaw and lower part of opercular region bright yellow; dorsal and caudal fins bright yellow, spotted with dark brown; pectoral yellow; branchiostegal membrane, pectoral region, outer edge of ventrals, and anal vermilion-red.

Total length 120 millim.

Two specimens of this handsomely-coloured fish, which bears the native name "Kasanga Malengi" on M. Dardenne's coloured sketch.

15. TILAPIA MICROLEPIS, sp. n. (Plate XX. fig. 3.)

Teeth very small, in 4 series close together in both jaws, outer larger, bicuspid, with a principal and a small lateral cusp. Depth of body $3\frac{2}{3}$ to 4 times in total length, length of head 3. Snout with straight or slightly convex upper profile, once and a half the diameter of the eye, which is nearly 4 times in length of head and equals interorbital width; mouth moderate, its width $\frac{3}{5}$ that of the head, extending to between nostril and eye; 7 or 8 rows of scales on the cheek; larger scales on the opercle. Gill-rakers short, rather thick, 13 or 14 on lower part of anterior arch. Dorsal XVI–XVII 14–15; spines subequal in length from the fifth or sixth, measuring $\frac{1}{3}$ length of head and a little shorter than longest soft rays. Pectoral acutely pointed, $\frac{3}{4}$ length of head, not extending to origin of anal. Ventral widely separated from vent. Anal III 9; third spine as long as and a little stronger than longest dorsals. Caudal with deep crescentic notch. Caudal peduncle twice as long as deep. Scales cycloid, 80–90 $\frac{10}{29\text{–}30}$; lat. l. $\frac{46\text{–}49}{38\text{–}44}$. Pale olive-brown above, white below; faint dark bars across the back and four round dark spots on each side, the last at the root of the caudal; fins yellowish.

Total length 115 millim.

Two specimens.—Native name: "Mocupi."

As in *Tilapia desfontainesi*, the dentition of this species may be regarded as connecting *Tilapia* with *Paratilapia*.

16. TILAPIA GRANDOCULIS, sp. n. (Plate XIX. fig. 6.)

Teeth very small, in 4 or 5 series in both jaws, of outer series larger, bi- or tricuspid, and very obtuse. Depth of body $3\frac{3}{4}$ times in total length, length of head 3. Snout short, with rounded upper profile; eye very large, a little longer than the snout, its diameter $2\frac{1}{2}$ in length of head, and slightly greater than the interorbital width; mouth small, $\frac{1}{2}$ width of head, extending to between nostril and eye; a few deciduous scales on the cheek; larger scales on the opercle. Gill-rakers very short, rather thick, 17 on lower part of anterior arch. Dorsal XIII 14; spines slender, equal in length from the seventh, measuring $\frac{2}{5}$ length of head, and a little shorter than longest soft rays. Pectoral falciform, slightly longer than the head, extending as far as origin of anal. Ventral prolonged in a long filament, extending beyond origin of anal. Anal III 10; third spine shorter but stronger than longest dorsals. Caudal with deep crescentic notch. Caudal peduncle a little longer than deep. Scales mostly ctenoid, $63 \frac{}{25}$; lat. l. $\frac{58\text{–}60}{32\text{–}36}$. Brown above, with ill-defined darker spots, whitish beneath; pectorals yellowish; other fins blackish towards the edge.

Total length 115 millim.

A single specimen.

SILURIDÆ.

17. AUCHENASPIS BISCUTATA Geoffr.

Native name: "Porocco."

18. CHRYSICHTHYS CRANCHII Leach.

Two young specimens are in the collection. A larger specimen is represented in the series of drawings made by Mr. Moore.

19. SYNODONTIS MULTIPUNCTATUS Blgr.

The young (150 millim.) have the spots on the head and body larger and fewer. Native name: "Katétia."

CHARACINIDÆ.

20. ALESTES MACROLEPIDOTUS C. & V.

Native name: "Ilala."

21. ALESTES MACROPHTHALMUS Gthr.

Native name: "Laala."

CYPRINODONTIDÆ.

22. HAPLOCHILUS TANGANICANUS Blgr.

Native name: "Mohanga."

EXPLANATION OF THE PLATES.

PLATE XVIII.

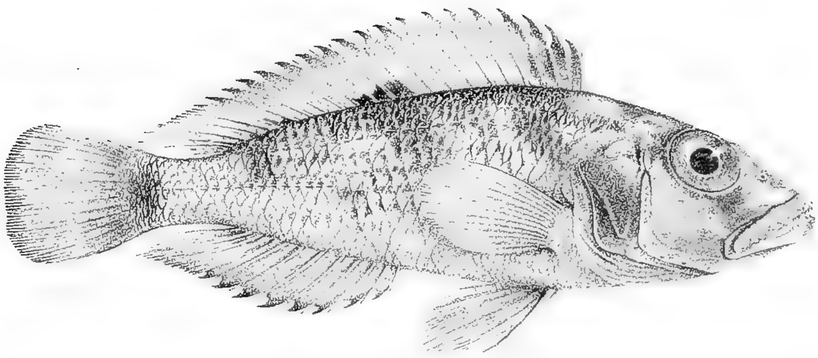
Fig. 1. *Lamprologus lemairii*, p. 88.
Fig. 2. *Paratilapia dewindti*, p. 88.
Fig. 3. *Grammatotria lemairii*, p. 90.

PLATE XIX.

Fig. 1. *Trematocara marginatum*, p. 89. 1 *a*. Side view of head; 1 *b*. Lower view of head, enlarged.
Fig. 2. *Ectodus descampsi*, p. 90.
Fig. 3. " *melanogenys*, p. 91.
Fig. 4. " *longianalis*, p. 91.
Fig. 5. *Xenotilapia sima*, p. 92.
Fig. 6. *Tilapia grandoculis*, p. 94.

PLATE XX.

Fig. 1. *Tilapia dardennii*, p. 93.
Fig. 2. " *rubropunctata*, p. 93.
Fig. 3. " *microlepis*, p. 94.



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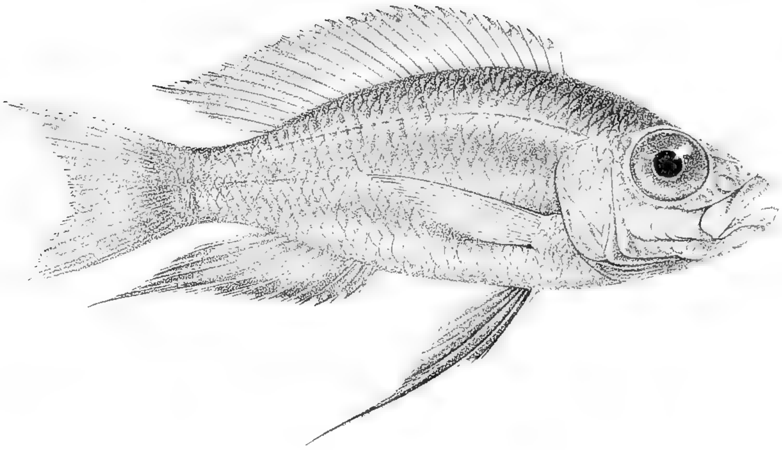

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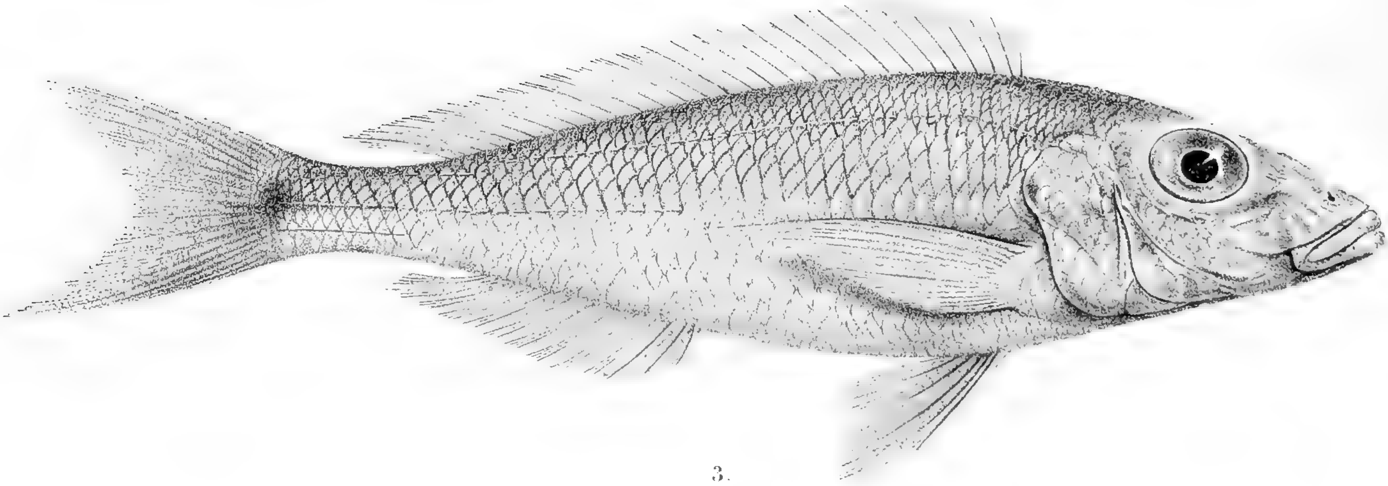
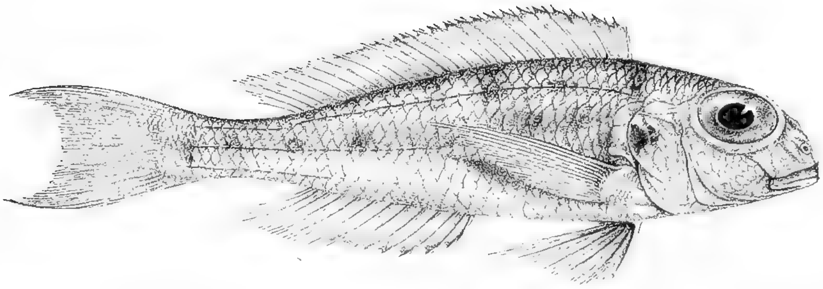


3.

J Green del. et lith.

Mintern Bros. imp.

1. LAMPROLOGUS LEMAIRII. 2. PARATILAPIA DEWINDTI. 3. GRAMMATOTRIA LEMAIRII.



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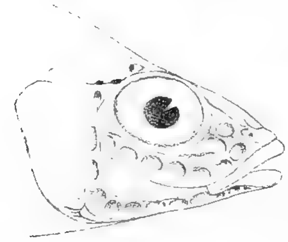

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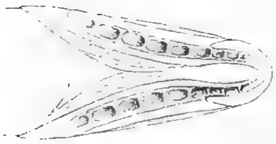

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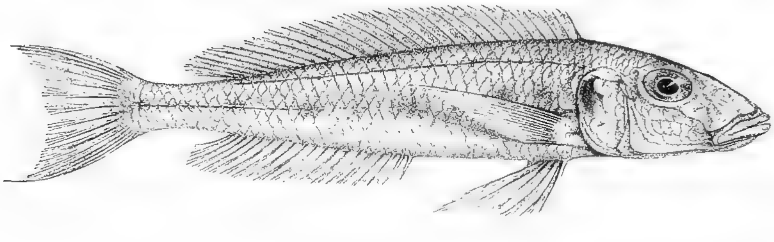

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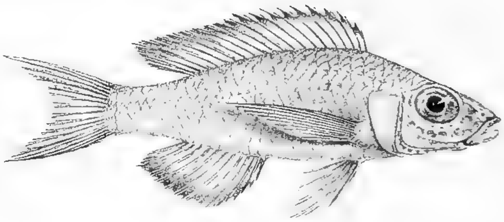

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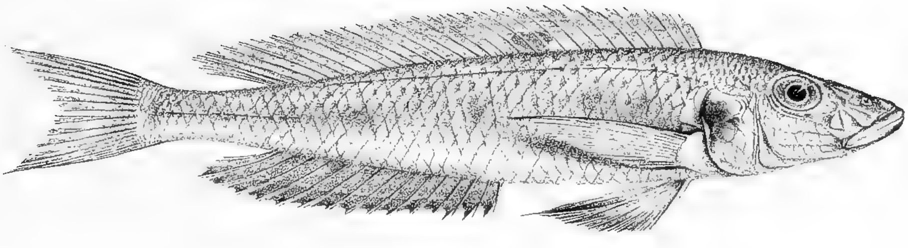

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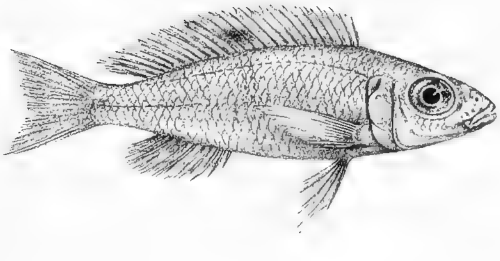

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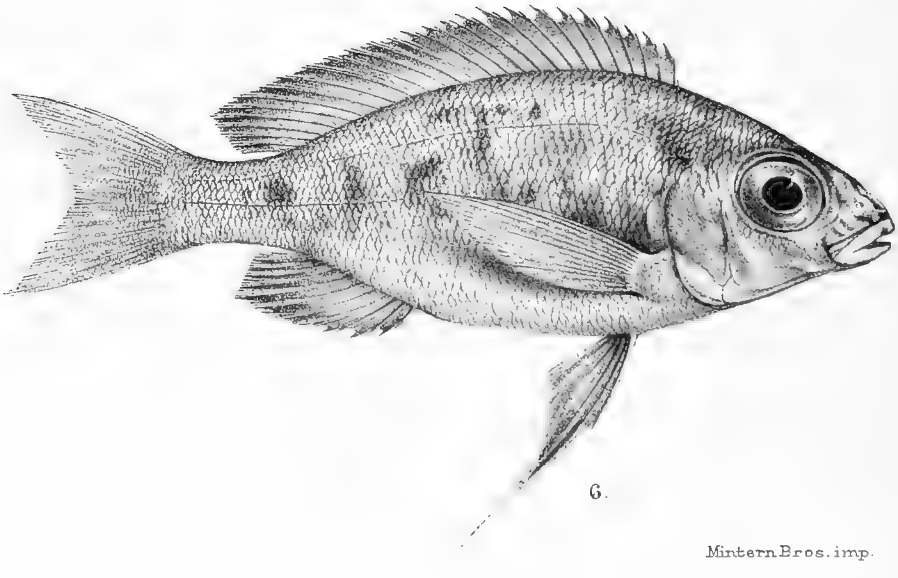
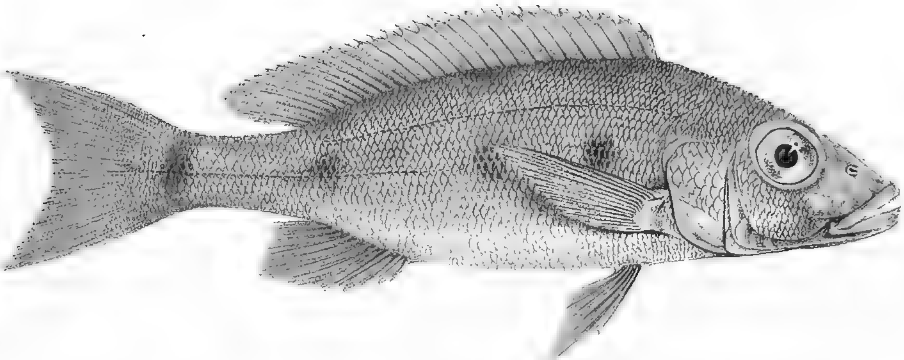


6.

J Green del. et lith.

Mintern Bros. imp.

1. TREMATOCARA MARGINATUM. 2. ECTODUS DESCAMPSI. 3. ECTODUS MELANOGENYS.
4. ECTODUS LONGIANALIS. 5. XENOTILAPIA SIMA. 6. TILAPIA GRANDOCULIS.



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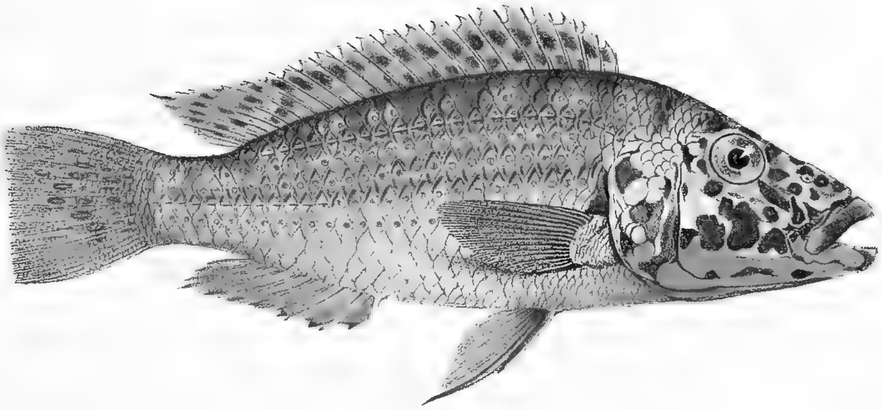

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J. Green del et lith.

Mintern Bros. Chromo.

1. TILAPIA DARDENNII. 2. T. RUBROPUNCTATA. 3. T. MICROLEPIS.

III. Atlas. (Nearly complete, but wanting the end of the left transverse process. The second series gives the measurements of the articulated specimen of *C. giganteus* (Irish) in the Woodwardian Museum at Cambridge.)

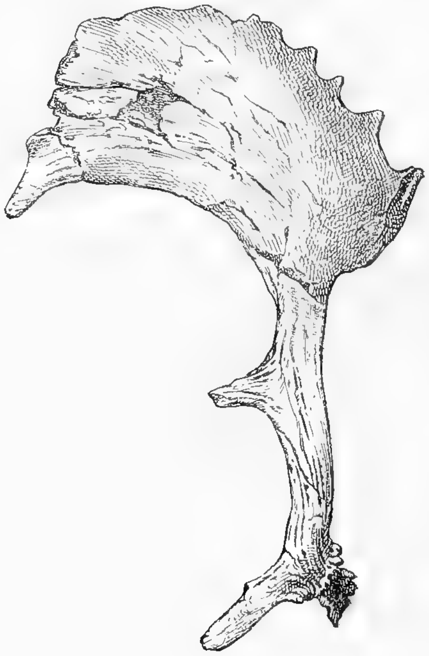
	C. belgrandi (Pakefield).		*C. giganteus* (Woodwardian Museum).	
	inches.	millim.	inches.	millim.
Centrum, greatest length of	2·5	64	2·7	68
Neural arch, length in median dorsal line	2·5	64	3·0	77
Greatest width of vertebra (estimated at twice the width of the perfect side)	7·3	185	8·7	221
Width between outer edges of facets for condyles of skull	4·0	102	4·5	115
Width between outer edges of facets for odontoid process	4·0	102	4·5	115
Front edge of facet for condyle to middle of lateral part of facet for odontoid process	4·0	102	4·5	115
Tip of neural spine to a point vertically below it on the ventral surface of the centrum	3·0	76	3·6	93
Tip of hypapophysis vertically to the level of the hinder edge of the neural arch in the middle line	3·0	76	2·9	74
Deepest point in the depression behind the ventral nerve-foramen to the dorsal edge of the facet for the odontoid process	1·6	41	1·8	46
Width of centrum between the two depressions	1·9–2·1	47–53	2·8	72
Width of neural canal, in front	1·7	44		
,, ,, ,, behind	1·7	44		
Vertical height of neural canal, in front	1 2	31		
,, ,, ,, ,, behind	1·7	44		

IV. Axis. (Practically complete.)

	C. belgrandi (Pakefield).		*C. giganteus* (Woodwardian Museum).	
	inches.	millim.	inches.	millim.
Centrum, greatest length (without odontoid process)	4·4	112	5·1	129
,, ,, ,, (with ,, ,,)	5·4	137		
Neural arch, length at the top of the neural canal	4·0	102	4·7	120
,, spine, length of	5·0	127	5·5	140
Facet for atlas, width of	3·9	100	4·4	112
Odontoid process, width at tip	1·6	40		
Top of neural canal to bottom of facet for atlas	2·9	74	3·2	82
Length of facet for anterior zygapophysis of 3rd vertebra	1·6	40	1·9	48
Greatest vertical height (at hind end)	5·4	137	6·2	157
,, width (near hind end)	4·0	102	6·8	173
Posterior zygapophyses, width across	3·0	76	4·0	102
Posterior end of centrum, vertical height of articulating surface	1·9	48		
Top of neural spine to top of neural arch	2·4	61	3·6	92

THE AFFINITIES OF *CERVUS BELGRANDI.*

It is now generally accepted that the Irish Deer (*C. giganteus*)[1] and its allies are members of the Damine group. The particular position which *C. belgrandi* should occupy in this group has not hitherto received adequate consideration, in consequence of the imperfect condition of all the previously described examples. It appears to me that *Cervus belgrandi* combines in a most interesting manner the characters of *C. dama* and its fossil allies (*C. browni*, &c.) and of the series of forms including the Irish Deer. Many specimens of *C. dama* agree precisely with *C. belgrandi* in the number and position of the tines and in the general character of the palmation. The principal differences between the two forms are: (1) the more horizontal position of the beam in *C. belgrandi*; (2) the position and characteristic downward curve of the first tine in that species; and (3) the existence of a scalloped edge of the crown in *C. belgrandi*, as distinguished from that of *C. dama*, which is prolonged into more definite tines. Both species agree in the absence of points on the anterior edge of the crown. The palmated region includes the back-tine in *C. dama*, whereas in *C. belgrandi* there is a distinct constriction between the back-tine and the palmation. The comparative suddenness with which the expansion begins in this species is probably the reason why its real character has not hitherto been suspected.



Right antler of *Cervus dama*, believed to be of preglacial age, from Belzig, 10 miles S.W. of Berlin; seen from the inner side. (After Keilhack.)

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[1] 'Manuel d'Hist. Nat., traduit de l'allemand de J. F. Blumenbach,' ii. 1803, p. 407.

A most interesting specimen, referred to *Cervus dama*, has been described by Keilhack[1] from Belzig, 10 miles south-west of Berlin. It would not be easy to find a specimen affording a more complete transition from *C. belgrandi* to the modern *C. dama* than this one, and I have accordingly reproduced one of Keilhack's figures of the right antler (woodcut, p. 104). The specimen far exceeds in size all the Fallow-deer measured by Keilhack, the base of the beam being no less than 180 mm. in circumference, as compared with 132 mm., the mean of the measurements of the recent individuals given by the same author. It further approaches *C. belgrandi* in the scalloped edge of the posterior part of the palmation and in the downward curvature of the large brow-tine, which, however, originates immediately above the burr. The brow-tine appears from the figures to spring from the beam somewhat on its posterior side, as in the Forest-Bed form. The affinity of Keilhack's specimen to *C. dama* is, however, shown by the angle made by the antlers with the skull, the direction being much less horizontal than in *C. belgrandi*, and by the inclusion of the back-tine in the palmation, from which it projects in much the same way as in the recent Fallow-deer. The beam terminates in a short but distinct snag at the distal and anterior edge of the crown, but the interval between this and the back-tine has a scalloped edge closely resembling that of the Pakefield specimen. Nehring[2], in remarking on the Belzig specimen, in a paper which preceded Keilhack's memoir, expresses the opinion that it must be regarded, if not as an actual *C. dama*, at least as a direct ancestor of that species.

The Belzig specimen indicates in the clearest way the probable derivation of the modern *C. dama* from forms resembling *C. belgrandi*, the principal changes which have taken place being apparently the diminution in size, the approximation of the crowns of the two antlers by the assumption of a less horizontal position, the inclusion of the back-tine in the palmation, and the replacement of the serrations of the crown by the snags which characterize the recent Fallow-deer. The discovery of the Belzig specimen and that of the form here described go far towards filling up the gap between *C. giganteus* and *C. dama*, to the existence of which attention is called by Rütimeyer[3], in insisting on the affinity of these two forms. It may be noted that the immature antlers[4] of *C. dama* have the posterior edge of the crown denticulated in a way strikingly suggestive of *C. belgrandi*.

The resemblance of *C. belgrandi* to *C. giganteus* is no less striking. Pohlig[5] has

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[1] K. Keilhack, "Ueber einen Damhirsch aus dem deutschen Diluvium," Jahrb. k. Preuss. geolog. Landesanstalt (1887), 1888, p. 283, pl. xi.

[2] "Ueber das fossile Vorkommen von *Cervus dama* . . . . in Norddeutschland," SB. Ges. naturf. Berlin, 1883, p. 69.

[3] "Beiträge zu einer natürlichen Geschichte der Hirsche," Abhandl. Schweiz. pal. Gesellsch. x. 1883, p. 111.

[4] *Cf.* Cuvier, "Recherches sur les Ossemens Fossiles," 3rd ed. t. iv. 1825, pl. iii. figs. 28, 29.

[5] "Die Cerviden des thüringischen Diluvial-Travertines, mit Beiträgen über andere diluviale und über recente Hirschformen," Palæontographica, xxxix. 1892, p. 215.

recently defined several forms of the latter species, which are accepted with certain modifications by Lydekker[1]. Taking the nomenclature of the latter, we have

1. *Cervus giganteus carnutorum* Laug., of which *C. verticornis* is regarded as a synonym. *C. verticornis* occurs typically in the Forest-Bed (early Pleistocene), and *C. carnutorum* in beds of equivalent age in France. Boyd Dawkins records the occurrence of one specimen of *C. verticornis* in the Pliocene (Red Crag).
2. *C. giganteus belgrandi* Lart., from the Mid-Pleistocene of France and Germany.
3. *C. giganteus italiæ* Pohl., from similar and later deposits of Italy, Hungary, &c.
4. *C. giganteus ruffi* Nehr. (= *C. euryceros germaniæ* Pohl.), the typical German race, found also in other parts of the Continent and in England, contemporaneously with the Cave-Bear, although first recorded from the Mid-Pleistocene.
5. *C. giganteus typicus* Lyd. (= *C. euryceros hiberniæ* Pohl.), the Irish Deer, the most recent form.

The conclusion that *C. verticornis* is a synonym of *C. carnutorum* appears to me in the highest degree doubtful. The latter, found at Saint-Prest, near Chartres, was described by Laugel[2] from some upper molars, some portions of the antlers, a metatarsal, and a lumbar vertebra, which were all believed to belong to one species, comparable in point of size with the Irish Deer. Laugel does not figure the antlers, but he calls attention to the fact that their bases are remarkably approximated. The crown was probably palmated, and is believed to have borne about five curved snags, the longest of which measured 26 cm. These characters are quite sufficient to show the difference between Laugel's species and *C. verticornis*, even without the illustrated account of the Saint-Prest fossils which has been given by Gervais[3]. From this memoir it appears that the vertex of the skull of *C. carnutorum* is much raised, so as to resemble that of the "Antilope Bubale"; this being an important difference between it and the Forest-Bed Stag. The antlers are closely approximated at their bases (*cf.* pl. xvi. fig. 4 of Gervais) and diverge from one another at an acute angle. An equally striking feature of this species is that, when looked at from in front, the brow-tine appears to originate from the outer outline of the beam, while that of *C. belgrandi*, viewed from the same aspect, appears to spring from the inner outline.

Professor Boyd Dawkins and Mr. E. T. Newton[4] have, however, referred several fragments from the Norwich Crag, and possibly from the Forest-Bed, to *C. carnutorum*. I am not prepared to express any opinion with regard to these specimens.

I am indebted to Professor Boyd Dawkins for a letter in which he informs me that he is inclined to regard his *Cervus verticornis* (1872) as identical with *C. belgrandi* (Lartet) Belgrand (1869), and for the further information that the type-specimens of the latter are no longer in existence. *C. belgrandi* was described in Belgrand's work

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[1] *T. cit.* pp. 134–141.

[2] Bull. Soc. Géol. France, (2) xix. 1862, p. 711.

[3] "Zool. et Paléont. Générales.—Nouv. Recherches sur les Vertébrés Vivants et Fossiles," 1e sér. 1867–1869, p. 84, pl. xvi. figs. 3–8.

[4] For references, see E. T. Newton, "The Vertebrata of the Pliocene Deposits of Britain," Mem. Geol. Survey, 1891, p. 26.

"La Seine"[1], parts of two frontals, with the bases of the antlers, being figured. These fossils appear to me to agree in all essential respects with the Pakefield specimen. The inclination of the antlers, the distance from one another of the pedicles, and in particular the position of the brow-tine agree in the two forms; the measurements correspond with a sufficient degree of accuracy; while it further appears from Belgrand's plate xix. that the second tine of *Cervus belgrandi* does not originate in the same line with the brow-tine, but at a point 90° further forward than the line containing the base of the brow-tine, in exactly the way that is characteristic of *C. verticornis.* Pohlig[2] regards the rudimentary condition of the brow-tine as a leading characteristic of *C. belgrandi.* Had he, however, copied Belgrand's representation of the right antler in pl. xviii., instead of that of the left antler, this condition would have been much less apparent; and in the specimen[3] from Taubach which he himself figures (pl. xxiv. fig. 1) the brow-tine has essentially the characters of that of the Forest-Bed form.

Cervus giganteus italiœ also shows some interesting resemblances to the Forest-Bed form. The specimens in the Museums of Milan and Arezzo figured by Pohlig[4] have a palmated crown which shows a distinct resemblance to the Pakefield specimen, from which they differ, however, in the larger development of the points of the crown and in having the brow-tine in the position characteristic of the typical *C. giganteus.* Part of the definition of this form given by Lydekker—the upward inclination of the palmation, the front border of which is curved inwardly so that much of the outer surface is seen in a front view, and the occurrence of the points of the crown near the summit of the palmation—will apply equally well to *C. belgrandi.* The general direction of the antlers, the beams of which spread out at first nearly horizontally, the palmated part then curving upwards, is again strikingly suggestive of that form.

C. megaceros ruffii was named and figured by Nehring[5], who calls attention to the absence of points on the anterior edge of the palmated part as an indication of affinity to *C. dama.* Although agreeing in this respect with *C. belgrandi,* it has already acquired long tines springing from the distal border of the crown in a manner suggestive of the Irish Deer. Some of the specimens of this race, for instance that from the Worms Museum figured by Pohlig (p. 222, figs. 4 *c* and 4 *d*), show a much closer approach to the Forest-Bed species, in the way in which the crown is set on to the beam and in the slight development of the terminal snags.

The general conclusion seems to be that *C. belgrandi* is the most central type of the Giant Deer, showing as it does a distinct affinity to the Fallow-deer as well as to the

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[1] "Hist. Gén. de Paris. La Seine.—I. Le Bassin Parisien," par E. Belgrand. 'Planches de Paléontologie,' 1869, p. 13, pls. xviii.–xx.

[2] *T. cit.* p. 232.

[3] I do not feel convinced that this really belongs to *C. belgrandi.*

[4] *T. cit.* p. 228.

[5] "Über eine besondere Riesenhirsch-Rasse aus der Gegend von Kottbus," Sitzungsber. Ges. naturf. Fr. Berlin, 1891, p. 151. See also papers by the same author, "Neue Notizen über *Cervus megaceros,* var. *ruffii,* Nhrg.," *ibid.* 1892, p. 3; and 'Deutsche Jäger-Zeitung,' xxxii. 1899, p. 681; xxxiii. 1899, p. 413.

Cervus giganteus series. The large size of the Pakefield specimen and the condition of the sutures of the skull preclude the idea that it can be a young form, and there is every reason to suppose that the characters shown by it are those of the adult animal. The crown has become conspicuously palmated, but the long tines found in *C. giganteus* are at present indicated merely by a slight serration of its distal border. Another point which seems to me to deserve special notice is the direction of the vascular grooves on the beam of the antler. In the Forest-Bed specimens these run in an accurately longitudinal course up the posterior and ventral surface of the beam, while in the Irish Deer, as well as in the specimens of *C. giganteus* from the Barrington gravel, the grooves have an elongated spiral course. This may indicate a torsion of the whole antler. It is a noteworthy fact that the palmated crown of the Irish Deer is much more horizontally placed than that of *C. belgrandi*, in which the direction is very oblique, the dorsal surface looking somewhat backwards. If the anterior edge of the crown in *C. belgrandi* were depressed by the torsion of the beam, so as to bring the palmation into a horizontal position, this new position would not only agree with that found in the Irish Deer, but it would result in a torsion of the vascular grooves, which would thereupon assume the spiral course characteristic of the latter. *C. dama* agrees with the Irish Deer in this respect. Although the brow-tine of the Irish Deer may have the same curvature at its base as that in *C. belgrandi*, it comes off immediately above the burr and from the extreme front edge of the beam. The second tine of the Irish Deer is more nearly opposite the back-tine than in *C. belgrandi*, and the palmation often begins soon enough to include it, instead of commencing above the back-tine, as in that species.

The geological occurrence of *C. belgrandi* agrees well with the conclusion above indicated. Its occurrence in the Forest-Bed is itself an evidence of its relative antiquity, while the existence of the species in the Red Crag (Boyd Dawkins) carries this form further back than any of the other races of Giant Deer.

EXPLANATION OF PLATE XXI.

Fig. 1. *Cervus belgrandi.*—Skull and antlers, from behind. × $\frac{1}{7}$. The specimen was obtained at Pakefield, near Lowestoft. *a*, burr; *b*, first tine; *d*, *d'*, back-tine. The tines *c*, which are not visible in this position, come off from the front edge of the beam, midway between *b* and *d*.

Fig. 2. View of the same specimen from the right side. The figure having been drawn from a photograph, the parts of the right antler appear much larger than they really are. *b*, first tine; *c*, second tine; *d*, *d'*, back-tine.

Fig. 3. Atlas vertebra of the same specimen, from the ventral side. The end of the right transverse process is partially obscured by the matrix.

Fig. 4. Axis vertebra of the same specimen, from the right side. The end of the neural spine is partially obscured by the matrix.

CERVUS BELGRANDI

E. Wilson, del. et lith. Cambridge.

V. *On a Specimen of* Cervus belgrandi *Lart.* (C. verticornis *Dawk.*) *from the Forest-Bed of East Anglia. By* SIDNEY F. HARMER, *Sc.D., F.R.S., Superintendent of the University Museum of Zoology, Cambridge.*[1]

Received April 24, read June 6, 1899.

[PLATE XXI.]

THE specimen which forms the subject of the present paper is from the Forest-Bed series of Pakefield, near Lowestoft, where it was found as a result of the great destruction of the cliff due to the high tides of November 1897. The pieces were obtained from the men who had dug it out by my assistant, Ernest Lane, to whom is due the credit of recognizing the importance of the specimen, which is now in the University Museum of Zoology at Cambridge.

I have been unable to find a record of any specimen belonging to this species which will compare with the present one in completeness. The posterior part of the skull, including the whole of the brain-case, is in excellent condition. The anterior parts, from the orbital region, are wanting. The left antler is nearly complete, and the parts which are missing are to some extent represented in the right antler, a large part of which is also present. The atlas and axis were found associated with the skull.

The specimen throws considerable light on the real characters of the antlers of the form usually known as *Cervus verticornis*; and in particular it demonstrates the incorrectness of the diagnosis which is usually given of this species. *C. verticornis* was originally described by Professor W. Boyd Dawkins[2], and a fuller account of it was given by the same author in a later publication[3]. The species is commonly represented by basal parts of the antlers only, in collections from the Forest-Bed, and is readily recognized by its massive cylindrical beam, with the brow-tine (usually situated about 2 inches above the burr) curving forwards and downwards. The restorations given by Boyd Dawkins indicate an antler which slightly widens out immediately above the back-tine, and ends in a short bifurcated tip, which was not, however, really represented in any of the specimens. Professor Dawkins's opinion, stated in his fuller account, that he cannot recognize any affinity between the antlers of *C. verticornis* and those of the

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[1] The abstract of this paper which appears on pp. 715, 716 of the 'Proceedings' for 1899 was published without giving me an opportunity of correcting the proof. The locality of the fossil and my conclusion with regard to the nomenclature are incorrectly stated in it.—S. F. H., Nov. 13, 1899.

[2] "On the Cervidæ of the Forest-Bed of Norfolk and Suffolk," Quart. J. Geol. Soc. xxviii. (1872), p. 406.

[3] "British Pleistocene Mammalia.—VI. British Pleistocene Cervidæ," Palæontographical Society, 1887.

Irish Deer (*C. giganteus*) was no doubt the result of this inadequate restoration, which is also responsible for such statements as those of Flower and Lydekker[1] that the antlers are very short and thick, or of Lydekker[2] that their palmation is generally slight.

The Pakefield specimen shows, on the contrary, that *C. verticornis* belongs to a type comparable with the Irish Deer not only in its size but in the amount of the palmation of the antlers, though differing from it in the absence of prominent snags springing from the palmated extremity. It fully bears out the conclusion stated by Lydekker[3] that this form indicates the ancestral stock of *C. giganteus*.

The specimen measures 6 feet in a straight line between the extreme points of the antlers, but this measurement hardly gives a correct idea of its real size. The crown of the right antler rises nearly vertically, while that of the left antler is much more horizontally expanded, besides being more perfect. The distance of the distal extremity of the left antler from the middle line of the skull is thus no less than 4 feet 5 inches. If both antlers had been equally well preserved and if the direction of the right antler had been as horizontal as that of the left antler, the total span, in a straight line, would have been 7 feet 3 inches. The more complete left antler is no less than 52·6 inches, measured along the curve; its pedicle is 2·9 inches in diameter (dorso-ventral) and the burr is 3·6 inches. The brow-tine (*b*) is 2 inches above the burr and is perfectly typical, springing from the back of the beam in such a way that its posterior surface is level with the posterior surface of the beam. The anterior surface of its base is hollowed out, and beneath it there is a slight tubercle corresponding with the accessory tines or with the "offers" described by Boyd Dawkins[4] in the same position. This is hardly indicated in the right antler. The beam is nearly cylindrical and is strongly furrowed by grooves for blood-vessels, which run in a longitudinal direction without showing any tendency to become spiral. Two inches above the brow-tine, the beam measures 2·6 inches in greatest diameter, its anterior part soon afterwards becoming flattened in a dorso-ventral direction to form the second tine (*c*), which is only represented by its base, the proximal edge of which is about 7 inches from the distal edge of the base of the brow-tine. Beyond the second tine, the beam nearly regains its cylindrical shape, although having a low ridge on its anterior aspect. It has hitherto been nearly straight, though slightly concave below and pointing somewhat backwards; but beyond the second tine it curves rapidly upwards, expanding and becoming flattened. At the origin of the back-tine (*d*) it is convex on its under surface and slightly concave above. The back-tine is fairly long (6 inches, though incomplete at its tip) and is directed backwards and inwards; the distance of the proximal part of its base from

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[1] "Introduction to the Study of Mammals," 1891, p. 323.

[2] "The Deer of all Lands," 1898, p. 140.

[3] *T. cit.* p. 141.

[4] Pal. Soc., *l. cit.* p. 23, pl. vii. fig. 1, b^1.

a point on the beam opposite the distal end of the base of the second tine is about 7 inches; and from the posterior edge of the burr, in a straight line, about 19 inches.

Opposite the back-tine, the beam is 2·1 inches in greatest dorso-ventral diameter; and it is still 1·9 inches thick, becoming flat above, but remaining convex below, at a point 9 inches above the middle of the base of the tine. The front edge of the antler is wanting from a point 6·5 inches above the tine *c*, and for 11 inches from its lower end the fractured edge varies from 1·4 to 1·7 inches in thickness. Posteriorly the edge has been getting thinner from the back-tine, about 10 inches above which it expands into a large palmated crown, the plane of which is different from that of the part which precedes it. The beam, from the second tine to the base of the palmation, was extended upwards in a plane about 45° from the median vertical plane, its edge being seen in a view of the skull from the front. The posterior edge of the crown is, on the contrary, rotated outwards and downwards, so that much of its lower surface becomes visible from in front. The posterior edge of the base of the crown is very concave, and passes obliquely upwards and backwards, the palmation extending further backwards than the end of the back-tine. The crown is quite complete except in front, and is everywhere thin, scarcely exceeding an inch in thickness in any part; its distal border is gently scalloped, about 7 points or rounded lobes being distinguishable, none of them being more than mere denticulations. The thinness of the palmated crown at its antero-distal extremity indicates that no other tines were present in this region. The part between the main palmation and the back-tine is, however, thick (1·7 inches) on its fractured anterior border; and another anterior tine may have been present in this region, or the beam may have terminated in a distinct point, as in the Belzig specimen (see woodcut, p. 104), mentioned below, or as in *C. dama*. From a comparison with the latter, I do not, however, think it likely that an anterior tine was present.

The right antler agrees closely with the left, except that the region above the second tine turns dorsally much more sharply than that of the other side. It is indeed almost at right angles to the beam, whereas that of the left side forms a much more open curve with the beam. The first and second tines agree almost exactly in position with those of the left side, but the second tine is much better represented, measuring 7·5 inches in length and being practically complete. At its base it is flattened and is a good deal broader than thick (breadth 2·8 inches, thickness 1·5 inches). The back-tine is lost. The anterior edge of the antler is complete for about 13·5 inches (measured round the curve) above the base of the second tine, and the antler is prolonged for another 10 inches above the point where the anterior edge ceases to be complete. Its thinness makes it practically certain that no other tine could have existed.

The part of the skull which is preserved measures 9 inches in greatest length, and extends as far forwards as the posterior portion of the orbit. The occipital region and the base of the skull are in good condition. The interval between the pedicles is wide (3 inches) and the pedicles are much more horizontally placed than in *C. dama*, to which the species appears to be related; they pass with an even curve into the top of the frontal, whereas in another specimen of *C. belgrandi* in the Cambridge collection they make a distinct angle with the frontal and are somewhat more vertical. The pedicles are nearly cylindrical above, but have a sharp ridge descending from their outer borders to the posterior margin of the orbit; their bases are deeply hollowed out behind, as in other species of *Cervus*. Below the pedicles, the skull has a median ridge, with a marked depression on either side of it, thus differing from a part of a skull described by Boyd Dawkins[1]. The posterior part of the parietals (apparently just in front of the suture with the occipital) has a round foramen nearly in the middle line, and a smaller one slightly to the left side of it and rather further forwards (the other side being here injured). I have found a similar vacuity in the roof of the skull in another Forest-Bed specimen which I refer to *C. savini* Dawk. The transverse occipital crest is strongly marked, in correlation with the great size of the antlers, and the occipital surface is nearly vertical. Ventrally there is a very deep emargination between the condyles. There was apparently a large supra-orbital foramen, but the skull is deficient in this region.

The specimens of the Irish Deer (*C. giganteus*) in the Cambridge collection differ from the above in having much shorter and less marked pedicles, in the comparatively slight median ridge on the frontals and their more depressed character in this region, and in the smaller size of the supra-orbital foramen. The vertex of the skull, between the two pedicles, is less raised in *C. belgrandi*, the roof of the skull of which is practically flat from the front of the occipital crest to a point between the two pedicles. In the Irish Deer, on the contrary, the skull between the pedicles is much higher than the most prominent part of the occipital crest, from which it is separated by a distinct concavity. A striking difference, which appears to me of some importance, is that whereas in *C. giganteus* the vascular grooves on the beam of the antlers have a markedly spiral course, those of *C. belgrandi* run quite straight up the beams. The race of *C. giganteus* found in the Barrington River-gravel agrees with the Irish Deer in this respect.

The occurrence of the atlas and axis vertebræ associated with the skull is of special interest. Their size is not far short of that of the corresponding vertebræ in an articulated specimen of the Irish Deer in the Woodwardian Museum at Cambridge, the spread of whose antlers is 8 feet 4 inches. This is brought out in the tables of measurements which follow. I have noted the following differences between the two forms, although some of them may be no more than individual peculiarities.

In the ATLAS:—The neural arch is flatter above in *C. giganteus*, while it rises externally more abruptly on the dorsal surface in *C. belgrandi*. The tip of the

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[1] Pal. Soc., *l. cit.* p. 28.

rudimentary neural spine is at the middle of the upper surface in the former, and in front of the middle in the latter. The dorsal nerve-foramina of *C. giganteus* are constricted into a figure-of-8 shape (and completely divided by a bridge in a specimen from the Barrington gravel in the Woodwardian collection), while they are long slits in *C. belgrandi.* The neural arch of *C. belgrandi* has a wider sinus behind on its dorsal side; its anterior dorsal emargination is more square-cut: the ventral depression behind the nerve-foramen is much deeper; the hypapophysis is most prominent behind, with a median ridge passing towards the anterior end of the vertebra (that of the Woodwardian specimen of *C. giganteus* having no ridge). In some of these latter points the Barrington specimen holds an intermediate position between the two others.

In the Axis :—The dorsal edge of the neural spine is thinner in *C. belgrandi*; the transverse processes, which are incomplete, were probably less projecting; the posterior zygapophyses are narrower (1·05 inches, as compared with 1·5–1·8 inches) and more raised; there is a distinct emargination between the posterior zygapophysis and the neural spine; and the ventral median ridge is distinctly higher and bounded by deeper grooves at its sides than in *C. giganteus.*

In the tables which follow, the measurements have been taken in such a way as to permit of easy comparison with those given by Boyd Dawkins [1], Belgrand [2], and others.

I. Skull.

	inches.	millim.
Greatest length of the part of the skull preserved	9·0	228
Greatest breadth of the skull	8·1	206
Occipital crest to fronto-parietal suture	4·1	104
,, ,, pedicle (shortest distance)	3·0	76
Interval between pedicles	3·0	76
,, ,, supra-orbital foramina	3·9	99
From burr to burr (shortest distance)	5·4	137
,, ,, (distance between outer edges)	10·4	265
Top of foramen magnum to top of occipital crest	3·0	76
Foramen magnum, height of	1·1	28
,, ,, width of	1·4	35
Frontal width, just below pedicles	7·3	185
Pedicle, length of	1·8	46
,, circumference of	8·5	215
,, antero-posterior diameter of	2·4	61
,, dorso-ventral diameter of	2·9	74
Interval between bases of R. & L. brow-tines	9·8	250
Brain-case, diameter (external) behind pedicles	4·6	117
Distance between outer edges of condyles	3·8	97

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[1] Pal. Soc., *t. cit.* pp. 25–28.

[2] "La Seine.—I. Le Bassin Parisien. Planches de Paléont.," 1869, p. 13.

II. ANTLERS.

	Left.		Right.	
	inches.	millim.	inches.	millim.
Circumference of base of beam	9·1	231	8·9	226
Diameter " "	2·9	74		
Diameter of burr	3·6	91		
Circumference of burr	11·0	280		
Burr to tine 1 (*b*)	2·0	51		
Burr to fork of tine 1 (measured to distal side of base)	4·0	102		
Circumference of beam above tine 1	8·2	208		
Tine 1, basal circumference of	6·8	173		
Tine 1 to tine 2 (*c*) (distal side of 1 to proximal side of 2)	7·0	178		
Tine 2, circumference of base of	..	..	7·0	178
Tine 2, length of	..	..	7·5	190
Circumference of beam above tine 2	9·5	241	10·5	261
Burr to distal side of base of tine 2	14·0	356	14·0	356
Tine 2 (*c*) to tine 3 (*d*) (point opposite distal side of base of 2 to base of 3)	7·0	178		
Posterior edge of burr to tine 3 (in a straight line)	19·0	482		
Burr to distal side of base of tine 3	22·0	560		
Tine 3, circumference of base of	6·5	165		
Tine 3, length of	6·0	152		
Circumference of beam above tine 3	12·2	310		
Total length (in a straight line)	50·5	1283	30·0	762
Total length (along curve)	52·6	1335	38·0	965
Total span (straight line)	6 feet.		1830 millim.	

The variability in the position of the tines in this species is illustrated by the following measurements of the interval between tine 1 and tine 2, taken from four other specimens in the Cambridge collection:—

Catalogue No.	inches.	millim.
184 *b*	3·5	89
184 *a*	4·0	102
184 *d*	4·5	114
184 *c*	5·0	127

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December 1899.

P. L. SCLATER,
Secretary.

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Continued on page 3 of Wrapper.

VI. *A Monograph of the Genus* Casuarius. *By the Hon.* WALTER ROTHSCHILD, *Ph.D., F.Z.S. With a Dissertation on the Morphology and Phylogeny of the* PALÆOGNATHÆ (RATITÆ *and* CRYPTURI) *and* NEOGNATHÆ (CARINATÆ). *By* W. P. PYCRAFT.

Received and read June 20, 1899.

[PLATES XXII.–XLV.]

PART I.—A MONOGRAPH OF THE GENUS *CASUARIUS*.

By the Hon. WALTER ROTHSCHILD, *Ph.D., F.Z.S.*

Genus CASUARIUS Briss.

1790. *Casuarius* Brisson, Orn. v. p. 10.
1801. *Rhea* (non Latham, 1790) Lacépède, Mém. de l'Inst. iii. p. 519.
1842. *Hippalectryo* Gloger, Hand- u. Hilfsbuch, pp. xxxxiii, 452.

The genus *Casuarius* is the typical genus of the group *Casuarii* of the *Palæognathæ* (*Ratitæ* of former authors), and inhabits the Papuan subregion, *i. e.*, New Guinea with the islands in Geelvink Bay, Salwatty, New Britain, the islands of the Aru group, Northern Queensland, and the island of Ceram in the Moluccas. The Cassowaries are evidently separable into a great many local forms, apart from the few very distinct good species; but owing to their large size, to the uncertainty about the localities of the living specimens that are brought to Europe, and to the disappearance after death of the most characteristic coloration and structure of the bare skin on the head and neck, our knowledge of the species is doubtless still limited. The material which I have been able to study is very large compared with that available in most Museums. For several years I have tried to procure a great number of living specimens and of skins as well, and I have been able to place numerous fresh bodies and skeletons before Mr. Pycraft, whose appended paper will, I trust, be of great value for the study of the anatomy of the *Palæognathæ*.

Outwardly the genus *Casuarius* may easily be recognized by the following peculiarities:—

The bill is short, generally shorter than the head, laterally compressed, strong, and with the culmen curved downwards near the tip. The nostrils are placed in the middle of the maxilla, in a wide membranous groove, and open anteriorly. Head and neck bare and mostly brightly coloured, the skin much carunculated and wattled in various places. The forehead is ornamented with a more or less developed helmet of various shapes. Wings quite rudimentary, with about five round black shafts, without any indication of webs in the place of remiges; no rectrices apparent. The metatarsus is shorter than in most other Ratitæ, very robust, and covered in front with hexagonal scutes, and transverse ones near the toes. Toes three, the two outer ones with obtuse, curved, and short claws; the inner toe with a long, straight, powerful, pointed claw, which is a dangerous weapon. The body is covered with stiff, hair-like feathers, in which the after-shaft is as long as the principal shaft. The old birds are black, the young ones brown, the nestling, when hatched, is striped longitudinally above.

The eggs are about six to eight in number, with a strong and very coarsely granulated surface. When fresh they are evidently all of a light green colour, but when exposed to the light they become first more bluish, then greyish, and at last almost cream-coloured. The male alone incubates.

Herr Schalow (Journ. f. Orn. 1894) has attempted to make a key to distinguish the eggs of the various species; but his key is a total failure and misleading, being principally based on the colour, which is the same in all, and on the transparency of the shell, which is not specifically different.

All Cassowaries are inhabitants of forests, while the rest of the large living *Palæognathæ* (or *Ratitæ*) are denizens of steppes and deserts. Their food seems to consist of all sorts of vegetable matter and fruits; but they also pick up insects and any creeping thing that comes in their way. In captivity, at least, they kill and devour chicks and small birds when they come across them. They also, like Ostriches, Rheas, and others, swallow quantities of stones and gravel to assist digestion. They are entirely diurnal, sleeping from sunset till morning.

The voice of the Cassowaries is a curious sort of snorting, grunting, and bellowing, usually not very loud, and differing according to the species.

Their temper is generally sullen and treacherous, and they are extremely pugnacious, even the different sexes often fighting at other seasons than the breeding-season. Exceptions are rather rare, but there is an adult Cassowary, now in the Society's Gardens, which is quite tame, and was always so, since I had him; while another young bird used to follow the keeper who fed him like a dog when I had him in Tring, but has since become somewhat shy.

It seems that the Dutch navigators in 1596 were the first Europeans who became acquainted with the Cassowary, at least there does not appear to be any indication that the Portuguese, who visited the East-Indian Archipelago long before, came across the bird. For more than two and a half centuries there was no certainty as to the existence of more than one species, but in 1854 Mr. Thomas Wall procured a specimen of *Casuarius casuarius australis* near Cape York, which was described by his brother, for the first time, in the 'Illustrated Sydney Herald'; but the description (made from memory) is as bad as it can be. In 1857 Gould described the New Britain Cassowary, in 1860 Blyth and Sclater described two new species, and since then the described forms have constantly been increasing, till they now number 20. The best general accounts are those by Salvadori in his monograph of the genus in the

'Memorie della Accademia di Torino,' and in his famous 'Ornitologia della Papuasia,' iii. pp. 473–503.

The Cassowaries are easily divided into three groups, as follows:—1. The typical group, containing two species, *Casuarius bicarunculatus* and *C. casuarius* with its seven subspecies; 2. The one-wattled Cassowaries, containing two species, *C. philipi* and *C. unappendiculatus*, with four subspecies; 3. The Mooruks, which number four species—*C. papuanus* with two subspecies, *C. picticollis* with two subspecies, *C. bennetti* with two subspecies, and *C. loriæ*. These three groups are readily separable externally and anatomically. Mr. Pycraft's memoir will detail the anatomical features. The external characters may be roughly designated thus:—

Casque compressed laterally, two wattles on fore-neck	TYPICAL GROUP.
Casque depressed posteriorly, sometimes compressed laterally, one wattle on fore-neck	ONE-WATTLED CASSOWARIES.
Casque depressed posteriorly, no wattle on fore-neck	THE MOORUKS.

In the typical group the species *Casuarius casuarius* and its subspecies vary enormously in the height and slope of the casque; and although in the "Key" to the species I have stated that certain forms are distinguished by a high or low casque, the fact remains that we often have greater differences among individuals of one subspecies than between two subspecies. Also we often find that males of one given subspecies show, as a rule, much higher and more erect casques, while the females have the casque lower and sloping back over the occiput. There is no doubt that certain differences exist in these two characters among the subspecies and species of the *Casuarius casuarius* section; but too much weight cannot and must not be placed on these differences: first, because there is considerable individual variation; secondly, because there is sexual variation; and, thirdly, because the period of growth seems variable (at least in captivity). I have seen young birds still in brown plumage with enormous casques, while fully adult birds with black plumage showed hardly any casque at all.

I have to thank Drs. Finsch, Gestro, Giglioli, and Heck, Count Salvadori, Dr. Sclater, Mr. Blaauw, and others, for their kind help in lending me specimens, drawings, &c.

Key to the Species and Subspecies of the Genus Casuarius.

1	Plumage striped. *Chicks.*	
	Plumage brown. *Immature.*	
	Plumage black. *Adult.*	2.
2	Two wattles on fore-neck; casque not depressed posteriorly, but compressed laterally	3.
	One wattle on fore-neck; casque depressed posteriorly or compressed laterally	8.
	No wattle on fore-neck, casque depressed posteriorly . .	11.

3	Wattles wide apart on sides of neck	*C. bicarunculatus.*
	Wattles close together on front of neck	4.
4	Size large; wattles very large, above 5 inches long	5.
	Size large; wattles medium, 3 inches or less, or small	6.
	Size small; casque low, sloping, and less erect; sides of neck anteriorly bluish purple, posteriorly red	*C. casuarius.*
	Size small; casque very high	7.
5	Sides of neck anteriorly bright blue, posteriorly scarlet	*C. casuarius sclateri.*
	Sides of neck anteriorly bluish purple, posteriorly scarlet	*C. casuarius australis.*
6	Casque low but very large, wattles joined at base; sides of neck anteriorly blue, posteriorly scarlet	*C. casuarius beccarii.*
	Casque low, not very large, wattles separate at base; sides of neck purplish mauve	*C. casuarius violicollis.*
7	Sides of neck entirely blue	*C. casuarius intensus.*
	Sides of neck anteriorly blue, posteriorly scarlet	*C. casuarius salvadorii.*
8	Fore-neck blue, wattle crimson and blue; casque very high, compressed laterally, depressed posteriorly	*C. philipi.*
	Fore-neck blue in front, orange-scarlet at the sides; wattle blue	*C. unappendiculatus rufotinctus.*
	Fore-neck orange or yellow, wattle yellow or livid	9.
9	Casque depressed posteriorly, not compressed laterally	10.
	Casque compressed laterally, fore- and hind-neck and sides of the neck uniform orange	*C. unappendiculatus aurantiacus.*
10	Casque low, the blue not extending below chin, naked sides of neck yellow veined with red	*C. unappendiculatus.*
	Casque very high, the blue extending on to the throat, naked sides of neck crimson	*C. unappendiculatus occipitalis.*
11	Fore-neck blue	12.
	Fore-neck red, throat pink	*C. loriæ.*
12	Hind-neck scarlet	13.
	Hind-neck blue	14.
13	Large black patch on side of throat below ear surrounded by a broad pink band	*C. papuanus edwardsi.*
	No black and pink patch on sides of throat	*C. papuanus.*
14	Head and neck blue, sides of neck black with pink between the wrinkles	*C. bennetti.*
	Head and neck blue, round patch on fore-neck and sides of neck rosy purple	*C. bennetti maculatus.*
	Head whitish blue, fore- and hind-neck blue, sides of neck purplish red	15.
15	Fore-neck entirely blue	*C. picticollis hecki.*
	Fore-neck with red patch in centre	*C. picticollis.*

1. Casuarius casuarius (L.). Common or Ceram Cassowary. (Plate XXII.)

1603. *Avis Eme* Aldrovand., Orn. iii. p. 541 (Banda, brought to Holland by Schellinger, who obtained one in Java: very bad figure).
1605. *Emeu* Clusius, Exotic. lib. v. p. 98 (good figure, taken from same specimen).
1635. *Emeu* Nieremberg, Hist. Nat. p. 218 (fig.).
1666. *Casuar* Olearius, Gottorffische Kunstkammer, p. 23, pl. xiii. (alive in Gottorff; figure copied from Clusius).
1666–1699. *Casoar* Perr. & Duvern., Mém. Ac. Sc. depuis 1666–1699, iii. 2, p. 155, pls. 56, 57 (*teste* Salvadori);
1770. Buffon, Hist. Nat. Ois. i. p. 464.
1676. *Emeu* Ray & Willughby, Orn. p. 105, pl. xxi.
1726. *Kazuwaris* (Ceram), Valentyn, Oud en nieuw Oost-Indien, iii. (Amboina), p. 298.
1738. *Cassowary* or *Emeu* Albin & Derham, Nat. Hist. B. ii. p. 56, pl. lx. (alive at George Tavern, Charing Cross).
1745. *Emeu* Barrère, Orn. spec. nov. class. 3, gen. xxxviii. 1.
1750. *Casearius* Klein, Hist. Av. Prodr. p. 17.
1752. *Cela* Moehring, Avium Genera, no. 56.
1755. *Emeu* Worm, Mus. Worm. p. 292.
1756. *Avis Emeu* Johnston, Theatr. Univ. de Avibus, p. 180, pl. 56.
1758. *Struthio casuarius* Linnæus, Syst. Nat. ed. x. i. p. 155;
1766. Id., Syst. Nat. ed. xii. i. p. 265;
1788. Gmelin, Syst. Nat. i. p. 726, no. 2.
1760. *Casoar* Brisson, Orn. v. p. 10, pl. i. fig. 2.
1763. *Casuarius* Frisch, Vorstell. Vög. ix. Hauptart. 1, pl. 105, 105 *a* (good fig. bird and egg).
1790. *Casuarius emeu* Latham, Ind. Orn. ii. p. 664;
1817. Dum., Dict. Sc. Nat. vii. p. 199;
1828. Lesson, Voy. Coq., Zool. i. pt. 2, p. 711 (partim!);
1831. Id., Traité d'Orn. p. 7, pl. ii. fig. 1 (partim!);
1845. Thienemann, Fortpfl. ges. Vögel, p. 2, pl. i. fig. 1 (egg);
1873. Schlegel, Mus. P.-B., *Struthiones*, p. 9.
1790. *Casuarius galeatus* Bonn. Enc. Méth. i. p. 4, pl. iv. fig. 2;
1816. Vieillot, Nouv. Dict. Hist. Nat. v. p. 345, pl. B. 11. fig. 1;
1819. Merrem, Abhandl. Berl. Akad. p. 179;
1819. Stephens in Shaw's Gen. Zool. xiv. 2, p. 432, pl. 29;
1825. Vieillot, Gal. Ois. ii. p. 77, pl. 225;
1826. Merrem in Ersch & Gruber's Encycl. xv. p. 348;
1859. A. v. Homeyer, Journ. f. Orn. p. 365;
1860. Sclater, Proc. Zool. Soc. Lond. pp. 210, 250;
1860. Des Murs, Tr. d'Oologie, p. 362;
1861. Rosenberg, Journ. f. Orn. p. 45;
1862. Crisp, Proc. Zool. Soc. Lond. p. 137;
1862. Sclater, Trans. Zool. Soc. Lond. iv. p. 358, fig. *a*, p. 360 (note), pl. 71;

1862. Schlegel, Jaarb. zool. Genootsch. Nat. Art. Mag. p. 196;
1863. Sclater, Proc. Zool. Soc. Lond. p. 234;
1864. Schlegel, Dierent., Vogels, p. 238;
1866. Sclater, Proc. Zool. Soc. Lond. p. 168;
1867. Id., op. cit. p. 179 (hatched in Society's Gardens);
1869. Wallace, Malay Archip. ii. p. 156;
1871. Flower, Proc. Zool. Soc. Lond. pp. 32–35;
1873. Garrod, Proc. Zool. Soc. Lond. p. 644;
1873. Rosenberg, Journ. f. Orn. p. 390;
1875. Sclater, Proc. Zool. Soc. Lond. pp. 86, 87;
1877. Harting, Ostriches & Ostr. Farm. p. 103, plate;
1879. Rosenberg, Malay. Arch. p. 323;
1881. Sclater, Voy. 'Challenger,' Birds, p. 64;
1881. Salvadori, Mem. R. Ac. Sc. Torino, (2) xxxiv. p. 188, pl. i. fig. 2;
1882. Id., Orn. Pap. e Molucc. iii. p. 479;
1891. Thébault, Bull. Soc. Phil. (8) iii. pp. 198–210;
1891. Salvadori, Mem. R. Ac. Sc. Torino, (2) xlii. p. 213;
1894. Schalow, Journ. f. Orn. p. 18 (egg);
1895. Salvadori, Cat. B. Brit. Mus. xxvii. p. 592;
1896. Oustalet, Nouv. Arch. Mus. Paris, (3) viii. p. 263 (one menagerie bird only in Museum).
1811. *Casuarius casuarius* Illiger, Prodr. Mamm. et Av. p. 247.
1842. *Hippalectryo indicus* Gloger, Hand- u. Hilfsb. p. 452;
1844. *Casuarius orientalis* S. Müll., Land- en Volkenk. p. 109 (partim!).
1872. *Hippalectryo casuarius* Sundev., Tentamen, p. 152.
1875. *Casuarius javanensis* (sic!) Gulliv., Proc. Zool. Soc. Lond. pp. 478, 488.
1879. *Casuarius beccarii* (non Sclater!) Pelzeln, Ibis, 1879, pp. 376, 377;
1881. Id., Ibis, p. 401 (egg).

Native name: called *Suwari* by the Malays; but it is not certain if this is a local name on Ceram, or, what is more likely, a word used for all Cassowaries in the trade and of Papuan origin.

Adult. Bill long; casque large, not very high, and somewhat sloping backwards, compressed laterally, of a dark brownish horn-colour. Head and occiput Nile-blue, becoming darker on the upper part of the hind-neck. Lower two-thirds of hind-neck scarlet. Chin, throat, and fore-neck dark blue. On the lower fore-neck are two large lappet-shaped wattles, joined at their base, rugose, granulated, and of a deep pink colour. Naked lower sides of neck bluish purple anteriorly and bright scarlet posteriorly. Lores black; iris dark brown; legs brownish grey. Plumage black. Size medium.

Total length about $1\frac{1}{2}$ m., bill from gape 98 mm., tarsus 250 to 275 mm., claw of inner toe 70–78 mm.

Young (two-fifths grown). Plumage of various shades of yellowish brown to rufous brown. Head and fore-neck dull leaden blue, hind-neck dull yellow, naked lower sides of neck a mixture of dull blue and livid purple.

Young (three-fifths grown). Plumage yellowish or rufous brown mixed with black. Fore-neck dull indigo-blue; head and occiput pale dull blue; hind-neck dull orange-red, naked lower sides of neck blue, posteriorly mixed livid purple and dull red.

Young (full-grown). Plumage black, mixed with a few rufous feathers. Fore-neck indigo-blue; head and occiput pale blue; hind-neck scarlet, naked lower sides of neck blue anteriorly, passing through plum-purple to scarlet posteriorly.

Chick. Head and neck rufous, paler below; three broad stripes on back, one irregular stripe on each side reaching from the anus to the wing, and two other lateral stripes extending to the thighs, the last two broken up into irregular blotches.

Hab. Ceram.

As shown in the synonymy, the Ceram Cassowary is the oldest known member of the genus. In the year 1595 a number of merchants in Amsterdam formed a company, and sent out four vessels to open communication with the Eastern Archipelago and to bring home spices and other valuable merchandise. In December 1596 the ships were anchored at Sydayo, in Java, and it was there that Jan Jacobsz Schellinger, the skipper of the ship 'Amsterdam,' was presented with a Cassowary, which had been brought to Java from Banda Island. This was a day or two before Schellinger was murdered by the chief of Sydayo. Although the ship 'Amsterdam' was left and burnt, the wonderful "large fowl" was brought on board of one of the other vessels and was landed alive at Amsterdam in 1597. It was at first exhibited to the public for some months, then came into the hands of Count George Everard Solms, of s'Gravenhage, who kept it for a long time at the Hague, and afterwards presented it to the Elector, Prince Ernestus of Cologne, who, again, subsequently gave it to the Emperor Rudolphus the Second. Count Solms, before parting with the bird, had an excellent coloured picture made of it, from which the very good figure in Clusius, representing the bird, one of its feathers, and an egg, was taken. This figure has been copied into several other works. A wretched figure of the same bird was also published in the diary of the long and dangerous voyage during which it was first observed by Europeans, and this figure is reproduced by Aldrovandus. In 1666 Olearius, in his somewhat despicable work 'Die Gottorffische Kunstkammer,' assures us that one had been kept alive at Gottorff in Schleswig; but he does not say how it was procured. Olearius's description is very amusing, but short and not very accurate. Valentyn (1726) seems to have been the first to give the actual home of this bird, which is Ceram. He says that some Dutchmen found it sitting on three eggs on that island as long ago as 1660. Valentyn also says that the Cassowary occurring in Aru differs from that of Ceram. Other writers have stated Sumatra, Ceylon, and all sorts of places to be inhabited by Cassowaries, and even Linnæus said: "Habitat in Asia, Sumatra, Molucca, Banda." Up to the present day erroneous statements respecting the home of *Casuarius casuarius* have often been made, but it is evident that of all the Moluccan islands only Ceram is inhabited by a Cassowary.

Linnæus, in 1758, bestowed our present specific name on this bird, calling it *Struthio casuarius*, and diagnosing it as "*Struthio pedibus tridactylis, vertice pleari-busque nudis.*" He then quotes Olearius, Albin, Dodart, Ray, Clusius, Bontius, Willughby, Aldrovandus, and finally adds: "Callus elevatus quasi diadema verticis. Palearia duo sub collo; collum a tergo nudum. Ungue intermedia majore ferit; ova punctis excavatis."

The species is admitted by Wallace and Rosenberg to be not at all rare in the interior of Ceram, but all travellers say that it is extremely shy and difficult to approach, and it seems that no European naturalist has ever seen it in its wild state. All we know about its life-history comes from native sources, and may be more or less trustworthy, but it seems certain that it feeds principally on fallen fruit. The eggs are said to be three to five in number; but we have had, at Tring Park, six to eight laid by one female, so that we cannot believe that its clutch can regularly contain three eggs only. A young *Casuarius casuarius* was hatched in the Society's Gardens in 1867, but observations respecting the time of incubation and other interesting points were apparently not made. I have never succeeded in getting a male that would pair, although I have had a female which laid many eggs. The egg described by Schalow (Journ. f. Orn. 1894, p. 19) is faded. There is, I am convinced, not a single form of Cassowary that lays "pale greyish-green" eggs with "dark grey-green" glazed granulations. In any case *Casuarius casuarius* lays light apple-green eggs, with darker bright green corrugations. They are elliptical, the thickest zone about the centre, though very often a thick and a thin end can be distinguished. The elevated glazed granulations are all more or less connected, forming a labyrinthic network. The measurements are:—150 : 94, 142 : 93, 140 : 90, 131 : 90, 129 : 87, 123 : 84, 145 : 85 mm.

The eggs are excellent food. Owing to their size it is difficult to boil them well in the shell, and besides it requires a number of persons to finish one; but for scrambled eggs, omelettes, cakes, and other purposes they are, like those of the Rhea and Emu, most excellent.

2. CASUARIUS CASUARIUS BECCARII Scl. Beccari's Cassowary. (Plate XXIII.)

1875. *Casuarius beccarii* Scl., Proc. Zool. Soc. Lond. p. 87, figs. 1, 2 on p. 86 (Vokan, Aru Islands!);
1877. Forbes, Proc. Zool. Soc. Lond. pp. 307, 316 (anatomy);
1878. A. B. Meyer, Journ. f. Orn. p. 300; Salvad. Ann. Mus. Civ. Genoa, xii. p. 421;
1881. Salvad., Mem. R. Ac. Sc. Torino, (2) xxxiv. p. 197 (partim: Aru only);
1882. Id., Orn. Papuas. e Molucc. iii. p. 484 (partim: Aru);
1894. Schalow, Journ. f. Orn. p. 21 (egg, Aru);
1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 596 (partim: Aru).
1875. (?) *Casuarius bicarunculatus* (non Scl.!) Beccari, Ann. Mus. Civ. Gen. vii. p. 717 (Aru).

1881. (?) *Casuarius galeatus* (non Bonn.!) Scl., Zool. Voy. 'Challenger,' Birds, p. 64 (young, bought in Ternate—seem to be young of *C. c. beccarii* from the Aru Islands; cf. Cat. B. Brit. Mus. xxvii. p. 597).

1884. (?) *Casuarius* sp. A. B. Meyer, Zeitschr. ges. Orn. i. p. 296 (egg from Aru—as there are, however, several Cassowaries inhabiting the Aru Islands, there is no certainty whatever about an egg without history!).

Adult. Plumage black; casque very high, broad and massive, dark brown; bill long and not pointed. Head and occiput pale greenish blue. Upper part of hind-neck deeper blue, followed by a space of mixed blue and red, producing a somewhat livid pale purple effect. Lower part of hind-neck scarlet. Chin, throat, and fore-neck dark blue. Wattles large, broad, and very conspicuously joined at base, of a deep fleshy-red colour, which colour runs up in a narrow line nearly to below the ear. Naked lower sides of neck mixed red and blue. A very large bird, but I have not been able to measure a fully adult dead example.

Young (three-fourths grown). Fore-neck indigo-blue, head and occiput pale blue; hind-neck orange-yellow, with a purple patch between blue and orange. Naked lower sides of neck, anterior half dull blue, posterior half orange-yellow. Plumage brown.

Young (about full-grown). Same as adult, only colours less bright and plumage brown.

Hab. Vokan, Aru Islands.

Dr. Sclater (P. Z. S. 1875, p. 87) first recognized the Aru Cassowary as a distinct species, and gave a woodcut, showing a side view of the head and the wattles from in front, accompanied by the following diagnosis:—

"Casuarius *similis* C. australi *et crista pari modo elevata: sed caruncula cervicis una media, ad apicem divisa.*

"*Hab.* Wokan, inss. Aroensium (*Beccari*).

"*Mus.* civit. Genoensis."

In the same volume our author also mentions a Cassowary from the south coast of New Guinea, of which he believes that it "probably is of the same species as that of the Aroo Islands," namely *C. beccarii.* This specimen was afterwards described as *C. sclateri*, but later on reunited with *C. beccarii*, and so it has remained also in the 'Catalogue of Birds.' However, I am fully convinced that the form from Southern New Guinea can be separated from that from the Aru Islands, where it inhabits, so far as we know, only the northern island of the Vokan group.

I am not able to give descriptions of well authenticated eggs of Beccari's Cassowary, but there is an enormous egg in the British Museum from the Aru Islands, which is named *C. bicarunculatus*, which, however, from its large size I am more inclined to believe is that of either *C. c. beccarii* or *C. c. violicollis.* It measures 140 : 98 mm. Its granulations are low.

Schalow (*l. c.*) describes an egg brought from the Aru Islands by C. Ribbe, measuring

128 : 89 mm. It is, however, not ascertained that it is an egg of *C. c. beccarii*, which, as we know, is not the only Cassowary living in the Aru group. That the eggs of any Cassowary are more transparent than those of any other species is evidently not the case.

3. Casuarius casuarius sclateri Salvad. D'Albertis's Cassowary.

1844. *Casuarius* sp. S. Müll., Land- en Volkenkunde, p. 22 (Utanata, Princess Marianne Strait).
1875. *Casuarius beccarii* (non anteà, p. 87, quod Aru!) Scl., Proc. Zool. Soc. Lond. p. 527, pl. lviii. (S. New Guinea);
1880. *Casuarius beccarii* (non Scl., P. Z. S. 1875, p. 87!) D'Albertis, Nuova Guinea, pp. 494, 588;
1881. Salvadori, Mem. R. Ac. Sc. Torino, (2) xxxiv. p. 197 (partim: New Guinea only), pl. i. fig. 5;
1882. Id., Orn. Papuas. e Molucc. iii. p. 484 (partim: New Guinea only!);
1895. Id., Cat. B. Brit. Mus. xxvii. p. 596 (partim: New Guinea only).
1877. *Casuarius australis* (non Wall!) D'Albertis, 'Sydney Mail,' p. 143; id., Ann. Mus. Civ. Genova, x. p. 19 (Fly River); id., Ibis, p. 372.
1878. *Casuarius sclateri* Salvad., Ann. Mus. Civ. Gen. xii. p. 422 (coast opposite to Touan or Cornwallis Island, S.E. New Guinea); A. B. Meyer, Journ. f. Orn. p. 300;
1879. Sharpe, Ibis, p. 116 (type now preserved in Brit. Mus.!).

Adult. Casque dull brown, very high and much compressed laterally, very thin, and when fully adult curved over to one side. Bill long and stout, black. Wattles very large and long, sometimes over 7 inches, but in the old birds they get torn and damaged either in fighting or when creeping through the thick scrub, so that often they are very short or split into a number of ragged ribbon-like appendages. This is well illustrated in the series of figures of D'Albertis's fine specimens in Count Salvadori's monograph. This is the largest form of the *C. casuarius* group and also the largest Cassowary, standing, when erect, as much as 6 feet high and the body being fully half as big again as that of an Emu (*Dromæus*). Plumage black, head and occiput pale whitish blue. Fore-neck and nape brilliant indigo-blue. Hind-neck of a most intense bright scarlet. Naked lower sides of the neck, posterior $\frac{2}{3}$ brilliant scarlet, anterior $\frac{1}{3}$ bright blue. Total length about 1600 mm., bill from gape 130 to 140 and even 145 mm., tarsus 280 to 300 mm., inner claw 80 to 95 mm.

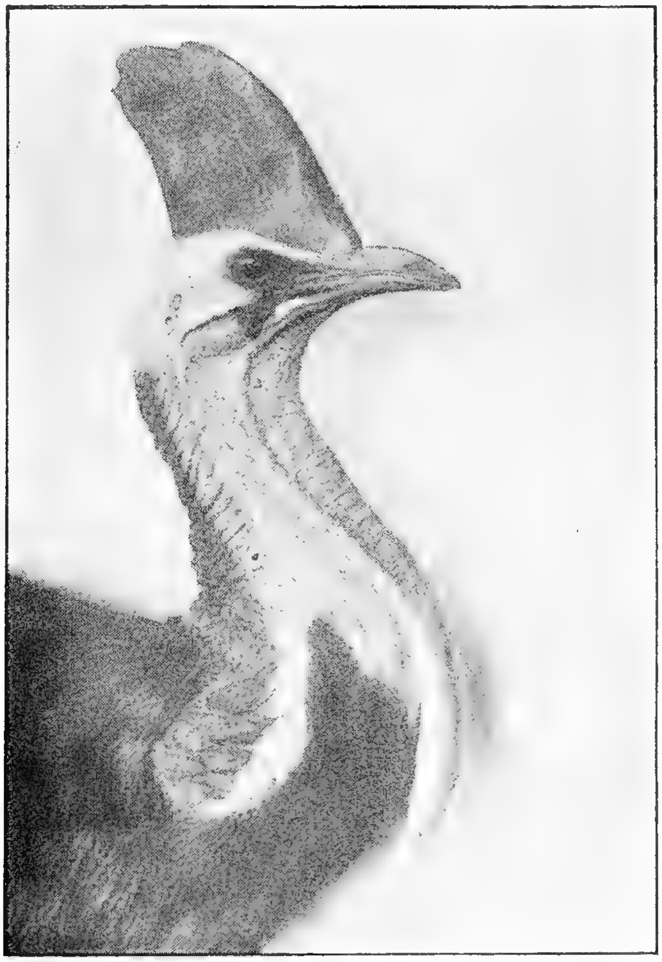
Juv. (two-thirds grown). Plumage dark brown, often nearly as black as adult, also occasionally pale yellowish brown. Fore-neck leaden blue; head and occiput pale blue. Hind-neck dull orange-yellow. Naked lower sides of neck, anterior $\frac{1}{3}$ blue, posterior $\frac{2}{3}$ yellow.

Chick. Head and neck dark rufous, variegated with black bands and spots. Longitudinal dorsal bands very broad, about $1\frac{1}{2}$ inches wide, black, slightly variegated with rufous, and 5 in number—*i. e.*, a central one and two lateral pairs; one band on flank extending down the thigh on each side, and a second one indicated by a number of dark brown irregular spots.

Hab. Southern New Guinea from Port Moresby to the Princess Marianne Strait, and perhaps even up to McCluer's Inlet.

I have had several examples of this bird alive, though none quite adult. They appear to be delicate and never to live long, and none ever seem to reach the size in captivity which the species attains in a wild state. Adult wild specimens of this race are the largest Cassowaries known. The fine adult bird from which the description and accompanying photograph were taken was shot by Mr. Emil Weiske on the Brown River in S.E. New Guinea.

Fig. 1.



Casuarius casuarius sclateri.

Sclater's Cassowary was at first thought to belong probably to Beccari's Cassowary; it was then separated, and afterwards united with the latter by Count Salvadori. The original diagnosis of this form is as follows:—

"Medius, niger, casside parum alta, crassa, superne rotundata, latere posteriore fere verticali, brevissimo, crasso; paleare unico, mediocri, ad apicem diviso; ungue digiti interni breviuscula; loris et mento violaceis; capite et gula cæruleis, paleare rubro.

"Long. tot. 1^m 500, rostri hiat. 147 mm., tarsi 300, ungu. dig. int. 80 mm."

A most magnificent series of this bird was procured on the Fly River by D'Albertis, and a number of woodcuts of the heads and necks of them are given in the Annals of the Genoa Museum and in Count Salvadori's splendid monograph of the genus *Casuarius*, and a coloured figure, from a sketch of D'Albertis, on plate i. (fig. 4) of the same work.

Some eggs from near Port Moresby, which I received together with a chick, are covered with glossy glazed granulations, which are not at all connected, but stand more or less separated from each other. They are bright green, and measure 150 : 103, 146 : 100, 146 : 97, and 146 : 95 mm.

4. CASUARIUS CASUARIUS SALVADORII Oust. Salvadori's Cassowary. (Plate XXIV.)

1875 ?. *Casuarius tricarunculatus* Beccari, Ann. Mus. Civ. Genova, vii. p. 717 (Warbusi);
1878. Salvad., Ann. Mus. Civ. Genova, xii. pp. 419, 420;
1881. Salvad., Mem. R. Ac. Sc. Torino, (2) xxxiv. p. 184;
1882. Salvad., Ann. Mus. Civ. Genova, xviii. p. 413;
1882. Salvad., Orn. Pap. e Molucc. iii. p. 473;
1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 591;
1896. Oustalet, Nouv. Arch. Mus. Paris, (3) viii. p. 263 (type in Mus.).
1878. (Feb. 23rd.) *Casuarius salvadorii* Oustalet, Bull. Assoc. Sc. de France, Bull. no. 539, p. 350 ("Warbusi");
1878. Scl., Proc. Zool. Soc Lond. pp. 213, 214, fig. 213 (Wandammen; head and neck); A. B. Meyer, Journ. f. Orn. p. 202; Salvad. Ann. Mus. Civ. Genova, xii. p. 420;
1879. Salvad., Ibis, p. 105;
1881. Salvad., Mem. R. Ac. Sc. Torino, (2) xxxiv. p. 204, pl. i. fig. 5;
1882. Salvad., Orn. Papuas. e Molucc. iii. p. 488 (footnote);
1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 595.
1878. *Casuarius altijugus* Scl., Nature, xvii. p. 375 (Wandammen);
1879. Salvad., Ibis, p. 105.

Adult. Plumage black; casque high, brownish black; bill thick, long, and not pointed. Head and upper part of hind-neck pale greenish blue, rest of hind-neck scarlet. Naked lower sides of neck blue anteriorly, purplish crimson posteriorly. Chin, throat, and fore-neck deep blue. Wattles small and widely separated, base and inner half blue, rest dark fleshy pink. Total length about $1\frac{1}{2}$ m., tarsus 300 to 316 mm., bill from gape 150 to 190 mm., inner claw about 80 mm.

Chick. Head and neck rufous; rest of body creamy white or pale buff, with three longitudinal dorsal black bands variegated with rufous. The three lateral stripes along the flanks and thighs are broken up into a number of irregular brown spots and patches.

Hab. North-west New Guinea.

Casuarius casuarius salvadorii was originally described by Oustalet and Sclater as *C. salvadorii* and *C. altijugus* respectively, from skins obtained by Laglaize near Wandammen on the south-west coast of Geelvink Bay, in North-west New Guinea;

and to this day we know nothing absolutely certain as to the colour of the naked parts of wild-shot Arfak birds; but there are a certain number of birds sent alive to Europe as coming from New Guinea, and which agree neither with *Casuarius casuarius* from Ceram, nor with *C. c. beccarii* from Aru, nor *C. c. sclateri* from Southern New Guinea in colour, and these birds I, for the present, take to be *Casuarius casuarius salvadorii* as they agree in other respects.

The bird from which I made the above given description lived two years at Tring and one year in the Society's Gardens. It is fully adult, and a male. I have had several younger ones, but none lived to maturity.

The bird shortly mentioned by Beccari in his ornithological letter (Ann. Mus. Genova, vii.) as agreeing in the form of the helmet with *C. casuarius*, but having three wattles, namely, two lateral ones, and below these a smaller median third one, was a young bird bought at Warbusi, a little to the south of Dorei. It was left at Ternate to grow up, where Laglaize saw it still alive in July 1877, but it was eventually lost. It must, in my opinion, have been an aberration of *C. c. salvadorii*. Oustalet says that the type of *C. salvadorii* came also from Warbusi, at the bottom of Geelvink Bay. Warbusi, however, is near Dorei, while Wandammen is the place at the southern end of the Bay whence the other specimens from Laglaize were said to come. Therefore Salvadori (1881) thinks that Warbusi might be a mistake for Wandammen; but I see no reason why it should not be correct, since *C. tricarunculatus* is not a species according to my judgment, as I have a similar aberration of *C. c. sclateri*. Laglaize probably bought his specimens from Bruijn or his hunters.

When excited these birds extend the neck horizontally and emit five or six very loud grunting and grating sounds; frequently, when very angry, they spit several times, elevate their wing-rudiments and the feathers of the hind-quarters, and peck and kick most viciously.

5. CASUARIUS CASUARIUS INTENSUS Rothsch. Blue-necked Cassowary. (Plate XXVII.)

1898. *Casuarius casuarius intensus* Rothsch., Bull. B. O. Club, viii. (nos. lviii., lxiv.), pp. xxi, lv.

Adult. Casque very high and laterally compressed, dark brown; bill pointed, short, black. Plumage black. Size small. Occiput, nape, upper half of hind-neck, chin, throat, and fore-neck deep brilliant blue. Lower half of hind-neck brilliant scarlet; between the blue and red of the hind-neck an irregular black patch. Naked lower sides of neck of an intense blue. Two wattles on fore-neck medium-sized, oval, close together, but separated their entire length, blue outer edge, and a few small spots pink. Bill from gape about 110 mm., tarsus 275 mm., greatest length of helmet 130 mm.

Young (half-grown). Plumage brown; head and neck dull blue; lower hind-neck dull orange-yellow. Lower naked sides of neck blue.

Young (three-fourths grown). Plumage brown, mixed with a few black feathers. Fore-neck dark blue; head and occiput indigo-blue, paler round ear. Lower hind-neck orange-red. Lower naked sides of neck bright blue.

Young (full-grown). Plumage black, mixed with brown feathers. Head and neck deep blue, paler around the ear; lower hind-neck scarlet. Naked lower sides of neck very bright blue.

Hab. unknown.

In addition to the type I have had five others alive, and they all agreed in having the intense blue colour and the entirely blue naked lower sides of the neck; but this Cassowary remains still a very little-known form, and will do so till its habitat is discovered. The original description is as follows:—

"♂ *ad.* The casque differs from that of *C. casuarius* in being very high and much more erect; the wattles almost entirely blue instead of dark red; the blue of the head and neck uniform and very dark; the orange of the hind-neck much restricted and separated at the upper end from the blue by a black crescent-shaped patch; naked sides of lower neck entirely uniform blue instead of red, bordered anteriorly with blue."

6. CASUARIUS CASUARIUS VIOLICOLLIS Rothsch. Violet-necked Cassowary. (Plate XXVI.)

1899. *Casuarius casuarius violicollis* Rothsch., Bull. B. O. C. viii. (nos. lix., lxiv.) pp. xxvii, lv.

Adult. Casque low, sloping back very much, laterally compressed, horny brown, green at base. Bill very long, straight and pointed. Plumage black. Face bluish green. Occiput and upper hind-neck pale greenish blue, throat and fore-neck brilliant deep blue. Hind-neck orange-scarlet. Naked lower sides of neck bright violaceous mauve, bordered anteriorly with a narrow line of blue, posteriorly with a narrow line of scarlet. Two wattles on fore-neck large, round, and close together in female; small, long, and wide apart in male, blue at base, rest fleshy pink.

Juv. (half-grown). Plumage brown; neck and head dull leaden blue; hind-neck dull gamboge-yellow; lower naked sides of neck dirty flesh-pink.

Juv. (three-fourths grown). Plumage brown, with a few black feathers; head and occiput pale dull blue; fore-neck dull indigo; hind-neck orange; lower naked sides of neck dark pink streaked with purplish red.

Hab. ? Trangan Island, Aru Islands.

The type of the species was imported along with two specimens of *C. bicarunculatus* from Aru, and is a female, for she has laid an egg; but I have since received seven others of this form, and they all agree in their characters. As the other islands of the group are inhabited by different forms of Cassowaries, I am inclined to think that Trangan Island must be the home of this interesting form.

I described this form at the January meeting of the British Ornithologists' Club in 1899 as follows:—

"This apparently undescribed form of Cassowary is most nearly allied to *Casuarius casuarius salvadorii*, but differs conspicuously in the colour of the naked parts and in the very large size, which fully equals that of *C. c. australis*.

"Bill much longer and straighter than in other Cassowaries. Casque horny brown, green at base. Face and a broad band running down the side of the bill bluish green. Base of lower mandible dark blue, with a yellow line running along one-third of the length of the mandible on each side. Wattles at base of fore-neck very large, round, and short, 3 × $2\frac{1}{4}$ inches, pale blue at base, otherwise pink all over, entirely separate for their whole length, but close together. Auricular orifice larger than in any other Cassowary. Throat and fore-neck bright ultramarine-blue. Occiput and upper hind-neck pale greenish or eau-de-Nil blue. Lower hind-neck brilliant orange-scarlet. Naked lower sides of neck magenta-purple, bordered anteriorly with ultramarine-blue, posteriorly with orange-scarlet; the magenta-purple space deeply carunculated and sharply cut off from the red and blue borders, which are plain and smooth."

The "song" of this bird is an extraordinary performance, generally as follows:—

It lowers its head and neck and remains in this position—with head and neck stretched out straight in front—for about fifteen seconds, with the bill open and gradually inflating its neck, without making a sound; then, bowing and jerking its head so that the bill and wattle clap together, it emits some barking grunts, apparently with great effort, the skin of the neck being then so much inflated that the wrinkles become quite obscure.

The type specimen laid an egg last year, which is, needless to say, bright green; but its shell is not properly developed, and a description of the surface and size is therefore better omitted.

7. Casuarius casuarius australis Wall. The Australian Cassowary. (Plate XXV.)

1854. *Casuarius australis* Wall, Illustr. Sydney Herald of June 3rd;
1857. Gould, Proc. Zool. Soc. Lond. pp. 269, 270;
1858. G. R. Gray, Proc. Zool. Soc. Lond. p. 196;
1860. Scl., Proc. Zool. Soc. Lond. p. 210; Ibis, p. 310;
1862. Scl., Trans. Zool. Soc. Lond. iv. p. 360; Schleg. Jaarb. zool. Genootsch. Nat. Art. Mag. p. 200;
1865. Gould, Handb. B. Austr. ii. p. 206;
1866. Schleg., Zool. Gart. p. 180; Scl. Proc. Zool. Soc. Lond. p. 557;
1867. Scl., Proc. Zool. Soc. Lond. p. 242 (*C. johnsoni=australis*); Bennett, Proc. Zool. Soc. Lond. p. 473;
1868. Scl., Proc. Zool. Soc. Lond. p. 376; Ibis, p. 348;
1868. Ramsay, Proc. Zool. Soc. Lond. pp. 381, 388;
1869. Gould, B. Austr., Suppl. pls. 70, 71; Krefft, Ibis, p. 348;
1870. Editors, Ibis, pp. 119, 120;
1871. G. R. Gray, Hand-list B. iii. p. 2, no. 9851; Flower, Proc. Zool. Soc. Lond. p. 32 (skeleton); Scl., Proc. Zool. Soc. Lond. p. 547 (in confinement);
1873. Schleg., Mus. Pays-Bas, *Struthiones*, p. 9;
1874. Ramsay, Proc. Zool. Soc. Lond. p. 325;
1875. Scl., Proc. Zool. Soc. Lond. p. 85;

1876. Ramsay, Proc. Zool. Soc. Lond. p. 119 (life-history) ; Rams., Proc. Linn. Soc. N. S. Wales i. p. 186 ;
1877. Rams., Proc. Linn. Soc. N. S. Wales, ii. pp. 196 (distribution), 376 (woodcuts of head) ; Harting, Ostr. & Ostr. Farming, p. 95 ; Salv. & Scl., Ibis, p. 327 ;
1881. Salvad., Mem. R. Ac. Sc. Torino, (2) xxxiv. p. 192, pl. i. fig. 3 (head) ;
1882. Salvad., Orn. Pap. e Molucc. iii. p. 473 ;
1888. Rams., Tabul. List Austr. B. p. 19 (distribution) ;
1889. Lumholtz, Among Cannibals, pp. 98, 99 ;
1890. North, Nests & Eggs Austr. B. p. 294, pl. xv. (egg) ;
1891. Sharpe, Cat. Osteol. Spec. R. Coll. Surg. iii. p. 439 ;
1892. Schalow, Zeitschr. f. Ool. p. 11 ;
1894. Schalow, Journ. f. Orn. p. 24 ;
1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 594 ;
1896. Meston, Proc. Roy. Soc. Queensland, x. pp. 59–64.
1866. *Casuarius johnsonii* F. Müller, Australasian of Dec. 15th (*cf.* Proc. Zool. Soc. Lond. 1867, pp. 241, 242) ;
1867. Carron & Bennett, Proc. Zool. Soc. Lond. pp. 473, 474 ; Krefft, Proc. Zool. Soc. Lond. p. 482 ; Diggles, Orn. Austr. pl. & text ;
1868. A. Newton, Ibis, p. 348 (critical note on Diggles) ;
1869. Krefft, Ibis, p. 348 (maintains that *johnsoni* is correct name) ;
1870. A. Newton, Ibis, p. 120 (contends with others that the name *australis* is to be used).
1873. ? *Casuarius regalis* (nomen nudum) Rosenberg, Journ. f. Orn. p. 390.

Adult. Casque very high and massive, compressed laterally, deep brown ; bill long and stout, black. Next to *C. casuarius sclateri*, the largest of the forms of *Casuarius casuarius.* Plumage black. Sides of head, occiput, and upper hind-neck pale greenish blue ; lower hind-neck scarlet, running a little into the blue of upper portion. Chin, throat, and fore-neck deep indigo-blue. Lower naked sides of neck mixed red and blue, giving a purple hue. Two wattles on fore-neck very large, deep pinkish red, mottled with paler pink, blue at base.

Young (quarter-grown). Head and hind-neck chestnut rufous. Chin, throat, and fore-neck densely covered with short downy feathers of a brownish-buff colour. Rest of body clayey brownish yellow mixed with dark rufous.

Young (two-thirds grown). Plumage brown. Head and occiput dull pale blue ; lower hind-neck orange ; fore-neck leaden blue ; lower naked sides of neck blue, mixed with livid purple.

Chick. Head and hind-neck pale rufous ; fore-neck yellowish buff ; rest of body yellowish buff. From base of neck to end of tail along the back run three broad longitudinal black bands, variegated with rufous, and each about seven-eighths of an inch wide. On the sides are three irregular wavy black bands extending from the shoulder-girdle down the sides to the beginning of the metatarsus.

Hab. Northern Queensland.

I have kept the adult female, described above, since 1890 : she laid some 40 or 50 eggs at Tring, and has now lived nearly two years in the Society's Gardens.

The first discovery of the fact that a Cassowary existed in Australia is due to Mr. Thomas Wall, who, like so many other explorers, left his bones in the waterless deserts of the Australian continent. Wall procured a specimen, but this was lost, and only a poor description, evidently made from memory, was published in the 'Illustrated Sydney Herald' of June 3rd, 1854, by Thomas Wall's brother, William Sheridan Wall. The account ran as follows:—

"The first specimen of this bird was procured by Mr. Thomas Wall, naturalist to the late expedition commanded by Mr. Kennedy. This was shot near Cape York, in one of those almost inaccessible gullies which abound in that part of the Australian continent. The Cassowary, when erect, stands about 5 feet high. The head is without feathers, but covered with a blue skin, and, like the Emu, is almost without wings, having mere rudiments. The body is thickly covered with dark brown wiry feathers. On the head is a large protuberance or helmet of a bright red colour, and to the neck are attached, like bells, six or eight round fleshy balls of bright blue and scarlet, which give the bird a very beautiful appearance. The first, and indeed the only, specimen of the Australian Cassowary was unfortunately left at Weymouth Bay, and has not been recovered. Mr. Wall being most anxious for its preservation had secured it in a canvas bag and carried it with him to the spot where, unfortunately for himself and for science, it was lost. In the ravine where the bird was killed, as well as in other deep valleys of that neighbourhood, they were seen running in companies of seven or eight. On that part of the North-eastern coast, therefore, they are probably plentiful, and will be met with in all the deep gullies at the base of the high hills. The flesh of this bird was eaten, and was found to be delicious; a single leg afforded more substantial food than ten or twelve hungry men could dispose of at one meal. The Cassowary possesses great strength in its legs, and makes use of this strength in the same manner as the Emu. Their whole build is, however, more strong and heavy than that of the latter bird. They are very wary, but their presence may be easily detected by their utterance of a peculiarly loud note, which is taken up and echoed along the gullies; and it would be easy to kill them with a rifle."

Most incorrect as this description is, there can be no doubt that it actually refers to the Australian Cassowary, and we can therefore, in accordance with all other authorities, accept the name of *australis* for this bird, and need not substitute that of *johnsonii* for it.

This form is most closely allied to the Ceram Cassowary and to Sclater's Cassowary. The key, descriptions, and plates, however, will show the differences.

This bird is known only from Northern Queensland, from Cape York south to Rockingham Bay. Of no other Cassowary are we so well acquainted with the life-history. The most complete description of the latter is that of Ramsay in the Proc. Zool. Soc. Lond. 1876, pp. 119–123. It runs as follows:—

"One of the chief objects of my visit to Rockingham Bay was to become acquainted with the habits of this noble bird. In 1872 I had sent my collector, Edward Spalding, to this district for this purpose, but with very poor results.

"While in Brisbane on my way up I purchased by telegram a fine young living specimen, the first that had been obtained and reared, and ultimately succeeded in bringing it alive to Sydney and shipping it to the Society, where I am glad to hear it arrived safely. I found also that several very young Cassowaries had been obtained, and, for the first time, a nest and eggs had been found. This was great news; and I need not relate how I made all haste to the Herbert River Police Camp, where I was most hospitably entertained and welcomed by Inspector Johnstone, who was the first to rediscover and bring under the notice of others the existence of this remarkable species. I found Inspector Johnstone a true sportsman, as well as an ardent lover of nature, a zealous and energetic naturalist, and a careful observer. I am indebted to this gentleman for much valuable information respecting the manners and customs of the aborigines, and notes on the habits of many birds and animals new to me, and especially for information on the present species.

"The Australian Cassowary is a denizen of the dense dark scrubs scattered over the district of Rockingham Bay, and extending as far north as the Endeavour River. It was tolerably plentiful only a few years ago even in the neighbourhood of Cardwell; but since the advent of sugar-planters, etc. on the Herbert River and adjacent creeks, these fine birds have been most ruthlessly shot down and destroyed for the sake of their skins, several of which I saw used for hearth-rugs and door-mats. Formerly they were easily enough procured; but latterly so wary have they become, and their numbers so decreased, that it is only with the greatest amount of patience that even a stray shot can be obtained. I know of no bird so wary and timid; and although their fresh tracks may be plentiful enough, and easily found in the soft mud on the sides of the creeks or under their favourite feeding-trees, yet the birds themselves are seldom now seen. During the day they remain in the most dense parts of the scrubs, wandering about the sides of the watercourses and creeks, diving in through the bushes and vines at the slightest noise. Toward evening and early in the morning they usually visit their favourite feeding-trees, such as the native figs, Leichardt-trees, and various species of *Acmena*, *Jambosa*, *Davidsonia*, &c.; they appear to be particularly fond of the astringent fruit of the Leichardt-trees and of a species of Maranta, which produce bunches of large seed-pods filled with juicy pulp, resembling in appearance the inside of a ripe passion-fruit (*Passiflora edulis*). Fruits and berries of all kinds are eagerly sought after; the tame semiadult bird which I had the pleasure of forwarding to the Society (1875) became so fond of the fruit of the Cape-Mulberry that he would allow no one to come near the tree he had taken possession of. This bird has frequently devoured at a time as much as three quarts of 'loquats' (fruit of *Eriobotria japonica*), and several fair-sized oranges *whole*, besides its usual amount of bread per diem (about 3 pounds). In nature, I found that in the afternoons they frequently came out and walked along the scrubs, or along the sides of the river or creeks, and swallowed large quantities of pebbles and small rough-edged stones. In confinement, plantains and sweet potatoes (in large pieces, which they swallow whole) are a favourite food, while nothing seems to come amiss to them—grasshoppers, spiders, earthworms, cockroaches, caterpillars of all kinds, dough, and even raw meat. They ascertain the flavour of their diet by first taking it up in the tip of their bill and giving it a slight pinch ; and if not suitable, they throw it away.

"I found they invariably refused green loquats, but always picked them up in the bill first to try them. In confinement they become very tame, and may be allowed to walk about the place without restraint, coming when called, or more often running after and following any one accustomed to feed them. If disappointed or teased, they not unfrequently 'show fight' by bristling up their feathers, and kicking out sideways or in front with force sufficient to knock a strong man down—a feat I have witnessed on more than one occasion. These birds are very powerful, and dangerous to approach when wounded. On more than one occasion a wounded bird has caused a naturalist to take to a tree; the sharp nail of the inner toe is a most dangerous weapon, quite equal to the claw of a large Kangaroo, and capable of doing quite as much execution.

"I found the Cassowaries to be excellent swimmers, and frequently tracked them across a good-sized creek or river. On Hinchenbrook Island, situated about 1½ mile from the mainland, they have been frequently met with; and I have myself heard them calling at night and early in the morning as I passed up the channel, at a distance of a least two miles from them. Mr. Johnstone informs me he met with one swimming across a river of considerable width during his explorations while on the 'North-east Coast Exploring Expedition.' Their note, most usually emitted by the male, is a series of harsh guttural prolonged croakings quickly repeated, and continued for about three minutes; it is very loud, and may be detected across the water at a distance of at least three miles on a still night. I have listened to it resounding through the scrubs at a distance of a mile and a half on land, and then thought it close and one of the most unearthly noises I ever heard. They breed during the months of August and September. The first nest procured was found by some of Inspector Johnstone's black troopers, from whom Mr. Miller, a settler on the Herbert River, purchased some of the eggs. One which he kindly presented to me is of the light green variety mentioned hereafter. The nest consists of a depression among the fallen leaves and débris with which the ground in the scrubs is covered, with the addition of a few more dry leaves. The place selected is always in the most dense part, and well concealed by entangled masses of vegetation. The eggs were five in number in the only two instances recorded; and in both cases one of the eggs in each set differed from the others, being of a light green colour, and having a much smoother shell. The others all have a rough shell, covered rather sparingly with irregular raised patches of dark but bright green on a lighter green and smooth ground. In the pale (No. 1) variety these raisings on the shell are closer together, and not so well developed; in both varieties they are more thinly spread over the central portion than at the ends. On the whole they closely resemble the eggs of *Casuarius bennettii*, in which similar variations are noticeable; but they are larger and of a greater diameter, being greatest in the middle. I am indebted to Inspector Robert Johnstone for the fine series of the eggs of this species which at present grace my collection.

"The following are measurements of some of the specimens of the eggs of both species:—

" *Casuarius australis.*

	Length in inches.		Width in inches.
"No. 1. Light-green smooth shell	5·33	×	3·73
No. 2. Dark-green rough shell	5·3	×	3·88

" *Casuarius bennettii.*

"No. 1. Light-green smooth shell	5·65	×	3·54
No. 2. Light-green rough shell	5·32	×	3·31
No. 3. Light-green rough shell	5·34	×	3·4
No. 4. Dark-green rough shell	5·2	×	3·32

"The young of *Casuarius australis* are of a dull rusty brown, the feathers having frequently a blackish shaft-stripe, giving to the back a streaked appearance. After the first year the plumage takes a deeper, lighter brown hue, and black feathers begin to appear mixed with brown, some being parti-coloured. After the second season, at the age of from 18 to 24 months, the black feathers predominate, and the helmet, which has hitherto been undeveloped, more like the shield of a Coot (*Fulica*), begins to show a keel or ridge in the centre, which rapidly increases in height. The skin round the head, on which still remain a few brownish hair-like feathers, begins to become wrinkled and coloured, varying from bluish-green to orange on the lower part, and bright blue on the sides of the neck, the wattles becoming carmine. The helmet still remains comparatively small and undeveloped long after the wattles and naked parts of the neck become coloured. I believe that the helmet does not attain its full size until the fourth or fifth year at least.

"In traversing these scrubs the head is carried low to the ground, and the vines and branches of trees striking the helmet slide over it on to the back. Otherwise, in the dense vine-scrubs bordering the Herbert River and elsewhere, progress would be greatly impeded; but as it is, the Cassowaries traverse the scrubs with wonderful speed, jumping over fallen trees and logs when in the way. A young bird (the identical specimen, I believe, forwarded by His Excellency the Marquis of Normanby to the Society), while in the possession of Inspector Johnstone, during my visit succeeded in jumping out of its yard over a fence more than 6 feet in height. I measured the fence, and found it 6 feet 6 inches to the top rail, on which its feet-marks were plainly visible;

the length of the yard was only 12 × 12 feet. I found the adult Cassowaries in full moult in March; but the new feathers had not all made their appearance in May. During these months specimens in confinement were remarkably irritable and frequently sulky, even refusing their food (which they invariably do when unwell), and were at times very spiteful, even attacking their keepers; but strangers chiefly come in for a share of their dislike. At all times I have noticed they are very fond of bathing; the semiadult bird before alluded to, which I forwarded to the Society, was remarkable in this respect, and might frequently be seen waiting at the pump in the yard until some one came for water, when he would sit down quietly under a copious shower, stretching out his neck and ruffling his feathers up to allow the water to reach the skin. They do not like any exposure, and always endeavour to get out of the sun. In the wild state they seldom leave the scrubs, and certainly never do so in the heat of the day unless hard pressed; but on the whole they are remarkably hardy, and bear confinement well. In February last (1875) I purchased four fine young birds about 6 months old, which were obtained from some settlers in the Herbert River district; these also I forwarded to England during the same month."

The eggs of *C. c. australis* cannot be distinguished from those of *C. casuarius*, although most of them, but not all, are slightly larger. Eggs laid in my aviary at Tring measure:—140 : 93, 131 : 87, 136 : 88, 138 : 89, 130 : 93, 135 : 95, 132 : 95, 128 : 91, 128 : 92, 129 : 92, 121 : 91 mm.; two in the British Museum measure 130 : 84 and 143 : 91 mm.

8. CASUARIUS BICARUNCULATUS Scl. The Two-wattled Cassowary. (Plate XXVIII.)

1860. *Casuarius bicarunculatus* Sclater, Proc. Zool. Soc. Lond. pp. 211, 248, 249, fig. (young: locality unknown);
1862. Id., Trans. Zool. Soc. Lond. iv. p. 358, fig. *b*, pl. lxxiii.;
1862. Crisp, Proc. Zool. Soc. Lond. p. 137 (gall-bladder);
1862. Schlegel, Jaarb. zool. Genootsch. Nat. Art. Mag. p. 198;
1864. Id., Dierent., Vogels, p. 239;
1866. Scl., Proc. Zool. Soc. Lond. p. 168;
1866. Schleg., Zool. Gart. p. 178; id., Nederl. Tijdschr. Dierk. iii. pp. 250, 347;
1867. Rosenberg, Reis naar Zuidoostereil. p. 52;
1869. Scl., Proc. Zool. Soc. Lond. p. 149 (young, alive);
1872. Scl., Proc. Zool. Soc. Lond. pp. 150, 495, pl. xxvi.;
1873. Garrod, Proc. Zool. Soc. Lond. pp. 470, 644 (anatomy);
1873. Schleg., Mus. Pays-Bas, *Struthiones*, p. 10;
1875. Rosenberg, Reist. Geelvinkb. p. 117;
1878. Salvad., Ann. Mus. Civ. Genova, xii. p. 316 (in Bremen Mus.); Rosenb. Malay. Arch. p. 373;
1881. Gould, B. New Guinea, v. pl. 73; Salvad., Mem. R. Ac. Sc. Torino, (2) xxxiv. p. 185, pl. 1. fig. 1 (head);
1882. Id., Ann. Mus. Civ. Genova, xviii. p. 414; id., Orn. Pap. e Molucc. iii. p. 475;
1894. Schalow, Journ. f. Orn. p. 19 (error: egg, Fly River !!);

1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 591.
1857. (?) *Casuarius galeatus* Wallace, Ann. Mag. Nat. Hist. xx. p. 477 (Aru Islands!).
1858. (?) *C. emeu* (non Latham!) G. R. Gray, Proc. Zool. Soc. Lond. p. 187 (sternum from Aru).
1861. (?) *Casuarius kaupi* (non Rosenberg!) G. R. Gray, Proc. Zool. Soc. Lond. p. 438;
1863. Rosenberg, N. Tijdschr. Ned. Ind. xxv. p. 252 (non p. 251) (Aru); id., Journ. f. Orn. p. 135 (non p. 134, quod *unappendiculatus*!).
1866. *Casuarius aruensis* Schleg., Nederl. Tijdschr. Dierk. iii. p. 347.
1867. *Casuarius galeatus* (non Vieillot!), Rosenberg, Reis naar Zuidoostereil. p. 52.
1884. (?) *Casuarius* sp. A. B. Meyer, Zeitschr. ges. Orn. i. p. 296 (egg from Aru).

Native name: "Kudari," in the Aru Islands (fide *Rosenberg*).

Adult. Plumage black; casque compressed at sides, not flattened at back, low and deep, horn-brown. Bill long, pointed, black. Head and occiput pale greenish blue. Upper part of hind-neck deeper blue, rest of hind-neck scarlet; fore-neck dark blue. On each side of the neck is a long pendent wattle, blue at base, deep pinkish red for the rest of the surface. Lower naked sides of neck deep blue.

Young (three-fourths grown). Plumage brown. Hind-neck dull orange; fore-neck and head dull blue; wattles pale pink.

Young (half-grown). Plumage yellowish brown. Hind-neck and wattles dull whitish flesh-colour; fore-neck and head dull greyish blue.

I have received from Dr. Finsch, among a number of chicks of Cassowaries in the Leyden Museum, one brought by von Rosenberg in 1866 from Kabroor Island, Aru group, which is clearly *C. bicarunculatus*. It appears to be much faded, but is very different from any other chicks I have seen; it is rufous all over, and has five dorsal bands and two bands of irregular patches on the thighs of a darker, more brownish rufous colour.

Hab. Wammer and Kabroor, Aru Islands.

The two birds on which the descriptions here given are based have been kept alive by me, both at Tring and in the Society's Gardens, and the older of the two has been in England five years.

The first notice that appeared about this Cassowary was the following note by Dr. Sclater on a young individual without locality (P. Z. S. 1860, p. 211):—

"*Casuarius bicarunculatus*, a name I propose to apply to a Cassowary of which I have recently obtained a young example for the Society in exchange from the Zoological Gardens at Rotterdam. It is easily distinguishable by the throat-caruncles being placed far apart on the sides of the throat, lighter colouring, &c. As the bird itself will shortly arrive in this country, I hope to be able to give full particulars concerning this new species at the next Meeting of the Society." This was done (p. 249), and the throat-wattles were figured. Adult individuals were first brought to London in 1872.

Valentyn (Oud en nieuw Oost-Indien, iii. p. 299) first mentioned that a Cassowary existed in the Aru Islands, and that it differs from *C. casuarius*, but he gave no description of it. Wallace (1857) tells us that a Cassowary (which he calls *C. galeatus*) is not at all uncommon in the Aru Islands, that the young are brought in numbers to Dobbo, where they soon become tame, running about the streets, and picking up all sorts of refuse food. It is probable that the birds he saw were mostly *C. bicarunculatus.* A sternum only was procured by Wallace.

Our first knowledge of the actual home of this bird is due to von Rosenberg, who ('Reis naar Zuidoostereil.') actually shot a Cassowary on the Aru Islands on April 15th, 1865, which he called *C. galeatus*, but which proved to be *C. bicarunculatus.* He tells us (from native sources) that the pairing-season is in June and July, and that the sexes live separate except at that time of the year: that the female makes a sort of rough nest and sits on the eggs for about 28 days; but both these latter reports are doubtless erroneous, as the observations in the Zoological Gardens have proved that it is the male alone which sits, and that the time of incubation is much longer. Rosenberg also tells us that not more than five eggs are found in the nest, and that some more eggs are placed outside the nest to serve as food for the young when hatched! This ridiculous story—which is also told of the Ostrich—is, it is needless to say, just as reliable as the former assertions. In spite of his want of knowledge of the habits of the birds, however, Rosenberg deserves full credit for discovering the home of *C. bicarunculatus*, which he obtained in the northern Aru Islands, Kabroor and Wammer. The native name of this bird in Aru is "Kudari." Specimens have from time to time arrived alive in Europe, and I have now two alive, both received when almost chicks.

Eggs from the Aru Islands have been described as those of *C. bicarunculatus*, but as two or three Cassowaries are found in that group of islands, there is not *à priori* any absolute certainty about any of these eggs, which, however, do not seem to differ very remarkably from those of *C. casuarius* and its allies. The egg identified as *C. bicarunculatus* in Nehrkorn's collection is said by Schalow (Journ. f. Orn. 1894, p. 19) to be from the Fly River, but in Nehrkorn's 'Katalog der Eiersammlung' it is said to be from the Aru Islands!! It is therefore not an egg to depend on. Nehrkorn says that it is so dark blue-green that it resembles the eggs of *Dromæus*, and that it measures 133:90 mm. According to Schalow its glazed granulations are less continuous and less numerous than those of *C. casuarius*, but this may be an individual character. Schalow also distinguishes between Cassowary eggs that are "durchscheinend" and "undurchscheinend" when held against the light; but this is by no means a specific difference, being mostly due to the way in which the eggs are emptied, and the thickness of the egg-shell varies also considerably.

Four eggs in the Leyden Museum from Kabroor, collected by Rosenberg, have more or less lost their original green colour, but agree in other respects. The corrugations are more or less interrupted and more or less elevated. The measurements are:—129:87, 132:87, 121:82, 129:86 mm.

9. CASUARIUS UNAPPENDICULATUS Blyth.[1] One-wattled Cassowary. (Plates XXIX. & XXX.)

1860. *Casuarius* sp., Blyth, Ibis, p. 193, and Sclater, P. Z. S. p. 210 (reprint Ann. & Mag. Nat. Hist. ser. 3, vol. vi. p. 145); *Casuarius unappendiculatus*, Blyth, Journ. As. Soc. Beng. vol. xxix. p. 112 (juv., no locality), reprint Ann. & Mag. Nat. Hist. ser. 3, vol. vii. p. 113; *C. unoappendiculatus*, Blyth, Ibis, p. 307; *C. uniappendiculatus*, Bennett, Ibis, p. 403, pl. xiv. (head and neck, from live bird in Amsterdam).

1861. *C. unappendiculatus* Blyth, Journ. As. Soc. Beng. vol. xxx. p. 193.

1862. *C. uniappendiculatus* Sclater, Trans. Zool. Soc. Lond. vol. iv. p. 359, pl. 74 (juv., fig. mala, typus); Schleg., Jaarb. zool. Genootsch. Nat. Art. Mag. p. 198, pl.; id., Dierentuin, p. 239, cum fig.;

1866. Scl., P. Z. S. p. 34 (first descr. of egg); Schleg., Zool. Gart. p. 179; id., Ned. Tijdschr. Dierk. vol. iii. p. 250 (Salwatti and opp. coast);

1869. Gould, Suppl. B. Austr. pls. 74, 75;

1871. Schleg., Nederl. Tijdschr. Dierk. vol. iv. p. 53; Gray, Hand-list, iii. p. 2, no. 9852;

1873. Schleg., Mus. Bays-Bas, *Struthiones*, p. 10;

1874. A. B. Meyer, Sitzb. der k. Ak. Wiss. Wien, vol. lxix. p. 218; Scl., Ibis, p. 417, note;

1875. Scl., P. Z. S. p. 533 (exact locality, Threshold Bay); Rosenberg, Reist. Geelvinkb. p. 117;

1877. Forbes, P. Z. S. pp. 307, 313, 314, 316 (bursa Fabr.);

1878. Salvad., Ann. Mus. Civ. Genova, xii. p. 346 (chick, Sorong); Rosenb., Mal. Arch. p. 396 (*kaupi*=*uniappend.*, woodcut);

1881. Salvad., Mem. R. Ac. Sc. Tor. (2) xxxiv. p. 205, pl. ii. fig. 6;

1882. Salvad., Ann. Mus. Civ. Gen. xviii. p. 414, no. 5; id., Orn. Pap. e Mol. iii. p. 490;

1886. Beddard, P. Z. S. p. 145 (anatomy);

1893. A. B. Meyer, Abh. Mus. Dresd. no. 3, pl. ii. (egg);

1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 597;

1896. Oust., Nouv. Arch. Mus. Paris, (3) viii. p. 264.

1861. *C. kaupi* Rosenb., Natuurk. Tijdschr. Nederl. Ind. xxiii. p. 43, pl.; id., Journ. f. Orn. p. 44, pl. i.;

1862. Schleg., Jaarb. zool. Genootsch. Nat. Art. Mag. p. 199;

1863. Rosenb., Natuurk. Tijdschr. Ned. Ind. xxv. p. 251;

1864. Id., Journ. f. Orn. p. 136;

1866. Scl., P. Z. S. p. 168 (=*uniappendiculatus*); Schleg., Zool. Gart. p. 180;

1867. Rosenb., Reis naar Zuidoostereil. p. 52;

1873. Schleg., Mus. Pays-Bas, *Struthiones*, p. 12; Rosenb., Journ. f. Orn. p. 390 (definite assertion of identity with *C. uniappendiculatus*).

1894. *C. unoappendiculatus* Schalow, Journ. f. Orn. p. 23 (egg).

Native names: "Mambeba" at Sorong, "Kallo" in Salwatti (*Rosenberg*).

Adult. Casque low, very much flattened behind, black; bill short, thick, and black. Head and upper part of hind-neck pale blue, with a greenish tinge. Cheeks dark

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[1] By an error, on the four Plates of the various forms of *C. unappendiculatus*, as well as on the distribution map, the name is spelt *uniappendiculatus*. The original spelling, however, is without the *i*.—W. R.

blue; face-wattles long, broad and thin, very bright dark blue. Chin dark blue; throat and a small part of hind-neck dark dull olive-yellow; fore-neck and rest of hind-neck dark golden-yellow. A golden-yellow transverse patch on occiput. Naked lower sides of neck dark orange-yellow. Plumage black; wattle dirty mauve. Size very large. Height from casque to ground about 5 feet 6 inches when walking, 6 feet 8 inches when erect.

Total length about 1655 mm., bill from gape 133, tarsus 280, claw of inner toe 84. (After Salvadori, *l. c.*)

Young (half-grown). Casque brown; plumage yellowish brown; neck and naked lower sides of neck pale yellowish flesh-colour. Head, chin, and occiput dirty bluish green; legs yellowish.

Chick. Head and neck uniform rufous; throat buff; body creamy buff, with five distinct brown longitudinal bands on the body and a line of broken brown patches along the thighs.

Hab. Salwatty and opposite coast of N.W. New Guinea (Threshold Bay, Tangion-Ram, Sorong).

The first communication referring to the One-wattled Cassowary is the following editorial note in 'The Ibis' for 1860, p. 193:—" Mr. Blyth in his last letters (dated Calcutta, Jan. 8th & 21st) speaks of an apparently new species of Cassowary (*Casuarius*) in the aviary of the Bábu Rajendra Mullick of Calcutta: 'It has a yellow throat, a single yellow throat-wattle, and a long strip of naked yellow skin down each side of the neck. In its present (first) plumage, it is of a much lighter colour than the young of the Common Cassowary of the same size, two of which are kept along with it; and from the size of the legs, it is easy to perceive that when full-grown it is a much smaller species.' "

In the 'Journal of the Asiatic Society of Bengal,' Blyth first published the name:—

" *Casuarius unappendiculatus*, nobis, n. s., from its peculiarity of having but a single pendulous caruncle in front of the neck. Specimen apparently more than half-grown, and much paler in the colouring of its plumage than specimens of the same age of the common *C. galeatus*, two fine examples of which are associated with it in the same paddock. In lieu of the two bright red caruncles of the latter, the new species has but a single small oblong or elongate oval *yellow* caruncle, and the bright colours of the naked portion of the neck are differently disposed. The cheeks and throat are smalt-blue, below which is a large wrinkled yellow space in front of the neck, terminating in front in the oval button-like caruncle, and its lower portion being continued round behind, while on the sides of the neck the yellow naked portion is continued down to its base, the bordering feathers more or less covering and concealing this lateral stripe of unfeathered skin; on the hind part of the neck the bare yellow skin is not tumous and corrugated as in the Common Cassowary, where also this part is bright red. The casque is about equally developed at this age in the two species. The legs of the new species are smaller, from which I doubt if it attains to quite so large a size as the other."

The next we hear concerning this species is the arrival of an immature bird in the Zoological Garden of Amsterdam; this grew up, and thus was afterwards the first adult described and figured by Schlegel. Also in this case Rosenberg was the first to discover the actual home, for he obtained it on the island of Salwatti, and afterwards specimens became known from several places on the opposite coast.

The bird in Amsterdam laid a pale green egg, "thickly covered with raised spots of dark green, and measuring 136 : 89 mm."

I have an egg in my collection (from the Buckley collection, bought from T. Cooke, 1871, who had it in exchange from "Mr. Franks": this means probably that it was from the Amsterdam dealer Frank, who had it from the Zoological Gardens, for it has on its label "Maart 1865" (or 6, the 5 being obliterated), this being about the time when the bird laid eggs there). This egg differs from other Cassowary-eggs in having numerous single glazed round knobs, like pin-heads, few of them being connected with each other. The descriptions of the two eggs of *C. unappendiculatus* by Schalow (*l. c.*), both from different sources, agree with mine—the peculiar isolated pin-head-like elevations being well described and discussed as distinguishing the *unappendiculatus*-egg from all others. One of those in the British Museum, about the origin of which there is no doubt, as it is one of the eggs laid in Amsterdam, agrees also with these in having the separate knobs, while two others, from Frank, and one said to have come from Salwatti, are more like those of *Casuarius casuarius*. The one with the isolated knobs measures 137 : 88 mm., my own 151 : 81, Schalow's 146 : 96, 148·5 : 49·5 mm., while Sclater gives only 136 : 89. Sclater also speaks of raised "spots" only. On the other hand, seven eggs in the Leyden Museum, sent by Bernstein and Rosenberg, and said to be from Sorong and Salwatti, do not show these characteristic isolated pin-head-like elevations, but rather a more connected network of glazed granulations. They measure 145 : 90, 145 : 91, 145 : 90, 143 : 91, 147 : 92, 142 : 95, 145 : 96 mm. They are all very large.

It must therefore be left to future research whether the peculiarly isolated knobs on some well-authenticated eggs of *C. unappendiculatus* are a specific character; but at present this view cannot be taken, unless the identity of all the eggs in the Leyden Museum and of some of those in the British Museum is doubted.

As usual, we know nothing definite respecting the biology of this bird in a wild state. Rosenberg tells us that an immature bird he got in Ternate was running about freely and was much attached to people, while it was a fierce enemy to cats and dogs. When it got angry it put up its feathers and emitted a peculiar blowing cry, followed by a grunting like that of a young pig.

10. CASUARIUS UNAPPENDICULATUS OCCIPITALIS Salvad. Jobi Island One-wattled Cassowary. (Plate XXXI.)

1875. (?) *Casuarius papuanus* Rosenberg, Reist. Geelvinkb. p. 117 (Jobi); *Casoar di Jobi* Beccari, Ann. Mus. Civ. Gen. vii. p. 718.
1875. *Casuarius occipitalis* Salvad., ibid. (footnote);
1876. Scl., Ibis, p. 245 (note);
1878. Salvad., Ann. Mus. Civ. Gen. xii. p. 423; Scl., Ibis, p. 482; A. B. Meyer, Journ. f. Orn. pp. 203, 300;
1881. Salvad., Mem. R. Ac. Sc. Tor. (2) xxxiv. p. 209, pl. ii. fig. 7 (head);
1882. Salvad., Ann. Mus. Civ. Gen. xviii. p. 414, no. 6; id., Orn. Pap. e Mol. iii. p. 494;
1893. Meyer, Abh. Mus. Dresd. no. 3, p. 29, pl. ii. fig. 4 (egg);
1894. Schalow, Journ. f. Orn. p. 22 (egg);
1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 598;
1896. Oust., Nouv. Arch. Mus. Paris, (3) viii. p. 264, pl. xiv.
1892. *Casuarius westermanni* Rey (nec Sclat.), Zeitschr. f. Ool. p. 19.

Native names: "Orawei," Jobi (*Rosenberg*); "Orawai" at Ansus on Jobi Island (*A. B. Meyer*).

Adult. Casque very high, conical, flattened posteriorly. Beak long and very stout. Iris deep brown. Face, head, chin, throat, and upper half of neck deep blue, rather paler on hinder part of neck. Face-wattles long, thin, pendent, and much swollen at their base. Lower half of neck deep yellow or pale orange. Pear-shaped wattle yellow, more or less suffused with blue. Naked sides of lower neck deep crimson. On the occiput is a transverse patch of dull dirty orange.

Plumage black and coarse; legs brownish grey; bill and casque black in most fully-adult specimens, but some occasionally retain the greenish-horn coloured or pale olive helmet of the immature bird. Legs dark olive.

The measurements of the type (*cf.* Salvadori, *l. c.*) are as follows:—Total length about $1\frac{2}{3}$ m., bill from gape 137 mm., tarsus 280 mm., nail of inner toe 70 mm.

Young (full-grown). Plumage brown; face-wattles absent; naked parts dull bluish green where deep blue in adult; dull yellow instead of pale orange on lower half of neck, and dirty red mixed with yellow on lower sides of neck. Casque dull green.

Young (half-grown) similar to that of *C. unappendiculatus*, but casque bright green.

Chick. Head and hind-neck pale rufous; body pale buff; back with five black bands variegated with rufous; flank and thigh stripes broken up into irregular spots.

This form differs from *C. unappendiculatus* principally in its more slender build and its greater height, the greater extension of blue on the neck, the crimson lower sides of the neck, and the very high casque.

It inhabits the island of Jobi and perhaps also the opposite coast of Geelvink Bay.

There occasionally occurs in this form, and probably also in all the other forms of *C. unappendiculatus*, a curious melanistic variety, where nearly the whole neck is blue and only a small spot of yellow remains at the base of the hind-neck. This was described by Oustalet as a distinct species under the name of *Casuarius laglaizei*; it may stand as

CASUARIUS UNAPPENDICULATUS OCCIPITALIS aberr. LAGLAIZEI.

[1893. *Casuarius laglaizei* Oust., Bull. Soc. Philom. (8) v. no. 9, pp. 1–3 (Jobi Island); 1896. Oust. Nouv. Arch. Mus. Paris, (3) viii. p. 265, pl. xv. (Specimen killed on Jobi and purchased by Laglaize; type of *C. laglaizei*, in Paris Museum. Careful description and measurements and plate to show the supposed specific value, in which, however, I do not believe at all.)]

It is most probable that it was *C. unappendiculatus occipitalis* of which A. B. Meyer (Sitzber. Ak. Wiss. lxix. p. 217) says that it occurs on Jobi, where it is called "Orawai," and of which Rosenberg had received some reports from the natives when stating ('Reistochten,' p. 117, and Malay. Arch. p. 563) that *Casuarius papuanus* occurred also on Jappen—the usual Dutch name for Jobi Island in Geelvink Bay. Beccari brought a grand adult male from Ansus, on Jobi Island, to Italy, and this was at once recognized by Count Salvadori as an undescribed form. In a footnote appended to Beccari's interesting ornithological letter in the Ann. Mus. Civ. Genova, vii. p. 718, our learned friend diagnosed this form as follows:—

"CASUARIUS OCCIPITALIS mihi.

"Casside compressa, postice depressa; appendice colli antici, ut videtur, nulla; capite, gula et parte superiore cervicis cæruleis; macula occipitali et colli parte nuda inferiore flavis; area nuda laterali colli imi carnea." This diagnosis is followed by a more detailed Italian description. Needless to say, the Count always recognized the close relationship this bird had to *Casuarius unappendiculatus* from Salwatti. In the 'Catalogue of Birds,' xxvii. p. 599, he says that it is "very similar to *C. uniappendiculatus*, but differs in having a triangular yellow patch on the occiput, the posterior surface of the casque narrower, the single caruncle smaller."

The measurements of the type are, according to Salvadori:—Total length about 1 m. 670 mm., bill from gape 137 mm., tarsus 280 mm., claw of inner toe 70 mm.

One egg obtained by Doherty on Jobi Island, and doubtless belonging to this form, unless more than one occur on that island, shows a good many rather isolated knobs, thus closely resembling those of *C. unappendiculatus*, which show this character. It measures 144 : 95 mm.

11. CASUARIUS UNAPPENDICULATUS AURANTIACUS Rothsch. Eastern One-wattled Cassowary. (Plate XXXII.)

1899. *Casuarius uniappendiculatus aurantiacus* Rothsch., Bull. B. O. C. vol. viii. p. 1 (17th May), p. lvi (21st June); id., P. Z. S. 1899, p. 774 (June 20th; published Oct. 1st).

Adult. Face, head, chin, and nape of neck bright turquoise-blue, darker round eyes and on face-wattles. Rest of fore- and hind-neck and naked lower sides of neck deep bright orange, without any red. Throat-wattle blue. On the occiput a very wide and large transverse patch of bright orange. Face-wattles large and very thick, balloon-shaped when inflated by the bird during anger. Bill short and thick. Casque low, compressed laterally, and not flattened posteriorly or hardly so. Plumage black and coarse; legs brownish grey; iris pale brown. Build slender and tall, but not so tall as either *C. unappendiculatus* or *C. u. occipitalis.*

Young and *chick* unknown.

This form differs both from *C. unappendiculatus* and *C. u. occipitalis* in its slender build and paler blue colouring, but principally in the uniform orange of the neck, the laterally compressed and posteriorly *not* flattened casque, and in the thick swollen face-wattles, which are very similar to those of the following species, *Casuarius philipi.*

Hab. German New Guinea.

This form is known from one individual living at present in the Zoological Garden of Berlin, where Mr. Keulemans made the accompanying picture. It is most interesting to find the one-wattled group of Cassowaries extending to Kaiser-Wilhelmsland, and I have no doubt whatever that my *aurantiacus* is a very good subspecies.

My original description (*l. c.*) is as follows:—

"Face, cheeks, and occiput pale sky-blue; throat dark blue. Occipital patch, fore-neck, hind-neck, and lower sides of the neck deep reddish orange. Casque horny green, and much more compressed laterally than in *C. unappendiculatus.* Long cheek-wattles absent, but the sides of the face distended as in *C. philipi.*"

12. CASUARIUS UNAPPENDICULATUS RUFOTINCTUS, subsp. nov. Red-tinted One-wattled Cassowary.

Casque greenish horn-colour, compressed laterally and not depressed posteriorly; plumage black, mixed with brown, as the bird is not quite in full adult plumage, though otherwise in full colour. Head, face, occiput, and upper hind-neck bright pale blue; on the occiput is a large patch of orange-brown. Chin and throat deep indigo-blue, which colour runs down the centre of the fore-neck in a triangular band to the base of the wattle, where it is about 1 inch wide. Wattle blue. Sides of fore-neck orange-scarlet, changing to crimson when excited and the throat distended. Lower naked sides of neck deep crimson, with a narrow anterior yellow border.

Hab. unknown.

I had this bird as a chick in striped plumage, and it was reared as a pet at Tring, but since it has been in this Society's Gardens (15 months) it has come into colour and is very different from any other form of *C. unappendiculatus.* It is now 3 years old.

13. Casuarius philipi Rothsch. Sclater's Cassowary. (Plate XXXIII.)

1898. *Casuarius philipi* Rothsch., Nov. Zool. v. p. 418.

Almost adult. Casque very high, compressed laterally and at the same time depressed posteriorly, thus combining both forms of casque; the colour of the casque pale whitish brown behind, darker in front; bill thick and apparently rather short. Plumage black; feathers long and much curled on the body, the webs being close and not disintegrated as in other Cassowaries, more like the tip of a freshly-moulted feather of *Dromæus.* Feathers of the rump and tail enormously lengthened, some of the tail-feathers when fresh-moulted trailing on the ground. Head, occiput, face, and upper part of hind-neck pale greenish Nile-blue; fore-neck and uppersides of neck and sides of nape deep indigo-blue; lower hind-neck lemon-yellow, flecked with a few reddish spots on the edges. Lower naked sides of neck bright cherry-crimson. Cheek-pouches, when extended and inflated during anger, of a dark lavender-blue colour. The feathers of the neck come very high up and are very thick; on the lower part of the fore-neck is a single round flat wattle, upper two-thirds cherry-red, lower third blue. On the occiput is a broad patch of dull clay-brown. Cry unlike all the other Cassowaries, being very loud and resembling a deep roar.

This, quite the most remarkable Cassowary, is not only distinguished by the colour of its naked parts, its curious casque and feathers, but also by its extraordinary shape. It is quite as short from the ground to the level of its back as *Casuarius bennetti*, but in every other respect it is a giant; in fact, it can only be compared with the extinct New Zealand *Dinornis* (*Pachyornis*) *elephantopus* as regards proportions.

Hab. unfortunately unknown.

It was shipped to London from Calcutta, and when it first came to the Society's Gardens was in brown plumage, and the colours of the head and neck were not developed. It was thought to be a young *C. unappendiculatus*, but as soon as it began to come into colour, I saw it was something quite new, in fact it is the most distinct of all the species of Cassowary.

I originally described this bird when it was much younger. My description was as follows:—

"This new species is founded on a bird now living in the Zoological Gardens, London, which, though far from adult, being almost brown in plumage, appears to be full-grown, and the naked parts are fully coloured. It is closely allied to *C. uniappendiculatus*, but differs much in colour.

"Plumage when adult evidently black. Casque as yet undeveloped, pale yellowish horn-colour. Throat and fore-neck deep purplish blue. A single small wattle on fore-neck, round and flat, not pear-shaped as in *C. uniappendiculatus*; upper third of wattle purplish red, rest dark blue. Hairy feathers of neck very thick and reaching high up the neck. Head, occiput, and upper half of hind-neck very pale greenish blue; lower half of hind-neck pale orange-yellow. Naked skin on lower sides of neck deep crimson, fading into cherry-red on the edges. Legs very stout and short; body set very low on the legs and very bulky, giving the bird the exact shape *Dinornis elephantopus* must have had.

"*Hab.* Probably Eastern German New Guinea[1].

"Named in honour of Dr. Philip Lutley Sclater."

14. CASUARIUS PAPUANUS Schleg. Westermann's Cassowary. (Plate XXXIV.)

1871. *Casuarius bennetti* (non Gould, 1857) Schleg., Nederl. Tijdschr. Dierk. iv. p. 53.
1871. *Casuarius papuanus* Schleg. (ex Rosenberg MS.), t. c. p. 54;
1873. Schleg., Mus. Pays-Bas, *Struthiones*, p. 11 (Andai); Rosenb., Journ. f. Orn. p. 390;
1875. Rosenb., Reist. Geelvinkb. pp. 84, 117, 144, pl. 17; Salvad. Ann. Mus. Civ. Gen. vii. p. 717 (Andai);
1878. Rosenberg, Malay. Archipel, p. 563; A. B. Meyer, Journ. f. Orn. pp. 200, 203;
1879. Salvad., Mem. R. Ac. Sc. Tor. (2) xxxiv. p. 210, pl. ii. fig. 8 (head);
1882. Salvad., Ann. Mus. Civ. Gen. xviii. p. 414, no. 7; id., Orn. Pap. e Mol. iii. p. 495;
1894. Schalow, Journ. f. Orn. p. 20 (egg).
1871. *Casuarius kaupi* Sclat. (non Rosenberg, 1861), P. Z. S. p. 627 (Mansinam);
1872. Sclat., P. Z. S. pp. 147–150, pl. ix. (Mansinam);
1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 599;
1896. Oust., Nouv. Arch. Mus. (3) viii. p. 265.
1872. *Casuarius papuensis* Sclater, P. Z. S. pp. 149, 150.
1874. *Casuarius westermanni* Scl., P. Z. S. p. 248; id., Ibis, p. 417 (footnote);
1875. Scl., P. Z. S. pp. 85, 87, 380, pl. xix.;
1877. Gould, B. New Guinea, v. pl. 15;
1878. A. B. Meyer, Journ. f. Orn. pp. 200–203.
1874. ? *Casuarius* sp. A. B. Meyer, Sitzber. k. Ak. Wiss. Wien, lxix. p. 216.

Native names: the following are given by Rosenberg; but it is, of course, doubtful whether they all apply strictly and only to this species, or to several, or whether they are meant for any form of Cassowary: "Mswaar" at Andai, "Nhamdia" at Hatam, "Wonggé" at Dorei.

Adult. Bill short and pointed; casque low and much flattened posteriorly, so as to make it quite triangular in shape. Face behind eye, and head white. Nape, throat, and fore-neck deep blue. Hind-neck scarlet. Anterior half of naked lower sides of neck livid magenta-purple, posterior half scarlet.

In the place where in the *Casuarius casuarius* and *C. unappendiculatus* groups

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[1] There is, however, no certainty about its home.

the throat-wattles are attached there is sometimes a small round knob of the same colour as the rest of the fore-neck. Plumage black; feathers long and more silky than in the species previously described, those over the tail being some 12 to 15 inches long and very thick, forming a sort of pendent train. Legs brown, bill and casque black.

Total length (according to Salvadori) about 1 m. 400 mm., tarsus 260 mm., bill from gape 120 mm., inner claw 78 mm.

Young (full-grown). Plumage brown, all colours on naked parts duller, the blue being of a dull leaden shade, and the red replaced by orange-yellow.

Young (half-grown). Plumage dark chestnut-brown or bay-brown, each feather crossed by several strongly defined black bars. Head and neck not bare.

Chick. Uniform dark brown, with two or three narrow longitudinal white bands on the body, and several similar lines on the neck.

This bird inhabits the Arfak Peninsula, and has been said to come also from Jobi, but this is not supported by any evidence.

Rosenberg discovered this Cassowary near Andai, in the Arfak Peninsula of New Guinea, where it is called "Mswaar" or "Meswaar" by the Papuans. When first mentioning it, in 1871, Schlegel called it *C. bennetti*, but stated that it differed from the latter in the coloration of the upperside of the neck, which, however, he did not consider of any importance, and remarked that Rosenberg believed it to be a new species which he wished to call *Casuarius papuanus.*

Rosenberg tells us that the first glance at the type of his *C. papuanus*, which was shot by his hunter Achmat (Achmed), convinced him that his former belief that the Cassowaries of New Guinea were the same as those from Salwatti, the *C. unappendiculatus*, was erroneous. Rosenberg further states that the adult female was shot during the breeding-season, which lasts from February to April, and that the nest consists of a depression on the ground, lined with leaves. He had all this information, however, from natives, and he repeats the old fable with which he also treated us when describing the Ceram Cassowary, that some eggs (five, he says) are placed in the nest, others (two) outside, so as to serve as food for the chicks, and that they are hatched in 28 days. Of the eggs he says that they are in every respect like those of *C. casuarius.* The adult bird shot by his hunter was at first only wounded, and attacked the man, who had not a little trouble in keeping it off, and subsequently killed it with his hunting-knife. Bruijn sent skins to Europe said to be from Andai and Emberbaki, or Amberbaki. Laglaize purchased one from Amberbaki, and A. B. Meyer obtained it near Dorei. Beccari says it occurs also on the mountains of Arfak, where he saw footprints of a Cassowary at a considerable elevation.

The type of *C. westermanni* belongs certainly to *C. papuanus.* Sclater informs us that it was said by the missionary who sent it to come from Munsinam (=Mansinam), near Andai, where also Rosenberg obtained *C. papuanus*. There is no reason to doubt this statement. Meyer (Sitzber. k. Ak. Wiss. Wien, lxix. p. 216) says that Mansinam is a small island near Dorei, where no Cassowary could live in a wild state, and that therefore the locality "Mansinam" is incorrect. However, there is also a village called Mansinam (or Mansiman) a few miles south of Andai, and, moreover, as "*C. westermanni*" does not differ from *C. papuanus*, it is evidently quite unnecessary to suppose that the Mansinam, whence the type of *C. westermanni* came, is the island of Manaswari (which is, according to Meyer, the proper name, its principal village alone bearing the name of Mansinam). It is more likely the Mansiman of the maps (*cf.* the map of Rosenberg and many others), which was quite recently found still to exist and was visited by William Doherty.

The eggs of *C. papuanus* in the British Museum are rather smoother than most eggs of the *C. casuarius* group and others, the granulations being rather flat. It is possible that this flatness of the granulations is the rule in the eggs of the *C. papuanus* group. Those in the British Museum measure 134 : 86 and 130 : 84 mm.

Unfortunately, by carelessly reading Dr. Oustalet's description of *C. papuanus edwardsi*, I erroneously gave Salwatty as a further habitat of this species, and it is thus marked on the maps (Plates XL. & XLI.) which show the distribution of the genus.

15. CASUARIUS PAPUANUS EDWARDSI Oust. Milne-Edwards's Cassowary. (Plate XXXV.)

1878. *Casuarius edwardsi* Oust., P. Z. S. p. 389, pl. xxi. (Dorey); Salvad., Ann. Mus. Civ. Gen. xii. p. 425; Cab., Journ. f. Orn. p. 203 (editorial note); A. B. Meyer, Journ. f. Orn. p. 299.

1895. *Casuarius papuanus* (partim!) Salvad., Cat. B. Brit. Mus. xxvii. p. 600.

Adult. Plumage black, feathers on rump and tail much elongated. Casque much flattened posteriorly and black; bill long, pointed, and black. Occiput, cheeks, and sides of face white; below ear and cheeks a large black patch surrounded by a broad pink band, this pink band extends right round the back of the head below the white occiput, but is concealed in the folds of the skin unless the bird is violently enraged. Chin, throat, and fore-neck deep blue, in centre of fore-neck usually a round black wart with green centre. Nape greyish black, rest of hind-neck scarlet. Naked lower sides of neck dull scarlet washed with livid pinkish purple, the spaces between the folds black.

Juv. (half-grown). Reddish brown, feathers on fore part of body and back faintly barred transversely with black. Occiput and sides of head bluish white, the occiput being whiter. Face and part of head round casque dark leaden grey, naked lower sides of neck pale flesh-colour; legs yellowish olive.

Juv. (three-fourths grown). Casque not yet developed. Crown of head and face black. Occiput dirty brownish white. Fore-neck and upper half of hind-neck dull blue. Large irregular patch between ear-hole and angle of gape buffy pink. Lower half of hind-neck rosy salmon-red. Centre of naked lower sides of neck scarlet-mauve, bordered with a colour mixed orange and cherry-rose. Plumage brown, curiously variegated with black.

Hab. Low country of N.W. Dutch New Guinea.

My living specimen performed as follows:—

It first extends its neck horizontally, then contracts it short and bends it, at the same time inflating it, and then makes a series of at least twelve short and deep grunting notes. Sometimes, when very angry, it, like other Cassowaries, spreads the feathers of the back and hind-quarters out and snarls viciously.

The young three-quarter grown bird described above is not yet old enough to perform these antics.

Milne-Edwards's Cassowary was first described by Oustalet from a male killed near Dorei, and brought to Paris by Messrs. Raffray and Maindron. The differences noticed by M. Oustalet are principally in the form of the helmet and the coloration of the naked parts of the head and neck. The latter are, indeed, very conspicuous; while the form of the helmet is more likely to be an individual character.

I cannot believe that *C. edwardsi* is "identical" with *C. papuanus*; but if it is a subspecies of the latter, then the two forms must inhabit different areas, and it is very likely that one of them frequents the lowlands, while the other lives among the hills.

An egg laid by a living bird in my possession has the network of granulations rather flat, like those of *C. papuanus* in the British Museum. It is rather pointed and seems abnormally small, measuring only 125 : 86 mm.

16. CASUARIUS LORIÆ Rothsch. Loria's Cassowary. (Plate XXXVIII.)

1895. *Casuarius picticollis* Salvad. (nec Sclater), Cat. Birds Brit. Mus. xxvii. p. 600 (description !).
1898. *Casuarius loriæ* Rothsch., Novit. Zool. p. 513.
1899. Id., Bull. B. O. C. viii. p. lvi (June 21st); id., P. Z. S. p. 775 (June 20th; appeared Oct. 1st).

Adult. Bill short and pointed, casque low and much flattened posteriorly. Throat and mesial line of neck dull pink, with three narrow longitudinal lines of blue, rest of fore-neck scarlet. In front of the ear a small patch of livid magenta, above the ear blue. Head and hind-neck bright blue. Anterior portion of naked lower sides of neck livid purple, posterior portion scarlet, the whole surrounded with blue. Plumage black, long and silky. Legs horny grey. Iris hazel.

The total length of the fully adult male in the Museum of Genoa is about 1½ m., the bill from gape measures 120 mm., the tarsus 244 mm., claw of inner toe 117 mm., according to Salvadori. My adult bird from the Upper Brown River (collected by Weiske) measures:—Bill from gape 122 mm., tarsus 246 mm., claw of inner toe 70 mm.

Young (half-grown). Rufous-brown, each feather marked with narrow transverse bars of brownish black.

Hab. Highlands of S.E. New Guinea.

Casuarius loriæ was found by Signor Loria at Moroka in the highlands of the Owen Stanley Mountains in British New Guinea. The fully adult specimen obtained by Loria is now in the Museo Civico of Genoa. Mr. Loria made a coloured sketch of the head and neck, which was kindly lent me by Dr. Gestro, and from which our plate is taken.

It is this same bird which is described in the 'Catalogue of Birds,' vol. xxvii. p. 601.

Another adult bird, a skin which shows the red of the neck well, was sent to me by Mr. Weiske from the mountains on the Upper Brown River. I cannot possibly confound these red-necked individuals with *Casuarius picticollis*, which has the neck blue with a small red spot in the centre of the fore-neck, and a red chin when young.

C. loriæ evidently replaces *C. picticollis* in the highlands, the latter being, according to our present knowledge, only found in the coast-region.

The second example mentioned in the list of specimens in the 'Catalogue of Birds' (*l. c.*) I could not find in the collection, at least not under that name.

17. CASUARIUS PICTICOLLIS Scl. Painted-necked Cassowary. (Plate XXXVI.)

1874. *Casuarius picticollis* Scl., Rep. Brit. Assoc. p. 138.
1875. Scl., P. Z. S. p. 84, pl. xviii. (Discovery Bay); ibid. p. 349 (pullus, Milne Bay);
1877. Gould, B. New Guinea, v. pl. 14; Forbes, P. Z. S. pp. 307, 315, 316 (anat.);
1881. Salvad., Mem. R. Ac. Sc. Tor. (2) xxxiv. p. 213, pl. ii. fig. 9 (head);
1882. Salvad., Ann. Mus. Civ. Gen. xviii. p. 415, no. 8; Salvad., Orn. Pap. e Mol. iii. p. 499;
1893. (?) A. B. Meyer, Abh. Mus. Dresd. no. 3, p. 29, pl. ii. figs. 1, 2 (egg);
1894. (?) Schalow, Journ. f. Orn. p. 25 (egg);
1895. Salvad., Cat. B. Brit. Mus. xxvii. p. 600.
1881. *Casuarius kaupi* (non Rosenberg!) Sharpe, Ibis, p. 500.

Adult. Plumage black; casque high and depressed posteriorly, black; bill pointed, black. Occiput and auricular region pale greenish blue. Chin, throat, fore-neck, and nape of neck deep bright blue. In centre of fore-neck a deep red patch. Lower hind-neck pale blue. Lower naked sides of neck bright rose-purple.

Total length about 1 m. 400 mm., tarsus 245 mm., bill from gape about 120 mm., inner claw 125 mm.

Immature. The immature bird varies considerably, and I describe the two most different:—

(1) Chin and throat dull red, nearly joining the red patch in centre of fore-neck; rest of naked parts as in adult, only duller in colour; plumage black, completely mingled with brown feathers.

(2) Plumage brown, slightly mixed with black feathers. Chin, throat, fore- and hind-neck, and occiput dull blue, base of hind-neck orange. In centre of fore-neck a large horseshoe-shaped red patch, lower naked sides of neck dull purple.

Juv. (one-third grown). Uniform pale brown.

Hab. Coast-region of British New Guinea.

In 1875 (P. Z. S. p. 85) Dr. Sclater characterized this bird as follows:—

"In *C. westermanni* (pl. xix.) the throat is blue and the hinder part of the neck deep orange-red. In the new species, which I propose to call *C. picticollis* (pl. xviii.), the middle of the throat is red, and the hinder part of the neck bright blue. There are, besides, minor differences, which will be evident on comparing the two drawings. Now, so far as I know, these colours in the naked parts of the Cassowaries are quite constant; and I can hardly doubt therefore that we have here to deal with different species." The original specimen came from Discovery Bay. It died, after having lived for about twenty-nine months in the Society's Gardens, and is now preserved in the British Museum. Other individuals are known from Milne Bay. The description of *C. picticollis* in the 'Catalogue of Birds in the British Museum' is that of a mountain form which I consider to be specifically distinct, and which I have separated as *Casuarius loriæ*, as I had been able to examine several specimens of it.

18. CASUARIUS PICTICOLLIS HECKI Rothsch. Heck's Cassowary. (Plate XXXVII.)

1899. *Casuarius picticollis hecki* Rothsch. Bull. B. O. C. viii. p. xlix (May 17th), p. lvi (June 21st); id., P. Z. S. p. 775 (June 20th; appeared Oct. 1st).

Adult. Bill short and pointed; casque low and flattened posteriorly. Occiput Nile-blue, rest of head and neck deep indigo-blue. Naked lower sides of neck bright crimson, bordered with indigo-blue. Cheek-wattles large and balloon-shaped when extended. Legs brown. Bill and casque black.

Young and *chicks* unknown.

This form differs from *C. picticollis* in the absence of red on the throat and chin, in the much darker blue of the head and neck, and in the bright crimson instead of purplish-red naked lower sides of neck.

Hab. German New Guinea.

Nothing is known of this form except one living individual in the Zoological Garden of Berlin. My original preliminary description of it (*l. c.*) is as follows:—

"This bird bears the same relationship to *C. picticollis* that *C. papuanus edwardsi* does to *C. papuanus*. The throat and hind-neck are deep indigo-blue. Occiput pale greenish blue. A small round black wattle on the fore-neck. Lower sides of neck dark crimson. Casque and plumage similar to those of *C. picticollis*."

This form is named in honour of Dr. Heck, Director of the Zoological Garden of Berlin, who kindly permitted Mr. Keulemans to make a drawing of the bird.

19. CASUARIUS BENNETTI Gould. The Mooruk. (Plate XXXIX.)

1857. *Casuarius bennetti* Gould, P. Z. S. p. 269, Aves, pl. 129;
1858. Gould, Ann. & Mag. Nat. Hist. (3) i. p. 299;
1858. J. E. Gray, P. Z. S. p. 271, Aves, pl. 144 (egg);
1859. Bennett, P. Z. S. p. 32; Gould, B. Austr., Suppl. pls. 72, 73; Scl., Ibis, pp. 212, 235;
1860. Bartlett, P. Z. S. p. 205, Aves, pl. 162 (egg); Scl., P. Z. S. p. 210; Bennett, Gath. Naturalist in Australas. p. 243, pl. iv.;
1862. Scl., Trans. Zool. Soc. Lond. ix. p. 359, pl. lxii.; Schleg., Jaarb. zool. Genootsch. Nat. Art. Mag. p. 198;
1863. Scl., P. Z. S. p. 234 (incubation), p. 518 (descr. of pullus), pl. xlii.; Jouan, Mém. Ac. Soc. Nat. Cherb. ix. p. 323;
1864. Scl., P. Z. S. p. 271 (successfully reared);
1865. Gould, Handb. B. Austr. ii. p. 561;
1866. Schleg., Zool. Gart. vii. p. 178;
1871. G. R. Gray, Hand-list, iii. p. 2, no. 9850;
1873. Schleg., Mus. Pays-Bas, *Struthiones*, p. 4; Benn. & Sclat., P. Z. S. p. 519 (corr. of locality); Garrod, P. Z. S. pp. 470, 644 (anatomy);
1875. Scl., P. Z. S. pp. 85, 87; Scl., Rep. Brit. Assoc. p. 112;
1876. Ramsay, P. Z. S. p. 122;
1879. Scl., P. Z. S. p. 5;
1880. Layard, Ibis, p. 303; Powell, P. Z. S. p. 493;
1881. Salvad., Mem. R. Ac. Sc. Tor. (2) xxxiv. p. 214, pl. ii. fig. 10 (head);
1882. Salvad., Ann. Mus. Civ. Gen. xviii. p. 415, no. 9; id., Orn. Pap. e Mol. iii. p. 501;
1891. Evans, Ibis, p. 84 (period of incubat.); Sharpe, Cat. Osteol. Spec. R. C. Surg. iii. p. 438;
1892. Ost, Zeitschr. Ool. pp. 15, 94; Schalow, ibid. p. 11;
1894. Id., Journ. f. O. p. 20 (egg);
1896. Oust., Nouv. Arch. Mus. Paris, p. 256.
1869. Cassowary from the Solomon Islands (error!), Hutton, Ibis, p. 352.

Native name: "Moorup" in New Britain (corrupted: "Mooruk").

Plumage black. Bill long, arched and pointed. Casque high, sharply depressed posteriorly, the various ridges being sharply defined. Back of head, occiput, and upper hind-neck black-blue; lower hind-neck dark blue. Chin, throat, and sides of fore-neck deep bright blue, rest of fore-neck blackish blue. Below the ear-hole and reaching to the gape is a large irregular patch of very pale blue. Upper half of the naked lower sides of neck black, with purplish-pink streaks between the wrinkles, lower half purplish pink with black spots.

Total length about 1 m. 330 mm., bill from gape 110 mm., tarsus 240 mm., inner claw about 73 to 90 mm.

Chick. Head and hind-neck bright rufous mingled with black spots. Chin and throat yellowish buff. Fore-neck and sides of neck rufous buff mingled with black. Rest of body creamy buff. Five longitudinal black bands variegated with rufous running along the back, and two black bands down the flanks and thighs.

Hab. New Britain.

The adult bird here described was sent me four years ago by Captain Cayley Webster; but it is impossible to say if the bird was adult then or not, for though the plumage was black, the casque was undeveloped, and the colours were dull.

The Mooruk is an inhabitant of the island of New Britain (now most unreasonably and unscientifically officially renamed "Neu Pommern"). It was for the first time made known in a letter from Mr. George Bennett, communicated to this Society by Gould, who proposed the name *Casuarius bennetti* for the new bird, and reproduced a drawing made by Mr. G. F. Angas from the live bird, which was not quite mature. The letter reads as follows:—

"My dear Gould, I send you an account of a new species of Cassowary recently brought to Sydney by Captain Deolin in the cutter 'Oberon.' It was procured from the natives of New Britain, where it is known by the name of 'Mooruk.' The height of the bird is 3 feet to the top of the back, and 5 feet when standing erect; its colour is rufous mixed with black on the back and hinder portions of the body, and raven-black about the neck and breast: the loose wavy skin of the neck is beautifully coloured with iridescent tints of bluish-purple, pink, and an occasional shade of green, quite different from the red and purple caruncles of the *Casuarius galeatus*; the feet and legs, which are very large and strong, are of a pale ash-colour, and exhibit a remarkable peculiarity in the extreme length of the claw of the inner toe on each foot, it being nearly three times the length which it obtains in the claws of the other toes. This bird also differs from *C. galeatus* in having a horny plate instead of a helmet-like protuberance on the top of the head, which callous plate has the character of and resembles mother-of-pearl darkened with black-lead. The form of the bill differs considerably from that of the Emu (*Dromæus novæ-hollandiæ*), being narrower, longer, and more curved, and in having a black and leathery cere at the base, and behind the plate of the head a small tuft of black hair-like feathers, which are continued in greater or lesser abundance over most parts of the neck."

The original specimen was sent to London by Dr. Bennett, and proved itself to be a female by laying eggs. It was, like most Mooruks, much more gentle and tame than most other Cassowaries; and this seems to be a peculiarity of the Mooruk, which is said to be often kept as a pet by the natives of New Britain. It bears itself less upright, and its neck seems to be shorter than that of other Cassowaries.

There is a very long and amusing account of its habits in captivity in Dr. Bennett's 'Gatherings of a Naturalist in Australasia,' accompanied by a figure by Wolf.

In 1863 the Mooruk hatched a nestling in the Society's Gardens. The female began to lay in the middle of March, and laid half a dozen eggs at intervals of about a week. The incubation, according to Dr. Sclater, lasted once 49 days, the next time 52 days. The young did not live more than a day. The eggs were for the first time described (and figured, P. Z. S. 1858) as being of a pale olive colour with darker olive tubercles, but the eggs laid in London show that they are when fresh of a bright apple-green colour (see figure, P. Z. S. 1860) with darker green glazed granulations. They do not differ perceptibly from the eggs of *Casuarius casuarius* and allies, though the glazed caruncles are somewhat less continuous and not so thickly and equally distributed over the entire surface of the egg. The following measurements have been obtained:—137 : 88, 128 : 81, 141 to 131 : 90 to 83, 150 : 88, 135 : 89, 136 : 90, 152 : 87 mm. The full fresh-laid egg weighs about 22 ounces. It will thus be seen that there is hardly any difference between the eggs of *C. bennetti* and *C. casuarius*. Schalow's description of the colour is not from fresh eggs—all he saw were evidently faded ones. The smooth ones (see P. Z. S. 1858 and 1860) are first-laid eggs, the roughly granulated ones the properly developed eggs.

The notes of my live specimen—evidently a male—are usually a low and short piping note, reminding one of that of a large chicken, and when a little excited this note is louder and more plaintive. When much excited it makes its neck quite short, and utters first some higher, then some lower barking sounds followed by some snarling ones.

The eggs of *Casuarius bennetti* in the British Museum have a very different surface, hardly two being alike. They are of different shades of brown, but, needless to say, that is due to exposure, as we know the fresh eggs are green like all other Cassowaries' eggs. One has very few, large and highly raised glazed granulations, one is almost smooth (like first-laid eggs of Cassowaries generally), one exactly like the eggs of *C. papuanus*. They measure:—141 : 89, 127 : 86, 146·5 : 90, and 137 : 90 mm. Schalow gives 137 : 88 and 128·5 : 81·5 mm. Ramsay gives 141 to 131 : 90 to 83 mm.

20. CASUARIUS BENNETTI MACULATUS, subsp. nov.

Casque high, much depressed posteriorly, and sharply ridged. Plumage black; bill long, arched, and pointed; inner claw long. (This bird was first identified by me as a second specimen of *C. picticollis hecki.*) Occiput and hind-neck bright indigo-blue; sides of head, face, and the fore-neck paler and brighter blue. On the lower part of fore-neck is a large round patch, $1\frac{1}{2}$ inches in diameter and of a rosy-purple colour. Naked lower sides of neck rosy purple: from and below the ear-hole extending to the gape is a large white patch washed with rose-colour.

Hab. unknown.

This form may eventually prove to be only a colour-aberration of *C. bennetti*; but, so long as we do not know the exact habitat of every species and subspecies of Cassowary, and the full extent of their individual variation, I consider it right to name and describe this bird as a subspecies of *C. bennetti.* The type is now living in the Society's Gardens, and was fully adult when it was imported. It seems to be a male, and is not so wild as my specimens of true *C. bennetti* usually were.

PART II.—*On the Morphology and Phylogeny of the* Palæognathæ (Ratitæ *and* Crypturi) *and* Neognathæ (Carinatæ). *By* W. P. PYCRAFT.

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INTRODUCTORY.

THE present investigation was undertaken at the request and with the co-operation of the Hon. Walter Rothschild, M.P., who has furthermore furnished the bulk of the material, and in numerous other ways greatly aided my work. The collection of skeletons in the British Museum of Natural History has proved a source of great wealth. I am besides indebted to Mr. Beddard, Dr. Gadow, Dr. Forsyth Major, and Prof. Howes for the loan of specimens in their possession or charge, and I take this opportunity of recording my thanks.

The object of this investigation has been to ascertain, as far so possible, the relations of the *Casuariidæ* to the remaining "Struthious" forms, and the position of these with regard to the "*Carinatæ*." That this attempt has not been fruitless will probably be admitted.

From the nature of the aim of this paper, it will I trust be agreed that the scheme of investigation adopted is about the best possible. The desire has been to select those characters which bear directly or indirectly upon the problem of the phylogeny of the group. Moreover, to have dealt in detail upon the anatomy of the group would have been to repeat a vast body of facts already well known and ably treated in the memoirs enumerated at the end of this work, and from which much has been extracted to serve the ends I had in view. Hence the majority of the omissions which may be noted in these pages are not accidental but of design. The memoirs of Garrod, Gadow, Fürbringer, Meckel, Cuvier, D'Alton, Parker, Beddard, Lydekker, and others are the milestones which mark the progress of the knowledge which has been accumulated on this group. There seemed to me to be no reason or end to be gained in transcribing the information which these individually impart, but rather it appeared more expedient to set myself the task of recording the substance of their achievements, and to endeavour to add a few courses more to the structures which they have reared.

The rejection of the old terms *Ratitæ* and *Carinatæ*, which I now propose, seems to me to be warranted. The Ratite condition is admittedly a secondary one, and the name is objectionable, in that *Hesperornis* and some "*Carinatæ*" are also "*Ratitæ*." The terms now suggested are mutually exclusive, and based upon a primitive character. On this account they are to be preferred. Furthermore, as will be shown, the change is not to be attributed to a desire to effect a change for change sake: it would not have been suggested but for the need, and it seems to me a real need, to include the *Crypturi* with the group hitherto known as "*Ratitæ*." To have retained the old terms would not perhaps have been so *very* contradictory, for, since some "*Carinatæ*" are really "*Ratitæ*," there is no reason why some *Ratitæ* should not be "*Carinatæ*"! A further discussion of the subject will be found in the summary.

In conclusion, I wish to record my grateful thanks to Mr. Rothschild for having entrusted this work to my hands.

PTERYLOSIS.

The description of the pterylosis of the *Palæognathæ* is most easily accomplished by an enumeration of the *apteria*. Though these are but few in number, they are nevertheless of considerable importance, inasmuch as they disprove the prevalent notion that the feathers in the "*Ratitæ*" are evenly distributed over the body. It has, however, long been known that *apteria* occurred in embryos of certain forms, e. g. *Struthio*, *Rhea*, and *Apteryx*.

The descriptions of the *Oil-gland*, *Rhamphotheca*, *Podotheca*, and of the structure of the feathers, both macro- and microscopical, will be found in this section.

a. *Pterylosis of the Adult.*[1]

CASUARIIDÆ.

CASUARIUS CASUARIUS Linn.

Apteria:—

A. spinale.—This was wanting.

A. mesogastræi.—This includes the characteristic and well-marked *sternal callosity*, and extends backwards to within a short distance of the cloacal aperture. It is widest on the abdomen.

A. trunci laterale.—Represented by the naked under surface of the wing and a small truncal area at its base.

The head and more or less of the neck are, in the adults of this and other species of the genus, bare, and brilliantly coloured. The extent and nature of this coloration have already been dealt with by the Hon. Walter Rothschild in the first part of this Memoir.

Pterylæ:—

P. alaris (Pl. XLV. fig. 10).—It is possible to distinguish in this both remiges and coverts as in *Neognathæ*. The former are represented by the characteristic elongated porcupine-like quills. These are six in number and distributed as follows:—mid-digital (1) and metacarpals (2) representing the primaries, and cubitals or secondaries (3).

The cubital series, at first sight, appears not to extend backwards to the elbow as in *Neognathæ*, the last of the spine-like remiges being attached not farther down the ulna than its proximal fourth. Beyond this, however, are three moderately long feathers occupying the position of remiges, but bearing each an aftershaft. Similarly at the distal end of the series, we have, in front of the mid-digital, a feather occupying the position of a remex—possibly representing the addigital—but small and bearing an aftershaft. This, like the three cubitals, appears to have a major covert, as also have the other spine-like remiges. The mid-digital is very small; the other remiges are of considerable length. The longest of these are the 1st metacarpal and the 1st cubital.

The remiges are remarkable in that they are open at the free end (see page 166). They are cylindrical, of irregular thickness and more or less crooked.

The tectrices are not distinguishable from the rest of the body-feathering. All bear aftershafts. Coverts representing the *tectrices majores* of the *Neognathæ* are certainly

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[1] As "adult" we have included nearly full-grown as well as full-grown specimens, *i. e.* those which have not yet attained the characteristic adult livery.

present, and bear the same relation to the remiges. Other coverts—*t. mediæ, minores,* and *marginales*—are not distinguishable.

There is no *ala spuria.*

Neither in this, nor in any other species of the *Palæognathæ* are there any semiplumæ, plumulæ, or filo plumulæ. The absence of these last is of more significance than of the two former. There are no rectrices. The oil-gland is wanting.

Eyelashes are present and well developed.

The *Rhamphotheca* of the upper jaw is compound, being composed of a small median rhino- and small lateral gnathotheca. The nasal fossa is not protected by the rhamphotheca, but is covered only by the integument. The anterior nares are impervious, slit-like, slope obliquely forward, and placed at the extreme end of the fossa.

The *Podotheca* (fig. 2 A, p. 155) has the acrotarsium clothed, below with broad scutes, above with large granular scales; the acropodium with scutes. The claw of the inner toe is greatly elongated, to serve as a weapon of offence.

The wing is not armed with the blunt claw found in many other species.

C. casuarius beccarii (Sclater).

The pterylosis of this subspecies agrees with that of the typical form *C. casuarius.* In one specimen I found 6 remiges, the additional quill representing a primary.

C. casuarius sclateri.

The pterylosis of this agreed with the two foregoing. In one half-grown specimen the *apterium spinale* could be faintly traced from the inner surface of the skin. The wing bore a long blunt claw.

C. casuarius salvadorii.

Apter. spinale.—Though not of great extent, in this species was well defined. It extended cephalad as far as a point corresponding with the exit of a vertical line passing through the body from the posterior end of the sternal callosity, and caudad to the middle of the pelvis above the acetabulum. Its total length was about 8 inches, its width about $\frac{1}{2}$ inch.

A. mesogastræi.—Very narrow, and bounded by degenerate feathers, indicating a tendency to increase the width of this space, and recalling similar conditions in the *Carinatæ.* It could be traced backwards to within a short distance of the cloacal aperture.

A. trunci laterale.—Represented by the naked under surface of the wing.

Pteryla alaris.—As in *C. casuarius.*

The wing was armed with a claw.

C. CASUARIUS VIOLICOLLIS.

C. UNAPPENDICULATUS.

A. spinale.—As in *C. casuarius salvadorii.*

A. mesogastræi.—This was much more clearly defined than in *C. casuarius.* Its width exceeded that of the *apterium spinale.*

I have not been able to examine spirit-specimens of nestling Cassowaries. Consequently I am unable to say whether there is an oil-gland, as in *Dromæus* (p. 154); or whether the general pattern of the body-coloration is continued on the podotheca, and the integument covering the nasal fossa: features which obtain in *Dromæus.*

One conspicuous difference between the nestling and the adult *Casuarius* is the fact that the head and neck are densely feathered in the former. The casque is indicated by a horny plate covering the roof of the skull.

DROMÆUS NOVÆ-HOLLANDIÆ. (Nestling.)

Apteria :—

A. spinale.—This is wanting.

A. mesogastræi.—In form and relations this agrees with *Casuarius*, but is relatively much smaller.

A. trunci laterale.—As in *Casuarius.*

Pterylæ :—

P. alaris.—There are 17 remiges in all. Of these, 10 are cubitals and 7 metacarpodigitals. These remiges in the adult are peculiar, lacking the calamus and possessing an aftershaft.

The tectrices are arranged in obliquely transverse rows, as in *Rhea* (p. 156), but they are not sharply separated one from another as in that genus. Furthermore, they are not separable into major, median, minor, and marginal series as in *Neognathæ.* They extend outwards on to the manus. All the primaries apparently belong to the metacarpal series. Digit II. is free. That is to say, so much of this vestigial digit as remains projects freely beyond the feathers, and bears a claw as in *Archæopteryx*, *Opisthocomus*, and the *Gallinæ.* In these last the claw appears in the embryo.

There is no ala spuria; and rectrices are also wanting.

Rhamphotheca.—That of the upper jaw resembles that of *Casuarius.* The rhinotheca, caudad, is sharply distinguished from a thin cere in which the nostrils, which are impervious, are placed. The position of the nostrils is about the middle of the beak. They are not protected by an operculum.

The sheath of the lower jaw is also composed, as in *Casuarius,* of three pieces—a median and two lateral. The tomium bears slight traces of denticulations similar to those described by myself in the Tinamous [81][1]. The young of *Casuarius* bear traces of similar denticles.

Podotheca.—The acropodium is made up of small reticulate plates which gradually fuse to form ten large transverse scutes, covering its distal third. These are widest in the middle of the series. The border region, between the acrotarsium and the acropodium, is clothed with tiny granulate plates; these extend downwards so as to clothe the proximal half of both outer and inner toes—the remaining region of these, like the whole of the middle toe, being protected by large scutes. The inner claw is not elongated as in *Casuarius*. The planta is covered with small reticulate plates.

It is interesting to note that the podotheca and the cere are mottled with black pigment, so as to carry out the general scheme of coloration which characterizes the feathers. This mottling is most distinctly marked in a ripe embryo (fig. 2 B). In a stage earlier than this, and in the nestling, they are not nearly so distinct.

The *Uropygium* is distinctly traceable in this nestling: in the ripe embryo it is much more easily demonstrable. Here it is represented by a small rounded oval mass partly embedded in the skin and lying immediately above the cloacal aperture, as in *Apteryx*.

Neither in this nestling nor in the embryos is there any trace of a separate, detachable, egg-tooth, as is found in the *Neognathæ*; but the region of the beak in which this is usually borne is, in the embryos, produced into a small conical elevation of a whitish colour. Perhaps we should be correct in regarding it as a non-detachable egg-tooth becoming absorbed after hatching. In the *Neognathæ* it is detachable, and falls off after this event.

RHEIDÆ.

RHEA AMERICANA.

Apteria:—

A. spinale.—In one adult and a three-months old nestling this was divided into two portions—more or less distinctly—an anterior and a posterior; thus recalling the form of this tract in some Tinamous, e. g. *Calodromas elegans*. The anterior space was cordiform in shape, with its base towards the head. Its greatest width was nearly 2 in., its greatest length about the same. A more or less perfectly feathered area of about 4 in. in length divided this from the posterior apterion which is continued to the tail. It was at first about $\frac{3}{6}$ in. wide, narrowed to $1\frac{1}{2}$ in., contracting again to 1 in. for the rest of its course. In another adult and three-months old nestling the anterior apterion was very small.

In other adults, and seven young birds ranging from embryos to half-grown specimens, the anterior space was wanting.

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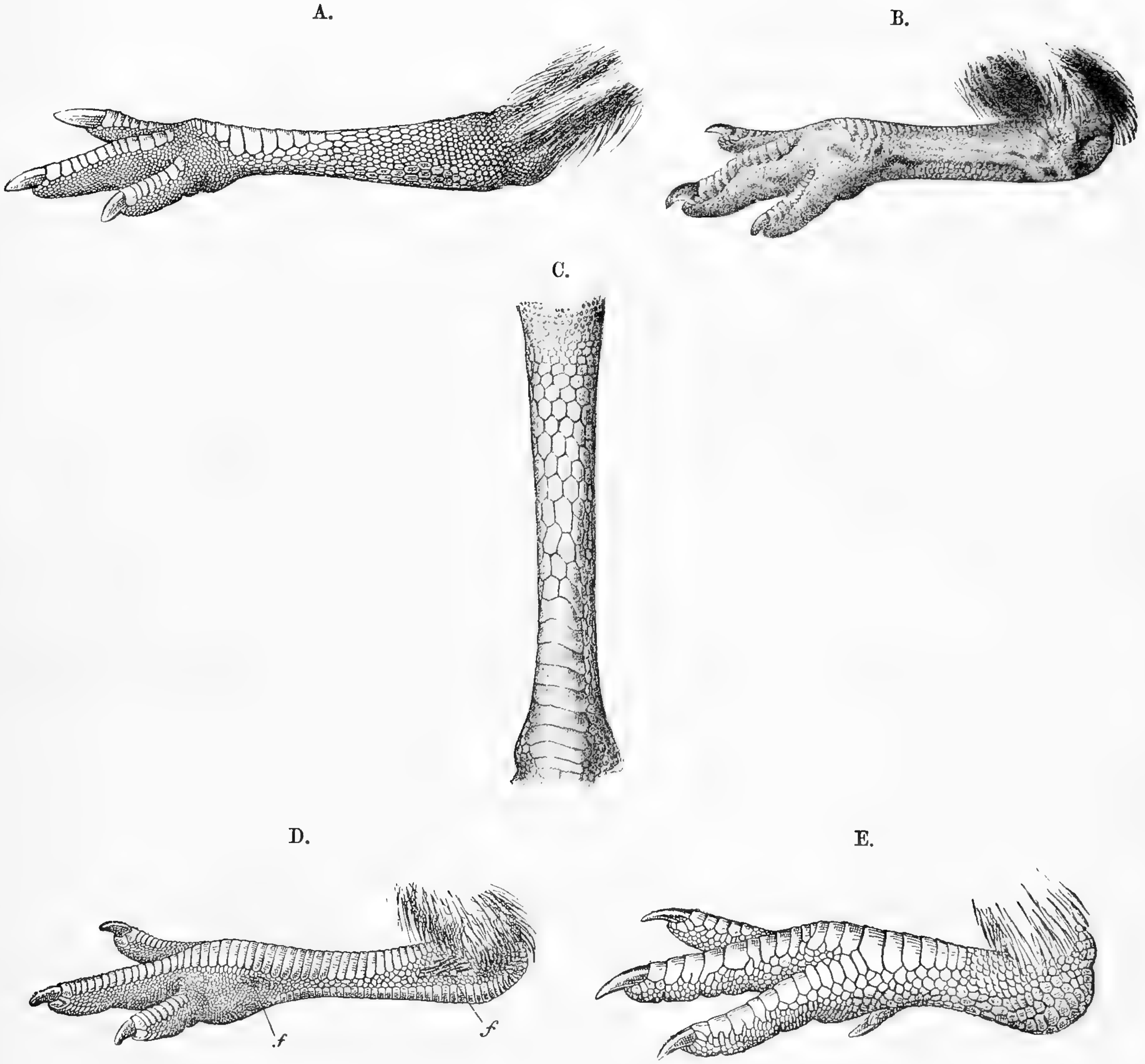
[1] Figures in brackets refer to Bibliography at end of paper.

Fig. 2.



A.—Left foot of a nestling *Casuarius casuarius sclateri*, to show the arrangement of the scutes of the podotheca.

B.—Left foot, anterior aspect, of *Casuarius loriæ*, for comparison with A, to show the large hexagonal plates clothing the proximal portion of the tarso-metatarsus.

C.—Left foot of a newly hatched *Dromæus novæ-hollandiæ*, to show the arrangement of the scutes of the podotheca, and the curious continuation of the pattern of coloration of the body down to the toes.

D.—Left foot of a ripe embryo of *Rhea americana*, to show the arrangement of the scutes. Note the presence of feathers (*f*) on the tarso-metatarsus—temporary in this species, permanent in *R. darwini*.

E.—Left foot of an embryo *Apteryx australis mantelli*, to show the form of the scutes of the podotheca.

A. trunci laterale.—This occupies the whole under surface of the wing, extending backwards to a point corresponding to the level of the free end of the scapula. Its width is considerable. It extends dorsad, above the scapula, about 1 in., and ventrad, below it, about 4 in. The feathers over the front and upper end of the thigh are small and sparse, suggesting the formation of an apterion, thus tending to form a distinct *pteryla femoralis* as in the *Neognathæ*.

A. mesogastræi.—This includes the sternal callosity, which is 3¾ in. long and 2 in. wide. Immediately caudad of this callosity the space narrows to 1¼ in., and again to about ½ in., which width is sustained for the rest of its length till it ceases about 3 in. in front of the cloacal aperture.

Pterylæ:—

P. capitis.—The region of the eye is surrounded by a bare space; so also is the external aperture of the ear. The rim of the aural orifice is surrounded by feathers which serve to close the aperture. The throat is bare along each side of the mandible. There are well-developed eyelashes.

Pt. alaris.—The wing is eutaxial and of great size. Remiges 28. Cubitals 16. Metacarpo-digitals 12 = metacarpals 7; addigital 1; mid-digitals 2; pre-digitals 2. The arrangement of the quills and coverts in the wing of the Rhea appears to be unique, at least in so far as the arrangement of the cubital remiges and the coverts are concerned. The pollex only bears a claw.

The cubital remiges are spaced about as wide apart as in the wing of a Neognathine of about the same relative size, *e. g.* Stork or Eagle. There is one point, however, in which they differ considerably: rows 1 to 6 do not rest, as the others, on the ulna. The 1st and 6th almost reach it, the 3rd and 4th are most distant from it. They seem to have been carried away by the tension of the ala membrana posterior, stretched in the angle between the manus and forearm.

The cubital remiges are rather shorter than their major coverts: those of the hand are longer. This difference in length between the remiges and their major coverts is probably an indication of degeneracy. It is interesting to note, in this connection, the fact that in the young chick the first cubital flight-feathers are *not* remiges, but major coverts.

The metacarpo-digital remiges are arranged much as in the *Neognathæ*, but somewhat farther apart, so that they tend to form pairs with their major coverts. Like the cubital remiges, they are of great length, but differ therefrom in that they are longer—by an inch instead of shorter by that amount—than their coverts. The 1st metacarpal remex is distinctly smaller than the rest of the series: see p. 157.

The ventral aspect of the wing is bare.

The coverts of the dorsal aspect are arranged in obliquely transverse series, the feathers of each series being piled as it were one upon another, from six to nine such coverts being included in each of these bundles. The bases of these coverts form a series of partitions, dividing the post-axial border of the wing into a number of wide and deep compartments.

Carpal covert and remex. (Pl. XLV. fig. 12.)

Two different sets of feathers seem to claim identification with these; one or other of which is invariably present in the *Neognathæ.* The 1st metacarpal remex appears to me to represent the carpal remex of the *Neognathæ.* This is smaller than the rest of the metacarpal series and has a large major covert. In its position and its relations to the 2nd remex, it closely resembles the carpal remex of many *Neognathæ.*

The second set of feathers, referred to as possibly representing the *Neognathine* carpal covert and remex, lie immediately pre-axiad of the base of the major covert of the 1st metacarpal remex; or, in others words, pre-axiad of the base of that feather which we have just tried to show *may* represent the carpal covert (*c.c.*, Pl. XLV. fig. 12). The identification of the covert must stand or fall by the quill.

The possible carpal remex, *c'.r'.*, as we have just remarked, lies immediately pre-axiad of the supposed carpal covert (*c.c.*, Pl. XLV. fig. 12). Furthermore, for the purposes of identification, we may mention that this new remex, **, is seen to be serial with the *t. mediæ* of the forearm on the one hand, and is the terminal feather to a transverse row of six on the other. In other words, it and its covert represents the 1st median and minor covert of the manus. In position, that is to say with regard to its relation to the 1st metacarpal remex—which is also to be regarded as possibly representing the true carpal remex, *c.r.* fig. 12,—it very closely agrees with the relation between the carpal remex and the 1st metacarpal remex of *Neognathæ* (*c.r.*, Pl. XLV. fig. 12).

It does not seem possible to settle this question definitely. It may be that these two feathers now under discussion may, in the *Neognathæ*, represent sometimes one, sometimes the other of these two sets. This seems the more probable when we remember the varying development and relations to the primary remiges which obtain in wings of *Neognathæ.*

If the first and most favoured interpretation of the identity of the carpal remex is correct, then it would seem that it represents, in Neognathæ, the 1st metacarpal, not the 1st cubital remex, as was contended by Mitchell [62]. If the second interpretation is correct, then the carpal remex of the *Neognathæ* is represented in *Rhea* by a median and minor covert of the metacarpus.

T. majores.—On the cubitus these are slightly longer than their remiges, about 1 in. On the manus they are slightly shorter. It is significant to note that in the young of many *Neognathæ* the cubitals are at first shorter than their coverts; the coverts performing for a brief time the function of the quills, as in the case of young *Gallinæ.*

T. mediæ.—The median coverts of the cubitus offer no features for discussion other than those included in the general remarks on the arrangement of the coverts. There are only two median coverts in the hand, and, as already hinted, one of these may represent the carpal remex.

T. minores.—There are 6 to 7 rows of minor coverts on the cubitus. They are wanting in the manus.

T. marginales.—A broad bare space separates these from the minor coverts. They are arranged along the pre-axial border of the wing, in groups of 3, just as in some *Neognathæ.* They are wanting in the hand.

Ala spuria.—There are 5 thumb-quills, as in the *Neognathæ.*

Parapteron and Hypopteron.—These humeral remiges are wanting in *Rhea.*

The feathers along the pre-axial border of the humerus are of great length.

The whole under surface of the wing is perfectly bare, a probably degenerate character.

Pt. caudæ.—There are no rectrices.

Uropygium.—Absent in adult (p. 159.)

The *Rhamphotheca*, like that of *Dromæus*, is made up of three pieces, both in the sheath of the upper and lower jaws. There is no trace of the denticulations found in *Dromæus*, either in the adult, nestling, or embryo. The aperture of the nostrils, which are pierced through the cere, is lateral.

The *Podotheca* of *Rhea americana* (fig. 1 D), according to Dr. Gadow [25], resembles that of *R. darwini*, and differs from that of *R. macrorhyncha* in that the whole of the acrotarsium is clothed in large scutes, whilst in *R. macrorhyncha* these scutes are confined to the distal extremity. The leg of this last thus resembles that of *Casuarius* and *Dromæus.* *R. darwinii* is furthermore peculiar in that the feathering of the tibio-tarsus is continued downwards on to the tarso-metatarsus for some distance. It is interesting and significant to note, however, that a few feathers occur in this region in the embryo of *R. americana.* Indeed, in this latter their extension may be traced downwards to within a short distance of the toes, as will be seen in fig. 2, p. 155.

The planta is also invested by large scutes. In the $\frac{3}{4}$-grown nestling and adult these are arranged in the form of a series of paired plates. In the nestling and ripe embryo they form a series of single transverse scutes. Along the inner side of these large scutes will be found a number of smaller, wedged in between the larger. These apparently gradually increase in size, and thus give rise to the secondary arrangement of paired plates.

The claws of the toes are laterally compressed, and form a strong median dorsal ridge or keel, not met with in other *Palæognathæ.* This is most marked in the outer and inner toes.

b. *Pterylosis of the Embryo and Nestling.*

The ripe embryo and the nestling *Rhea americana* appear to differ from the adult only in that the anterior portion of the *apterion spinale* is absent, and that there is a distinct oil-gland.

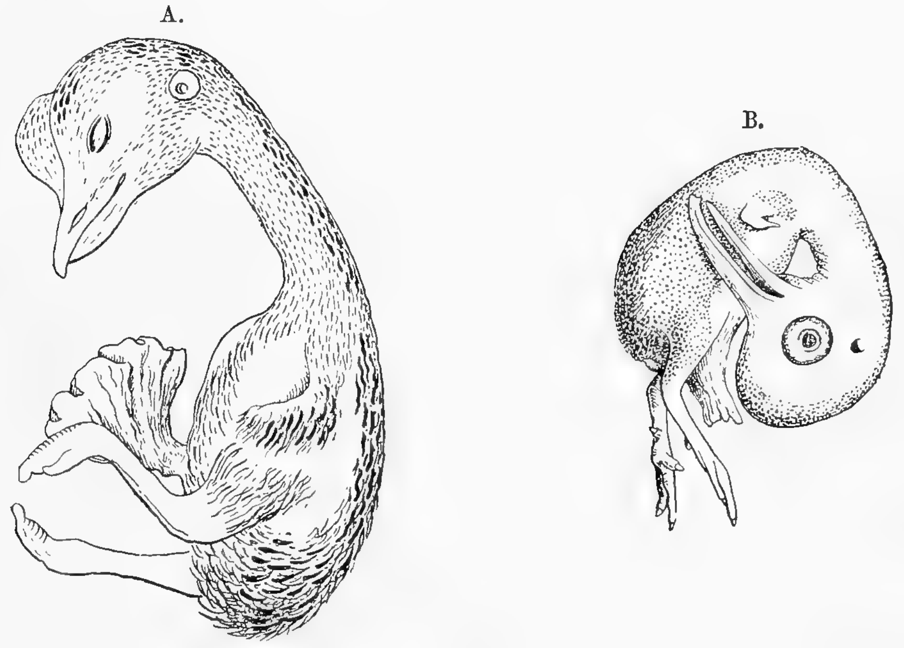
I find no trace of an "egg-tooth" in the ripe embryo, which I myself removed from the egg. This is also wanting in the embryo *Dromæus* and the nestling *Casuarius*. Concerning *Dromæus*, however, see p. 154. The late Prof. Jeffery Parker failed to find it in *Apteryx* at any stage of its growth.

STRUTHIONIDÆ.

STRUTHIO CAMELUS.

I have not been fortunate enough to secure either nestling or adults of *Struthio*; consequently I am obliged to fall back upon the published accounts of others. Nearly all that can be gathered, moreover, concerning the pterylosis of the trunk of *Struthio* concerns embryos only. The wing of the adult Ostrich has been ably described by

Fig. 3.



A.—Lateral view of an embryo of *Struthio*, after Lindsay, to compare with *Apteryx*. Note the absence of a lateral cervical apterion.

B.—Lateral view of an embryo of *Apteryx australis*, right side (after Parker), to show the pterylosis. Note the distinct *pteryla colli ventralis* and *dorsalis* and the *pteryla humeralis*.

Wray [97]; the figure illustrating his paper has been reproduced here by the kind permission of the Zoological Society. The pterylosis of the trunk of the embryo has been figured by Lindsay [48], and is reproduced here (fig. 3A).

Apteria:—

Apt. spinale.—Very narrow, longer relatively than in *Casuarius*, which it resembles.

Apt. mesogastræi.—According to Hildebrand [37] this extends from the beak to the cloaca, but judging from Miss Lindsay's [48] figures it did not extend beyond the sternal callosity, as in other flightless *Palæognathæ*.

Apt. trunci laterale.—This would appear in size and form to closely resemble that of *Apteryx*, and to differ from all the remaining *Palæognathæ*.

Hildebrand also describes an apterion on the crown of the head.

Pterylæ:—

Pt. alaris (Pl. XLV. fig. 11).—According to Wray [97] there are 16 metacarpo-digitals, distributed as follows:—metacarpals 8; addigital 1; mid-digitals 4; pre-digitals 3.

According to Wray's figure, reproduced on Pl. XLV. fig. 11, the primaries are placed wide apart and almost at right angles to the long axis of the hand. The number of the metacarpals is higher than in any other bird—8. In *Rhea* and some *Neognathæ*, i. e. Flamingo, there are 7 metacarpals. In no other bird, save *Struthio*, are there 4 mid-digitals and 3 pre-digitals. The arrangement of the coverts appears to differ materially from that of *Rhea*. The ala spuria is made up of 4 remiges. I await a spirit-specimen before attempting the search for the carpal remex and its covert.

It would be interesting to know whether the *flexor carpi ulnaris* resembled that of *Rhea* in the large fleshy portion for the attachment of the remiges (fig. 5 A, p. 240) and what is the condition of the vinculum tendineæ. Assuming that the disposition of these parts in *Rhea* represents a proto-carinate condition, we should expect to find the wing of *Struthio* very similar in these particulars.

Both pollex and index are armed with a claw.

Rhamphotheca.—Compound as in *Rhea*

Podotheca.—Acropodium and lower portion of acrotarsium with broad transverse scutes. Only 3rd and 4th toes are present; of these in the adult only the 3rd bears a claw.

Uropygium wanting.

APTERYGIDÆ.

APTERYX AUSTRALIS MANTELLI.

Apteria:—

A. spinale.—This is wanting.

A. mesogastræi.—This is a well-marked space, extending forwards from the cloacal aperture, along the middle line, as far as the base of the neck, to a point corresponding to the interclavicular region of the *Neognathæ*. Its greatest width (1 in.) is on the abdomen; in the middle of the sternum it is nearly ½ in.

A. trunci laterali is of very considerable extent. It runs from a point immediately over the head of the femur downwards and forwards as a conspicuously broad bare space of about 1 in. in width; terminating at the base of the neck. At the wing it gives off a branch downwards and backwards between the thigh and the *pteryla ventralis* as usual, and terminates about 2½ in. from the cloacal aperture.

Pterylæ:—

Pt. capitis.—This is very dense, and bears numerous rictal bristles of great length.

Pt. spinalis.—Forms a broad saddle-shaped tract blending posteriorly with the femoral tract, and anteriorly passing into the *pt. colli.*

Pt. ventralis is well defined. Anteriorly it blends with an incipient *pt. colli ventralis*, and is continued backwards as a sharply defined tract bounded on the one side by the *apterion trunci laterale* and the other by the *apt. mesogastræi.*

The *pt. colli* is almost divided into a dorsal and ventral tract by the forward extension of the *apt. trunci laterale.*

Pt. alaris (Pl. XLV. fig. 13).—Remiges 13. Cubitals 9. Metacarpo-digitals 4= metacarpals 1; addigital 1; mid-digitals 2.

The innermost cubital is very weak, and is counted a remex solely on account of its position. Yet I think that most would agree with me in this decision. The 3rd metacarpal remex (? mid-digital) is cramped in position, and forced dorsalwards almost into the position of a major covert. The calamus of these quills is very long in proportion to the length of the whole feather, and is fusiform in shape. The form of these quills is exactly reproduced, as will be seen in the figure (Pl. XLV. fig. 15), in the first quills of the nestling Cassowary (see p. 165).

The proximal end of the forearm, over the region of the elbow-joint, is bare, as in many *Neognathæ*.

The arrangement of the coverts is that of obliquely-transverse rows, as in *Neognathæ*. Only *tectrices majores*, however, can be certainly made out. There appears to be but one major covert on the manus.

The index-finger bears a large claw. There is no pollex.

Pt. femoralis.—Uniformly feathered, passing forwards into a sharp, cone-shaped point.

The *Uropygium* is a large, compressed, naked, conical gland lying at the bottom of a conspicuous depression—formed by the great development of the gluteal muscles,—and immediately above the cloacal aperture. A figure of the uropygium will be found in Mr. Beddard's recent paper [8].

Rhamphotheca.—Apparently made up of the same elements as in the other *Palæognathæ*; but this is masked by the greatly elongated form of the beak. There is a distinct cere at its base, but this is not pierced, as in *Rhea*, *Dromæus*, and *Struthio*, by the nostrils. These, in *Casuarius*, open near the top of the beak, and in *Apteryx* at its extreme tip, where they will be found as a pair of minute slit-like apertures.

Podotheca (fig. 2 E).—The acrotarsium may be either made up of large rounded scales, or of large scutes as in *Rhea americana*. The latter form occurs, so far as I have been able to make out, only in *A. australis mantelli*. The *planta* in this species is covered with large coarse papillæ. In an embryo of *A. australis mantelli* the fusion of small plates into scutes in the acrotarsium is well shown (fig. 7).

CRYPTURI.

The pterylography of this group of the *Palæognathæ* has been described in considerable detail by myself [81]. It will suffice here to say that the *apteria* are more marked than in the flightless forms. In the form of the *apt. spinale*, *Calodromas elegans*, one of the Crypturi, closely resembles *Rhea*. Unlike the flightless members of the group, filo-plumes occur—though very sparingly; and down-feathers. These last, however, are restricted to the *pteryla alaris*.

The neossoptiles, in the large size of the aftershaft, differ from those of the flightless forms; but in the remarkable development of the radii and in the elongated flattened shape of the rami, the Crypturi closely resemble the Struthiones (Pl. XLV. fig. 2).

The denticulated tomium of the nestling *Calodromas* recalls that of *Dromæus*.

THE STRUCTURE OF THE FEATHERS.

The Neossoptiles.

The neossoptiles of the *Palæognathæ* consist of prepennæ only, but these present many features of great interest.

The prepennæ of *Casuarius* have a moderately long rhachis, bearing some 3–4 pairs of rami. The radii are unsegmented, of relatively medium length, and bear minute fila, sparsely distributed (Pl. XLV. fig. 5). The aftershaft is apparently represented by about 6 rami standing at the base of the main shaft, and *not* seated along a separate rhachis, as in the Fowl or Tinamou.

The prepennæ of *Dromæus* (Pl. XLV. figs. 4, 4 *a*) appear to be distinguishable from those of *Casuarius* chiefly, and probably only, on account of their rather greater length;

the rhachis bears about 6 or 7 pairs of rami. The radii are slightly stouter, relatively. As in *Casuarius*, fila are minute and rare.

The nestling-down of *Apteryx* (Pl. XLV. fig. 6) is easily distinguishable from that of the remaining *Palæognathæ*. Like that of *Dromæus* and *Casuarius*, it has a well-developed shaft, but it differs from these in its greater length and in the very numerous rami. From *Rhea* and *Struthio* it differs entirely, in that, in these, the neossoptiles are umbelliform.

The most striking feature perhaps of the nestling-plumage of *Apteryx* is its great length. In texture we appear to get three gradations. *A. australis mantelli* and *australis* very closely resemble one another and differ from the remaining species in that the feathers are coarser and slightly harsh to the touch. *A. oweni* and *A. haasti* stand at the other extreme and are peculiarly soft. Some individuals of *A. australis*, however, seem to stand between the two.

A. haasti is the most markedly distinct of all. The feathers clothing the head, neck, and thighs are of a peculiarly downy character, recalling, in texture, the down-feathers on the breast of the adult Duck. On the back and breast they are of a peculiar "woolly" texture, resembling very strongly the intermediate plumage or pseudo-definitive feathers, (mesophyles of Palmer), which follow the prepennæ in the Owls.

There is no trace of an aftershaft to these prepennæ.

The rami are closely set, very numerous (18 to 20 pairs), and moderately long. The radii are relatively short, and have the appearance of being formed of a number of short, laterally compressed joints, the dorsal and ventral angles of the anterior ends of which are produced forwards to form a pair of minute fila.

In the length of the shaft and the great number of the rami the prepenna of *Apteryx* stands alone amongst the *Palæognathæ*; moreover it is further peculiar in that it is not produced beyond the most distal radii into long filaments.

A peculiarly interesting feature of the prepennæ, and of the first definitive feathers, is that the latter do *not* thrust out the former, as they appear to do in all other known birds. Exactly how this is avoided is a point for further investigation. I hope to be able to explain this mystery shortly[1]. That this process of thrusting-out is avoided can be still seen in a downy nestling of *A. haastii* in the Rothschild Collection. Here the first definitive feathers are about halfway through the skin, and show no trace whatever of a prepenna surmounting the tips, as do the other *Palæo-* and *Neognathæ*. Furthermore, they are peculiar in that they are not invested by the sheath common to all developing feathers. This appears to break away as soon as it reaches the surface of the skin.

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[1] It may possibly turn out that this nestling-down plumage may represent preplumæ instead of prepennæ: this would account for their non-ejectment by the teleoptiles. The fact that plumulæ do not occur in the adult is of no importance. Zander [101] has described "pinsel-artig" down-feathers in the embryo *Rhea*, but this is probably an error.

The structure of the adult contour-feather does not differ much from that of the prepenna. The chief distinction—apart from size—whereby the two differ appears to be in this:—that in the adult the rami are arranged in pairs, and not alternately up the shaft; that the radii are confined solely to the rami, and do not grow along the shaft in the inter-ramal spaces; and, thirdly, the rami are not so distinctly divisible into nodes and internodes; but there is not much difference in the form and length of the fila.

Casuarius, *Dromæus*, and *Apteryx* all agree in that the prepenna has an elongated main shaft, and no distinct aftershaft.

Rhea and *Struthio* agree one with another, and differ from the above-mentioned, in that the prepenna is umbelliform (Pl. XLV. figs. 3, 3 *a*). The main shaft appears to be represented by 3 rami conspicuously stronger than the rest with which they are associated. The prepennæ are borne upon the tips of the definitive feathers for a very considerable time, giving a quite peculiar appearance to the first plumage.

In *Rhea* the bases of all the rami, 9 in number, are seated around the upper umbilicus. The main axis of the feather—the rhachis—as just remarked, is represented by 3 elongated rami, bearing radii from the base upwards for a short distance, and produced beyond these into a long slender filament. The aftershaft is represented by some half-dozen rami, furnished with numerous delicate radii. These last are moderately long, strap-shaped filaments, with scarcely the faintest trace of fila.

In *Struthio* the typical neossoptile (Pl. XLV. figs. 7, 7 *a*) has the three rami representing the main shaft produced far outward beyond the tip of the feather; the projecting region of each taking the form of a hardened, glistening, ribbon-shaped lamina, hollowed in its ventral surface. In this particular it closely agrees with the *Crypturi*. The radii are short, and run along the rami as a series of relatively broad, flattened, and pigmented laminæ, set obliquely on to the ramus, and overlapping one another much as in the normal adult *Neognathæ* contour-feather. Moreover, each radius bears numerous but small, probably degenerate, fila and hooklets. The formation of the remarkable "eye-spots" seen in these radii of many *Neognathæ* are worthy of notice and further examination.

The aftershaft rivals the main shaft in size, numbering some 12–15 rami, which do not, however, differ from those of the main shaft, save only in that the rami are not produced into elongated horny bands, whilst the radii are larger than those of the three rami representing the main shaft.

The Structure and Homologies of the Adult and Nestling Remiges of Casuarius.

The Nestling.—The youngest nestling in which these can be studied is that of a stuffed *C. casuarius salvadorii* (Rothschild Mus.).

In the dried wing of this there are 6 remiges. These are widely spaced, and seated in a distinct posterior wing-membrane as in *Neognathæ*. Each consists of a moderately long calamus and a long and tapering rhachis bearing from 4–5 pairs of symmetrically disposed rami set very far apart. There is but the feeblest trace of the fusion between the prepenna and the displacing definitive feather now under discussion.

In *C. casuarius sclateri* the growth of the wing-spines has proceeded a stage farther. The definitive feather is seen to bear rami as well as prepennæ.

In *Casuarius loriæ* the quill-spines have grown very long and have lost the prepenna. The 5th or innermost spine, representing the 3rd cubital remex, yet bears a few rami.

In this stage, and in the last described (*C. c. sclateri*), we get an inkling into the developmental history of these remarkable wing-spines.

This is not the place for a recapitulation of the developmental history of a feather, yet it would be well to recall one or two facts concerned with this for the better understanding of what is to follow.

The axis of a feather, then, is divisible into two parts—the calamus or quill, and the rhachis or shaft. The latter appears to be a continuation forwards of the dorsal region of the tubular calamus. This being so, it is obvious that this drawn-out portion must have two lateral free edges. These in the normal feather turn inwards towards the middle line and finally meet, leaving a very fine seam to indicate the line of junction. But the calamus, it will be remembered, is a thin, dense, horny, and semitransparent structure and perfectly hollow, whilst the rhachis in section is solid, being composed of an outer layer continuous with that of the calamus, and an inner, medullary portion or pith—a white, soft, cellular structure resembling elder-pith. This pith seems to be added for the sake of supporting the outer horny membrane, thus insuring lightness, toughness, and strength. The whole forms the shaft.

The dorsal elongated region of the shaft, now swollen out by pith, forms a sort of plug to the otherwise open mouth of the calamus. The ventral edge of this mouth is always visible. It forms the boundary of the upper umbilicus.

The aftershaft, so conspicuous a feature in the feathers of the Cassowaries, represents an elongation of the ventral region of the calamus exactly similar to that which obtains on the dorsal. Thus we have a dorsal and ventral rhachis.

In the remiges of *C. loriæ* and *C. c. sclateri* we have only the dorsal rhachis, and this is of great interest as only its outer layer is present, there being no pith-cells. This layer takes the form of a delicate scroll-like, ribbon-shaped lamina whose free edges turn inwards, but from the absence of the packing material, or pith, they fail to meet in the middle line (Pl. XLV. fig. 14 A).

The fate of the prepenna which remains attached to the young definitive feather can be conjectured with probable certainty. It is shed or rubbed off as in *Carinatæ*. The definitive rhachis with its rami appears to be carried for a short while longer, and then to break off from the calamus by which it was supported. The fracture takes place at the upper umbilicus, and leaves only the calamus. This appears to go on growing and thickening its walls, so that in course of a short time it becomes the solid, elastic spine so familiar in, and peculiar to, the Cassowaries.

In the wing of the adult *Apteryx* we have an almost similar series of wing-spines. These differ, apparently, from those of *Casuarius* only in that they have retained the rhachis and its rami, and in that the calamus is yet hollow. In one point, however, they differ markedly, inasmuch as they have what is possibly a vestigial aftershaft. This can be readily seen as an elongation of the central lip of the calamus, the sides of which bear numerous rami.

The Teleoptiles.

In the *Palæognathæ* there is but one form of teleoptile, corresponding to the contour-feathers of the *Neognathæ*, semiplumulæ, plumulæ, filoplumulæ, and powder-down are all absent. Rictal bristles, such as occur in *Apteryx*, and eye-lashes, such as are found in all other *Palæognathæ* save *Apteryx*, are modifications of contour-feathers.

Meijere claims to have discovered filoplumæ in *Struthio*, *Rhea*, and *Casuarius*, and gives figures of each. I cannot, however, confirm this. I have found degenerate feathers in the wing of *Casuarius* similar to that he figures from the neck of *C. papuanus*: these, however, I regard as degenerate contour-feathers. I failed to find anything in *Rhea* corresponding to his figure; *Struthio* I have not had an opportunity of examining. He failed to find them in other *Palæognathæ*.

In *Casuarius* the teleoptiles are, on the lower region of the back, of great length, and relatively larger than in *Dromæus*. Only the rami of the lower part of the feather, from wherever taken, bear radii, and these appear to be entirely destitute of fila. The rami throughout the greater part of the length of the feathers are long and hair-like, reminding one of egret-plumes.

The hyporhachis is nearly or quite as long as the main shaft, and does not differ therefrom structurally, as in *Neognathæ*.

The *Casuariidæ* are remarkable for the enormous spines, 5 in number, which are borne by the wing. These are degenerate remiges, and are dealt with above.

The plumage of the *Dromæidæ* differs conspicuously from that of the *Casuariidæ* by its greater softness of texture. In the latter it is harsh and coarse.

The rami are closely set, as in typical contour-feathers of *Neognathæ*. In a feather taken from the middle of the *pteryla spinalis* the radii are of great length, and give the surface of the feather a very soft, silky appearance ; towards the tip they decrease in length, and finally disappear. The distal end of the feather—about one-sixth of its whole length—is peculiar, in that the rami bear no radii, but fuse more or less completely into one common laminate mass. Separate rami may, however, be distinguished here and there under the microscope. The radii are very long, filamentous, and bear only minute pointed fila, for the most part unpaired.

On the neck the feathers are of a looser structure, the radii being shorter, and disappearing much sooner than in the back-feathers.

The contour-feathers of the *Apterygidæ* appear at first sight to differ but little from those of many *Neognathæ*, the vane of the feathers, seemingly, being continuous. The fact that it is discontinuous is only proved after microscopic examination.

The rami are paired, set close together, and moderately long. The radii are long, filiform, more or less distinctly jointed, and armed with numerous minute fila, set in pairs, following close one upon another. These run in this fashion through almost the entire length of each radius, only the extreme proximal end lacking such appendages. According to Parker [71] they are longer in the embryo than in the adult. The entire absence of hooklets at once distinguishes this from a laminate feather.

There is no aftershaft. (See also p. 163.)

In the *Struthionidæ* the adult contour-feather more nearly resembles that of the *Neognathæ* than is the case with any other of the *Palæognathæ*.

The rami are set closely together, precisely as in the typical Carinate feather. The radii take the form of narrow blade-shaped bands, directed upwards and outwards, so that the rami from which they spring form the bottoms of **V**-shaped troughs. The distal end of each radius bears fila disposed as in normal *Neognathæ*, but none are sufficiently elongated to form hooklets: they are probably, however, vestiges of these. Moreover, the radii differ from those of more perfect feathers in that the distal and proximal radii do not differ one from another: both series are alike, long and blade-shaped. Thus, the vane is discontinuous—a probably degenerate condition.

In the *Rheidæ* the contour-feathers of the trunk are characterized by the markedly discontinuous character of the vane; the rami appearing as a number of hard lines, between which radii are only faintly traceable.

The remiges are of very considerable size, though far inferior to those of the Ostrich. The rami bear numerous short and fairly conspicuous radii.

The radii of the track-feathers, under the microscope, appear to have degenerated rather less than have those of the remiges. They approach those of the Ostrich. At its proximal end, each radius is laterally compressed, the resultant lamina bearing some 4 or 5 long fila, probably vestiges of hooklets, and of the processes which occur on the ventral edge of the lamina in the proximal radii of Neognathine feathers.

The radii of the remiges are filiform, but distinctly flattened from side to side. The fila suggest vestiges of hooklets; they are frequently bifid.

In the *Dinornithidæ* the rami and radii are short. The latter, from the middle of the feather to its base, are filiform and divided into a series of numerous short joints, the anterior ends of which are produced into two or three pointed fila. Thus these radii most nearly approach those of *Apteryx*, but they may be at once distinguished therefrom by the relatively great length of the fila.

The distal ends of the rami bear no radii.

The feathers of *Dinornis* were first described by Dallas [15]. His description is appended below:—

"The structure of the web is somewhat different from that which occurs in the Emu and the Cassowary. Towards the base of the shaft the barbs spring in groups of four or five together from nearly the same spot, and thus this part of the web assumes a tufted aspect. As we advance towards the apex this arrangement speedily ceases; the number of barbs springing from the shaft gradually diminishes until each side bears only a single series of these appendages. The barbs consist of slender, flattened fibres, bearing long, silky, and very delicate barbules, without any trace of barbicels, and presenting a distinctly beaded appearance when examined by a simple lens. Under the microscope . . . . . the barbule appears merely divided by faint transverse partitions into a series of cells, some of which towards the apex exhibit small tooth-like projections representing rudiments of barbicels. . . . . The barbs nearest the base of the feather, both in the main web and accessory plume, are destitute of barbules for some distance from their base; but this distance gradually decreases until the barb is furnished with barbules throughout its whole length."

As Dallas remarks, these fragments still leave us in ignorance of many points, such as whether the basal rami (barbs) possessed the hair-like tips of the Emu and Cassowary, and whether the apical portion of the feather supported simple rami as in these last.

SUMMARY OF PTERYLOLOGICAL CHARACTERS.

Perhaps the most interesting pterylological result of the present enquiry has been the light thrown upon the history of the remarkable wing-spines or vestigial remiges of *Casuarius*. The comparison of these with the remiges of the nestling on the one hand, and with the wing of *Apteryx* on the other, leaves little or no doubt but that the explanation, or rather interpretation, of the nature of these degenerate feathers is correct.

The form and disposition of the apteria have been described at greater length than ever before, and some new facts added. The existence of apteria has long been known—at least in *Struthio* and *Apteryx*; though these facts had not yet found their way into the text-books, which still repeat the old error that the feathers of the *Palæognathæ* were evenly distributed over the body.

The form and structure of the nestling-down has been worked out in considerable detail. Prepennæ only are represented. In the *Crypturi* only is there a distinct aftershaft, and this is of great size, equal, indeed, to the main shaft. In these particulars, and in the complexity of the main shaft, it is unique. In *Casuarius*, *Dromæus*, and *Apteryx*, these have a well-developed rhachis. An aftershaft appears to be represented only in the two former, and here it consists only of a few sessile rami without any trace of a rhachis. The remiges of the adult *Apteryx* show how the loss of this may have come about (Pl. XLV. fig. 13). In *Rhea* and *Struthio* the prepenna is umbelliform, and thereby differs from that of the other *Palæognathæ*: the aftershaft is represented, as in *Casuarius*, by a few sessile rami. In *Struthio*, however, the number of these is very great. In both *Rhea* and *Struthio* the main shaft is represented by 3 thickened rami, which in the latter are produced forwards beyond the rest of the feather to form broad, hollow, ribbon-shaped laminæ, recalling in form the nestling-down of the *Crypturi* (Pl. XLV. fig. 2).

The following point involves a mystery which I am anxiously endeavouring to solve. The prepennæ are regarded by some as nothing more than portions of the distal extremities of the developing rami of the teleoptiles below. If this is so, how comes it that the prepennæ of *Casuarius* and *Dromæus* have a scarcely recognizable aftershaft, whilst in the teleoptile it is of such great length as to be hardly distinguishable from the main shaft? In the Tinamous these relations are exactly reversed. The aftershaft in the adult feather is very small or wanting, and in the nestling it is as long as the main shaft!

A further most serious objection to the probability of the truth of this view is the fact that in *Apteryx* the nestling-down feathers are not driven out by the teleoptiles. These arise at the side of the prepennæ, the ultimate fate of which my series of nestlings is not large enough to show. It is probable that they are shed as soon as the definitive feathers have completed their growth. The peculiar downy nature of these feathers does not seem to have been recorded before.

The discovery of a uropygium in *Dromæus* and *Rhea* is a point of some interest.

The podotheca appears to be of some slight value for systematic purposes. Dr. Gadow [25] long since pointed out the differences between the three species of *Rhea*. I have not succeeded in finding any appreciable difference between the different species of Cassowary, or in distinguishing that of *Casuarius* from *Dromæus*. *Casuarius loriæ* seems to differ from the other species in this respect and to form a type of its own (fig. 2 B, p. 155), just as *Apteryx australis mantelli* seems to differ from the other Apteryges in having, as a rule, the acrotarsium clothed with transverse scutes in place of small rounded plates.

Dromæus represents the less specialized of all the *Palæognathæ*. *Casuarius* undoubtedly comes next; though in the brilliant coloration of its head and neck, its remarkable casque, spine-like remiges, and elongated claw on its inner toe it has made a distinct advance upon *Dromæus*.

Apteryx should be placed next. It has lost the aftershaft to the feathers; the prepenna has a well-developed rhachis. In the large size of the apteria and in the possession of an oil-gland it resembles the *Carinatæ*; so also it does in the softness of the neossoptiles.

Rhea and *Struthio* are undoubtedly the most highly specialized of the group. One of the chief pieces of evidence of this, from the point of view of pterylological characters, is the fact that the prepennæ has neither aftershaft nor rhachis. The fact that the wing is larger in these two than in the remainder of the group, only means that the need for this organ remained longer, and is not to be regarded as an advance upon that of *Casuarius* or *Apteryx*, as the case may be. In them the decline of the wing set in earlier.

The structure of the teleoptiles in these last two is more complex than in the other groups: hooklets are feebly represented. These have lingered longer, just as the power of flight.

We may briefly sum up the salient features of the pterylosis of the *Palæognathæ* as follows:—

All the flightless *Palæognathæ* agree, and differ from the *Neognathæ*, in having the under surface of the wing naked [1], and in that all the feathers have discontinuous vanes.

A. ADULTS.

Dromæus, Casuarius, and *Apteryx* have no ala spuria. Lacking a pollex.
    The teleoptiles of *Dromæus* and *Casuarius* have a large aftershaft. There is no oil-gland.
        Dromæus has numerous though greatly degenerate remiges—17 in all.
        Casuarius has few remiges—6 in all. These are degenerate and peculiarly modified to form elongated porcupine-like quills, representing only the calamus of ordinary feathers.
    The teleoptiles of *Apteryx* have no aftershaft and a large oil-gland; it has few remiges—13 in all—and these have a long calamus. Apteria are larger. Rictal bristles are of great length.
Rhea and *Struthio* have a large ala spuria.
    The teleoptiles of *Rhea* and *Struthio* have no aftershaft: there is no oil-gland. Remiges are numerous and large.
        The remiges of *Rhea* number 28; metacarpo-digitals 12. There are no rectrices.
        The remiges of *Struthio* number 32; metacarpo-digitals 16. There are large rectrices.
Apteryx and the *Crypturi* are the only Palæognathinæ lacking a sternal callosity.

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[1] The naked under surface of the wing of the flightless Struthious birds is probably a secondary feature due to the suppression of the feathers by the long continued application of the wing to the side of the body.

B. Nestlings.

The neossoptiles consist of prepennæ only.

- In *Dromæus, Casuarius,* and *Apteryx* the prepenna has a well-marked rhachis and numerous rami. The aftershaft is feeble or wanting.
  - In *Dromæus* the rhachis bears about 8 pairs of rami: the rami are produced into points beyond the distal radii.
  - In *Casuarius* the rhachis does not bear more than 5 pairs of radii.
  - In *Apteryx* the rami exceed 8 pairs; the rami are not produced beyond the radii; the prepennæ of some parts recall the adult down of Ducks.
- In *Rhea* and *Struthio* the prepenna is umbelliform; the main shaft is represented by 3 rami, the aftershaft by numerous rami.
  - In *Rhea* the rami of the main shaft are not greatly elongated or flattened.
  - In *Struthio* the distal ends of the rami of the main shaft are much elongated and peculiarly flattened and grooved, as in *Tinamidæ.*
- In *Crypturi* the prepenna is very complex; the aftershaft equals the main shaft in length.

OSTEOLOGY.

The Skull of the Adult.

The skull of the *Palæognathæ*—which, as we have elsewhere shown, includes the so-called *Ratitæ* and Tinamous—differs from all other known birds in that, in the adult, the pterygo-palatine connection is by symphysis or anchylosis, and not by an arthrosis.

The skull of the Tinamous, as will be shown presently, closely resembles that of *Rhea.*

The Occipital Region (Pl. XLII. fig. 7).—The occipital condyle is sessile, and the plane of the occipital foramen is inclined backwards, in all the *Palæognathæ* save *Dinornis, Æpyornis,* and *Apteryx,* and in the Tinamous. In *Dinornis* the plane of the occipital foramen is nearly vertical; in *Apteryx* the occipital condyle is pedunculated. In *Dinornis* and *Æpyornis* this condyle projects beyond the dorsal margin of the foramen. In *Dromæus* and *Apteryx* the supra-occipital, immediately above the foramen magnum, presents the concavo-convex "cerebellar dome" so characteristic of the *Tubinares* and *Sphenisci.* There is a well-marked *supra-foraminal ridge* (Pl. XLII. fig. 8) running laterad on either side to become lost on the paroccipital process in all save *Apteryx* and the Tinamous. In *Apteryx* the ridge ends abruptly in the form of two pendent tubercles on either side of the foramen at about halfway down. In the Tinamous the ridge terminates in the same region, but is without tubercles. The *occipital crest* is most strongly marked in *Rhea.* The lambdoidal ridge runs outwards and downwards as a sharply-defined ridge, terminating in a pair of strongly compressed paroccipital processes, in all save *Dinornis* and *Struthio.* In these the ridge has a more or less sinuous outline, and is not so easily followed. Only in *Dinornis* does the lambdoidal ridge delaminate, as it were, in the region above the occipital crest, to form anterior and posterior lambdoidal ridges.

The *paroccipital processes* pass gently forwards at their base into the zygomatic process, in all save in the Tinamous and *Apteryx*, *Rhea*, and *Dinornis*. In *Apteryx* and the Tinamous they are separated from the zygomatic process by a notch more or less deep. In *Dinornis* they pass forward into the squamosal prominence, and there lose themselves. In *Rhea* only, externally, they are continued upwards as a strong ridge to join the posterior boundary of the temporal fossa, and, internally, sweep round towards the middle line in the form of a thin, curved, laminated plate of bone to form the inner boundary of the tympanic recess.

The Roof of the Cranium (Pl. XLII. figs. 1–4).—The roof of the cranium is produced laterally, in front of the temporal fossa, into a pair of pendent post-orbital processes, in all save *Apteryx* and the *Crypturi*. In the former, post-orbital processes are entirely absent, and in the latter they are reduced to a mere prickle. The anterior region of this roof, in all save *Dinornis*, *Æpyornis*, *Apteryx*, and *Crypturi*, is characterized by a pair of very long outstanding and backwardly-directed spines, being the elongated supra-orbital process of the lachrymal. In *Struthio* these are continued backwards, by means of fused supra-orbital ossicles, to join the frontals; thus enclosing a space between the ossicles and the combined frontal and nasals (fig. 8).

In *Dinornis* the lachrymal passes backwards insensibly into the frontal to form a broad overhanging ledge to the orbit. In the *Crypturi* it projects conspicuously on either side of the skull, but is without the backwardly-projecting spines. In *Apteryx* the lachrymal has become reduced to a mere vestige fused with the alinasal.

In all save *Apteryx* and the Tinamous the frontal is produced laterally to form an overhanging pent-house to the orbit. In *Apteryx*, the frontal passes downwards and inwards in the form of a smooth convex infolding of the bone, leaving the orbit without any sharply defined boundary; and in the Tinamous this region is deeply hollowed out, almost to the middle line, so that the interorbital region of the skull is very narrow. Young skulls of *Rhea* and *Dromæus* resemble the Tinamous in this respect.

There is a conspicuous cerebral dome in *Æpyornis* and *Dromæus ater*. In profile, in *Dromæus ater*, the skull slopes rapidly downwards and forwards in front of this dome; in *Æpyornis* the gradient is much less marked.

The inter-orbital region in *Dromæus* is very wide, in *Rhea* very narrow: thus, taken in connection with the development of the supra-orbital processes of the lachrymals, this forms a useful character for systematic purposes.

In the *Tinamidæ* the frontals bear shallow supra-orbital grooves.

The Base of the Skull (Pl. XLII. figs. 5–8).—*Casuarius*, *Dromæus*, *Struthio*, and the *Tinamidæ* all agree, more or less closely, in the form of the basitemporal platform. In all, viewed below, it takes the form of a flattened, slightly tumid area, roughly pentagonal in shape, the base being caudad. Its postero-lateral angles are not produced into mammillary processes, nor are there, save the Eustachian apertures, any sharply defined boundaries forwards. *Struthio* and *Dromæus* somewhat closely resemble one another in the form of this platform. In *Dromæus ater* it is very sharply defined, presenting a steep face to the pre-condylar fossa; in the other species of *Dromæus* and in *Struthio* this face slopes gently upwards and backwards. Thus, in all save *D. ater*, the pre-condylar fossa is shallow and moderately wide.

The pre-temporal platform is very sharply defined in *Apteryx*, *Dinornithidæ*, and *Rhea*.

In *Apteryx* and *Dinornithinæ* amongst the Moas, it is roughly triangular in form, its postero-lateral angles are produced downwards into moderately or very large mammillary processes. These in some of the *Dinornithinæ* coalesce in the middle line, and present a deep vertical face when the skull is seen from behind. In the *Emeinæ* the platform takes a laterally expanded pentagonal form, sharply defined along its antero-lateral angles by a raised ridge helping to form the Eustachian groove. The anterior basicranial fontanelle is marked by a deep groove. In *Æpyornis* the basitemporal platform is much shortened antero-posteriorly. The mammillary tuberosities run in the form of a low rough ridge along the whole of each postero-lateral side of the pentagon.

In *Rhea* the platform has the shape of an elongated pentagon presenting steep faces on all sides, though anteriorly it may slope gradually into the rostrum. The Eustachian apertures lie immediately below the bases of the basipterygoid processes.

The *Eustachian grooves* are short, widely separated one from the other in the middle line, and, in all except *Dinornis* and *Casuarius*, arched over by bone. In these last the groove remains permanently open. In *Rhea*, *Struthio*, and *Dromæus* the mouth of the aperture of each is conspicuous, lying on either side of the base of the basipterygoid processes. In *Apteryx* they lie nearer the middle line and are inconspicuous. In the Tinamous these apertures are very wide apart, opening immediately behind the basipterygoid processes.

The paroccipital notch is more or less wide in all save *Apteryx*, where it is narrow and deep. As in *Rhea*, it is more or less completely bounded on its outer side by a much compressed, forwardly directed lamina of bone from the paroccipital process (p. 172).

Within this notch, in *Struthio*, *Rhea*, *Dromæus*, *Casuarius*, *Apteryx*, and the Tinamous, occurs the vagus foramen for the ninth and tenth nerves, the condyloid foramina for the exit of the twelfth nerve lie behind it, between it and the occipital condyle.

In the *Dinornithinæ* the vagus foramen occurs behind the notch and much nearer to the condyloid foramina, forming, with them, a little cluster of apertures, that of the vagus being much the longest of the group. The carotid foramen in the *Dinornithidæ* lies immediately in front of the notch, in all the other forms it occurs some distance further forwards.

Traces of both *anterior* and *posterior basicranial fontanelles* occur in many of these Palæognathine skulls, sometimes both are indicated in the same skull. The former is the small pit in the middle line between the anterior ends of the basipterygoid processes; the latter is more often slit-like and lies in the middle of the basitemporal platform.

The parasphenoidal rostrum, which is of great length, is thin and rod-like in *Apteryx*, *Casuarius*, *Rhea*, *Dromæus*, more or less inflated in the *Dinornithidæ*, *Struthio*, and Tinamous.

The Lateral Surface of the Cranium.—The tympanic cavity is moderately deep in all save *Apteryx*, in which it is comparatively shallow. The mouth of the cavity is somewhat lozenge-shaped in *Dinornithidæ*, *Æpyornis*, and more or less circular in the other forms.

It is bounded posteriorly, in every instance, by the base of the paroccipital processes, save only in the Tinamous, where, on account of the greater relative smallness of the process, the tympanum is stretched along its free outer border. It is bounded externally by the free inferior border of the squamosal. In all save *Rhea* and the Tinamous, this border represents the posterior free edge of the zygomatic process. In *Rhea* this process has shifted somewhat further forwards, and its place is taken by a second but much shorter. This second process may be regarded as a flange-like downgrowth of the squamosal. The posterior region of this cavity lodges the apertures of the internal ear; the anterior, in front of this, is continued forwards as a long, spacious, tunnel-like pneumatic cavity to form the *anterior tympanic recess.* This aperture is largest in *Rhea*, *Dromæus,* and *Casuarius*; it is much smaller in *Æpyornis.*

The pre-temporal or alisphenoidal wing of the parasphenoid bounds the aperture of this recess in front, and the pro-ötic forms its roof, the basi- and exoccipitals share in the formation of its posterior and ventral walls. The basitemporal plate and the highly pneumatic basisphenoid receive the final termination of this recess beneath the pituitary fossa, as is shown when the skull is seen in section. The bones taking part in the formation of this cavity can of course only be made out in the skulls of very young nestlings. Each recess curves gently forward to meet its fellow of the opposite side.

In *Apteryx* this recess is exceedingly small, and appears to lie, for the most part, if not entirely, within the basisphenoid. There is no intercommunication between the two recesses.

The roof of the tympanic cavity is formed for the most part by the large articular surface of the quadrate. Behind this is a conspicuous cavity, the roof of which is perforated by numerous pneumatic apertures leading into the diploë between the pro-ötic and squamosal. It represents the superior tympanic cavity. Mesiad of this is the *fenestral* recess containing the fenestra ovalis and rotunda and the aperture of the posterior tympanic recess. In the larger *Dinornithidæ* there is a small superior tympanic recess.

The Squamosal Prominence.—This is bounded in front by the temporal fossa, behind by the paroccipital process. It passes dorsad into the parietal, and is continued downwards to form the zygomatic process. In *Casuarius*, *Dromæus*, *Æpyornis*, and *Rhea* this process is of considerable length, and runs down to within a short distance of the cup-shaped fossa for the articulation of the quadrato-jugal bar. In *Rhea* it runs forwards and downwards to overhang this articulation.

In *Dromæus*, except *D. ater*, the anterior border of the squamosal prominence bears a strong protuberance.

In *Struthio* and *Apteryx* the zygomatic process is very short.

In *Dinornithidæ* the middle region of the squamosal is much inflated, making the squamosal prominence very conspicuous.

The temporal fossa is more or less conspicuous in all the *Palæognathæ*, save *Apteryx*.

In *Casuarius* and *Dromæus* it is narrow and deep. In the latter its limits are sharply defined.

In the *Dinornithidæ* the size of the fossa varies, but is generally wide and deep, its general direction is backwards.

In *Rhea* it is wide and shallow, and with a linguiform impression. In *Crypturi* it resembles that of *Rhea*, but is shallower.

In *Struthio* narrow, moderately deep, and slopes obliquely backwards.

Æpyornis has the same type of fossa as *Struthio*, but deeper and much more sharply defined.

In *Apteryx* it is represented by a shallow but sharply defined depression extending far forwards. It is peculiar from the fact that it is not bounded anteriorly by a post-orbital process.

The post-orbital process in *Casuarius* is strongly developed; it forms a broad linguiform process extending downwards to within a short distance of the quadrato-jugal bar. In *Dromæus novæ-hollandiæ* and *D. ater* its downward extent is much less.

In *Emeus*, amongst the *Dinornithidæ*, it is even larger than in *Casuarius*.

In *Rhea* it is relatively small, somewhat pointed, and directed slightly backwards.

In *Struthio* it is but slightly developed, and runs forward to blend with a shelf-like projection of the frontal overhanging the orbit.

In *Crypturi* it is represented only by a minute prickle.

The *trigeminal foramen* is a conspicuous aperture lying, in *Casuarius*, at the bottom of the temporal fossa at the point where the outer angles of the alisphenoid d pre-temporal wing meet, and in the same transverse plane as the basipterygoid processes. Immediately behind this, in *Dromæus*, and less distinctly in *Apteryx* and *Rhea*, is a smaller aperture leading into the tympanic cavity.

The *orbits* in *Casuarius*, *Dromæus*, and *Rhea* are all more or less alike in form and size. All are strongly walled-in behind by overhanging and laterally projecting post-orbital processes, and are in front protected and increased by long backwardly directed spurs from the lachrymal.

Struthio differs markedly from the above in that the spurs of the lachrymal over-arching the orbits are short and blunt, but are connected with the frontals by a more or less imperfect chain of supra-orbital ossicles, as in the *Crypturi*. Generally it would seem, from the number of skulls which I have examined, that these supra-orbitals fuse completely with one another and the lachrymal and frontal so as to obliterate all trace of their independence. A specimen in the Rothschild Museum, however, has this chain on one side perfectly developed (Pl. XLII. fig. 3). The existence of this supra-orbital chain seems to have escaped the notice of all recent writers. On looking up the subject I find it was first described by Cuvier [14] in 1799. Hildebrand [37] in 1806 seems to have rediscovered them. Meckel [56] and other writers at the beginning of the century were also aware of their existence.

There is a distinct, but small, *pre-sphenoid fossa*. The optic foramina are distinct and raised high above the rostrum, as in *Æpyornis*.

Æpyornis and *Dinornithidæ* agree in the form of the supra-orbital ledge. The pre-orbital region of this is formed externally by the lachrymal, which has completely fused with the frontal to form one uniform plate of bone. This is just what would happen in *Struthio* if the fossa between its backward spur and the nasal were filled up.

In *Æpyornis*, as in *Struthio*, the optic foramen is raised high above the level of the parasphenoidal rostrum. Below the lacerate fossa, and between it and the trigeminal foramen, the surface of the combined alisphenoid and pre-temporal wing is much inflated and roughened by numerous elongated spine-like processes for the attachment of muscles.

In *Dinornithidæ* the optic foramina are deeply overhung by the outstanding orbito-sphenoids; in this respect resembling *Apteryx*.

In *Apteryx* the orbits are small and tubular, without post- or pre-orbital processes, and the interorbital region of the frontals reduced to its smallest possible limit.

In *Crypturi* there is no lacerate or pre-sphenoid fossa or post-orbital process; the pre-orbital backward spurs of the lachrymal are wanting, and the interorbital region of the frontal is deeply notched, being cut away to within a short distance of the interorbital septum.

The *lacerate fossa* in some *Dinornithidæ* takes the form of a deep pit; generally, however, it is represented only by a shallow depression. In and around this lie certain of the cerebral nerve-apertures worthy of note.

In *Dromæus* and *Æpyornis* these are very distinct. In the former those of the first division of the V. (orbito-nasal) and the VI. (abducent) nerves lie, the latter below and slightly mesiad of the former, and both external to the rest. That of the IV. (pathetic) lies mesiad of and slightly above the III., being divided only by a narrow bar of bone from the II. (optic). The III. oculo-motor lies directly below the IV.; like the IV. it is only separated from the II. by a narrow bony bar. Lowest of all, and forming a triangle with the III. and VI. foramina, lie the foramen for the *arteria ophthalmica interna*.

In many *Dinornithidæ* these apertures lie closely packed together down the mouth of a deep lacerate fossa.

In most of the other *Palæognathæ* more or fewer of these foramina become more or less confluent one with another and with the optic foramen.

The Ethmoidal Region.—The mesethmoid, in all but *Dinornithidæ* and *Apteryx*, forms the thin median septum known as the interorbital septum. It is continued forward into the pre-lachrymal fossa as far as the cartilaginous *septum nasi.* Its ventral border rests upon the parasphenoidal rostrum; its dorsal border affords support to the frontal and nasals. This it does by means of paired, lateral, horizontal, ectoethmoidal plates. These, the *superior aliethmoids*, curve outwards and downwards, as the *inferior aliethmoids*, to form the walls of the olfactory chamber. It is perforated superiorly in the dried skull so as to place the two olfactory chambers in communication in all but *Apteryx*, *Casuarius*, and *Crypturi.*

In *Dromæus* and *Casuarius* the whole of the outer wall of the aliethmoidal region—the only region that ossifies—is deeply invaginated. The lower region of this invaginated wall forms a large, outstanding, antorbital plate, to the outer free edge of which the lachrymal is closely applied (Pl. XLIV. fig. 1 *a*). The olfactory chamber is thus reduced to a narrow slit-like cavity, whose outer wall is scroll-shaped, the scroll being formed by the invagination before mentioned.

This invagination lodges the Harderian gland, and is called therefore the Harderian fossa. Opening above and behind this is a small supra-orbital fenestra.

In *Rhea* the invagination of the aliethmoidal wall is less sharply marked, and the Harderian fossa, though larger, passes gently backward into the orbit. Except in very old specimens, the greater portion of the wall of this fossa remains unossified. The supra-orbital fenestra, when ossification is complete, is large.

In *Struthio* only the superior aliethmoidal wall is ossified. The postero-inferior region forms the antorbital plate; this is continued upwards and forwards to form the roof of the olfactory chamber. There is a supra-orbital fenestra.

In *Crypturi* the antorbital plate stands out at right angles to the mesethmoid as a narrow bar of bone. The upper portion of the aliethmoidal wall resembles that of *Rhea* in being deeply invaginated, so much so as to force it inwards almost on to the mesethmoid, thus forming a huge Harderian fossa and reducing the olfactory chamber to the smallest possible limits. There is a well-marked supra-orbital fenestra.

In all the *Palæognathæ*, save the *Crypturi*, the ossified ectoethmoidal plate extends backwards, on either side of the dorsal border of the interorbital septum, as far as the brain-case. Thus only the lower region of this septum is visible in the skeleton, not its whole extent as in *Neognathæ*. This feature is most noticeable in the *Dinornithidæ* and in *Apteryx*. In these the olfactory chambers are of enormous size, extending backwards nearly or quite as far as the optic foramina, thus so far encroaching upon the orbit as to obliterate the interorbital septum. This last is traceable only in the *Dinornithidæ* as the vertical plate dividing the pre-sphenoid fossæ. There is a well-marked supra-orbital fenestra.

The *Dinornithidæ* are apparently peculiar in the development of a pair of well-developed *triangular processes*, forming a horizontal plate projecting from the ventral border of the mesethmoid, and extending outwards to the level of the lachrymal.

In *Apteryx* the ossified ectoethmoidal plates form two oblong, much inflated bullæ on either side of the head, nearly filling up the very small orbit, the horizontal plates of the mesethmoid sweeping outwards, downwards, and inwards, the ventral edge fusing with the mesethmoid immediately above the parasphenoidal rostrum. Forwards, the part corresponding to the antorbital plate affords support to the lachrymal, as in *Dromæus*.

As the late Prof. T. J. Parker has pointed out [71], "One of the most striking characteristics of the skull of *Apteryx* is the extreme complexity of the turbinals. When the mesethmoid is removed there are seen in the olfactory chamber proper four well-marked obliquely vertical folds, while a fifth is continued into the narrow or respiratory portion of the nasal cavity. The three hindmost of these folds are perfectly distinct one from another, and I propose to call them, respectively, the *anterior*, *middle*, and *posterior* turbinals. The fourth and fifth folds are intimately connected with the anterior turbinal: I call the uppermost of the two, which forms part of the olfactory region, the *anterior accessory turbinal*, and that which extends forwards, and has no olfactory function, the *ventral accessory turbinal*.

"All the turbinals, with the exception of the ventral accessory, are covered by Schneiderian membrane, and are therefore analogous to the ethmo-turbinals of a mammal. The ventral accessory turbinal is covered with ordinary mucous membrane, and belongs to the merely respiratory portion of the nasal chamber; it may be compared with the maxillo-turbinals of mammals.

"On each side of the ventral edge of the mesethmoid, in the vomerine region, ... is a slender rod of cartilage, imbedded in connective tissue, and lying parallel to, and either immediately dorsad or slightly laterad of the dorsal edge of the trough-like vomer . . . . . it can be readily prepared in a well-macerated skull by carefully removing the vomer. It is obviously the vestigial cartilage of Jacobson's organ . . ."

The ventral accessory turbinal does not appear to ossify in the adult *Apteryx* skull.

There are no ossified turbinals in the other *Palæognathæ*.

The *lachrymal* in *Casuarius* is crescentic in form, with convex border forwards.

Its upper limb, when visible, is very broad and deeply notched. It forms a broad overhanging ledge to the orbit. Its lower limb is flattened from before backwards and extends downwards to within a short distance of the quadrato-jugal bar. At the junction of the upper and lower limbs it is perforated by a large foramen for the passage of the lachrymal duct. In the adult, the inferior inner lateral border is fused with the antorbital plate.

In *Dromæus* the outer fork of the >-shaped notch of the upper limb is greatly developed, forming a long, backwardly directed, spine-like supra-orbital process (Pl. XLII. fig. 2). The inferior limb is notched below the lachrymal foramen. In *D. novæ-hollandiæ* the inner fork of this notch is short and confluent with the free edge of the ventral border of the antorbital plate. The outer fork is produced downwards far beyond this, and rests upon the quadrato-jugal bar. In *D. irroratus* and *D. ater* the outer and inner forks of the prong are subequal, and do not quite reach the level of the ventral border of the antorbital plate, which is continued downwards by means of a slender column on to the maxillo-palatal process, where it expands.

In *Struthio* (Pl. XLII. fig. 3) the outer fork of the upper limb is comparatively short and blunt, and projects more laterally than in the above mentioned. Furthermore, it differs in that it is joined by a series of large bony scales lying between its posterior extremity and the supra-orbital ledge of the frontal, recalling the supra-orbital chain of bones in the Tinamou. Late in life the scales fuse with the lachrymal in front and the frontal behind, thus enclosing a large supra-orbital foramen. The lower limb of the lachrymal takes the form of a slender backwardly curved rod, whose free end is curved sharply outwards to join the inner border of the quadrato-jugal bar. To the inner side of this outwardly directed free end is attached a larger *ossiculum palatinum*, which in the adult fuses with the lachrymal on the one hand, and the antorbital plate on the other. Below the ventral border of its inner end comes in contact with the palatine.

Æpyornis and *Dinornis* have the lachrymal so completely fused with the frontal and antorbital as to be with difficulty distinguishable. The upper limb in both has completely merged into the supra-orbital ledge. The lower in *Dinornithidæ* is much flattened antero-posteriorly. The lachrymal foramen is imperfect, its outer bar being wanting. In some, e. g. *Anomalopteryx*, it is perfect. Its ventral extremity is squarely truncate and articulates with the maxillo-jugal bar.

In the only *Æpyornis* skulls I have been enabled to examine, this lower limb has been broken away.

In both these groups the anterior border of the lachrymal rests against a well-marked, spine-like, maxillary nasal process.

In *Apteryx* the lachrymal is described by Parker [71], from young specimens, as "a small irregular bone consisting of a shell-like central portion applied to the surface of the aliethmoid, and of an ascending portion which articulates with the descending process of the nasal. It is perforated obliquely by the lachrymal foramen." In the adult it is completely fused with the aliethmoid. Its anterior border is often traceable as a thin suture between it and the maxillary process of the nasals.

In the *Crypturi* the lachrymal is indistinguishably fused with the nasal, and forms therewith a prominent outstanding process bounding the orbit in front. There are no backwardly projecting spines. The ventral limb fuses with the antorbital plate.

The Cranial Cavity.—The *metencephalic fossa* in all, save *Dinornis* and *Æpyornis*, takes the form of a moderately deep basin, the floor of which is tilted upwards to a very considerable extent. The anterior tilted portion forms the posterior wall of the pituitary fossa. Posteriorly it is continued backwards on to the occipital condyle. Its postero-lateral border, immediately below the pro-ötic is pierced by the vagus foramen, to the inner side of, and slightly posterior to, which lie one or two condyloid foramina. Mesiad of the internal auditory meatus, and anterior to the same, is the *abducens foramen* (VI.).

In *Æpyornis* and *Dinornis* the floor of this fossa is almost flat.

The *cerebellar fossa* is roofed by the parietal and supra-occipital bones. The pro-ötics bound it laterally, ventrally it passes into the metencephalic fossa. It is bounded behind by the free edge of the occipital foramen, and in front by the median portion of the *tentorial ridge*. The late Prof. Jeffery Parker, in his masterly monograph, states that in *Dinornithidæ* the supra-occipital region of this fossa is marked by "transverse grooves corresponding with the gyri of the cerebellum." Immediately above the *internal auditory meatus* lies the floccular fossa. The size of this, according to Parker, appears to vary individually in *Dinornithidæ*. It is of considerable depth in the other *Palæognathæ* and in Tinamous.

The *mesencephalic fossa* is a deep basin-like depression in all save *Dinornithidæ* and *Apteryx*.

It appears to be more sharply defined in *Casuarius* than in any other member of this group. It is bounded above by a very prominent shelf of bone, forming the lateral portion of the tentorial ridge, behind by the pro-ötic. It extends forwards considerably beyond the level of the pituitary fossa which bounds it in the middle line. The *trigeminal foramen* (V.) leaves by a large aperture excavated out of the ventral border of this fossa, between it and the pro-ötic, and is of considerable size. Just within the mouth of this foramen, below the rim of its anterior border, lies the aperture of the orbito-nasal nerve (V.′), which has its exits in an almost obsolete lacerate fossa. In *Dromæus* the trigeminal and orbito-nasal foramina are distinct. The tentorial ridge, bounding the fossa superiorly, is almost as strongly developed as in *Casuarius*.

In *Struthio* this fossa is relatively smaller and shallower, neither are its boundaries so sharply defined. The apertures of the trigeminal foramen and the orbito-nasal nerve lie close together.

Rhea and *Crypturi* have the fossa somewhat more sharply defined than in *Struthio*, but in none of these does that portion of the tentorial ridge bounding the fossa superiorly form anything more than a low ridge.

In *Dinornithidæ* this fossa is relatively ill-defined and shallow. The aperture for the trigeminal foramen steals away a large portion of its external wall. The orbito-nasal aperture opens as in *Casuarius*, is tunnel-like, and bounds the fossa anteriorly, separating it from the pituitary fossa.

In *Apteryx* it appears to be reduced to the vanishing point. It is extremely small, oblong in shape—its long axis horizontal,—and more or less sharply defined, when seen at its best. It lies entirely behind the level of the pituitary fossa. It is bounded above by a low tentorial ridge, in front by a ridge of bone dividing it from the pituitary fossa, below by the rim of the metencephalic fossa, and behind by a huge projecting shelf-like ledge from the tentorial ridge. The *trigeminal foramen* opens at its postero-dorsal border, the *orbito-nasal* in its anterior border.

In *A. haasti* the outer wall of this fossa is almost entirely absorbed by a large aperture common to the trigeminal and orbito-nasal nerves.

The *pituitary fossa* in *Casuarius* is a deep pocket-shaped depression. Its mouth is directed slightly forwards. The rim thereof forms the *dorsum sellæ* behind, and the pre-pituitary ridge in front. Within the mouth of this fossa (*Dinornis*) or on its rim (*Dromæus*) is the oculo-motor (III.) foramen. The pathetic (IV.) foramen lies above and to the outer side of the oculo-motor, often it serves also for the passage of the internal ophthalmic artery. Anterior to the prepituitary ridge in the middle line is a narrow knife-like optic platform, on either side of which are the confluent *optic foramina*. The optic platform is continued upwards vertically and again expands to form the pre-optic ridge, which in *Dromæus*, and slightly less obviously so in *Casuarius*, joins the *tentorial ridge*.

In *Struthio* the pituitary fossa is of great depth; the pre-pituitary ridge and optic platform are well marked.

In *Dinornithidæ* the fossa is comparatively shallow, but of considerable circumference. The optic platform is very wide.

In *Apteryx* the pre-pituitary ridge is but feebly developed. The optic platform is not distinguishable from the pre-pituitary ridge, which divides the optic foramina one from another. The pre-optic ridge is well developed and overhangs the fossa, the mouth of which, in consequence, has a semicircular outline. It should be mentioned here that the bottom of the fossa is produced forwards into a yet deeper, almost spherical, depression, overhung by the pre-pituitary ridge.

In Tinamous this fossa is deep and tubular in form.

The *cerebral fossæ* are sharply defined in all the *Palæognathæ* save *Apteryx*. In all, with the exception just mentioned, the cerebral lies entirely in front of the cerebellar fossa. In *Apteryx*, and to a lesser extent in the *Crypturi*, the cerebellar contour is scarcely distinguishable from the cerebral. The tentorial ridge, which serves to cut off the cerebral from the remaining fossæ, arises from the level of the pre-optic ridge and trends outwards and backwards to the level of the top of the pro-ötic; from this point it turns sharply upwards and forwards to meet in the mid-dorsal line, over the region corresponding with a vertical line passing upwards from the dorsum sellæ. That portion of the ridge which forms the upper boundary of the mesencephalic fossa in *Casuarius* and *Dromæus* is of great depth, and projects into the cranial cavity like a deep shelf. This is less marked in *Rhea*. In *Dinornis* and *Crypturi* it is but feebly developed.

The cerebral fossæ in *Dinornithidæ* do not taper forwards to finally pass into the infundibuliform olfactory fossæ, but, on the contrary, are of great size and width in this region, reducing the olfactory fossæ to the dimensions of shallow pits.

The median bony falx, continued forwards from the tentorial ridge to the *crista galli*, is extremely well developed in *Casuarius* and *Dromæus*, less so in *Rhea*, and only feebly in *Struthio* and *Dinornis* and Tinamous. There is no trace of it in *Apteryx*.

In *Casuarius* and *Dromæus* the fossæ bear distinct and deep impressions for the temporal and frontal lobes, a low ridge indicating an indistinct Sylvian fissure.

The *olfactory fossæ* in all, save *Dinornis* and *Apteryx*, are paired, more or less tubular, infundibuliform chambers, separated one from another by a *crista galli*. Anteriorly they are closed by a more or less perforated plate for the passage of the olfactory nerves.

In *Dinornis* the olfactory fossæ take the form of shallow pits lying at the anterior end of the large cerebral fossa. The cribriform plate is large.

In *Apteryx* these fossæ are of great size, and pass insensibly backwards into the cerebral fossæ. They are not, in the dried skull, shut off anteriorly from the turbinals by a cribriform plate as in other *Ratitæ*, but continued forwards directly into the olfactory chamber.

The Premaxilla.

The *premaxilla* in all the *Palæognathæ* is peculiar, in that the nasal process is median, and not paired as in all other birds (Pl. XLII. figs. 1–3). In all save *Struthio* there are well-developed palatine proceses.

In *Casuarius* the beak is more or less laterally compressed. The body—that portion of the premaxilla from which the nasal, maxillary, and palatine processes are given off—is short, and more or less deeply grooved on either side, so that the distal end of the nasal process seems to be continued forwards into a strongly marked ridge. The maxillary processes extend backwards as a pair of slender splints to the level of the lachrymal on either side. The palatine processes are a pair of short narrow laminæ extending backwards to a point corresponding with a vertical line passing upwards behind the top of the free end of the median nasal process. They enclose anteriorly a small chink-like palatine notch. In *C. australis* there is a small *prenarial septum*, corresponding to that described by Parker in *Dinornis*, as the "strong ascending keel, formed posteriorly of paired plates, but solid in front and gradually diminishing in height towards the top of the beak." This keel is derived from the dorsal surface of the palatine processes.

The nasal process is rod-like, its free end passes backwards into a tunnel-shape in the inflated, mesethmoid mass forming the characteristic casque of these birds.

In *Dromæus* the beak is flattened dorso-ventrally. The premaxillary body is larger than in *Casuarius*, and, as in this genus, the rod-like nasal process seems to be continued forwards to the tip of the beak by reason of paired lateral grooves which divide it from the maxillary processes.

The nasal process is relatively longer than in *Casuarius.* Posteriorly it is received into a shallow groove excavated out of the median borders of the nasals. The tip of its free end rests upon the mesethmoid.

The maxillary processes are splint-like, and extend backwards to the level of the anterior region of the orbit—beyond the body of the lachrymal.

The palatine processes are short pointed lamellæ, rather more widely separated one from another in the middle line than in *Casuarius.* The chink-like anterior palatine foramen is closed caudad, as in *Casuarius*, by the vomer. This process extends backwards as far as the level of the anterior border of the *posterior narial aperture.* In *Casuarius*, it should be mentioned, it falls short of this.

In *Dinornis* the median nasal process is markedly flattened and expanded dorso-ventrally. The maxillary processes are very short, not extending backwards beyond the level of the hinder end of the *antorbital fossa.*

The *palatine processes* take the form of flattened laminæ, extending backwards, as in *Dromæus*, to the level of the anterior end of the posterior nares. The alveolar borders are deeply pitted.

The anterior palatine foramen is small and cordiform. It is closed above by the parasphenoid rostrum, and posteriorly by the vomer. In *Emeus* it is more completely closed than in any other *Palæognathæ* by a pair of processes from the postero-internal angles of the palatine processes, which meet in the middle line, serving at the same time as articular surfaces for the anterior ends of the probably paired vomers.

The *prenarial septum* is most clearly marked in *Dinornis.* Its postero-ventral border is bilaminate, but the laminæ rapidly fuse to form the single median vertical septum.

In *Æpyornis* the nasal process rises sharply from the body of the bone, giving the beak a peculiar conical form. The alveolar border is deeply pitted. The backward extensions of the palatine and maxillary processes cannot be made out in either the British Museum skull or that belonging to the Hon. Walter Rothschild. In the British Museum skull there is a prenarial septum, but the laminæ composing this have not fused to form a median plate as in *Dinornis.* Instead, as indicated, they remain widely separated, and enclose between them a long tunnel-like cavity extending forwards to the tip of the beak.

In *Rhea* the premaxillary body is of greater length than in any other Ratite, and much depressed dorso-ventrally. It is grooved dorsally on either side of the distal end of the nasal process, as in the other forms.

The nasal process is very broad and flattened, but tapers more or less caudad

The maxillary, which is confluent for about half of its length with the palatine process, is styliform, and terminates in the anterior region of the antorbital fossa.

The palatine process is of great size, extending beyond the maxillary process, and terminating at, or falling but little short of, the anterior border of the posterior nares. I this it agrees with *Dromæus.*

Struthio differs from all the other *Ratitæ* in the absence of a palatine process, and the consequent enormous size of the palatine foramen.

The whole premaxilla has a unique triradiate form; the radii are of great length, so that the body of the bone is reduced to the smallest possible dimensions.

The nasal process is broad and flattened, tapering somewhat abruptly posteriorly.

The maxillary processes are long and styliform, terminating at the level of the anterior region of the orbit.

In *Crypturi* the form of the premaxilla is precisely similar to that of *Rhea.* The free end of the palatine process is brought to the level of the anterior border of the posterior nares, and interlocks with the distal end of the palatine. In this last point it differs from *Rhea.* The palatine foramen, as in *Rhea*, is long and narrow.

Apteryx is the most abnormal of all the *Palæognathæ.* The whole beak is produced forwards into an elongated probe, curved slightly downwards, in the tip of which the external nostrils lie.

In the adult skull the fusion of the separate elements, not only of this region of the beak alone, but of the skull generally, is so complete, that it is impossible to make out their boundaries.

The body of the premaxilla is reduced to its smallest possible limits, being composed only by the confluent end of the rod-like nasal process, and of the combined maxillary and palatine processes, which for this reason are but delicate rods.

The nasal process takes the form of a long slender rod, grooved ventrally and running backwards to the mesethmoid. Its posterior region rests upon the elongated nasal bones.

The maxillary and palatine processes are fused throughout the greater part of their length, and form elongated flattened rods, divided in the middle line by a narrow groove representing the palatine foramen. Posteriorly there is given off a short splint-like palatine spur, representing the palatine process. The extremest limit of this falls considerably short of the anterior end of the antorbital fossa.

The maxillary process can be traced backwards splint-wise as far as the level of the foot of the lachrymal. Thus the maxillary processes are of about equal length.

The nasal, and nasal process of the premaxilla above, and the maxillary process of the premaxilla below, serve to form a long narrow groove leading forwards into the anterior nasal fossa, this last having shifted forwards to the extreme end of the beak. This nasal furrow bears a strong resemblance to that of the Ibises, the difference being that the nasal fossa lies behind instead of in front of the groove, as in *Apteryx.* It seems to suggest that the shifting forward of the nasal aperture has followed the course of the orbito-nasal nerve, accompanying it to its tip, so as to bring the sense of smell to aid the sense of touch found in the Ibises.

It is interesting to note that in the very early embryo, as shown in Parker's figures, the position of the external nares is near the middle of the beak. Its forward shifting seems to be involved in the growth of the elongating beak.

The Maxillo-jugal Arch.

The *maxilla* in *Casuarius* takes the form of an elongated flattened splint. Its interior half has the outer and inner borders turned upwards to meet in the mid-dorsal line so as to form a long thin-walled tunnel tapering forwards to a point. This is the antrum. The rim of the mouth of this is produced backwards into two short spikes; the outer forms a strong dorso-lateral and the inner a lateral spike, conspicuous when the skull is viewed ventrally. The floor of this tunnel, viewed ventrally, is twice as wide as the posterior region of the maxilla. This wider region—the floor of the antrum,—which in the ventral view presents a deeply hollowed free posterior border forming the anterior boundary of the posterior narial aperture, is the *maxillo-palatine process.*

The whole inner border of this process is grooved for the reception of the vomer. The maxilla extends forwards above the maxillary and palatine processes of the premaxilla. The latter process is received into a shallow depression in the maxillo-palatine, a raised ridge of which bone can be seen lying between the palatine and maxillary process. The backward extension of the maxilla is considerable. It runs below the quadrato-jugal bar on the outer side and the palatine on its inner side to a point slightly beyond the level of the free border of the hinder end of the posterior nares, or, to take another standard, to within a short distance of the base of the vomer.

The *quadrato-jugal fossa* is the name which I have applied to indicate the large space enclosed by the quadrato-jugal bar on the outside, the palatine and pterygoid in the inside, and the hinder end of the maxilla in front.

In *Casuarius* it does not extend forwards beyond the hinder end of the posterior narial aperture.

In *Dromæus* the maxilla is relatively much wider than in *Casuarius*, and does not extend so far backwards. The maxillo-palatine processes are wider but very much shorter antero-posteriorly than in *Casuarius.* The antrum, in consequence, is much reduced in length and capacity. Its dorsal wall, moreover, is fenestrated. The mesial borders of the maxillo-palatine processes rest upon the vomer.

The quadrato-jugal fossa extends forwards to within a short distance of the middle of the posterior narial aperture.

In *Dinornithidæ* the maxillo-palatine region of the maxilla is short and broad. Its anterior end is wedged in between the maxillary and palatine processes of the premaxilla. Ventrally it appears as an oblong flattened plate. Its postero-internal border bounds the anterior end of the posterior nares. Its posterior border is either notched or hollowed and forms the anterior boundary of the quadrato-jugal fossa.

From its dorsal surface in *Dinornis* there arises a large hollow shell of bone, the inner wall of which embraces the triangular plate of the rostrum. The cavity of this bony shell—the *antrum*—opens posteriorly by a large foramen into the quadrato-jugal fossa. It articulates with the palatine by a short recurrent process from its postero-internal angle.

In *Emeus* there is no *antrum*. What corresponds to its inner wall in *Dinornis* exists as a flat concavo-convex vertical plate applied to the anterior border of the mesethmoid triangular process and the rostrum.

In *Rhea* the maxilla is almost entirely represented by the maxillo-palatine process. Viewed dorsally it is seen to take the form of a flat, triangular, perforate plate of bone, with its sharply pointed end running forwards to within a short distance of the anterior end of the external narial aperture. This more pointed region rests upon the palatine process, and is bounded externally by the maxillary process of the premaxilla. Its postero-mesial border is bounded by the vomer. Its hinder end presents free postero-internal and external borders. The former lies more or less markedly forward than the latter, and bounds the posterior nares anteriorly. The latter lies more or less considerably caudad, and bounds the anterior end of the quadrato-jugal fossa. Its postero-internal angle is produced backwards into a long spine, which is closely applied to the outer border of the palatine, extending backwards for a considerable distance. Its postero-external border is also produced backwards spine-wise, and underlies the quadrato-jugal bar. From the dorsal surface of the maxillo-palatine plate there arises a long slender style which, directed upwards and backwards, ultimately articulates with the anterior angle of the lachrymal, and thus serves to divide the lachrymo-nasal (antorbital) from the nasal fossa (Pl. XLIII. fig. 9). In all other birds this is done by the descending maxillary process of the nasal. The *antrum* is represented only by a minute aperture at the base of the vertical rod—the lachrymo-nasal process of the maxillo-palatine—just described.

The *quadrato-jugal* fossa extends forwards nearly as far as the level of the anterior end of the posterior nares.

In *Struthio* the maxilla is splint-shaped, produced posteriorly into two spine-like processes, the inner of which runs dorsad over the distal end of the palatine, the outer running ventrally below the quadrato-jugal bar. Anteriorly it extends forwards nearly as far as the body of the premaxilla. The maxillo-palatine processes are small and hatchet-shaped; their mesial borders clamp the vomer, which is grooved laterally for their reception. There is a small shallow antrum, the roof of which is fenestrated. The anterior border of the maxillo-palatine process bounds the enormous palatine foramen posteriorly.

The ossified style, described in *Rhea* as dividing the lachrymo-nasal from the nasal fossa, is here represented by a ligament springing from the external dorsal angle of the mouth of the antrum and inserted into the short descending process of the nasal.

The quadrato-jugal fossa extends forwards to within a short distance of the anterior border of the posterior nares.

In *Crypturi* the maxilla resembles that of *Rhea*, but its maxillo-palatine process is much narrower and is unfenestrated. There is no antrum. The lachrymo-nasal fossa is bounded anteriorly by a descending process of the nasal and not by a spur from the maxillo-palatine as in *Rhea*.

In *Apteryx* the maxilla is of great size, its maxillo-palatine processes, seen ventrally, extending forwards to the middle of the elongated beak, and backwards along the outer border of the palatine to within a short distance of the level of the free end of the orbital process of the quadrate. They are separated one from another in the middle line, forwards, only by the narrow vomer. Posteriorly there is an external lateral spur for articulation with the quadrato-jugal bar. The proximal mesial border is closely fused with the external border of the short palatine. There is no antrum. Immediately in front of the distal end of the palatine the maxillo-palatine process occasionally sends inwards a very short process to articulate with the vomer, which apparently corresponds with the much larger vomerine process found in *Struthio*.

The *quadrato-jugal* is so reduced in size in *Casuarius* as to be represented by little more than a nodule of bone, scarcely projecting beyond the limits of the glenoid cup of the quadrate.

The *jugal* in *Casuarius* is connected by a close vertical suture with the quadrate portion, and projects above it at this part in the form of a more or less prominent spine. It extends forwards as far as the middle of the lachrymo-nasal fossa.

In *Dromæus*, seen from the outside, the quadrato-jugal scarcely exceeds that of *Casuarius* (Pl. XLIII. fig. 4*a*). On the inner side, however, it extends forwards along the jugal for about one-third of its length. In *Casuarius* it does not extend beyond the rim of the quadrate cup on the inside. The forward extent of jugal is about the same as in *Casuarius*.

Rhea and *Struthio* resemble *Dromæus* in the size and relations of these two bones.

In *Apteryx* the *quadrato-jugal* is a long slender style, reaching as far forwards as the middle of the zygomatic arch. The *jugal* is long and slender, extending forwards along the dorsal aspect of the quadrato-jugal as far as the level of the anterior extremity of the palatine, which corresponds with a line drawn transversely across the vomer about its middle.

In *Crypturi* the quadrato-jugal is as much reduced as in *Casuarius*. The mesial border of the proximal end of the jugal articulates, as in this form, with the quadrate.

The Vomer, Pterygoid, and Palatine (see also p. 206). (Pl. XLII. figs. 5–8.)

In *Casuarius* the vomer is of great length and slenderness. In *C. c. salvadorii*, *C. c. sclateri*, and *C. c. beccarii* it is cleft from behind forwards for more than half its length into two slender rods grooved dorsally; in *C. bennetti* only about one-fourth is so divided: the cleft not extending more than half the distance of the posterior nares, in the other forms it is continued forwards beyond this point. *C. c. australis* differs from both types, the cleft of the vomer being rather less than half the total length and terminating in the region of the anterior end of the posterior narial aperture. Anteriorly the vomer becomes laminate and wedged in between the maxillo-palatine processes, and passing forwards rests upon the palatine processes of the premaxilla. The palatine foramen by the great forward extension of the vomer is almost obliterated.

In a ventral view—before complete anchylosis has taken place—the feet of the vomer appear to be wedged in between the pterygoid and palatine. Removal of this latter, or a dorsal view, however, reveals the true relations of these parts. It will then be seen that the right and left limbs are closely applied to the external ventral border of the twisted pterygoid, extending backwards to a point very near its middle. The pterygoid can be traced forwards along the mesial border of the vomer as a slender spike for some considerable distance. On a dorsal view, the right and left grooved limbs of the vomer are well displayed, and show that each has been twisted outwards so that its inner free border comes to look dorsally, and the latter ventrally. The flattened surface of this twisted region is closely-applied to the ventral surface of the anterior end of the pterygoid, so that vomer and pterygoid form one common rod articulating with the quadrate. The dorsal border of the twisted end of the vomer is slightly thickened and, traced backwards, trends downwards beneath the outer border of the pterygoid. From the vomer backwards, the sutural surface is continued as a shallow groove along the outer ventral border of the pterygoid, terminating at the level of the basipterygoid processes. It is this ventral union of palatine and pterygoid that gives the impression that the vomer is wedged in between these two bones, when the skull is viewed from this surface.

In *Dromæus* (Pl. XLII. fig. 7) the "feet" of the vomer extend forwards for about one-third of its total length. Anteriorly it expands into a broad oval plate tapering again forwards to terminate, as in *Casuarius*, near the body of the premaxilla. The maxillo-palatine process overlaps the distal end dorsally; the palatine processes underlie it ventrally. Its relations with the pterygoids and palatines posteriorly are precisely similar to those which obtain in *Casuarius*. As a matter of fact, it should be remarked, the palate of *Dromæus* is even simpler in type than in *Casuarius*, and consequently represents, as we shall see, the simplest arrangement of these bones of all the *Palæognathæ*.

After these, the simplest palate amongst the remaining Palæognathine forms is that of *Struthio*.

The vomer of *Struthio* (Pl. XLII. fig. 8) is a degenerate structure. Anteriorly it does not extend beyond the middle of the enormous palatine foramen; posteriorly it is cleft, but has entirely lost all connection with the pterygoid, falling short thereot by some very considerable space. It has assumed a trough-like form, the hollow of the trough closely embracing the parasphenoidal rostrum. On either side the vomer is closely embraced by the maxillo-palatine processes, which fit into specially roughened facets. A similar, but less perfect, arrangement of these parts obtains in the Cassowary.

If the vomer were produced backwards on the pterygoid we should have a type of palate more nearly resembling that of *Casuarius* and *Dromæus* than any other Ratite.

In *Rhea* the vomer is cleft posteriorly for rather less than half its length, and is produced anteriorly into two large blade-like laminæ, widely separated in the median line, and each terminating in a pointed extremity. These anterior laminæ are embraced between the palatine processes of the premaxilla and the maxillo-palatines. The parasphenoidal rostrum appears in the median line, between these processes, terminating at the level of their free anterior ends. In *Casuarius*, *Dromæus*, and *Struthio* the anterior end of the rostrum is entirely concealed by the vomer. In the two former the free end of the vomer projects far beyond the rostrum, in the latter the free end of this and of the vomer terminate at the same point. The body of the vomer takes the form of a pair of vertical laminæ, fused anteriorly, and moulded on to the rostrum, upon which it slides; the forward anterior horns lie in a horizontal plane; the feet are obliquely truncated, their external lateral borders suturating with the pterygoid (Pl. XLII. fig. 5).

The true relations of the vomer to the pterygoid cannot be made out except from a study of the dorsal view; they will then be seen to be precisely what obtains in *Casuarius* or *Dromæus*, the foot of the vomer underlying the anterior end of the pterygoid. This last is in *Rhea* rod-shaped in form, but the sutural surface is dorso-ventrally compressed and closely applied to the vomer; at least in young birds, in adults it seems to become less compressed and yet more pointed. In a ventral view of the skull the vomer would appear to suturate with the palatine only and not the pterygoid, the former being apparently thrust in between them.

Examined from the dorsal surface, however, it will be seen that the palatine—the exact form of which will be discussed presently—underlies the foot of the vomer on either side, and is continued backwards along the pterygoid in the form of a long pointed spur, concealing all but the proximal end of the pterygoid, so that, seen ventrally, as already remarked, the vomer and pterygoid would seem to be shut off one from the other.

This is a fact of considerable significance, inasmuch as this isolation of the vomer is a point wherein all the *Neognathæ* appear to agree, and differ from the *Palæognathæ*. But, as I have elsewhere shown, when discussing the palatine of *Rhea* (p. 206), this is only an apparent difference.

In *Crypturi* the vomer is precisely similar in form and proportions to that of *Rhea*.

Furthermore, it agrees with the same in the nature of its relations with the pterygoid. The palatine, in the part played by it with regard to the pterygoid and vomer, differs but little from that of *Rhea*. Its chief difference consists in the fact that it is much narrower from side to side, and that it terminates in a pair of spines, an outer and an inner, instead of an outer pterygoidal only as in *Rhea*. The form of the palatine, as a whole, will be described latter.

In *Dinornithidæ*, e. g. *Emeus* (Pl. XLIII. fig. 3), the vomer takes the form of a pair of perfectly distinct vertical laminæ embracing the parasphenoidal rostrum. They are continued forwards only for a very short distance beyond the level of the anterior end of the posterior narial aperture. It differs from that of *Rhea* (1) in the greater vertical extent of the paired laminæ, (2) in that these are often free throughout, and (3) in that there are no anterior horns running forward between the palatine processes of the premaxilla and the maxillo-palatine. In *Emeus*, the palatine processes send inwards a pair of flattened spurs to embrace the sides of the anterior end of the vomerine plate.

Posteriorly, the feet of the vomer suturate with the pterygoid exactly as in *Rhea*. The relations between these bones and the palatine is also the same. Indeed, the inturned under-flooring region of the palatine in *Emeus* is more strongly developed than in *Rhea*, projecting backwards to the level of its pterygoidal spur.

In *Apteryx* the vomer is relatively short, and cleft from behind forwards for about half its length. Its form and relation are described on p. 205.

The *pterygoid* in *Casuarius* is, seen ventrally, an elongated, crescentic rod of bone dorso-ventrally compressed, with convex surface directed towards, and partly resting on, the parasphenoidal rostrum, and its concavity, for the most part, articulating with the palatine. Anteriorly, it runs forwards along the inner side of the hinder limb of the vomer—which is at this point wedged in between the pterygoid and palatine—and terminating thereon in a sharp spine. Its proximal end articulates with the quadrate, below the orbital process; mesiad and anterior to this articulation is a second for articulation with the basipterygoid process. Seen dorsally, the pterygoid is fusiform, not crescentic, a large median tube overlapping that part of the palatine which on a ventral view appears within a crescentic hollow. Thus the true shape of the pterygoid cannot be seen without the removal of the palatine, which discloses the dorsal overlapping lip.

In *Dromæus* (Pl. XLII. fig. 7) the form and relations of the pterygoid are simpler. Its relative length is about the same, and it terminates anteriorly in a point. The anterior region of its external lateral border is directed upwards in the form of a thin vertical plate affording a sutural surface for the external vertical plate of the vomer. The posterior region of this border is straight and affords attachment to the palatine. Its internal, mesial border is convex, the convexity facing the angle between the parasphenoidal rostrum and the basipterygoid processes. The palatine is but loosely attached to this bone. The free end of the vomer underfloors its anterior end.

In *Struthio* the form of the pterygoid (Pl. XLII. fig. 8) closely resembles that of *Dromæus*: the points wherein it differs are points wherein it is also degenerate. It lacks the upstanding vertical plate from its antero-external lateral border, and it has fused with the palatine.

In *Rhea* the pterygoid (Pl. XLII. fig. 8) has undergone a very considerable reduction in size, and now takes the form of a  -shaped rod. The short upper limb bears facets for articulation with the quadrate and basipterygoid processes. The longer is laterally twisted around its own axis, and continued forwards till it reaches the parasphenoidal rostrum. Ventrally it is grooved. This grooved surface is applied, anteriorly, to the superior border of the vomer, and posteriorly to the upper surface of the postero-external angle of the posterior extremity of the palatine. Thus the posterior end of the palatine comes to underlie the posterior extremity of the vomer.

In the *Dinornithidæ*, e. g. *Emeus*, the form of the pterygoid very closely resembles that of *Rhea*. The points wherein it differs are such as must be regarded as representing a more primitive condition: the chief of these lies in the greater width dorso-ventrally; the pterygoid of *Emeus* possessing a broad ledge along its mesial border. Its relations with the vomer and palatine are practically the same as in *Rhea*.

In *Crypturi* the pterygoid is rod-like as in *Rhea*, relatively longer, much straighter, and more slender.

In *Apteryx* the pterygoid is elongate, laminate, and pointed in front where it rests upon and fuses with the vomer. It anchyloses very early and completely with the palatine, so that the precise form of the pterygoid as a whole cannot be made out in the adults (see p. 204). Proximally, it is tightly wedged in between the basipterygoid process on the one side and the orbital process of the quadrate on the other, the pterygoid having the appearance of being "morticed" in between these two points of contact.

The *palatine* in *Casuarius* takes the form of a roughly triangular plate. Its base articulates with the pterygoid and vomer, and the anterior half of its outer side with the maxilla. Its connection with the pterygoid is by means of an overlapping suture, the pterygoid underlying a broad shelf of bone given off from the palatine. The vomerine suture is that of a simple apposition of contiguous edges, as also is the junction with the maxilla. In the adult the palatine and pterygoid become indistinguishably fused proximally.

In *Dromæus* the palatine resembles in form that of *Casuarius*. It is, however, fenestrated. Its suturations differ only in that there is no overlapping shelf above the pterygoid. There is no fusion between pterygoid and palatine as in *Casuarius*.

In *Rhea* the palatines (Pl. XLII. fig. 6) are broad thin laminæ, roughly quadrangular in form, with the external border produced backward into a pointed spur which runs along the pterygoid, and forwards for a considerable distance along the maxilla. Its mesial border is cut away anteriorly so as to embrace the external border of the vomer instead of underlying it, as is done by the remaining posterior portion. Its form is seen best from the ventral aspect of the skull.

In the *Dinornithidæ*, e. g. *Emeus*, the form of the palatine resembles that of *Rhea*, but by a little tension the body of the bone has come to be vertical instead of horizontal in position, thus giving a rod-shaped superficial appearance.

In the *Crypturi* the main body of the palatine is, as in *Rhea*, horizontal, but the anteriorly produced external lateral border is of much greater length, and takes the form of an elongated and slender rod suturating anteriorly with the maxilla.

In *Struthio* the palatine (Pl. XLII. fig. 8) resembles that of many *Carinatæ* in that the main body of the bone is twisted into the form of an almost vertical scroll. It is peculiar, however, in that it is fused at its base with the overlapping pterygoid. The external lateral border is produced forwards, as in Tinamous, into an elongated slender rod, but which fuses anteriorly with the base of the hastate maxillo-palatine process.

In *Apteryx* the palatine (Pl. XLII. fig. 5) takes the form of a more or less flattened rod, differing in its relations from all the other associated forms. Anteriorly, it is fused with the maxillo-palatine process. The greater part of its external border is anchylosed with the maxilla.

The remaining posterior end of this bone anchyloses with the external border of the pterygoid. What corresponds with the posterior region of the mesial border in *Dromæus* is here free, and runs in a backwardly transversely oblique direction across the skull. For the precise relations of the bone however, see p. 204.

The Quadrate. (Pl. XLIII. figs. 10–12.)

The quadrate in *Casuarius* has its various processes very sharply defined.

The *otic* process is very slender, tapering gradually downwards into the body of the bone. At its base, where it merges into the main body, is a large pneumatic foramen, it opens on the posterior surface. The head for articulation with the pro-ötic and squamosal is single, oblong in form, with its long axis directed backwards and inwards.

The inner and outer mandibular condyles join mesially, the two projecting backwards to form a conspicuous spur. The difference in the level of the two condyles is but slight.

The orbital process is well defined, moderately large and free, with a sinuous superior border. At its extreme base, and on its inner side, is a small demi-facet for the pterygoid.

The outer surface of the quadrate is very closely applied to the long stout zygomatic process of the squamosal, which terminates only a short distance above the level of the cup-shaped quadrato-jugal fossa.

The quadrate of *Dromæus* differs but slightly from that of *Casuarius.* The outer and inner mandibular condyles are on distinctly different levels, the inner being ventrad of the outer, shorter from without inwards and wider from before backwards. The backwardly projecting condylar spur is less marked and formed entirely by the outer condyle.

The orbital process is less hollowed above.

In the *Dinornithidæ*, e. g. *Emeus*, the quadrate resembles that of *Dromæus* in the difference of level between the outer and inner mandibular condyles and in the form of the orbital process. This process is, however, peculiar in that its whole inner surface is requistioned for the articulation of the pterygoid. The inner mandibular condyle is peculiar in that the middle region of its articular surface is produced downwards, whilst the outer condyle looks more directly downwards than in *Dromæus.*

The pneumatic foramen is mesiad, and not posterior. A posterior foramen is, however, sometimes present in the *Dinornithidæ.*

In *Struthio* the inner and outer mandibular condyles are widely separated; otherwise they closely resemble those of *Dromæus.* The orbital process differs from that of the other forms so far described, in that its distal end turns sharply upwards, and in that there projects from its inner ventral border a sharply defined articular facet for the pterygoid. The *otic* process is relatively longer than in the other forms. Both the mesial and posterior foramina are present, though the latter may apparently be sometimes absent.

In *Æpyornis* the mandibular condyles resemble in form and disposition those of *Struthio*, and in some respects *Dinornis.* The form of the orbital process seems to have differed from all other genera in its great breadth. Its free end is missing, but from the sharp edge of the proximal end it is probable that it articulated with the pterygoid as in *Struthio.* The pneumatic foramen is mesial. The specimen from which this description is taken was kindly lent me by Dr. Forsyth Major.

In *Rhea* the quadrate resembles that of *Dromæus* rather closely. The external mandibular condyle is broken up into two distinct articular facets. The inner is similarly subdivided but not so distinctly; of these two last the outer is vertical and looks forwards and outwards, the inner ventral. The *otic* process is very short. Its articular head has its long axis at right angles to the long axis of the skull. The posterior pneumatic foramen lies immediately below the articular condyle. The *orbital* process is very short, blunt, and very wide, it does not project beyond the level of its articulation with the quadrate.

In *Crypturi* the form of the quadrate is quite peculiar in the development of a distinct cingulum projecting backwards above the external mandibular condyle. The *otic* process is bent backwards at a sharp angle, and forms with the orbital process a **Y**-shaped bone. The external form of the orbital process resembles that of *Struthio* but is more slender; the method of articulation with the pterygoid closely resembles that of *Dinornis.* The form of the outer and inner mandibular condyles is not unlike that of *Dinornis.* The inner condyle is, however, more nearly spherical than in any of the other forms herein described.

Apteryx possesses a readily distinguishable quadrate. The height of its vertical axis is less than that of a line passing backwards through the orbital process, which is very long.

The articular condyles for the mandible present the same ground type as in *Dromæus* and *Casuarius,* but the external condyle presents a tendency to split into two facets, the region nearest the quadrato-jugal bar being scooped out. The zygomatic process of the squamosal is closely applied to the outer side of the quadrate. In *Struthio* and *Rhea,* it should be mentioned, there is a considerable space between these two points.

In all the *Palæognathæ* the quadrate is peculiar in that the pterygoidal articulation extends upwards on to the orbital process for more than half of its length.

In *Apteryx* the articular surface for the pterygoid is rather more sharply defined than in the other *Palæognathæ.* Arising at the base of the internal mandibular condyle, it extends outwards on to the inferior border of the base of the orbital process, taking the form of a deep hollow into which the pterygoid closely fits.

The *otic* process has two fairly distinct articular facets. Superiorly transversely elongated, its mesial extremity is expanded into an almost circular head and articulates with the pro-ötic. Its external extremity runs obliquely down to the shaft towards the middle line, and affords an articular surface for the alisphenoid and squamosal.

The pneumatic posterior aperture is sometimes absent.

The separation into pro-ötic and squamosal heads in the other *Palæognathæ* is only very feebly indicated.

The *exoccipital* does not contribute towards the articular surface for the quadrate in *Apteryx.*

The Mandible. (Pl. XLIII. fig. 9.)

The mandible in *Casuarius* is long, slender, and sigmoidally curved. Posteriorly, it is expanded to afford an articular surface for the quadrate. This is moderately deep, and with sloping sides meeting at a sharp angle at the bottom of the fossa. Internally, it is produced into a blunt *internal angular process.* The surface for the external condyle forms a long narrow facet running parallel with the external border of the cup; that for the inner forms a band-shaped facet, hollow from within outwards. Immediately without the inner end of this internal facet is a pneumatic foramen. The *posterior angular process* is only feebly developed.

In *Dromæus* the *internal* and *external angular processes* are larger than in *Casuarius.* The *rami* are almost straight, and the symphysis is very broad. In other respects the jaw agrees with that of *Casuarius.* In *Dinornithidæ,* e. g. *Dinornis,* the articular surface for the *external condyle* of the quadrate is cup-shaped. The *internal* and *external* angular processes are feebly developed.

In *Rhea* the form and disposition of the articular surfaces agree with those of *Dromæus.* The internal *angular process* is large. The symphysis is very broad. The ramus bears a small, perforate posterior lateral vacuity.

Struthio in the form of its mandible rather closely resembles *Dromæus.* It differs, however, in its greater relative slenderness, in that it is sigmoidally curved, in the greater relative size of the expanded posterior portion, and in the elongated form of the articular facet for the external condyle of the quadrate.

Æpyornis also resembles *Dromæus.* The rami are, however, more laterally compressed, have an elongated anterior lateral vacuity, a broad dentary border, and the articular facet for the internal condyle of the quadrate situated at the bottom of a deep cup. The internal angular process is well developed and bears a large pneumatic foramen.

In *Crypturi* the mandible resembles that of *Rhea.* The *posterior angular process* is, however, longer in Tinamous, and the *posterior* lateral vacuity appears to be wanting.

Apteryx differs from all the other forms in the great length of the symphysis, which is about half the length of the ramus. The internal angular process is well developed.

The *coracoid* in all the Palæognathine forms is small and rod-shaped. Sometimes, as in *Struthio,* it is reduced to a mere vestige. The dentary suture is always distinct.

The Hyoid.

Except in *Apteryx*, only the cerato-branchials appear to ossify in the Palæognathine forms. Epibranchials and the true hyoid elements appear to remain permanently cartilaginous. In *Apteryx* the *basihyal* appears to ossify at least occasionally.

THE SKULL OF THE NESTLING.

The Cartilage-bones.

The youngest of the Palæognathine skulls in my possession is that of an embryo *Dromæus.* The cartilage-bones are in all the stages herein described completely ossified.

The *basi-occipital,* in the young *Dromæus* mentioned above, is perfectly distinguishable from the neighbouring bones (Pl. XLIII. fig. 5).

It is bounded antero-laterally, and in front, by the basi-temporal plate of the parasphenoid, and postero-laterally by the exoccipital. It is produced caudad to form the median portion of the occipital condyle. It is interesting to note, however, that it forms only the ventral part of this. It is entirely shut off from the occipital foramen by the exoccipital portions of this condyle, which meet in the median line above it. Seen dorsally, the basi-occipital is cut off from the pro-ötic by a broad patch of cartilage. Anteriorly it only just touches the basisphenoid.

In the youngest Cassowary and Rhea skulls in the Museum collection, the sutures of the basi-occipital have almost closed. It takes, however, a slightly larger share in the formation of the occipital condyle, inasmuch as it takes a small share in the formation of its free border.

In a half-grown *Apteryx australis mantelli* it agreed very closely with that of *Dromæus*, and, as in this form, the exoccipitals meet in the middle line above the basi-occipital.

The exoccipital, externally, is relatively large. The upper portion of its posterior (inner) border bounds the infero-lateral border of the epiotic (fig. 4). The lower region of this border is hollowed to form the lateral boundary of the foramen magnum. The share which it takes in the formation of the occipital condyle is considerable: in *Dromæus* the right and left plates meeting in the middle line behind the basi-occipital. Its dorso-lateral border is bounded by the parietal and squamosal in *Dromæus*, *Casuarius*, and *Apteryx*, and by the squamosal only in *Rhea*—this last, in *Rhea*, extending backwards to join the supra-occipital. The lower portion of the antero-lateral border is free, and in the shape of a large paroccipital process bounds the tympanic recess posteriorly. Its internal dorsal angle lies within the tympanic cavity, and helps to form the inferior pro-ötic articulation for the quadrate.

Internally, the exoccipital is almost entirely concealed by the opis- and pro-ötics.

The *supra-occipital*, in *Dromæus* and *Rhea*, runs upward and forward in the form of a blunt cone; in *Apteryx* the superior border is gently hollowed. In *Dromæus*, *Casuarius*, and *Apteryx* it is cut off from the squamosal by the exoccipital; in *Rhea* it runs upwards to join the squamosal. That portion of its outer (inferior lateral) border which comes into contact with the exoccipital really belongs to the epiotic. In the Penguin this last is easily distinguishable, but in the forms now under description it can only be made out on a reference to the interior of the skull.

The *epiotic* is not indicated externally in the peculiarly distinct manner seen in the Penguins; even in the skull of the youngest of the embryo Apteryxes in our collection its only indication is the venous canal which points the boundary line between this and the supra-occipital. Internally, it is fairly distinct in all save *Apteryx*. In all the skulls of this collection save those of the embryo *Apteryx* and *Dromæus*, it has fused with the pro-ötic.

The *pro-ötic*, even in the youngest *Apteryx* (Pl. XLIII. fig. 3) and *Dromæus* (Pl. XLIII. fig. 5) skulls, is not visible externally above the tympanic cavity, being concealed by the squamosal. In this it differs markedly from the young Penguin, in which a large portion of this bone remains uncovered until the bird is quite half-grown (82).

The pro-ötic completely shuts out the squamosal from the interior of the skull in all but *Apteryx*. In this type a large, roughly triangular plate appears immediately above the pro-ötic and wedged in between the parietal and alisphenoid.

The floccular fossa is deep, and oblong in all but *Apteryx*, the long axis running vertical to that of the skull. In *Apteryx* it is represented by a small but deep and perfectly circular pit.

Externally, the pro-ötic appears only within the tympanic cavity and affords two more or less distinctly separated articular surfaces for the quadrate: the one lying slightly above and in front of the other. Distad of the superior glenoid surface lies a similar articular surface furnished by the alisphenoid; caudad of the inferior lies a second facet furnished by the exoccipital. These appear to be most distinctly traceable in *Casuarius*. Externally, articular surface for the quadrate is completed by the squamosal Thus there are two pro-ötic, one exoccipital, one alisphenoid, and one squamosal articular facet for articulation of the quadrate.

The *opisthotic* is seen as a small oblong nodule of bone wedged in between the pro-ötic and the exoccipital, and bounded above by the inferior end of the epiotic. It is not visible externally.

The *foramen* for the *vagus* lies at its ventral extremity and between it and the exoccipital.

The *basisphenoid* has in every case fused completely with the underlying basi-temporal plate, and is therefore traceable only from the superior aspect of the skull. It is moderately thick in section, the body of the bone being thickened by a mass of diploë.

It is bounded behind by the basi-occipital, laterally by the pro-ötic and alisphenoid. Anteriorly, in *Rhea,* it is produced forward into a thin vertical plate of bone, to join the cartilaginous presphenoid; in the other forms this vertical plate is much shorter. It serves to form the inner half of the circumference of the foramen for the orbito-nasal nerve (v.), the outer portion being contributed by the alisphenoid. Out of its anterior region is scooped the pituitary fossa. The abducent foramen pierces it on either side near its postero-lateral angle. It forms the floor of the anterior region of the metencephalic fossa.

In *Apteryx* it is almost quadrangular. In *Casuarius* and *Dromæus,* and in *Rhea*, it is expanded laterally to form a pair of wings, and is narrower behind than in front.

The *alisphenoid* is bounded by the parietal and squamosal behind, the orbital plate of the frontal above, and the combined basisphenoid and alisphenoid as rings of the parasphenoid.

In *Dromæus*, *Casuarius*, and *Rhea* it bears a share in the formation of the post-orbital process.

The alisphenoid lodges the greater part of the mesencephalic fossa, and contributes a share towards the formation of the anterior wall of the cerebral fossa.

The *orbitosphenoid* is represented only by cartilage and is much reduced in size.

The *presphenoid* is represented by a thin vertical plate of cartilage resting upon the parasphenoidal rostrum and wedged in between mesethmoid in front and the anterior, laterally compressed vertical plate of the basisphenoid just described. It extends upward and backward to the orbital plate of the frontal. From this region it sends outwards and backwards a pair of cartilaginous wings, which represent the orbito-sphenoids.

The *mesethmoid*, in all but *Apteryx*, in common with the presphenoid region, forms a conspicuous *interorbital septum*. In the nestling *Dromæus*, *Casuarius*, *Rhea*, and ? Ostrich, and in the adult Tinamou, this is pierced by a large interorbital fenestra. This fenestra appears to be excavated partly out of the large, backwardly directed plate which unites with the orbital plate of the frontal, and partly (caudad) out of the anterior border of the presphenoid. In the nestling, the antero-ventral border is more or less linguiform, and terminates at the level of the anterior border of the lachrymal. From this, there runs forward a narrow, triangular, cartilaginous septum nasi. In the adult *Casuarius*, *Dromæus*, *Dinornithidæ*, and Tinamous, ossification extends forwards almost to the end of the rostrum, and terminates in a vertical truncate border, beyond which there is a small cartilaginous septum nasi. In *Rhea* and *Struthio* the ossification extends quite to the free end of the rostrum, *i. e.* relatively further forwards, and terminates in a sharp point instead of a vertical truncated border. In these, the cartilaginous septum nasi is wanting or greatly reduced.

The dorsal border of the mesethmoid, in *Dromæus*, *Casuarius*, and *Dinornithidæ*, is of considerable thickness and very slightly convex; it forms a complete floor to the olfactory fossa, extending outwards on either side to the orbital plate of the frontal (Pl. XLIV. fig. 4). In this particular, as will be seen later, it differs conspicuously from *Apteryx*, wherein this region forms a thin median partition between two extensive cavities. At the anterior end of the olfactory fossa, both in *Dromæus* and *Casuarius*, it sends upwards, and then backwards, a strong median pillar deeply grooved on either side for the passage of the olfactory nerves. This corresponds to the *tegmen cranii* described in *Apteryx* by T. J. Parker, and referred by Kitchen Parker to the tegmen cranii of the lower vertebrates. Thus the *crista galli*, in these two forms, is furnished entirely by this tegmen cranii, the " tegminal process " of Jeffery Parker.

At the apex of this *tegminal* process, as has been well described by Parker, the mesethmoid reaches the outer surface of the skull; here it throws out lateral horizontal ecto-ethmoidal plates—the aliethmoids, as Jeffery Parker proposed to call them. In *Dromæus* the upper surface of these plates forms a lozenge-shaped area, bounded by the frontals behind, the nasals laterally, and the nasal process of the premaxilla in front. The free edges of these right and left aliethmoidal plates in the nestlings turn downwards and inwards (Pl. XLIV. fig. 4), and in the adult become further extended and intricately folded to form the lower region of the aliethmoid and the antorbital plates. In the nestling *Dromæus* it should have been remarked that the median vertical portion of the mesethmoid is pierced by a large vacuity, the cranio-facial fissure.

Casuarius differs conspicuously from *Dromæus* and the other forms associated herewith in that, that portion of the mesethmoid which in *Dromæus*, for instance, reaches the outer surface of the skull to form the lozenge-shaped plate already described, is surmounted by an independently ossifying mass forming the centre of the characteristic casque of the adult—the lateral portions of the casque being furnished by the inflation of the nasals and that portion of the frontal bone which comes into juxtaposition with the nasal and median masses (Pl. XLIV. figs. 3 & 4 *a–b*). The median portion often extends so as to cover the parietal.

In the adult this casque is seen to be built up of a homogeneous mass of cancellated tissue of great delicacy, and protected in the living bird by a horny sheath. The form and development of this casque varies considerably, and is one of the factors employed in the determination of species.

The exact homology of this casque has yet to be made out. That the lateral portions are simply inflations of the nasal and frontal bones there can be no doubt, but the origin of the median portion is not so certain. It appears to be an independent structure superimposed upon the mesethmoid, rather than an outgrowth of that element.

Stages in the growth and composition of this casque are shown in Pl. XLIV. figs. 3 and 4 *a–b*.

In *Rhea* and the Tinamous, as in *Dromæus* and *Casuarius*, the dorsal border of the mesethmoid comes into close relation with the orbital plate of the frontal, but the relationship is even closer, this border being narrower, so that the crista galli is formed only by the tegminal process. But the passage for the olfactory nerves is restricted to an exceedingly narrow space lying on either side of this process. In *Dromæus* and *Casuarius* this passage, though formed in precisely the same way, is much larger.

In *Apteryx* the dorsal border of the mesethmoid is exceedingly narrow and knife-like, and slightly concave. It is, moreover, relatively much shorter antero-posteriorly than in *Casuarius* or even *Dromæus*. The tegminal process is less well-developed. In the embryo, it appears on the surface of the skull as in *Dromæus*, and also, as in this form, sends out horizontal plates which form a lozenge-shaped shield between the frontal and nasal bones. Later in life all trace of this shield is obliterated.

The *quadrate* in the embryo of *Dromæus* differs in shape from that of the adult in the lack of an ossified orbital process, and in that the external mandibular condyle is <-shaped instead of transversely oblique.

In *Apteryx* that of the embryo appears to differ in nowise from that of the adult.

The other skulls in the Museum collection are too advanced to afford any intermediate characters.

The *articular* is a pyramidal nodule of bone, bounded cephalad by the coronoid the base of which conceals its anterior face; externally (in *Rhea*) by the supra-angular. It furnishes the articular surface for the quadrate. In *Dromæus* and *Apteryx*, both angular and supra-angular take part in the protection of its external face.

The *stapes* is represented in the dried skull only by the bony base. It does not apparently offer any characters of value from a systematic point of view. The extra-columella has been already admirably described by Gadow, Parker, and others.

The Membrane-bones.

The *parietal*, in *Casuarius*, *Dromæus*, and ? *Struthio*, is a transversely oblong plate of bone, the anterior and outer borders of which are produced forward into a small but sharp point which is wedged in between that portion of the frontal which overhangs the post-orbital process and the process itself. This parietal spur thus helps to form the base of the post-orbital process, the main body of which is furnished by the alisphenoid.

In *Rhea* and ? Tinamous this antero-external parietal angle is not produced forwards, and fails entirely to reach the postorbital process (Pl. XLIII. fig. 9). Its postero-external angle is overlapped by an upstanding process of the squamosal.

Internally the parietal carries on the tentorial ridge from the alisphenoid upwards to its junction with the falx. Behind this ridge it is gently scooped out to complete the roof of the cerebellar fossa, in front it is also hollowed out to form the posterior wall of the cerebral fossa.

In *Apteryx*, as in the other forms, the parietal is irregularly four-sided. Its external border is bounded entirely by the squamosal. In all the other forms, it will be noted, it extends forward beyond this.

Internally, it is found to lack the tentorial ridge. Its hinder and external borders pass insensibly the one into the other. The former skirts the supra-occipital and a portion of the pro-ötic beyond, the latter rises gently from the hinder region of the superior border of the pro-ötic—where the hinder border may be said to cease—upwards to skirt the upper border of the small triangular area of the squamosal which enters into the formation of the inner wall of the skull. It is entirely cut off from the alisphenoid. In the other forms, e. g. *Rhea*, *Dromæus*, the superior borders of the pro-ötic and the alisphenoid form the boundaries ventrad of this bone.

The *frontal* extends backwards so as to form the greater part of the roof of the cerebral fossa. Its hinder border is more or less sinuously curved, and traced from within outwards will be found, in *Casuarius* and *Dromæus*, to run transversely from the middle line to the base of the post-orbital process, from which, however, it is actually cut off by a very slender spur from the parietal. In *Rhea*, on reaching the antero-external angle of the parietal, it turns abruptly upwards and outwards, so as to rest upon the base of the post-orbital process itself. Externally, the frontal is bent in upon itself to form a deep orbital plate which articulates caudad with the alisphenoid and cephalad with the mesethmoid, eventually terminating in a long spike, in *Rhea*, resting upon the mesethmoid, and overlapped by a greatly elongated posterior extension of the nasals and the free end of the inner spur of the lachrymal. In *Dromæus* the relations are similar, but the nasal spur is shorter.

In *Casuarius* the forward extension of the frontal is curtailed, since it terminates with the mesethmoidal region of the orbital plate, at the level of the origin of the antorbital plate. The greater part of its mesial border is much thickened and inflated; this region being involved in the formation of the casque, and representing its hindmost postero-lateral boundary. In some species this inflation of the bone extends backwards as far as the parietals.

Furthermore, it is significant to note the fact that the frontals fail to meet in the middle line anteriorly, where they under-floor the median ossification of the casque (Pl. XLIV. fig. 4). Thus a portion of the ventral border of the casque comes to take part in the formation of the roof of the cerebral fossa. It would seem, from this, as though this secondary ossification was gradually engrafting itself more and more completely upon the skull, by absorption of the underlying bone in much the same way as bone has replaced cartilage in other cases in the cranial skeleton.

The extreme anterior end of the mesial border of the frontal is gently hollowed out so as to form the external lateral boundary of the superficial lozenge-shaped plate of the mesethmoid.

In *Apteryx* the frontal presents one or two points of difference from that of the remaining forms associated herewith.

Its mesial border joins its fellow of the opposite side, and its hinder border is bounded by the parietal, as usual. Its postero-ventral or lateral border joins the aliethmoid. Immediately in front of this, the frontal sends downwards and inwards a narrow plate of bone which, eventually, meets its fellow of the opposite side in the middle line, immediately behind the crista galli. From the outside, this orbital plate of the frontal gives off a short slender plate to the aliethmoid.

Cephalad of this orbital plate is a deep notch, the *supra-orbital fontanelle.* This fontanelle is bounded anteriorly by a narrow bar of bone, called the *descending process* of the frontal, which at its ventral extremity joins the aliethmoid. Mesiad of this bar—between its upper and the outer wall of the aliethmoid—the orbito-nasal nerve passes from the orbit to the nasal cavity.

The *squamosal,* in all the forms herein dealt with, entirely conceals the pro- and opisthotics. In the embryo *Dromæus,* which forms the subject of this paper, it is almost quadrangular, its antero-ventral angle is produced into a blunt process which extends downwards to the level of the quadrato-jugal articulation. This downward process of the squamosal is thickened on its inner surface and so closely applied to the quadrate as to render it immovable.

In the embryo skulls of *Dromæus,* the squamosal and the parietal are connected by means of a close suture, the juxtaposition of the two elements forming a perfectly level surface. Posteriorly the squamosal rests *upon* the outer border of the exoccipital, and later fuses therewith. Similarly the squamosal, anteriorly, rests *upon* the alisphenoid, anchylosis therewith taking place later. Thus it is that the pro-ötic comes to be entirely concealed.

In all this, *Dromæus* and *Casuarius* seem to be less primitive than the Penguin. In a skull of this group recently described and figured by me [82] the squamosal was attached to the dried skull simply by its articulation with the parietal. Its hinder border was deeply emarginate and free, exposing the pro-ötic. Its anterior border was also free, not extending to the alisphenoid, but exposing between itself and this last a small portion also of the pro-ötic.

There is one great point of difference, however, between the squamosal of *Dromæus* and that of the Penguin. In the former, its antero-ventral angle is produced downwards into a large "zygomatic process," to embrace the quadrate; in the latter, this spine is replaced by two small spines, as in all the *Neognathæ.*

Except in *Apteryx* the squamosal takes no part in the formation of the inner wall of the skull.

In *Apteryx* the squamosal has entered into a slightly closer relation with the alisphenoid and exoccipital than in the forms described above, resembling in this respect the *Neognathæ.* Thus the anterior border is concave and fits the corresponding convex border of the alisphenoid; whilst the posterior border, though separated by a narrow line of cartilage from the exoccipital, yet gives signs of effecting a close union therewith immediately.

The squamosal appears on the inner surface of the skull as a small triangular plate above the pro-ötic.

The *nasal* in *Dromæus* is holorhinal. The maxillary process is greatly reduced, especially so in the adult, where it exists only as a vestige. It is produced caudad into a long slender process resting on the frontal, and projecting beyond the lozenge-shaped plate of the mesethmoid, to which it binds externally. Its premaxillary or internal process is of considerable length, extending forwards almost the whole length of the nasal process of the premaxilla, which protects them from above.

Dinornis is holorhinal.

A skull of *Megalapteryx*, in the collection of the Hon. Walter Rothschild, retains sufficient of the traces of sutures in this region to indicate the form of the nasal in the *Dinornithidæ.*

In this skull, it is seen to be relatively much shorter than in *Dromæus.* Its backward extension does not pass the level of the horizontal mesethmoid plate and is not so pointed as in *Dromæus.* Its maxillary process is wanting. The ossified aliethmoidal plate projects beyond its lateral border.

In *Casuarius* the nasal is *schizorhinal.* The maxillary process is vestigial, and the premaxillary process long, as in *Dromæus.* It is peculiar in that the body of the bone is greatly inflated and takes part in the formation of the casque as already described

In *Rhea* the nasal must be regarded as holorhinal, though the maxillary process is absent. Inasmuch as this process, when present, serves as the boundary, caudad, of the anterior nares, its place must be regarded as being filled by a vertical spike of bone arising from the maxillo-palatine process to the anterior border of the lachrymal. In *Struthio* this vertical spike—in *Rhea* separating the anterior nares from the lachrymo-nasal fossa—is represented by a ligament which is attached dorsad to the free end of the maxillary process of the nasal.

In *Struthio* the nasal is holorhinal (Pl. XLII. fig. 3). Its maxillary process is well developed, and continued downwards on the maxillo-palatine by ligament.

The *Tinamidæ* may be regarded as holorhinal, though the nasal cleft has extended backwards so far as to lie level with the free end of the nasal process of the premaxilla. The maxillary process is not wanting as in *Rhea*, though reduced to a mere vestige. The nasal cleft is bounded externally by a vertical, bony rod, representing the maxillary spike found in *Rhea*. It differs therefrom in being rod-like, very slender, and is perfectly free. Above, it articulates, by means of a short inturned process, with the anterior border of the lachrymal and the vestigial maxillary nasal process, whilst ventrally it articulates with the extreme postero-external border of the maxillo-palatine process where it joins with the rod-shaped portion of the maxilla. This vertical rod was regarded by Kitchen Parker as the maxillary process of the nasal. It is, however, in all the skulls I have examined, quite distinct from this.

The *lachrymal*, in *Dromæus*, sends backwards a very long, curved, rod-like process to overhang, and thereby greatly increase the size of the orbit (Pl. XLII. fig. 2). It sends downwards a large antero-posteriorly flattened limb, the outer border of which is produced still further downwards into a short rod-like spine which articulates with the quadrato-jugal bar. The body of this ventral process of the lachrymal is perforated by a large foramen for the passage of the lachrymal duct. The inner border of this ventral process articulates with the antorbital plate.

In *Casuarius* the lachrymal differs from that of *Dromæus* in the greater relative shortness of its external orbital process, which is scarcely longer than the internal. A further point of difference lies in the fact that the external orbital process passes insensibly forwards and downwards into a laterally compressed plate, which, after forming the boundary caudad of the posterior narial aperture, turns sharply backwards, and becomes the antero-posteriorly compressed ventral process bounding the lachrymo-nasal fossa as described in *Dromæus*. From this it differs in that the laminated portion is continued downwards to the level of the quadrato-jugal bar, instead of stopping short of this, and sending downwards thereto a spine from its outer border. The foramen for the lachrymal duct is smaller than in *Dromæus*. Internally it articulates with the antorbital plate.

In *Rhea* the lachrymal resembles that of *Dromæus*. The supra-orbital process is large. The lachrymo-nasal process is also antero-posteriorly compressed. The foramen for the lachrymal duct is very large. This lachrymo-nasal process stops short of the quadrato-jugal bar and is connected therewith by a large subquadrate ossiculum lachrymo-palatinum. Internally the last eventually fuses with the antorbital plate.

In *Struthio* the lachrymal resembles that of *Rhea*. Its *supra-orbital* process is, however, relatively shorter and thicker. In two nearly adult skulls (one of which is from the collection of the Hon. Walter Rothschild) this orbital process supports one end of a chain of irregularly shaped ossicles which is continued backwards along the frontal as far as the post-orbital process. Normally this chain of ossicles is so completely fused as to be indistinguishable from the frontals on the one hand, and the lachrymal on the other. There is a large supra-orbital fenestra bounded in front by the lachrymal and behind by the frontal; externally by a portion of this chain of supra-orbitals.

The lachrymo-nasal process is continued downwards as a sigmoidally curved rod to terminate on the inner side of the quadrato-jugal bar. On the inner side of this extremity of the lachrymal there lies a subcylindrical *ossiculum lachrymo-palatinum* articulating mesially, in very old specimens, with the antorbital plate. The lachrymal foramen is represented only by a deep notch.

In *Apteryx* the lachrymal is vestigial, and takes the form of a small roughly triangular plate of bone closely applied to the outer surface of the aliethmoid and the maxillary process of the nasal. It is perforated by the lachrymal foramen.

The *premaxilla*, *maxilla*, *jugal*, *quadrato-jugal*, *vomer*, *palatine*, and *pterygoid* differ in no important respects from that of the adults already described (p. 187).

The *vomer*, *pterygoid*, and *palatine* of *Apteryx* demand, however, a further examination, as these in the adult are too completely fused with the neighbouring bones to render it possible to make out their boundaries.

The *pterygoid* is bifid cephalad, being divided into two moderately long, pointed and widely separated prongs. The inner prong, which constitutes the main body of the bone, is deeply grooved along its mesial border, producing two shelf-like projections one above the other: these converge near the tip of the prong to form a slender pointed style resting in a groove on the outer border of the posterior extremity of the vomer as in other *Palæognathæ*, and as in the hemipterygoid of *Neognathæ*, e. g. *Impennes*, *Colymbi*. The outer limb is closely applied to the ventral and external aspect of the extreme hinder end of the maxillo-palatine process, extending as far forwards as the point from which the maxillary portion of the quadrato-jugal bar is given off. In the cleft between the outer and inner limbs the palatine is interposed, as will be seen presently.

The *palatine* is short and broad, with a slightly bifid free extremity. It can only be seen in its entirety from above. It is closely applied, throughout its entire length, to a backwardly projecting plate from the maxillo-palatine process. This it entirely conceals from above. Its proximal extremity sends off, upward and inward, a flange-like plate to articulate with, and underlie, the extreme hinder end of the vomer. Thus this last has its right and left limbs sandwiched, on either side, between the pterygoid above and the palatine below. A portion of this flange-like plate of the palatine helps to fill up the cleft between the pterygoid fork already described. As mentioned above, the palatine rests upon a backwardly directed plate from the maxillo-palatine process, the whole of which it conceals from the dorsal aspect. Ventrally, this process is found to run along, and below, the external palatine border, and to terminate near its extreme posterior end. The forward extension of the palatine on the ventral surface corresponds with the level of the tip of the vomer. This extension is derived from the ventral surface-layers of the main body, the palatine terminating abruptly on the dorsal aspect in a **V**-shaped notch at the level of the middle of the vomer. This ventral process rests in a groove along the mesial border of the maxillo-palatine process.

The relations of the vomer have already been more or less indicated. Suffice it to say, that the free end of each posterior limb is wedged in between the spine-like extremity of the pterygoid above and the flange-like inward projection from the dorsal surface of the palatine below.

The palate of *Apteryx* will be found, on a close comparison with that of the remaining *Palæognathæ*, to have departed from the typical Struthious form in the direction of that taken by *Rhea*, the relations between palatine and vomer being similar in both. The form of the pterygoid differs from that of all other birds, in that it is bifid, or, in that it sends off a separate limb whose mesial border passes downwards to underlie the external border of the palatine. This external, palatine limb is elsewhere unrepresented. The internal, vomerine limb may be regarded as a flattened plate folded upon itself, the edge being inwards. The superior edge, or upper lip, must be regarded as representing the mesial border of an originally flattened pterygoid such as that of *Dromæus*.

The *dentary* is of great length. In *Dromæus*, *Casuarius*, *Rhea*, *Apteryx*, and Tinamous it extends backwards to within one-fourth of the whole length of the ramus. It is relatively less in *Struthio*. Caudad each ramus divides into dorsal and ventral limbs, of which the ventral is the larger. In *Rhea* the dorsal limb is paired.

The *splenial* is of great length in all, extending forwards to the symphysis of the jaw, and backwards to within a short distance of the level of the glenoid cavity for the quadrate. It is rod-like in *Struthio*, laterally compressed in the remaining forms.

The *angular*, in all save *Apteryx*, articulates, proximally, with the supra-angular, being embedded caudad in its external border; distally, it twists downwards so as to form the ventral border of the ramus. In *Casuarius* and *Dromæus* its extreme posterior and inner border comes into contact with the articular. In *Rhea* and *Struthio*, it falls considerably short of this.

In *Apteryx*, the angular articulates proximally with the ventral border of the articular, which is hollowed out to receive it. The supra-angular rests upon its dorsal border.

The *supra-angular*, in all, articulates proximally with the articular. Its dorsal border is received between the right and left moieties of the superior limb of the dentary. Its ventral border descends caudad to the level of the inferior border of the angular; distad it rises gradually so as eventually to cross the dorsal border of the same.

The *coronary* is in all a short, slender, and rod-like bone. In many *Neognathæ* it is often of considerable size and laterally compressed.

In all the *Palæognathæ* it appears to extend backwards so as to embrace the inner border of the articular and to form the internal boundary of the articular surface for the quadrate. In *Rhea* and *Apteryx* it is very feebly developed distad, and may be described as vestigial. In *Casuarius* and *Dromæus* it is much larger. *Struthio* is intermediate. In no case does it extend forwards beyond the posterior third of the ramus.

Such characters of the skull as are of use for systematic purposes will be found in the "Keys" at the end of this paper.

More material is needed before these can be made complete, since a "Key" to the species has not been possible in the case of *Casuarius.* Whether the characters considered to be specific in the case of the other genera will stand the test of time remains to be seen. In several instances I have been obliged to rely upon the characters of a single skull, as in the cases of the skulls of *Rhea macrorhyncha*, for instance.

I feel justified in reviving Dr. Sclater's *Struthio meridionalis* [90] on account of the many marked peculiarities which the skull and the trunk of this skeleton presents.

The work of distinguishing the skulls of the four species of *Apteryx* has been a very difficult one. Indeed, as Mr. Beddard has already remarked [8], "the very slightest differences, apart from those of size, distinguish the *Apteryges.*"

Some Points of Significance in the Struthious Palate.

The following points appear to be worthy of special consideration and may fitly be discussed here.

In comparison with the palatines of the *Neognathæ,* it will be remarked that in *Rhea,* as in the other *Palæognathæ,* the palatines are widely separated one from another by the laterally expanded feet of the vomer. In the *Neognathæ* the palatines meet in the middle line, thrusting the vomer forwards, so that it now appears to articulate not with the pterygoid but with the palatines. In *Rhea* and *Crypturi* we have probably a clue to the way in which this has come about. Turning once again to the skull of *Dromæus,* we notice that the palatines are only loosely attached to the outer border of the vomerine feet, whilst in *Rhea* (Pl. XLII. fig. 5) the palatines have moved inwards so as to overlap these feet and approach one another mesially. Their relation to the pterygoid has also changed, for they no longer are connected with its outer border but by this same inward movement have come to underlie it.

In the *Neognathæ*, the inward movement has attained its maximum, the palatines meeting one another mesially, as we have just remarked, thrusting the vomer forwards in so doing. As a matter of fact, however, as we have already shown in earlier papers [82], this is not altogether the case. In the young bird the pterygoid extends forwards in a spike-like form, much as in *Rhea*, so as to articulate with the vomer, though but by the slightest contact. The palatines have succeeded in moving inwards beneath these anterior pterygoid ends so as to all but entirely sever the original relations between them and the vomer.

Later in life (soon after hatching) the severance is complete. At this stage, the anterior end of the pterygoid fractures at a point corresponding with the free end of the palatine. The fracture later becomes a true joint, and the anterior end of the pterygoid resting upon the palatine gradually merges with this bone so as to obliterate all traces of its original existence. Thus the free pterygoid of the *Neognathæ* is a secondary feature, the palato-pterygoid connection in the late embryo not differing materially from that of the *Palæognathæ*. Further, the apparent isolation of the vomer from the pterygoid in the *Neognathæ* is seen to be a cœnogenetic character, so that the palate of this group is brought into close relation with that of the *Palæognathæ*.

A further point of interest in this comparison between the Palæo- and Neognathine skull is the change which the vomer in the latter has undergone in relation to the parasphenoidal rostrum, a change which indicates a shortening both of vomer and rostrum.

The vomer in the *Neognathæ* rarely extends backwards beyond the base of the antorbital plate, in the *Palæognathæ* it may reach nearly as far as the basipterygoid processes. This is an undoubted proof of the shortening of the vomer.

That the rostrum has also undergone a considerable shortening is shown by the fact that in the *Palæognathæ* it extends forwards for a very considerable distance beyond the level of the lachrymo-nasal fossa, in the *Neognathæ* it commonly ends in the region of the antorbital plate.

Yet other evidences of shifting and modification of the dromæognathous palate reveal themselves in the *Neognathæ* when we come to closely compare them, and whilst these show how closely the two groups are related they show still more the lower grade of type persistent in the *Palæognathæ*.

In the *Palæognathæ* the free ends of the basipterygoid processes articulate with the extreme proximal end of the pterygoid quite close to the articulation with the quadrate. In *Neognathæ* these processes, when present, have shifted forwards on to the rostrum, so as to articulate with the middle of the pterygoid.

The forward shifting of the Neognathine vomer, which we have already noticed—a shifting which brings its proximal end more or less immediately under the antorbital plate—appears to have been accompanied by a similar shifting of the palatines, since these no longer are connected with the main body of the pterygoid bone but with its distal end. This, as we have already shown, ultimately fractures and fuses with the palatine, a joint forming at the line of fracture. This connection of the palatine and pterygoid by means of a joint is a point of great difference between Palæo- and Neognathine skulls.

In the *Tinamidæ* we have an intermediate stage between the *Palæo-* and the *Neognathæ.* The vomer is undoubtedly relatively shorter posteriorly than in *Rhea*, its free end lying midway between the level of the antorbital plate and the basipterygoid processes. The pterygoid has increased in length, so that the vomer and palatine articulate with its distal extremity only. The quadrato-jugal fossa has also increased in length relatively, extending forwards now beyond the level of the antorbital plate as far as the vestigial maxillo-nasal process.

A careful study of these points will greatly facilitate the conviction that the ægithognathous and schizognathous skulls are but modifications of the dromæognathous type. The desmognathous is a further modification of the schizognathous palate.

The single-headed otic process of the quadrate in the *Palæognathæ*, upon which so much stress has hitherto been laid, appears to have less importance than the points to which attention has just been drawn, for in *Apteryx* the otic process is two-headed, as in *Neognathæ.*

THE VERTEBRAL COLUMN.

The memoirs of Owen, Mivart, and T. J. Parker on the vertebral column of the struthious skeleton render it quite unnecessary to do more than briefly comment thereon here.

a. *The Presynsacral Vertebræ.*

All the presynsacral vertebræ of the *Palæognathæ* are heterocœlous, and all of this region are free except in the *Tinamidæ*, in which certain of the thoracic vertebræ fuse.

The vertebræ of *Dromæus* are the least specialized in type; those of *Casuarius* are very similar.

Both in *Dromæus* and *Casuarius* the cervical vertebræ are conspicuously shortened antero-posteriorly. In *Casuarius* the neural spine, traced from the head backwards, undergoes considerable change of form. Anteriorly it is little more than a median tubercle rising from the centre of a flat neural plate. At about the 6th vertebra it sends backwards a pair of low ridges which terminate in a pair of hyperapophyses. At about the 10th vertebra, the spine has exchanged its <-shape for a transversely crescentic form. This, for the next 4–5 vertebræ, becomes broken across in the middle line to form two high curved ridges sloping downwards and backwards to terminate in metapophyses. At about the 15th vertebra the two ridges again coalesce and form a very high vertical transverse neural spine. From the 18th backwards this gradually becomes more and more laterally compressed, so as to pass insensibly into the typical neural spines of the thoracic vertebræ. Every neural spine, from that of the axis backwards, bears a fossa at its base, both anteriorly and posteriorly. The latter is the deeper. The vertebræ from the middle of the neck backwards have these fossæ of very considerable size. They lodge a ligament.

From 6–10 in *C. casuarius* and *C. c. australis* the diapophysis sends back a bar of bone to the hyperapophysis.

The vertebræ are all pneumatic. In the hinder cervicals there is a large pneumatic aperture dorsad of the interzygapophysial ridge. In the thoracic there are several very large ones—one below the transverse process, one between the transverse process and the postzygapophysis, and one dorsad, lying between the anterior zygapophysis and the base of the neural spine. This last is represented by a deep fossa in *Dromæus*. The aperture ventrad of the anterior zygapophysis is feebly developed or wanting in *Dromæus*.

The cervical ribs (pleurosteites) and hypapophyses resemble those of *Dromæus*.

In *Dromæus* the vertebræ are less specialized than in *Casuarius*. The high transversely expanded neural spines are wanting, though the ligamental neural fossæ, especially that caudad of the neural spine, are very deep. The pneumatic fossa in, or above, the interzygapophysial ridge is very deep, as also is that lying at the base and in front of the neural spine. The sides of the fossæ, moreover, are smooth, not obscured by cancellated tissue as in *Casuarius*.

In *Struthio* the centra of the vertebræ are relatively much longer than in *Dromæus* or *Casuarius*. The neural spines of the anterior cervicals are long, low, and rise to form a sharp median ridge. The ligamental fossæ are narrow grooves channelled out of this ridge. The posterior cervicals have the neural spines wider and shorter, antero-posteriorly, and they are deeply hollowed for the ligament.

The cervical ribs, as in *Casuarius* and *Dromæus*, are long, but more slender than in these. As in *Dromæus* they fuse with a plate of bone depending from the diapophysis and a lateral parapophysial outgrowth from the anterior end of the centrum below the prezygapophysis. The presence of this rib serves to enclose a canal for the vertebral artery. One great point of difference between this region of the vertebra and that in *Dromæus* and *Casuarius* lies in the fact that in *Struthio* the lamella depending from the diapophysis, and with which the rib articulates, is continued backwards along the centrum for a considerable distance, forming an extensive and tunnel-like passage for the artery.

The pneumatic apertures are not so conspicuous as in *Dromæus*. There is no aperture in the interzygapophysial ridge of the anterior cervicals as in *Dromæus*. In the hinder cervical and thoracic vertebræ there is a large aperture beneath the diapophysis, opening in the roof of the tunnel for the vertebral artery, or in the thoracic vertebra below the prezygapophysis and between the dia- and parapophysial articulations of the tuberculum and capitulum. The deep fossa at the base of the anterior border of the neural spine of the hinder thoracic vertebræ is here very shallow.

In *Rhea* the vertebræ have departed still more from the normal type. The cervicals are very long and cylindrical. Neural spines are present only on the 2nd to 5th vertebræ. The free hinder borders of the postzygapophyses of the 6th vertebra are received into a pair of shallow pits on the 7th, lying mesio-caudad of the prezygapophyses. Cervical ribs are only feebly developed. From the 2nd to 11th vertebræ they are represented only by short styliform processes; from this vertebra backwards they are represented only by the extreme anterior articular end of the rib which serves to form the band-shaped external wall of the vertebrarterial canal. As in *Struthio*, the vertebrarterial canal is roofed by a backward extension of the lamelliform plate depending from the diapophysis and serving as an articulation for the cervical rib. This plate is described and figured as the "rudimentary rib" by Mivart [63]: doubtless by a slip.

In *Apteryx* the form of the atlas and axis vertebræ bears some resemblance to *Dromæus*. The rest of its vertebræ differ conspicuously from those of the forms herewith associated. The neural spines never bifurcate. On the anterior vertebræ they form compressed blades from the 8th to the 12th; they are columnar and vertical in form and central in position with regard to the neural laminæ. The diapophyses of the 6th and 7th vertebræ project outwards and backwards beyond the level of the prezygapophysis; from the 7th to the 13th backwards and downwards; from this vertebra caudad they project directly outwards, and merge gradually into the transverse processes of the thoracic vertebræ. The neural spines of the thoracic vertebræ are equal in size, of great breadth antero-posteriorly, and interlock along the dorsal ridge by anterior and posterior bifurcations as in many *Neognathæ*.

There are no pneumatic apertures in either cervical or thoracic vertebræ. Cervical ribs are vestigial.

In *Crypturi* the thoracic vertebræ are anchylosed and bear hypapophyses. In the *Palæognathæ* these occur only on the posterior cervicals (cervico-thoracic). The penultimate is free, the ultimate fused with the synsacrum. The interzygapophysial ridge is perforated by pneumatic apertures. In the cervical vertebræ pneumatic apertures open into the roof of the vertebrarterial canal.

The diapophyses of the cervicals project forwards beyond the prezygapophyses. The neural arch is constricted in the middle, immediately behind the prezygapophyses.

The vertebræ of *Dinornis* resemble those of *Casuarius*. The fossæ lying beneath the transverse process of the thoracic vertebræ, absent in *Dromæus*, were much larger relatively than in *Casuarius*. The cervicals resembled those of some species of

Casuarius in having a bony bar running from the diapophysis backwards to the hyperapophysis.

The *thoracic vertebræ* call for no special remark here. They have already been minutely and carefully described by Mivart.

The vertebræ known as the cervico-thoracic should probably be regarded as true thoracic vertebræ, the ribs of which have lost their sternal segments through the backward shifting of the sternum. This view has already been promulgated by the late T. J. Parker. Writing of *Apteryx*, he says: "The occasional absence of the cervico-thoracic uncinates, taken in connection with the vestigial condition of the ribs in one case and with the fact that in the same skeleton the first thoracic rib of the right side terminates ventrad in a blunt free end and has no sternal portion, seems to point to an inclusion of anterior thoracic vertebræ in the cervical region by atrophy of their ribs."

b. *The Synsacral Vertebræ.* (Pl. XLIV. fig. 5.)

In *Casuarius* there are 8 (eight) pre- and 8 (eight) post-sacral vertebræ, with the two true sacrals numbering eighteen synsacrals.

Of these, two are thoracic. The 1st lumbar has large parapophysial processes; the 2nd to 3rd of this series are much smaller; the 4th and 5th become larger and abut, the 4th against the pectineal process and the 5th against the ischium. Behind these follow two lumbo-sacral. The true sacrals are closely crowded and have slender parapophysial processes, which abut against the ilium and ischium *immediately* behind the acetabulum. Behind these in *C. bicarunculatus* lie two pseudo-sacrals with large parapophysial processes abutting against the ilium. But for the sacral plexus they might readily be mistaken for true sacrals. They are really the first two caudals, behind which follow six fused caudals with diminishing and backwardly directed transverse processes. In other Cassowaries there is but one pseudo-sacral. The sacral vertebræ do not bear diapophyses.

In *Dromæus* the number of synsacral vertebræ is the same as in *Casuarius*. The 6th lumbar, however, does not send out a parapophysis to abut against the pectineal process.

The neural spines of the synsacral vertebræ are all highly pneumatic, and made up of loose cancellated tissue. They remain separate for some time after hatching, but in the adult are fused into one mass, all traces of separate vertebræ being lost. In the young bird the pre-sacral vertebræ are just distinguishable between the closely approximated pre-acetabular regions of the ilium. The post-sacral have the neural spines laterally expanded so as to keep the post-acetabular ilium moderately widely separated, so that between each vertebra is a deep loculus (Pl. XLIV. fig. 5). In the adult the whole becomes roofed over by a thin bony plate extending across from the post-acetabular ilium of one side to that of the other.

Seen dorsally in the half or even three-quarter grown birds the neural spines from above the acetabulum backwards for some considerable distance are found to take the form of vertical transverse plates, forming a series of loculi between the post-ilia. Though further back in the series the transverse plates become columnar, the loculi remain. In the adult these loculi are completely covered in by a thin sheet of bone, formed by the fusion of a series of thin plates capping the neural spines.

In the embryo *Dromæus* (Pl. XLIV. fig. 6) it is worth noting that the lofty transversely expanded neural spines of the sacral and anterior post-sacral vertebræ of the adult are represented only by low cartilaginous ridges, and bounded on either side by the free edge of the dorsal border of the ilium. In the dried skeleton the cartilaginous portion shrinks up, revealing (1) a pair of ossified neuroids, which fail to meet one another in the middle line, and (2) a low osseous ridge marking the foundation of the similar cartilaginous ridges already described. The increase in height of the neural spines is followed by a corresponding increase in depth of the ilium (p. 227).

The centra of these synsacral vertebræ in this early stage are, in the dried skeleton, represented only by a flat bony plate, so that a single vertebra, with its neural arches, is stirrup-shaped. The thinness of the centrum makes the neural space of a relatively much greater size than in the adult. The nerve-apertures are single and not paired as in the adult. This is well shown in Pl. XLIV. figs. 5–6.

In *Struthio* there are ten pre-sacral and eight post-sacral vertebræ.

The series commences with the last two thoracic vertebræ. Then follow seven lumbar vertebræ. The parapophysial elements of these are all short and thick. The diapophyses of the lumbar vertebræ from the 4th backwards extend upwards on to the inner side of the ilium as forwardly directed spikes. Short and triangular on the 4th, they gradually increase in length up to the 8th, where they form long rod-shaped bars of bone. On the 10th, this process is short and rod-shaped.

The lumbo-sacral vertebræ are possibly represented by a single vertebra which bears vestigial parapophyses. In one skeleton in the Museum collection the lumbo-sacrals were certainly unrepresented. The last lumbar bore distinct parapophysial elements, which on the left side extended backwards to join the first sacral rib.

The sacral vertebræ are two in number and have large diapophyses. They lie more caudad than those of *Casuarius*, resting against the hinder border of the downward *ischiadic* or post-acetabular process of the ilium, and therefore conspicuously caudad of the acetabulum. In *Casuarius* the sacral ribs lie immediately behind the acetabulum. The outer free ends of the sacral ribs give rise to a large swollen process from the dorsal surface, which extends upwards and backwards to reach the diapophysis of the 2nd sacral, sometimes extending forward to that of the 1st. In one specimen in the Museum collection the lumbo-sacral has developed a parapophysial process on the left side.

The 1st caudal bears both para- and diapophyses. Sometimes the former fuse with those of the sacral. Behind this lie seven caudals without parapophyses, before the first free caudal is encountered. The neural spines of these are not transversely expanded as in *Casuarius*.

In *Rhea* there are ten pre- and five post-sacral vertebræ.

The pre-sacral comprise two thoracic, four lumbar, and four lumbo-sacral; the last of these may develop parapophysial processes.

The sacral ribs fuse with the ilium more dorsad than in *Struthio*, *Casuarius*, or *Dromæus*. In the last three they abut more or less extensively against the post-acetabular ascending process of the ischium. In *Rhea* they rise dorsad, so as to reach the level of the centre of the acetabular arc.

The 1st sacral is intermediate in position, with regard to the acetabulum, between *Casuarius* and *Struthio*. In the latter, it will be remembered, it lies considerably behind the acetabulum, in *Casuarius* level with its hinder border.

The *sacral ribs* are very short and almost indistinguishably fused with their diapophyses. In the possession of diapophyses these vertebræ differ from those of *Casuarius* and *Dromæus*, and resemble *Struthio*, in which, however, they are much more extensively developed.

The first post-sacral, or 1st caudal, bears both para- and diapophysial processes, but they are almost indistinguishably fused. The 2nd caudal bears diapophyses only. The 3rd to 5th caudals are somewhat remarkable in that they are represented only by atrophied vertebræ. The centra of these are reduced to thin delicate rods, supporting slender diapophyses and feeble neural spines. The 6th vertebra resembles the 5th, but has a stronger neural spine. It is the first vertebra to escape from the clasp of the post-acetabular ilium. The 7th has a much stronger neural spine and slightly thicker centrum, but like the 6th has lost its diapophyses. The 8th and 9th have inflated cancellous centra and short neural spines; they fuse by their ventral aspects with the ischia. The 10th is the first free caudal, of which there are eight in all: these have short thick centra and short neural spines.

In *Apteryx* there are nine pre- and five or six post-sacrals, with the true sacrals sixteen in all.

The pre-sacrals represent two thoracic, four lumbar, and three lumbo-sacral. The first post-sacral (1st caudal) bears short para- and diapophysial processes. The post-sacral are chiefly remarkable for the great lateral compression which they have undergone.

The synsacrum of the *Dinornithidæ* differs in many respects from that of all the other *Palæognathæ*. It resembles in many ways that of *Dromæus* and *Casuarius* on the one hand, and that of *Struthio* on the other. The pre-sacrals are apparently eleven in number, viz., two thoracic, six lumbar, and three lumbo-sacral. There is an indication of a fourth lumbo-sacral bearing parapophysial processes, which have almost completely fused with those of the 1st sacral. There are five post-sacrals.

The pre-sacrals resemble those of *Dromæus* and *Casuarius* in that they descend below the level of the ventral border of the pre-ilium, but not greatly so. In *Struthio* this feature is much more marked, the whole centrum and base of the neural spine being exposed in side view. The parapophysial processes of the first caudal are directed backwards instead of forwards. From this cause the true sacral vertebræ are completely isolated.

In *Struthio*, *Casuarius*, *Dromæus*, and *Apteryx*, it will be remembered, the para pophysial process of the first or even first and second caudals may combine with those of the true sacrals to form a sacral mass, the true nature of which is difficult to make out in the adult. The post-sacrals (caudals) resemble those of *Struthio* rather than any other *Ratitæ* in the great development of the diapophysial process, which extends upwards, outwards, and backwards to separate the post-acetabular ilium.

In *Dinornis*, however, this separation of the post-acetabular ilia is carried to a greater length than in any other Ratite. The neural spines of the *Dinornithidæ* are peculiar in that they combine dorsally to form a broad lozenge-shaped superficial plate of bone which serves as a cover to the huge fossa that otherwise exists between the upwardly directed transverse processes and the post-ilia.

The synsacrum of the *Crypturi* differs from that of all the other forms herein described. Moreover, in the points wherein it differs from these it resembles the *Neognathæ*.

One of the most noticeable differences is the fact that the post-sacrals have lost their neural spines. In all the flightless *Palæognathæ* these are of great length. The diapophyses of the post-sacral region rise from the top of the centrum, at the base of a long, faint, median ridge marking the position of the neural spines in other forms. These diapophyses develop thin plates of bone which fuse one with another to form a lozenge-shaped plate, protecting the inter-diapophysial fossæ, as is done by the similar plate from the neural spines in *Dinornis*.

The synsacrum of the Tinamous includes one thoracic, four lumbar, five lumbo-sacral, and five post-sacral. There are no parapophysial processes abutting against the pectineal process as in the flightless *Palæognathæ*. This process, it should be mentioned, has shifted further backward relatively to the sacral vertebræ, so that a line drawn across from the base of the anterior concave border of the one would pass immediately in front of the first sacral.

The sacral ribs are very long, and articulate with the ilium immediately behind the acetabulum by a long vertical roughened surface. The rib of the second sacral is vestigial or wanting.

The free caudal vertebræ in the *Palæognathæ* do not exceed ten in number. Sometimes the 9th and 10th are more or less fused.

In *Struthio* the 10th is laterally compressed to form a kind of pygostyle.

In *Rhea* there are but seven free caudals. This is due to the great backward extension of the ischia. Counting from the free end of the post-acetabular ilium backwards, as in other forms, there are eleven post-iliac caudals.

Ribs.

The anterior cervical ribs (pleurosteites) have already been described.

It is probable that the free cervical ribs (cervico-dorsal, Mivart) and the vertebræ to which they articulate really belong to the thoracic series. This is indicated by the fact that these ribs have lost their connection with the sternum, and have lost their sternal ribs through the backward shifting of the sternal plate.

In *Casuarius* and *Dromæus* there may be three or four free cervicals. In *Struthio* and *Rhea*, two. In *Apteryx* one, which bears a large uncinate (in *A. oweni* there is a shorter and more style-like rib anterior to this and wanting the uncinate).

In the *Crypturi* there are two free cervicals.

The thoracic ribs in *Casuarius* and *Dromæus* agree with *Struthio*, and differ from *Rhea*, in the fewness and slight development of the uncinates.

In *Casuarius* the 1st five pairs of thoracic ribs articulate with the sternum by means of sternal ribs. The 6th and 7th are long, but have no sternal segments. The 7th pair are more or less overlapped by the pre-ilium. The 8th pair are very short and underlie the pre-ilium. The 9th pair are represented by a scale-like vestige representing little more than the tuberculum and capitulum, which in the young bird can still be made out (*e. g.* 1374 *a* Mus. Coll.) closely applied to the pre-ilium.

In *C. bennetti* there are but three free cervical ribs and only four pair of thoracic ribs articulating with the sternum by means of sternal segments. The 5th pair have very long sternal segments, but they fail to reach the sternum. We may gather from this, however, that they have not long lost their connection therewith.

The uncinates of the ribs of *Casuarius* are never large. Generally only two or three appear to be present, and these may anchylose with their respective ribs. In a half-grown *C salvadorii* I find five uncinates. These have been probably lost in maceration in most of the skeletons which I have examined.

In *Dromæus* there are two free cervicals; the second is very long, and almost articulates with the anterior lateral process of the sternum. Following these come four pairs of thoracic ribs connected with the sternum by sternal ribs. These are succeeded by a pair (7th) with very long sternal segments, but which fail to reach the sternum. The next two pairs have no sternal segments, and are overlapped by the pre-ilium.

In *Struthio* there are two free cervicals and five pairs of thoracic ribs articulating with the sternum by means of sternal ribs. The pair next behind these has long sternal segments which do not reach the sternum. In a mounted specimen in the collection of *S. camelus* this 6th sternal segment actually articulates with the sternum.

The following pair (7th thoracic) are long, but without sternal segments; the 8th pair are short and fuse with the pre-ilium.

In *Rhea* there are two free cervicals, three pairs of thoracic articulating with the sternum by sternal ribs, and provided with very long uncinates. The 4th and 5th pairs are long, but have no sternal segments. The 6th pair are very short and fuse with the pre-ilium.

Amongst *Dinornithidæ* there appears to be some variation.

In *Dinornis maximus* there are three free cervicals, two thoracic connected with the sternum by sternal segments, one long free rib, and three free ribs behind this overlapped by the pre-ilium.

In *Pachyornis* there seems to have been but one free cervical or cervico-thoracic, three thoracic articulating with the sternum, four long free ribs, and short free ribs, these last two being overlapped by the ilium. The uncinates were very long.

In *Apteryx* the ribs are remarkable for the great breadth and flatness of their vertebral segments. There may be one or two pairs of cervico-thoracic; there are four thoracic articulating with the sternum (in a skeleton of *A. australis* I found five on one side, and in a skeleton of *A. oweni*, both in the Rothschild Coll., I found but three thoracic vertebræ connected with the sternum) and four pairs of free ribs behind these, all of which are overlapped by the pre-ilium. The last pair are often exceedingly short. Six pairs of ribs bear uncinates, the series commencing in the last cervico-thoracic. The uncinates are long and broad, extending backwards to the hinder border of the rib next behind.

In the ribs of all the *Palæognathæ*, save *Apteryx* and some Tinamous, there is a large pneumatic aperture lying in the cleft between the tuberculum and capitulum.

THE STERNUM AND PECTORAL ARCH.

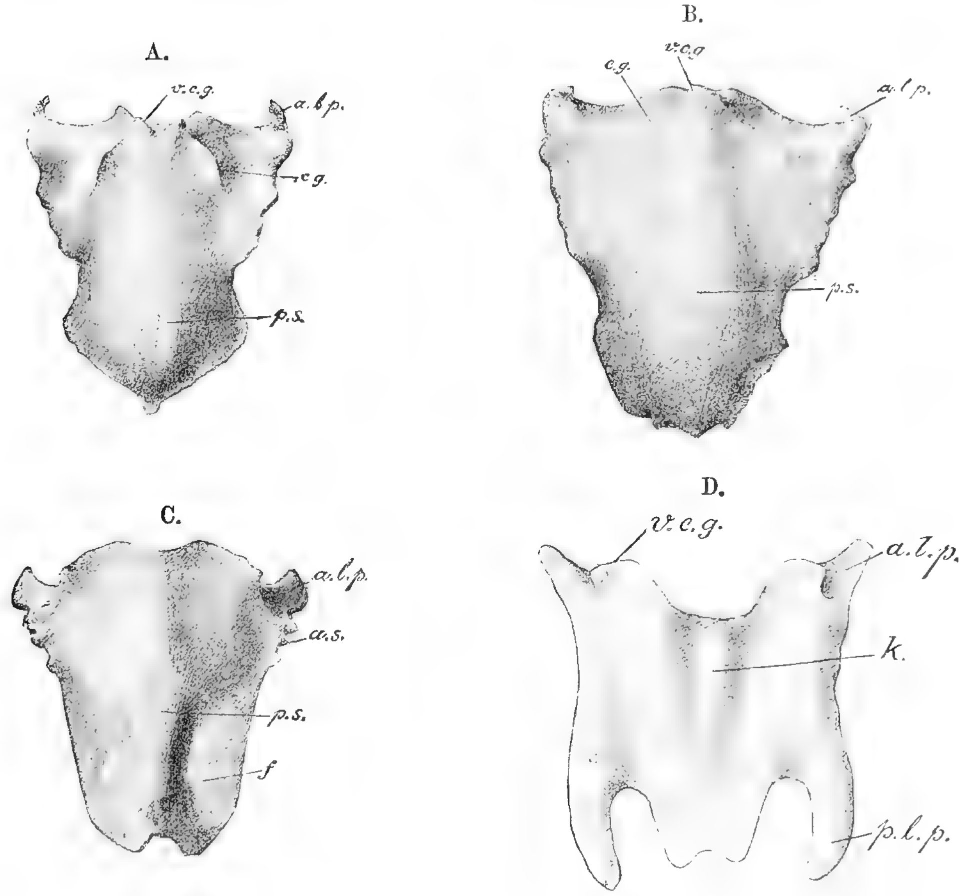
a. *The Sternum.*

As with the other portions of the skeleton so far examined, so with the sternum, *Dromæus* possesses the most generalized type.

The sternum of the young *Dromæus* and that of the young *Casuarius* are very similar in appearance; in the adult they are readily distinguishable.

In the adult *Dromæus* the anterior lateral processes are very long, slender, and directed upwards and backwards. There is no *spina externa* nor *interna*, but a deep emargination in their place. The ventral lips of the coracoid grooves are well developed. The articular surfaces for the coracoids are short, not exceeding in length the distance between the articulation for the first and third sternal ribs. These grooves differ from those of all the other *Palæognathæ* in that they overlap, causing the bases of the coracoids to cross one another in the middle line as in many *Carinatæ*.

Fig. 4.



A.—Ventral aspect of the sternum of *Dromæus novæ-hollandiæ*, to show the form and position of the coraciod grooves and anterior lateral processes.

B.—Ventral aspect of the sternum of *Dromæus ater*. Note the degenerate condition of the coracoid grooves and the well-marked *protuberantia sterni*.

C.—Ventral aspect of the sternum of *Rhea macrorhyncha* for comparison with that of *Dromæus*. Note the difference in the position of the coracoid grooves, of the articulation for the sternal ribs, the large protuberantia sterni, and the thin places indicated by shading denoting the position of former fenestræ or fissures.

D.—Ventral aspect of the sternum of an embryo *Apteryx* after Parker, to show the possible vestigial keel.

a.s. = articulation for sternal rib.
c.g. = coracoid groove.
a.l.p. = anterior external process.
p.s. = protuberantia sterni.
p.l.p. = posterior lateral process.
k. = keel.
v.c.g. = ventral lip of coracoid groove.

The sternum of *Dromæus ater* is remarkable, possessing as it does characters in common with both *Casuarius* and *Rhea*, but is at the same time Dromæine.

As in *D. novæ-hollandiæ*, the anterior lateral processes are conspicuously large and have the same form. The outline of the free edge of the *corpus sterni* from the articulation of the last thoracic rib backwards is the same. The coracoid grooves are obsolete. That of the right side is represented by a portion of the inner angle of the lower lip of the groove. This, as is seen in the figure (4 B), persists in the form of a median asymmetrical tubercle. The obsolescence of these grooves indicates that the pectoral arch and wing were much more degenerate than in *Dromæus novæ-hollandiæ* or *D. irroratus*. The corpus sterni differs from that of *D. novæ-hollandiæ* in the relatively much greater development of the protuberantia sterni, which resembles that of *Rhea*, and in the relatively narrower width across the region of the incipient posterior lateral processes. Four ribs articulate with the sternum, in *D. novæ-hollandiæ* only three.

The following measurements in millimetres are of interest:—

	D. novæ-hollandiæ.	*D. ater.*
Greatest length	160	95
Greatest width (across ant. lat. proc.) . .	140	90
Least width (across post. lat. proc.) . . .	105	55

It should be noted that the metasternum of *D. ater* bears traces of fracture, indicating a somewhat greater length than the above measurements. The breadth of the sternum nearly equals its length. In *Casuarius* it is much longer than broad. The articular surfaces for the sternal ribs are divided one from another by pneumatic apertures forming pockets of great depth, extending from without inwards towards the middle line. The hinder border, both in *Dromæus* and *Casuarius*, is shield-shaped. No external lateral processes are present. The sternal plate is of great thickness and highly pneumatic.

In the young *Dromæus* the anterior lateral processes are very short, and the ventral margins of the coracoid grooves are almost confluent and not separated by a deep median notch.

In *Casuarius* the sternum is relatively much longer than in *Dromæus*, the increase in length being most noticeable from the articulation for the last thoracic rib backwards. The coracoid grooves are much longer, and the anterior lateral process is almost obsolete. In the middle line between the ventral lips of the coracoid groove in *Casuarius* there opens forward a large pneumatic aperture; this runs backwards into the body of the bone for some considerable distance, penetrating a low median ridge or protuberance resembling a vestigial keel. This is wanting in *C. unappendiculatus*, a shallow groove taking its place, the sides of which further back become conspicuously raised to form a pair of long low ridges.

The sternal plate of *Casuarius* is of great thickness and highly pneumatic.

Such specific differences as I have been able to find will appear in the "Key."

The sternum of *Rhea* resembles that of *Dromæus* and *Casuarius* in several respects, but is yet very readily distinguishable from either.

The coracoid groove, though shallow, is sharply defined. The outer and inner lips, though but feebly developed, are subequal in length. The groove of the left side is separated from its fellow of the right by a smooth-lipped and gently hollowed plate of bone representing the anterior border of the sternum, equal in length to the groove itself. The anterior lateral processes are large.

The articular surfaces for the ribs are closely crowded, and follow immediately behind the anterior lateral process. Thus the distance from behind the articular surface for the last rib to the hinder border is more than twice the distance of the space separating the coracoid grooves; or, in other words, the articular surfaces of the ribs occupy only one-sixth of the whole lateral sternal border, in *Casuarius* it occupies about one-third.

The body of the sternum is notched posteriorly and tapers from before backwards. It presents a deep basin-like hollow dorsad and is produced ventrad into a long, swollen, ridge-like prominence. The corpus sterni is much thinner than in *Dromæus* or *Casuarius.*

The articular surfaces for the sternal ribs are each more or less distinctly divided into two, the outer being the larger. The pocket-like interarticular spaces (incisuræ intercostales) are of great depth.

Large pneumatic apertures open below the base of the anterior lateral process. For further remarks on the sternum of *Rhea*, see p. 224.

In *Struthio* the sternum is roughly about as broad as long. It resembles that of *Dromæus* in some respects and *Rhea* in others. The form and position of its coracoid grooves resemble that of *Dromæus.* The ventral lip, however, is wider than the dorsal. Both dorsal and ventral lips converge mesiad. The right and left grooves are separated by a slight hollowing out of the anterior sternal border. The anterior lateral processes are moderately well developed and project outward and forward.

The articular surfaces for the sternal ribs are of great width and occupy nearly the whole lateral border of the sternum, thus differing from both *Dromæus* and *Rhea.* The pocket-like pneumatic incisuræ intercostales are relatively less deep than in the foregoing forms. The median portion of the bar serving for the articulation of the ribs has lost its glenoid surface, which is preserved only at either end. In this point *Struthio* and *Rhea* agree.

There are large posterior lateral and in some sterna incipient median lateral processes.

The ventral prominence of the sternum lies behind the centre of the sternal plate, and is broader and more flattened than in *Rhea*; in which, by the way, it lies in the middle of the sternal plate.

Apteryx, in the form and position of its coracoid grooves, resembles *Rhea* more closely than any other group. Like *Rhea* they are widely separated by a deeply concave median portion of the anterior border of the sternal plate. The groove lies at the base of the anterior lateral process. It is very short, and has a conspicuously projecting lower lip.

The sternal plate differs from that of all the foregoing in being non-pneumatic. Its breadth exceeds its length. Posterior lateral processes are well marked, and divided one from another and a median process by a pair of notches. The articular surfaces for the ribs, as in *Struthio*, extend along the greater part of the lateral sternal wall.

Occasionally, *e.g.*, in an *A. australis* described by Owen, the sternum was fensterated. Beddard describes a pair in *A. australis mantelli.* In another of this species were a pair " of pin-hole size."

Parker directs attention to a distinct keel on the sterna of *A. australis mantelli.* As Beddard remarks, though not easy to *see*, this is readily felt. He found traces in *A. haastii*, and I think to these we might add *A. oweni*. A similar keel, and much more easily seen, often occurs on the sterna of *Struthio.*

The researches of T. J. Parker and Beddard, which I am able to confirm, show that no really reliable specific characters can be obtained from the sternum of *Apteryx.*

Roughly, as Parker and Beddard point out, " in *A. australis* the length of the corpus sterni appears to be constantly more than half its breadth."

In *A. australis mantelli* " the length of the corpus sterni is—often considerably—less than half its breadth."

In *A. oweni* " the length of the body is less than half its breadth."

A. haastii, according to Beddard, belongs to the same category as the last two.

The emargination of the anterior border of the sternal plate and the length of the metasternal and posterior lateral processes vary so much that they cannot be relied upon as specific characters.

The anterior emargination of the sternum seems to offer at least one more or less constant character. Thus, both Parker and Beddard agree that this is usually a semicircular incision, but that *A. australis mantelli* may be distinguished " from *A. australis* by the greater depth of the emargination in the former subspecies." Mr. Beddard finds at least one exception to this, in *A. australis mantelli.* Parker points out that " in *A. oweni* . . . . the emargination of the anterior border is slightly sinuous, each side presenting a sigmoid curvature." There would appear to be no exceptions to this rule.

The sternum of *Dinornithidæ* more closely resembles that of *Apteryx* than of any other form herein described. From this it differs in the following points:—That portion of the anterior border of the sternal plate which separates the coracoid grooves in *Apteryx* is in the present group perfectly straight instead of hollow. Furthermore, this region of the sternal plate is much thickened to form a prominent lip, looking upwards. The coracoid grooves are exceedingly shallow and only just visible. As in *Apteryx*, these grooves lie far apart, at the antero-lateral angle of the sternal plate. The anterior lateral processes are short; the articular surfaces for the sternal ribs lie crowded together immediately behind the anterior lateral process, as in *Rhea*. The posterior lateral processes are of great length; the metasternum is often of great length. The form of this and of the posterior lateral processes varies much in the different groups into which the Dinornithes are divided. The length of the metasternum in *Apteryx* does not extend beyond the posterior lateral processes.

In *Æpyornis* the sternum resembles that of *Apteryx* more nearly than any other *Palæognathæ*. As in *Apteryx*, the anterior border of the sternal plate is deeply notched, the coracoid grooves are widely separated and very similar in form. The rib-facets are wide and well spaced along the lateral border as in *Apteryx*, not crowded together as in *Rhea* or *Dinornis*. There are short but well-marked posterior lateral processes, but there is no metasternal element. As Andrews has pointed out in a recent and admirable paper on the skeleton of this bird, the sternum of *Æpyornis* represents an embryonic stage.

As Mr. Andrews has pointed out [4], the "sternum of *Æpyornis* consists of the two primitive costo-sternal elements only, and in this respect corresponds to an embryonic stage in the development of the sternum in the recent Ratitæ." More especially does this seem to apply, he goes on to point out, to the embryonic sternum of *Apteryx*.

The sternum of the *Crypturi* differs from that of the flightless *Palæognathæ* chiefly in the possession of a large keel. In general form the corpus sterni recalls that of *Anomalopteryx*. This is chiefly due to the large posterior lateral processes, which in *Crypturi* arise very far forwards. The articular surfaces for the sternal ribs are closely crowded and lie on either side of the coracoid grooves. The interarticular spaces—incisuræ intercostales—form deep pocket-like apertures, as in *Dinornis* and *Rhea*, for instance. The crowding together and forward position of the articular surfaces for the sternal ribs is another Rheine character.

The anterior lateral processes are very similar in form and position to those of *Rhea*, which they still further resemble in that the ventral aspect of the base lodges a pneumatic aperture.

The coracoid grooves in the *Crypturi* are separated by a deep gorge carved out of the *corpus sterni*. These grooves differ from those of *Rhea* in that the upper and lower lips are better developed, and in that their transverse extension is less while their depth is greater relatively.

There is a large spina interna.

Turning once again to the *corpus sterni* and comparing that of *Rhea macrorhyncha*, kindly lent me by Mr. Beddard, with that of a Tinamou, we notice a point of some significance. To wit, that in *Rhea* on either side of the great median *protuberantia* *sterni*, near the middle of its extent (fig. 4 C), is an area of bone conspicuous on account of its thinness. Now it seems more than probable that these thin areas are the last traces of a once deep fissure which has gradually closed up, thus uniting to the body of the sternum a pair of posterior lateral processes. Parker has noticed a similar indication of the closure of these fissures in *Apteryx*.

Fusion probably first took place, in the case of *Rhea*, between the free ends of the processes and the mesosternum by syndesmosis of the membrane, by which the fissure is invariably closed. A slight expansion of the free ends of the processes and metasternum, such as is indicated in *Tinamidæ*, would materially hasten this process of closing. It is also to be noted that the membrane closing this fissure is generally thicker posteriorly than anteriorly; this also would contribute towards the work of obliteration. If, once again, we imagine these fissures open, the resemblance between the sternum of *Rhea* and *Crypturi* will be found to be significantly striking.

It has been already suggested by Gadow that the protuberantia sterni may represent a degenerate keel. This seems quite probable. Seen in profile its keel-like resemblance is quite as close as that claimed for *Apteryx* by Parker (fig. 4 D). The sternal callosity so conspicuous in the living bird is represented amongst the *Neognathæ* in *Opisthocomus* and is a quite secondary character.

b. *The Pectoral Arch.*

The shoulder-girdle of the flightless *Palæognathæ* has undergone considerable modification and bears evidence throughout of retrogression. The coracoid and scapula are no longer free, except in the very young bird, but completely anchylosed, forming, the one with the other, a very obtuse angle, instead of an acute angle as in modern birds.

In *Dromæus* the sternal (epi-coracoid) border of the coracoid, though wide, is less than the length of the whole coracoid. Only the inner half of this border is received within the coracoid grooves; its outer portion is free and underlies the anterior-lateral process. The pro-coracoid is ligamentous. The supra-coracoid foramen is large and receives several pneumatic apertures.

The *scapula* is slender, and looks like an outward, upward, and backward outgrowth of the coracoid. It bears a strongly marked articular facet for the vestigial furcula.

The pectoral arch of *Dromæus ater* does not appear to differ materially from that of *D. novæ-hollandiæ*. I gather this from a sketch by Dr. Henri P. Gervais, kindly made for me at the request of Prof. Oustalet, to whom I am much indebted, as well as to Dr. Gervais.

The following measurements (in millim.) accompanied the sketch of Dr. Gervais:—

Length from pro-coracoid process to tip of scapula	0·127
Greatest length of coracoid	0·062
Width, epi-coracoid region	0·047

In the sketch the supra-coracoid foramen is not indicated, neither is there any indication of clavicles.

In *Casuarius* the coracoid is relatively much shorter than in *Dromæus.* Its breadth equals its length. The whole sternal border rests within the coracoid groove. Unlike *Dromæus*, the pro-coracoid is large and there is a small pro-coracoid fenestra. In the young *Casuarius* the pro-coracoid is ligamentous. The supra-coracoid foramen is large and receives numerous pneumatic apertures. The scapula resembles that of *Dromæus* in the general form and in the size of the acromion.

In *Rhea* the coracoid is long and comparatively slender, tapering rapidly from its sternal border forwards to the supra-coracoid foramen. The pro-coracoid is ligamentous, leaving a conspicuous notch on the mesial border of the macerated coracoid. There is generally a supra-coracoid foramen, but this never receives pneumatic apertures. The whole sternal border rests in the coracoid grooves. At the base of the coracoid and on its dorsal surface is a large pneumatic aperture. This does not seem to be represented in any other *Palæognathæ* except, and feebly, some *Crypturi.*

The scapula is peculiar, curving from the coracoid first inwards then backwards. The glenoid surface for the humerus lies at the distal end of the coracoid instead of at its antero-lateral angle.

In *Struthio* the size of the pre-coracoid is enormous, extending backwards as a long finger-like process ultimately to reach and fuse with the internal angle of the base of the coracoid, enclosing in this way a huge fenestra. The sternal (epi-coracoid) border of the coracoid is of great width. The supra-coracoid foramen is wanting. We might mention here that the pre-coracoid of *S. molybdophanes* appears to be peculiar in its greater relative slenderness.

In *Apteryx* the pre-coracoid seems to be wanting only in *A. oweni*, and in this species, it would seem, at all stages of its growth. In the remaining species it is represented in the adult by ligament only; so that in the macerated skeleton the pre-coracoid fenestra is represented only by the deep notch on the mesial border of the coracoid. In a skeleton of *A. australis mantelli* this notch has been nearly filled up by a secondary extension of bone in the coracoid of the left side. The supra-coracoid fenestra is minute or absent in all but *A. oweni,* in which it is large. This point, remembering the absence of the pro-coracoid in the latter and its presence in the remaining species, is interesting.

In the *Dinornithidæ* the coracoid has reached a state of extreme reduction, being rod-like and merging almost insensibly with the scapula.

In the *Æpyornithidæ*, in the form of the pro-coracoid, it is intermediate between *Rhea* and *Dromæus.*

The coracoid of the *Crypturi* differs from that of its congeners—the flightless *Palæognathæ*—chiefly in that it has a well-developed acro-coracoid. There is a well-marked external lateral process at its base. The pre-coracoid is wanting. The scapula is free, as in the young of the flightless members of this group.

The furcula is slender and **U**-shaped.

THE DEVELOPMENT OF THE STERNUM AND PECTORAL ARCH.

a. *Sternum.*

Miss Lindsay's [48] researches have shown that during development the sternum undergoes a process of shortening both anteriorly and posteriorly, at least in so far as its costal elements are concerned; the posterior shortening is, however, more than compensated by the addition of a long metasternum. That the shortening takes place both anteriorly and posteriorly is proved by the existence of ribs, which in the embryo are connected with the sternum, but which in the adult become divided therefrom and atrophied. The cause of the shortening is "consequent on that posterior translation of the shoulder-girdle which is at once expressed by the lengthening of the neck and the shortening of the trunk in the avian as compared with the reptilian type." This sternal abbreviation is common to both *Palæo-* and *Neognathæ.*

In *Struthio* "the 7 days' embryo shows an anterior part which may probably be compared to the *manubrium sterni* of mammals." A study of a series of embryos shows that the *anterior lateral processes* are an outgrowth of the costal sternum; in the *Neognathæ* these processes are to be regarded as vestiges of a former extension of the costal sternum anteriorly.

The posterior lateral processes in the very early chick, according to Miss Lindsay, "consist of the ends of the primitive costal bands, preserved and prolonged for the attachment of the lateral part of the rectus, and subsequently modified . . . to afford attachment to the obliquus externus."

These processes, as existing in the adult, may be considered a part of the metasternum, since the primitive part bears but a small proportion to the later additions.

The *metasternum,* both in *Struthio* and *Rhea,* remains for the most cartilaginous throughout life. The cartilaginous metasternum of *Dromæus* and *Casuarius* is relatively somewhat smaller.

Posterior lateral processes are wanting in the sterna of *Rhea, Casuarius,* and *Dromæus.*

In *Apteryx,* according to Parker [71], "it appears certain that . . . each half of the sternum is not formed by the antero-posterior union of the whole of the sternal ribs." In one stage of the series which he examined the sternum apparently increased in length from before backwards to the level of the fourth sternal rib, which extended mesiad to meet it.

The metasternum did not appear until after the posterior lateral processes had attained nearly their full length. In one specimen the metasternum was double, and in another it was perforated by an oval foramen, which Parker suggests indicates a paired origin.

No traces of a keel were observed, though such are undoubtedly present in some adults (fig. 4 D).

Ossification of the sternum, according to Gadow, begins during the last week of embryonic life.

In *Struthio* and *Apteryx* a pair of pleurostea only are represented ; in *Rhea*, *Casuarius*, and *Dromæus* there are a pair of additional centres representing *pro-ostea*.

Although there is no positive trace of a keel in the developing "Ratite" sternum, it is generally assumed that such a structure was present in more remote ancestors, and that its loss is the result of degeneration accompanied by decaying, and terminating in absolute loss of the power of flight. It is possible, however, that the earliest birds did not possess a carinate sternum. The Ratite sterna of the *Palæognathæ* may well represent this ancient type. The keel was never largely developed in the sterna of the Pterodactyle, and is not always present among the Chiroptera.

b. *Pectoral Arch.*

In *Struthio* and *Apteryx* only is there a well-developed pre-coracoid.

Apteryx, however, presents, as Parker [72] points out, "the remarkable circumstance that in one species of *Apteryx* (*A. oweni*) the coracoid is solid, presenting no coracoid fenestra and therefore no procorácoid, while in another species (*A. australis*) the procoracoid is present at a comparatively early age, and is frequently retained in the form of a ligament in the adult. In other words, the differences between the shoulder-girdle in two species of *Apteryx* are of precisely the same nature as those distinguishing the *Struthiones* from the other Ratitæ."

In *Dromæus* and *Casuarius* and in *Rhea* the pre-coracoid is vestigial. It may even be, as Lindsay has suggested, a new growth of the coracoid rather than the homlogue of the pre-coracoid of *Struthio*.

Clavicles occur only in the adult *Dromæus* and embryo *Casuarius*.

PELVIC ARCH.

The pelvic arch of the *Palæognathæ* differs from that of the *Neognathæ* chiefly in two points :—(1) The great height of the neural spines of the synsacrum (Pl. XLIV. fig. 5); and (2) the persistent ilio-ischiadic fissure. But though there can be no difficulty whatever in distinguishing the Struthious from the Neognathine pelvis, yet these cannot apparently be defined in mutually exclusive terms. There is no comprehensive definition that will cut off the one from the other. To keep to the pelvic arch of the Struthious birds : it is difficult to find a definition for this which shall not be subject to any exceptions ; for although the persistent ischiadic fissure is undoubtedly a Struthious, because a primitive, character, yet the Rhea and the Cassowary contradict this.

The long and narrow synsacrum, with its high neural spines, finds its counterpart in the synsacrum of the *Pygopodes*; and this is a point fraught with some significance to this last group, inasmuch as we have already evidence to show that the *Pygopodes* are a primitive type, and it would seem that this last character is to be regarded as a piece of additional evidence to this end.

The synsacrum, however, of the *Pygopodes* differs from that of any Struthious bird in (1) its much greater lateral compression; (2) the absence of any pleurosteal elements caudad of the last thoracic vertebra; and the exposure of the whole of the fused neural crest lying between the pre-acetabular ilium. In *Podicipididæ* the post-acetabular ilia meet dorsad of the neural crest, whilst in *Colymbidæ* they do not rise beyond the level of the base of this crest.

In the *Pygopodes*, again, the ischiadic fissure of the post-acetabular ilium is reduced to a comparatively small foramen, and the post- greatly exceed the pre-acetabular ilia in length.

In the elongated synsacrum, the vertical ilia, and the comparatively high neural spines of the synsacrum the *Podicipides* resemble the flightless *Palæognathæ.*

It may be, the long, narrow synsacrum is primitive, and that this form of synsacrum, which is characteristic only of the *Pygopodes* (including *Hesperornis*) amongst the *Neognathæ*, was derived from a primitive ancestor which had not yet adopted the more usual Neognathine form of pelvis. The fact that the much more recent and highly specialized Auks, which have adopted the same mode of life as the ancient Divers, have a distinctly Neognathine type of pelvis with widely separated post-acetabular ilia supports the view that the synsacrum of the *Pygopodes* and *Palæognathæ* is primitive in type.

In the flightless members of the *Palæognathæ* the pre-ilium is always vertical in position, and always meets its fellow in the middle line above the synsacrum. Pleurosteal elements representing the sacral vertebræ are always present.

The *Æpyornithidæ* and *Dinornithidæ*, whilst they agree with the remaining *Palæognathæ* in the great height of the synsacral neural spine, differ, as we shall see, in one or two important features from the other *Palæognathæ*, though these structures are readily traceable back to the more primitive form.

In *Dromæus* the pre- and post-acetabular ilia are subequal in length, or the post-acetabular is markedly the longest. The pre-acetabular ilium has a strongly arched dorsal border, a sigmoidally curved ventral border, which caudad sends down a long acetabular process to join the pubis and serves at the same time as the anterior boundary of the acetabulum. The depth from the dorsal to the ventral border is considerable, this portion of the innominate bone forming a vertical blade very slightly hollowed in its middle. The post-ilium is narrow cephalad and tapers rapidly from before backwards, this region of the pelvis in this respect resembling *Struthio*. In half-grown specimens it is quite pre-caudad; in adult birds it becomes fused with the extreme postero-dorsal angle of the ischium.

The ilium increases markedly in breadth during its growth. This increased breadth accompanies a corresponding increase in the height of the neural spines of the sacral and post-synsacral vertebræ, which, as has already been described (p. 208), in the embryo are represented only by low cartilaginous transverse ridges. In the embryo the pre- and post-acetabular ilia are slightly convex superficially, in the adult they become slightly concave.

The supra-trochanteric process marks the region, more or less, of the sacral vertebræ. It lies immediately above the anti-trochanter, but does not project outwards as in *Rhea*. One of the most remarkable features of the pelvis of *Dromæus* and *Casuarius* is the close embrace with which the post-ilia receive the post-sacral vertebræ of the synsacrum, almost entirely suppressing the para- and diapophysial processes.

In *Dromæus* and *Casuarius* the sacral vertebræ extend outwards beneath the vertical border of the ilium to articulate with the ascending process of the ischium at its junction with the ilium.

The pelvis of *D. ater* differs from that of *D. novæ-hollandiæ* chiefly in that the development of the pectineal process is but slight—wherein it approaches *Casuarius*,—and in that the obturator fissure is wider, the rotation backwards of the pelvis being less. The crest of the pre-ilium is less arched.

The pelvis of *Dromæus* can scarcely be distinguished from that of *Casuarius*.

In the young bird (half-grown) the neural spines of the sacral region of the synsacrum appear to be more transversely expanded than in *Casuarius*. In the adult the pre-ilium appears to be relatively of greater breadth in *Casuarius* and the post-ilium is relatively longer and narrower. The strong <-shaped supra-trochanteric processes and the width across from one side to the other are apparently rarely attained by the Cassowary.

Judging from the skeletons in the Museum collections it would seem that in the width across the supra-trochanteric process and the relatively long post-ilium, the pelvis of *Dromæus* is readily distinguishable from that of *Casuarius*.

Unfortunately, however, these data do not appear to be really reliable, for in a pelvis of *C. casuarius* the resemblance to these very characteristic points in *Dromæus* were so close as to render it most difficult to distinguish between the two genera.

In *C. bennetti* the width across the supra-trochanteric process is as conspicuous as in *Dromæus*, but the whole pelvis is of course much smaller than in *Dromæus*.

In the young (half-grown), both of *Casuarius* and *Dromæus*, the ischiadic fissure is complete. Later in life it is closed by fusion of the extreme antero-dorsal angle of the fore end of the ischium fusing with the ilium. In very old birds the width of this fissure caudad becomes seriously encroached upon by the downgrowth from the post-ilium of an exceedingly thin plate of bone with a jagged free edge. It arises in the region of the 5th post-sacral vertebra, and is continued backwards from this point. From the superior border of the ischium there arises a similar plate of bone of corresponding length. In very old birds these two jagged-edged plates nearly meet, foreshadowing the formation of the ilio-ischiadic foramen of the *Neognathæ.*

The interobturator process, both in *Casuarius* and *Dromæus,* is well marked.

The *ischia,* both in *Dromæus* and *Casuarius,* are more or less rod-shaped and very distinctly bent inwards towards the middle; this is a point of great significance when considered in connection with the ischium of *Rhea.* The ischium is roughly -shaped. Its vertical process articulates with (in the young) and eventually fuses with the pre-ilium, forming the lower half of the anti-trochanter. Antero-ventrally it articulates with and eventually fuses with the pubis, the fusion with the pubis taking place much earlier than is the case with the vertical process and the ilium.

The pubes are very slender relatively, with a strong outward curve in *Dromæus* and *Casuarius casuarius,* straight or only slightly curved in the remaining species of *Casuarius.* In the nestling they do not extend backwards as far as the level of the free end of the post-ilium. In the adult they extend beyond this, reaching nearly to the end of the ischia. They are always free posteriorly in the dried skeleton, connected by cartilage in the living bird with the ischia.

The pectineal process seems to be formed for the most part by the descending process of the ilium. It reaches its greatest development apparently in *Dromæus,* but in a pelvis of *Casuarius casuarius* it is only slightly less in size. In the remaining species of *Casuarius* it is but feebly developed.

The outline of the pre-ilium differs, but the series of adult skeletons in the Museum collection is not sufficiently large to enable any reliable data to be drawn from comparisons.

Specific differences in the form of the pelvis of *Casuarius* may possibly be found, but I think it extremely doubtful. The collection of adult skeletons which forms the subject of this paper is not nearly large enough to afford the material necessary for such a task.

The pelves of the *C. bennetti* group seem distinguishable from the *C. casuarius* group by reason of the relatively longer and narrower post-acetabular ilium. We have no adult skeletons of the *C. unappendiculatus* group.

In *Rhea* the form of the pelvis is unique, but, as will be shown, is probably a direct modification of the Dromæine type.

In the nestling the pre- and post-acetabular ilia are subequal in length. The latter is abruptly truncated caudad, and rests by its postero-ventral angle upon the closely approximated ischia, to be described presently. The supra-trochanteric process is but feebly developed, and the anti-trochanter is but slightly below the level of the neural crest of the synsacrum. The post-acetabular ilium is long and narrow and closely resembles, at this stage, the permament condition which this bone obtains in *Struthio.*

The extreme antero-ventral angle of the pre-ilium is sharply defined and produced outwards, overlapping the penultimate thoracic rib, with which it ultimately becomes completely fused. The innominates meet in the middle line above the synsacrum, cephalad and caudad, but leave the neural spines of the synsacrum exposed at the bottom of a groove over the sacral region.

The ischia, which, it will be remembered, in *Casuarius* approached one another in the mid-ventral line, in *Rhea* actually meet at a point corresponding with a line passing downwards from behind the anti-trochanter. From this point backwards they remain in close juxtaposition, later in life more or less completely fusing. These approximated ischia form a long backwardly projecting median bar, produced caudad far beyond the level of the post-acetabular ilium. Thus a kind of false roof is formed to the abdominal cavity and a floor to the renal fossa.

The pubes, as in *Dromæus* and to a lesser extent in *Casuarius*, are bowed outwardly and terminate freely near the end of the ischia.

The pectineal process is formed in part by the descending acetabular process of the ilium and partly by the pubis.

The adult pelvis differs in many respects from that of the nestling, carrying the points wherein it is peculiar a stage further in development.

The supra-trochanteric process now forms a large overhanging ledge, directly above the acetabulum. The innominate bones now meet in the mid-dorsal line throughout the whole of their length. The post-acetabular ilium fuses on either side by a broad expanded foot with the ischia, and beyond this fusion—a point of contact only in the nestling—is continued backwards a long pointed process. The pubes, turning suddenly caudad and mesiad, fuse eventually with the ischia.

The sacral vertebræ in *Casuarius* lay level with the ventral border of the innominate, and extended outwards to articulate with the vertical acetabular process of the ischium. In *Rhea* these vertebræ are raised up so as to lie above the level of the acetabulum.

The post-acetabular ilium, in the nestling Grebe, is subequal in length with the pre-acetabula, in the adult it is longer than this.

In *Struthio* the pelvis presents one or two points wherein it differs markedly from that of the other *Palæognathæ.*

Like *Dromæus*, the post-acetabular is longer than the pre-acetabular ilium, only the difference is much greater in *Struthio.* The post-acetabular region remains permanently and widely separate from the ischium, and is so narrow in proportion to its length as to be almost rod-shaped. The pre-acetabular ilium is relatively as long as in *Dromæus.* The *fovea iliaca anterior* is rather convex than concave. In this particular *Struthio* is peculiar: since the pre-acetabular ilium instead of being concave externally, so as to, on this account, more or less completely embrace the neural spines of the synsacrum, is convex, and forms, with its fellow of the opposite side, a long tunnel divided into right and left halves by the neural spines of the synsacrum, which acts as a median partition.

The dorsal plane, which in *Dromæus*, *Casuarius*, and *Rhea* was restricted to a small area between the supra-trochanteric processes, here, in *Struthio*, extends backwards to the extreme end of the post-acetabular ilium, though it is very narrow. Furthermore, this plane slopes gently downwards on either side, so that its extremest outer angles approach the anti-trochanter.

The pre-acetabular ilium meets in the mid-dorsal line above the synsacral spines: the post-acetabular ilia remain widely separated one from another throughout the greater part of their length; in old individuals they meet and fuse with the last two post-sacral vertebræ of the synsacrum. Down the median space, between the two post-ilia, runs a long bony bar, formed by the fusion of anterior and posterior ossifications of the neural spines. In *Dinornithidæ*, it will be remembered, it was pointed out [1] the equivalent ossifications extended laterally, so as to reach the ilia on either side, and thus close what would otherwise form a deep lateral trench lying on either side of the synsacrum. This trench in *Struthio* remains permanently open.

The *ischium* is very slender and rod-shaped. At its posterior extremity it sends downwards a broad plate of bone which fuses with the pubis. In the young bird, it should be mentioned, the ischium is free posteriorly. The post-acetabular ilium and the ischium remain widely separated throughout life.

The *pubis* is long, slender, and rod-shaped. In the adult it extends caudad far beyond the post-ilium and ischium, and curving sharply downwards and forwards, meets its fellow of the opposite side in the middle line, and becomes permanently fused therewith in a long, forwardly directed symphysis. This fusion of the pubes posteriorly occurs in no other living bird.

As is well known now, the pubis of *Struthio* is further remarkable for a small bony plate, attached to the middle of its ventral border by cartilage. In macerated skeletons this is generally lost; in this case its position is indicated by a roughened surface.

This bone appears to have been originally described by Meckel [56], who held it to represent the marsupial bone of the Marsupials. More than forty years later this bone was rediscovered and described by Garrod and Frank Darwin [28]. They also regarded it as probably homologous with the marsupial bone of the Kangaroo and its allies. With this view Beddard [7] seems also to agree.

The pectineal process is long, slender, and curved, its free end being directed upwards.

The ilio-ischiadic fissure remains permanently open in *Struthio*. In *Casuarius* and *Dromæus* and in *Rhea* it closes later in life. The obturator fissure is closed, by fusion of the free end of the pubis with the ischium, both in *Rhea* and *Struthio*, and only in these.

The pelvic girdle of *Apteryx* resembles that of *Dromæus* and *Casuarius* in some respects. This is what we should expect, since *Dromæus* probably represents the ground form from which the other *Palæognathæ* have been derived.

In the extraordinary relative length of the pre-acetabular ilium *Apteryx* stands alone. It extends forward so as to overlap some four thoracic ribs. The post-acetabular ilium is as short relatively as the pre-acetabular is long; it never exceeds half the length of the pre-ilium. As in *Struthio*, the post-ilium and ischium are widely separated, but the separation is more marked since the backward rotation of the ischium is somewhat less than in *Struthio*.

The innominates meet in the mid-dorsal line as in *Rhea*, but with this difference: whereas in *Rhea* although the median borders meet, yet a dorsal plane is present as a widening out and flattening of that portion of the dorsal aspect of the pelvis which lies between the supra-trochanteric processes, in *Apteryx* these dorso-median edges meet along their whole length, save in the region of the sacrum proper, where a narrow chink reveals the presence of some three neural spines. There is no supra-trochanteric process, but the ilia meet in the middle line to form a long knife-like ridge. The *fovea iliaca anterior* extends backwards into the post-acetabular ilium, terminating caudad of the anti-trochanter. Behind the acetabulum the vertebral column is bent sharply downwards, and has undergone great lateral compression, so that the centra of the vertebræ have become vertically compressed plates but little thicker than their neural spines. Furthermore, owing to the downward flexure of the posterior synsacral vertebræ the post-acetabular ilia have come to embrace the neural spines of the vertebræ instead of the centra. The synsacrum extends, moreover, by a single vertebra beyond the level of the free (caudad) end of the post-acetabular ilium.

The *ischium* is a relatively long flattened blade, forming a wider angle with the ilium than in any other of the *Ratitæ*.

The pubis is slender, with a more or less well-marked ventral curve. Caudad, its free end may touch the postero-ventral angle of the ischium, but it never fuses therewith.

The obturator foramen and fissure are confluent.

The pectineal process is large and pointed, and formed in part by the descending process of the ilium and in part by the pubis.

Specific differences in the pelves of *Apteryx* are, as Beddard has already shown, very slight. According to him the pectineal process is shorter in *A. oweni* than in *A. australis*. In our specimens if there is any real difference the reverse would appear to be the case. I have managed to find sufficient differences to construct a key for the species, though with difficulty. Mr. Beddard has already shown that the width across the pre-ilium varies, but I think that this, in spite of variation, combined with other characters may be relied on.

Apteryx australis seems to stand alone in the great width of the pre-acetabular ilium, a width due to a highly arched dorsal border and a very considerable lateral expansion of its antero-ventral border. A rather sinuous post-acetabular ventral border and a sudden widening of the post-acetabular ilium caudad are combinations apparently peculiar to this species. In *A. haastii* the pre-ilia are sharply truncated forwards, and the pre-ilium is generally broader in proportion than in *A. oweni.* The post-acetabular ventral border appears to be concave.

A. australis mantelli appears, superficially, not to be very readily distinguishable from *A. oweni.* The chief differences appear to lie in the smaller pectineal process and broader ischia of *A. australis mantelli.*

The pelves of *Dinornithidæ* and of the *Æpyornithidæ* very closely resemble one another, and differ from all other flightless members of the *Palæognathæ* in that the post-acetabular region of the pelvis is flattened out into a large, pentagonal plate, nearly as broad as long. This is made up partly by the great length of the transverse processes of the synsacral vertebræ, and partly by the great widening of the dorsal plane of the ilia—a widening only feebly represented among the *Palæognathæ* elsewhere in *Struthio.*

In the relations of the ischium and pubis the two pelves now under discussion most nearly resemble *Apteryx.* *Apteryx*, however, differs in one respect, in that in this genus the obturator fissure and foramen are confluent. In the *Dinornithine* pelvis the foramen is shut off from the fissure. The pectineal process is large in *Apteryx*, very small and wanting in the *Dinornithine* pelvis.

In the *Dinornithidæ* the sacral are more or less easily distinguishable from the post-sacral. In the *Æpyornithidæ* this is not the case.

In the *Dinornithidæ* the post-sacral neural spines lie in the middle of a deep fossa, the floor of which is formed by the upwardly directed neural spines. In the adult this fossa is closed more or less completely by a bony roof formed by tabular lateral expansions from the crest of the neural spines. Caudad, however, this closure is not quite complete: a pair of lateral slits run up on either side of the median neural plate, from behind forwards; the extent of these slits decreasing with age, but never entirely disappearing.

In *Æpyornis* the roofing of the fossa is ample: a double row of foramina only excepted, which run from behind forwards to the *crista transversa.*

The pelvis, both in *Dinornithidæ* and *Æpyornithidæ*, is relatively much shorter in proportion to its width than in the other *Palæognathæ.*

The Pectoral Limb.

The pectoral limb is in all the flightless *Palæognathæ* a very degenerate structure. Perhaps that of *Rhea* should be regarded as the least degenerate.

In the *Rhea* the length of the extended ante-brachium and manus is only very slightly greater than that of the brachium. The length of the manus is greater than the ante-brachium. The length of the pollex with its claw is very nearly as great as the II. metacarpal. In a nestling *Rhea* I find on the III. digit a vestige of a claw; a similar vestige has been already detected by Wray in the Ostrich. The *ulnare* possesses the typical Neognathine form—in *Struthio* this is a mere nodule. The 1st phalanx of the second digit is broad and flat, the 2nd phalanx is pointed.

The ante-brachium is about one-third shorter than the brachium. The post-axial border of the ulna from the olecranon outwards for some considerable distance is greatly compressed. The superficial appearance of the forearm resembles that of many long-winged *Neognathæ*.

In the humerus the pectoral crest is obsolete, as also is the crista inferior. is no subtrochanteric fossa, and the fossa for the brachialis internus is only faintly indicated.

In *Struthio* the length of the extended ante-brachium and manus is about one-third less than the length of the humerus, and falls far short of that of *Rhea*, being but a little more than two-thirds as long as the brachium.

In *Struthio* the manus is longer than the forearm, in *Rhea* the reverse is the case. In *Rhea* the forearm is about two-thirds and in *Struthio* about one-third the length of the humerus. The distal carpal mass only just reaches the base of the 1st metacarpal; in *Rhea* it extends pre-axiad so as to support the whole base of the pollex. The 1st phalanx of the II. digit is relatively longer in *Struthio* than in *Rhea*. The II. metacarpal in *Struthio* is more or less rod-shaped, that of the III. is rod-shaped and bowed. In *Rhea* the distal end of metacarpal II. is flabellate, the III. metacarpal is very slender, rod-shaped, and sigmoidally curved.

The ulna, in *Struthio*, is much expanded distally by a more or less triangular outgrowth of its pre-axial border. The olecranon is but feebly developed. The distal end of the radius is grooved and much expanded in the direction of its articular surface for the radiale.

The pectoral crest of the humerus is more conspicuous than in *Rhea*, forming a long, low, swollen ridge. There is a wide and shallow fossa distad of the *caput humeri*, possibly representing the *sulcus transversus*. There is also a shallow incisura capitis. The *crista inferior* is wanting. The subtrochanteric fossa is present but shallow, but it receives no pneumatic apertures. The tuberculum medius is moderately well developed.

The *linea aspera* for the triceps is raised into a long and sharp ridge, which reaches its greatest development rather below the middle of the humerus. There is a feebly developed ectepicondylar process.

The *radiale* is well-developed; the ulnare is reduced to a small nodule.

In *Dromæus*, *Casuarius*, and *Apteryx* the wing has undergone extreme reduction.

In *Dromæus* the length of the whole wing is scarcely longer than the skull. The length of the extended forearm and hand is about equal to the length of the humerus. The manus is considerably shorter than the forearm. There is no distinguishable carpal region, and the radius is anchylosed with the fused carpo-metacarpal mass. The metacarpals and phalanges have all fused into one indistinguishable rod of bone. The pectoral crest is but faintly represented.

There is a small subtrochanteric fossa, into which opens several pneumatic foramina.

In the skeleton of *D. ater* which I have had for examination the wing is wanting. Judging from the measurements given in Milne-Edwards's memoir, however, it seems to have been smaller relatively than in *D. novæ-hollandiæ*. From the vestigial character of the coracoid grooves one would have expected a much greater difference.

In *Casuarius* the wing, strangely enough, though relatively smaller than in *Dromæus*, is yet less degenerate. The proportions of the brachium, ante-brachium, and manus are much the same as in *Dromæus*.

In the adult, the three metacarpals can be plainly made out. That of the pollex is vestigial. Only one phalanx appears to be represented—that of the II. metacarpal, and this is but a vestige. The radiale has anchylosed with the radius, but is still distinguishable. There appears to be no ulnare. The humerus has the pectoral crest more strongly developed than in any other *Palæognathæ*. The subtrochanteric fossa, smaller in *Dromæus*, is very large in *Casuarius*.

In a nestling *Casuarius*, a radiale, ulnare, and distal tarsal mass are plainly distinguishable.

In *Apteryx* the degeneration of the wing has reached a stage somewhat intermediate between that of *Dromæus* and *Casuarius*. In the relatively great length of the humerus, however, it differs from both and resembles *Rhea*. The extended ante-brachium and manus are only a little more than half the length of the humerus.

The radius is shorter than the ulna.

The carpus and manus, as both Parker and Beddard have already pointed out, are extremely variable. In *A. haastii* Parker found an ulnare, radiale, and a fairly distinct metacarpale III. In *A. australis* there are no distinct carpals, but traces are distinguishable of three metacarpals. The index has two or three phalanges, the last terminating in a claw. In *A. oweni* the radiale appears to be always distinguishable.

The manus appears to vary most, according to Beddard, in the matter of degeneracy, in *A. australis mantelli*.

In an embryo of *Apteryx australis*, T. J. Parker found, not only a separate radiale, ulnare, and distal carpal mass, but also an intermedium, an element which has so far been recorded previously in *Opisthocomus* and *Dendrœcia.*

The fact that in the adult *Apteryx* there is a distinct alar membrane, or patagium, as has been pointed out by Parker, is strong evidence in favour of the view that the wing of *Apteryx* is a degenerate structure, once capable of performing the duties of an organ of flight.

In *Æpyornis,* apparently the wing was represented only by the humerus. A humerus, believed to be that of an *Æpyornis,* has been described by Andrews. Its length was 63 mm. The upper end resembled that of the humerus of *Aptornis,* the lower that of *Casuarius,* "but still further reduced, the radial and ulnar trochleæ uniting completely to form a single articular surface."

The Pelvic Limb.

The differences between the pelvic limbs of the existing *Palæognathæ* are neither many nor great.

In *Dromæus* the *femur* differs from all the other *Palæognathæ,* save *Struthio,* in that it is highly pneumatic, and bears on the *ventral aspect* of the femur a large pneumatic foramen. It lies between the great trochanter and the head of the femur. The popliteal fossa is of moderate depth.

The *tibio-tarsus* is not easily distinguishable from that of *Casuarius.* The chief difference appears to rest in the slighter and less vertically extended procnemial crest. This vertical direction is rather marked in *Casuarius.* The *fibula* extends to the lower fourth of the shaft of the tibio-tarsus.

The *tarso-metatarsus* is as long as the tibio-tarsus, grooved in front, and has a moderately developed median keel to the hypotarsus.

The proximal phalanx of digit II. is relatively long, the 2nd very short; in digit IV. the proximal phalanx is long, the 2nd and especially the 3rd and 4th are very short.

The pelvic limb of *D. ater* closely resembles that of *D. novæ-hollandiæ.* The anterior metatarsal groove is, however, somewhat deeper.

The outer toe, in each foot, in this skeleton has lost one phalanx.

In *Casuarius* the femur is non-pneumatic. The position of the pneumatic fossa in *Dromæus* may be indicated by a minute aperture. The tibio-tarsus, as already pointed out, differs but slightly from that of *Dromæus.*

The *tarso-metatarsus* is much shorter than the tibio-tarsus, is very deeply grooved anteriorly, and is pierced by a foramen dorsad of the scar for the tibialis anticus. Thus it can readily be distinguished from the tarso-metatarsus of *Dromæus.*

The ungual phalanx of the inner toe is greatly elongated; in other respects the size of the phalanges closely agrees with those of *Dromæus,* but the proximal phalanx of digit II. is relatively shorter.

In *Struthio* the femur, as in *Dromæus*, is highly pneumatic, and, as in *Dromæus*, bears a large pneumatic fossa between the head of the femur and the great trochanter. The shaft is relatively much thicker than in *Dromæus* or Cassowary, and the fibular condyle is much larger than the inner tibial condyle. The groove dividing them is also narrower and deeper than in *Dromæus.*

The tibio-tarsus, apart from its greater size, is peculiar in the relatively smaller size and hooked form of the ectocnemial crest, and the great length of the fibula, which extends to within a short distance of the upper border of the proximal tarsal mass. The extensor groove is shallow. Furthermore, the lateral borders of the posterior trochlear surface are produced backwards and upwards into a pair of proximal ridges at right angles to the long axis of the shaft.

The tarso-metatarsus is of course at once distinguishable by the absence of ento-trochlea. It is grooved anteriorly, and bears a pair of foramina dorsad of the scar for the *tibialis anticus.*

The ungual phalanx of the outer toe is represented by a small nodule.

In *Rhea* the femur is non-pneumatic. It may be at once distinguished from that of any other *Palæognathæ* by the great depth of the popliteal fossa.

The tarso-metatarsus resembles that of *Struthio* in the feeble development and in the form of the ectocnemial crest and in the backward projection of the condyle of its distal extremity. The femur falls far short of the level of the tarsal mass. The tarso-metatarsus has a shallow groove anteriorly, a deep fossa above the scar for the tibialis anticus, and a very broad and low intercotylar process. The hypotarsal keel lies to the inner side of the median line. In *Dromæus* and *Casuarius* it is median in position.

The 1st phalanx of digit II. is conspicuously lengthened, the 2nd is very short; of the IV. digit the proximal phalanx is long, the 2–4 very short.

In *Apteryx* the femur is relatively large and more slender than in any other living *Palæognathæ*, save the Tinamous. It is non-pneumatic, and the popliteal fossa is deep.

The tibio-tarsus proximally is broad and flattened from back to front, neither the ecto- nor procnemial crests are much developed. The extensor groove is deep. The intercondylar gorge is deep, and the ento-condyle of great size.

The *tarso-metatarsus* is shorter than the femur, much flattened from back to front; the intercotylar tubercle is well marked; there is a fossa above the scar for the tibialis anticus; the 2nd and 4th trochleæ are widely separated from the meso-trochlea. The hypotarsus bears a pair of low median ridges.

There are four digits. The digits contain no conspicuously shortened or elongated phalanges, and therein differ from the other *Palæognathæ* herein described.

In *Dinornis* the femur is relatively much shorter and thicker than in *Struthio.* Its distal end is of great width; the intercondylar gorge is very wide and shallow and extends proximad on to the shaft, terminating rather behind its middle. There are no conspicuous pneumatic foramina. The great trochanter is very large; it is produced upwards above the head, and not backwards caudad of the head, being an exaggeration of what obtains in *Dromæus* and *Casuarius*. The popliteal fossa is well defined, but not deep.

The tibio-tarsus is much flattened from front to back, as in *Apteryx* and *Æpyornis*; the ectocnemial crest is large, and gives the anterior view of the proximal end of the bone a flabellate form; the procnemial crest is feebly developed. The shaft may or may not be inflected—according to the genus. There is a strong extensor bridge and an intercondylar tubercle.

In *Æpyornis* the femur is also very short. The great trochanter is very lofty and produced caudad. The intercondylar gorge is wide and deep, and the popliteal fossa shallow.

The tibio-tarsus has its proximal end much flattened from front to back; a feeble procnemial and large laterally directed ectocnemial crest. Distally the shaft is inflected. There is no extensor bridge, and the groove is shallow.

The tarso-metatarsus is short, wide, and grooved anteriorly, but the groove is shallow. The ectotrochlea is widely separated from the mesotrochlea. There is a low, median, hypotarsal ridge.

Phalanx 1 of digit II. is moderately long, the 2nd is short; phalanges 2, 3 of digit IV. are conspicuously short, the 4th is shorter. The proportions of the phalangeals agree closely with those of *Dromæus*.

In working out the development of *Apteryx*, Parker [71] found, in the earlier stages, all five digits present—as in some *Neognathæ*. The fifth digit was a short conical cartilage attached by its proximal end to the fibulare, and by its pre-axial border to the distale.

The fibula was of the same length as the tibia.

The tarsus contained the usual elements—a tibiale, fibulare, and distale. The ascending process of the tibiale at no stage showed any sign of a separate origin, comparable to an intermedium. Later, after hatching, there appears in the mesotarsal articular pad a pair of centralia. Sometimes only one is present.

The procnemial crest ossifies, as usual, from a separate centre. Concerning this ossification I would remark that it is doubtful whether it has any phylogenetic significance. Rather it would seem to be comparable to the separate ossification-centre of the great trochanter of the mammalian femur, and to indicate a position of great strain. In a recent paper I, however, described it as an epiphysis, as also, though unknown to me at the time, did the late W. K. Parker [79]. In my own case I may claim some justification, since the base of this procnemial ossification—that of a young Grebe—was sufficiently large to form a complete tibial cap, divided from the shaft by cartilage, as is a true epiphysis. Moreover, the resemblance to a true epiphysis is the more complete in that it affords an articular surface for the femur. I will not comment further upon the matter here as I have the subject still under investigation.

MYOLOGY.

The musculature of the *Archæopalatinæ* is now well known, thanks to the researches of Beddard, Fürbringer, Gadow, Garrod, Haughton, Meckel, Owen, Parker, and others. So well have these been done, that, gleaning late in the day, I have but little to add. It must not be supposed, however, from this, that the subject is now quite exhausted. On the contrary, many points yet await investigation ; mention of these finds no place here, however, either because material for this paper was lacking or the points appeared to be of little or no value so far as it was concerned.

THE SKIN-MUSCLES.

The dermal muscles appear to be most strongly developed in *Apteryx*.

Casuarius and *Dromæus* appear to be peculiar in that they possess a strongly developed dermo-dorsalis. In a *Casuarius unappendiculatus* this extended from the base of the skull down the skin of the neck and back along the middle line. At the base of the neck the muscle gives place to tendon, which, becoming rapidly stronger, is inserted, by means of numerous long, coarse, tendinous fibres, along the back as far as the pre-acetabular ilium.

THE MUSCLES OF THE WING AND SHOULDER-GIRDLE.

To the loss of flight we may attribute the absence of many muscles found in *Neognathæ*. Furthermore we must regard this loss as one of considerable antiquity, since the flightless members of the *Neognathæ* exhibit no such reduction in the number of the muscles concerned in this form of volition.

Mr. Beddard [7] has given an admirable summary of the missing wing-muscles of the *Palæognathæ*. They are the *pectoralis propatagialis*, *biceps propatagialis*, *deltoides propatagialis*, *deltoides minor* (excluding *Apteryx*), *scapulo-humeralis anterior*, and *expansor secundariorum*. Concerning the last mentioned, traces occur in the wing of *Rhea* (see fig. 5 A, p. 240).

The form of *flexor carpi ulnaris* of *Rhea* is extremely interesting, as will be seen by a comparison of the accompanying figures (pp. 240, 241).

It will be noticed that in *Rhea* (fig. 5 A) this muscle is divided into two parts: (1) a pre-axial ribbon-shaped and partly tendinous, which is inserted on to the ulnare, and (2) a post-axial, much larger, strap-shaped, fleshy portion inserted on to the 1st metacarpo-digital remex. The post-axial border of this hinder strap-shaped portion is bounded by a narrow thread of tendon—a rudimentary *vinculum elasticum*.

In the *Crypturi* we have a second modification (fig. 5 B, p. 240). The post-axial fleshy moiety has here apparently degenerated so as to be represented only by the vestigial muscular slips from the body of the pre-axial portion, which is thick and fleshy. The *vinculum elasticum* represented in *Rhea* by a *rudiment* only—by rudimentary I mean nascent, not vestigial—is here increased to form a great tendinous sheet. We may suppose that this is an improvement on the proto-carinate form seen in *Rhea.*

In *Opisthocomus* (fig. 5 C, p. 241) both pre- and post-axial moieties are fleshy. The post-axial shows the first indication of the complex *vinculum elasticum* of the *Neognathæ.*

In *Leptoptilus* the pre-axial portion is almost entirely tendinous. Proximally, the tendon divides, one branch running directly to the ulnare, and one fusing with the anterior border of a muscular post-axial portion throughout the greater part of its length, finally trending upwards to join the main pre-axial tendon on the ulnare. This last, muscular, post-axial portion apparently represents the broad strap-shaped portion of *Rhea* ; it differs therefrom only in that it is inserted into the first cubital instead of the first metacarpal remex.

There are numerous other modifications, varying in complexity, to be found amongst the *Neognathæ*, a study of which would probably yield important results.

The wing of *Rhea* represents, probably, as Dr. Gadow—to whom I showed these facts—remarks, a proto-carinate form.

In the manus of *Rhea,* Mr. Beddard writes, " we have more evidence of degeneration than in *Struthio.* There are, in the first place, only twenty-one muscles at most, and some of these are much simplified.

" The muscles that appear to be totally wanting are (1) the *extensor digitorum communis*, (2) the *pronator profundus.*

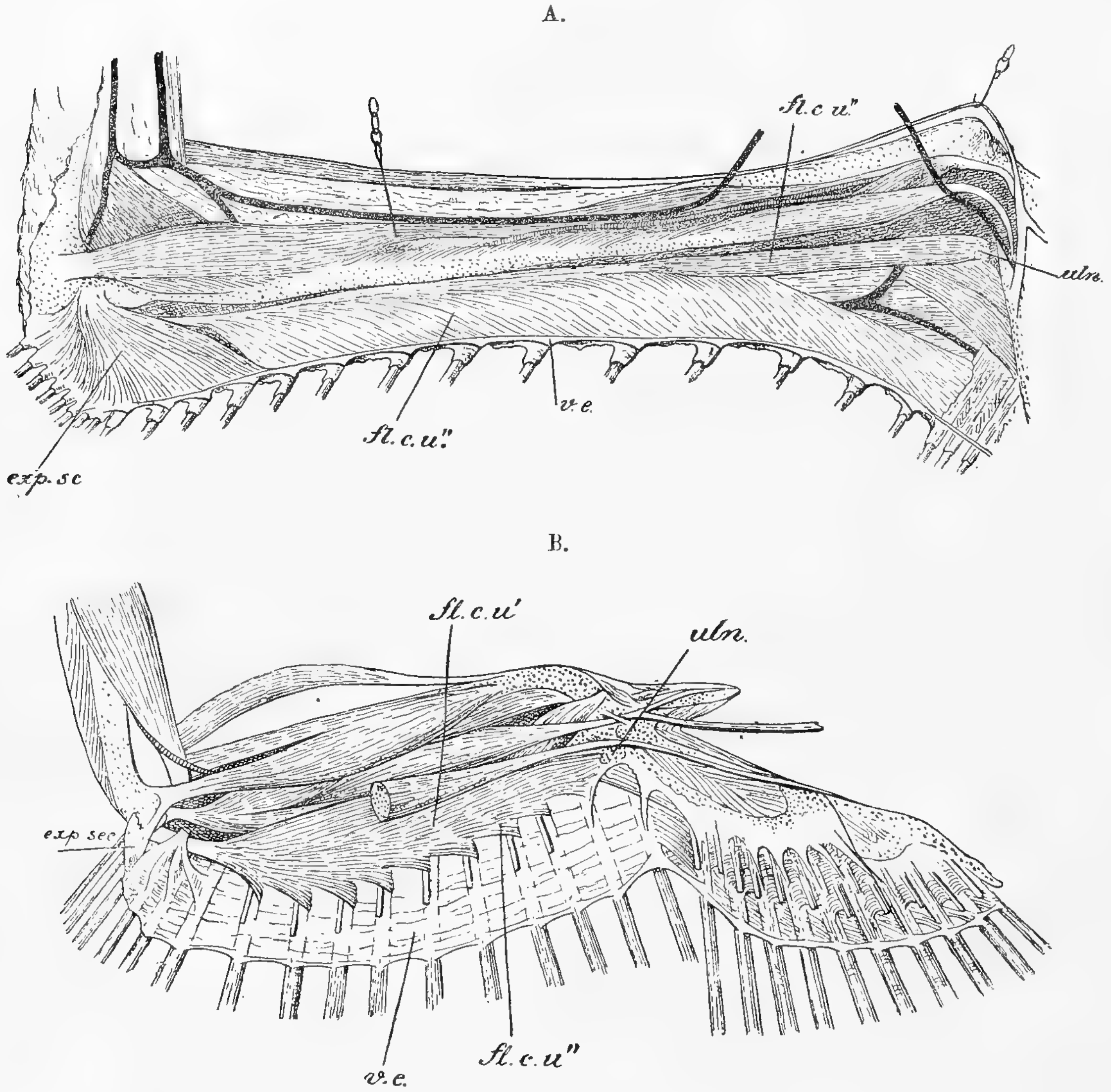
" The *extensor indicis* is only represented by the belly arising from the wrist. The *flexor sublimis* may possibly be represented by a slip of muscle arising from the tendinous edge of the *flexor metacarpi ulnaris* . . . .

" The origin of the biceps is peculiar; it arises not only from the coracoid spine by a rounded tendon, but also by a sheet of tendon edged with muscle from the whole of the coracoid and from just an adjacent bit of the sternum. It is inserted on to both radius and ulna.

" As in the Ostrich, the *radio-metacarpalis ventralis* arises from the ulna. In *Rhea* there is a special peculiarity in the presence of a muscular slip running from the tendon of the *extensor metacarpi ulnaris* near to its insertion to the *extensor indicis.* Finally the *ectepicondylo-ulnaris* is distinct."

Of *Struthio*, Mr. Beddard writes that, " in spite of the small size of the manus . . . . relatively to that of flying birds, there is but little, if any, evidence of degeneration in its musculature. On the contrary, indeed, for it might be said that the wing-muscles of *Struthio* are less degenerate, or at any rate less modified, than those of Carinates, in that amount of muscle compared with tendon is greater. The complication of the

Fig. 5.

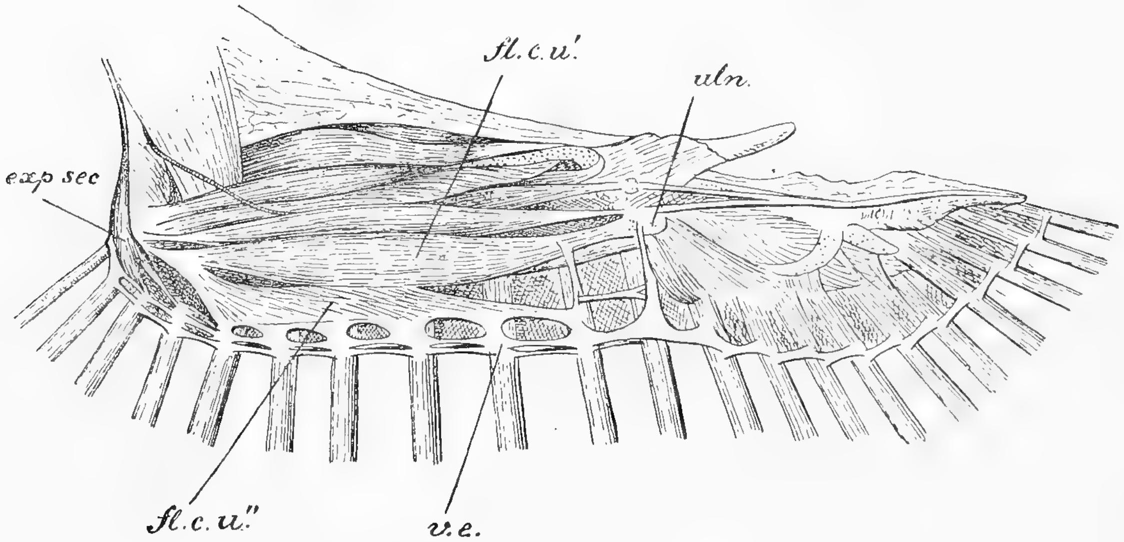


conjoined flexors digitorum is highly suggestive of a walking or climbing animal. It seems to be conceivable that the Ostrich branched off from the avian stem before the power of flight was perfectly established.

"The *biceps* of *Struthio* arises from the *spina coracoidea* and is inserted on to the radius and ulna and the membrane between them. The *extensor metacarpi radialis* is single. The *ectepicondylo-ulnaris* is absent or fused with the *extensor metacarpi ulnaris*. The *extensor digitorum communis* supplies only the index. The two *pronators* form only one muscle. The *flexor digitorum sublimis* and *profundus* arise by a single head from the flexor condyle of the humerus. The two muscles immediately divide; the upper part (=sublimis) ends in two tendons, of which one is inserted on to (the)

Fig. 5.

C.



A.—Inner view of a dissection of the wing of *Rhea americana*, to show the remains of the expansor secundariorum and the ? proto-carinate condition of the *flexor carpi ulnaris*. Note the large, fleshy inferior portion eventually inserted into the base of the 1st primary remex and the thin tendinous band which runs along its free border, probably representing the *vinculum elasticum*.

B.—Inner view of a dissection of the wing of *Calodromas elegans*. Note that the fleshy posterior portion of the *flexor carpi ulnaris* has become reduced to slender slips of muscle to the bases of the secondary remiges, whilst the *vinculum elasticum* has greatly increased in size to form a broad tendinous sheet.

C.—Inner view of a dissection of the wing of *Opisthocomus cristatus*, showing another phase in the development of the *vinculum elasticum* and the persistence of a strongly developed posterior belly to the *flexor carpi ulnaris*. Numerous intermediate stages occur amongst the *Neognathæ*.

exp.sec. = expansor secundariorum.
fl.c.u. = flexor carpi ulnaris: ′=anterior, ″=posterior portion.
uln. = ulnare.
v.e. = vinculum elasticum.

radiale, the other fuses with the upper tendon of profundus, and also gives off two slips which surround that tendon and, reuniting, fuse with the lower tendon of the profundus. The lower part of the muscle (=profundus) gives off two tendons, of which the upper ends on the first metacarpal, while the lower runs to the base of the last phalanx of the index.

"The *flexor metacarpi ulnaris* ends fleshily on the ulnare, but is prolonged beyond this bone, receiving also some fibres from it to the metacarpal.

"The *radio-metacarpalis ventralis* . . . . arises from the ulna and not from the radius.

"The total number of muscles in the hand of the Ostrich is twenty-three, allowing for the absent *ectepicondylo-ulnaris*. The additional muscle is a small *pronator quadratus*."

In *Apteryx* the usual flexors and extensors of the forearm are present, and, as the late Prof. T. J. Parker points out, a rather unusually large development of muscles acting as pronators and supinators for so small and vestigial an organ.

The biceps of *Apteryx* is single-headed, arising only from the coracoid; it is inserted only on to the radius. *Apteryx* differs only from the other genera in the possession of the Gallinaceous and Tinamine entepicondylo-ulnaris and an *accessory brachialis anticus.*

In *Casuarius* and *Dromæus* the wing seems to have reached its most vestigial condition.

The *biceps* in *Casuarius* arises only from the coracoid, and is inserted by a single tendon both upon the radius and ulna. In *Dromæus*, according to Beddard, the biceps has the same peculiar origin to that of *Rhea* (p. 241).

"All the Struthious birds," writes Beddard [7], "except *Apteryx*, have lost the *serratus metapatagialis*, the *latissimus dorsi metapatagialis*, and the *pectoralis abdominalis.*

"On the other hand, *Apteryx* has lost what the other Struthious birds have retained, the *latissimus dorsi anterior* and the *rhomboideus profundus*; the latter muscle, however, is not distinguishable in the Cassowary.

"It must be admitted, therefore, that *Apteryx*, so far as concerns the anterior extremity, has diverged from the hypothetical ancestral condition in slightly different lines from other *Struthiones*."

The *rhomboideus superficialis* in *Rhea* and *Struthio* arises as in *Neognathæ.* In *Rhea* it is inserted on to both the coracoid and scapula, in *Struthio* on to the scapula only.

In *Apteryx*, *Casuarius*, and *Dromæus* it arises from the ribs.

The *rhomboideus profundus* in *Casuarius* and *Dromæus* arises from the ribs. In *Casuarius* it is with difficulty distinguishable from the *serratus profundus*, and on this account Fürbringer [22] inclines to disallow its existence as a separate muscle.

The *serratus superficialis* of *Apteryx* retains the *pars metapagialis*, which is wanting in the other *Palæognathæ.*

The *coraco-brachialis internus* of *Casuarius* is entirely tendinous; in *Rhea* largely so. Furthermore, in this last genus it extends on to the sternum. In *Struthio* it is larger than in any other *Palæognathæ.*

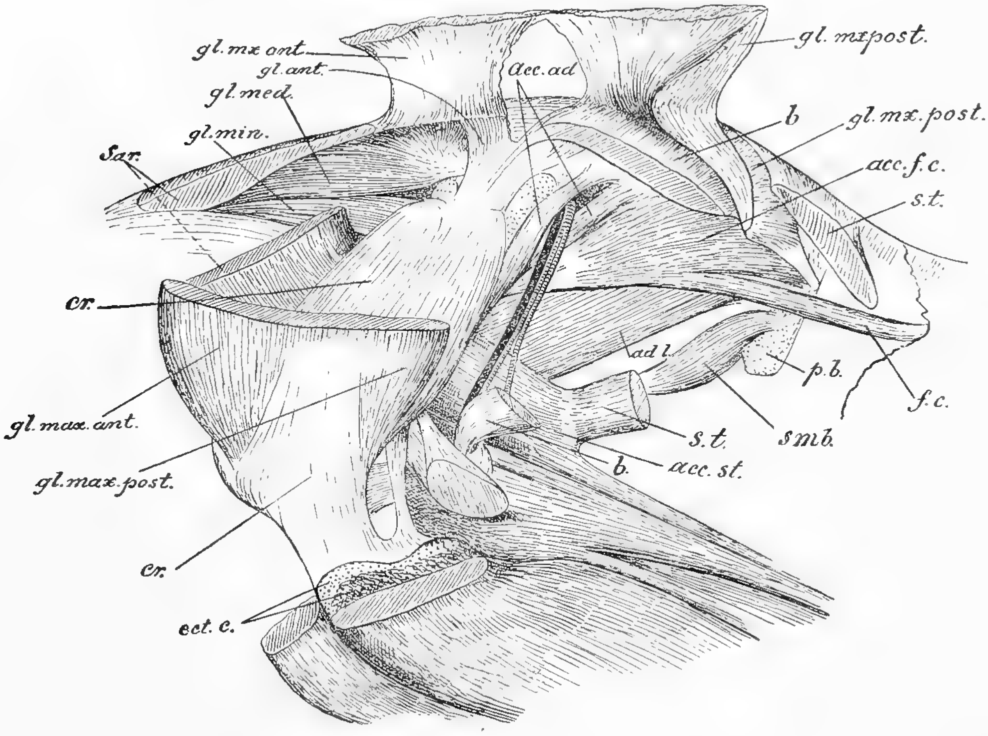
THIGH- AND LEG-MUSCLES.

Struthio and *Apteryx* only have the leg-muscles complete, which make up the formula AB . XY +.

In the *Struthiones* generally the accessory femoro-caudal (pars iliaca *m. caud-ilio-femoralis*) calls for special comment. In all save *Apteryx* it is characterized by its great size, in *Struthio* and *Casuarius* being rightly described as enormous. The femoro-caudal, on the other hand, is relatively but feebly developed or absent.

Rhea and *Dromœus* both agree in having lost the femoro-caudal.

Fig. 6.



Left side view of a dissection of the thigh-muscles of *Casuarius unappendiculatus*, to show the accessory Struthious adductor, the femoro-caudal, and accessory semitendinosus muscles. The accessory adductor, femoro- and accessory femoro-caudal = the caud-ischio-ilio-femoralis of Gadow.

Acc.ad. = accessory Struthious adductor.
b. = biceps.
f.c. = femoro-caudal.
acc.f.c. = accessory femoro-caudal.
s.t. = semitendinosus.
acc.st. = accessory semitendinosus.
ad.l. = adductor longus.
cr. = crureus.
gl.med. = gluteus medius.

gl.min. = gluteus minor.
gl.mx.ant. = ,, maximus anterior.
gl.mx.post. = ,, posterior.
gl.ant. = ,, anterior.
Sar. = sartorius.
smb. = semimembranosus.
ect.c. = ectocnemial crest.
ad.l. = adductor longus.
p.b. = pubis.

The femoro-caudal muscles of *Apteryx* are peculiar and are differently determined by Garrod and Beddard. Garrod's view is adopted in the present contribution, after independent dissections. Garrod [30] says :—" The accessory femoro-caudal is peculiar ;

for, on removing the biceps cruris, its superficial portion is seen running obliquely upwards and forwards to the whole length of the linea aspera of the femur, from its usual origin. The sciatic artery and nerve are superficial to this muscle (adductor longus of Owen) and parallel to its insertion, as in most birds; but they, as is not the case except in the *Struthiones* and *Crypturi*, perforate it at the ischiadic notch, leaving a small portion of the muscle (the adductor brevis of Owen) above them. The anterior terminal fibres of this muscle are situated external or superficial to the accessory semitendinosus.

"After this muscle has been removed or turned back, there is seen a deeper muscle, which, if the one described above did not exist, would be justly considered to be the femoro-caudal and the accessory femoro-caudal, part springing from the iliac ridge and part from the coccyx, whilst both are inserted into the posterior portion of the linea aspera and have the nerve to the semi-membranosus situated between them and the adductor magnus." This deeper muscle Garrod does not further distinguish. Probably it should be regarded as representing the obturator externus.

The femoro-caudal, it should be remarked, is very slender; it lies deep of the *semimembranosus*. In Garrod's paper he appears to associate it first with the superficial and then with the deeper muscle.

Mr. Beddard apparently regards the obturator externus of this paper, and the deep layer of muscle described by Garrod, as the muscle which would be justly considered the accessory femoro-caudal, in the absence of the superficial layer just described.

The muscular mass embracing the emergence of the sciatic nerve and artery should be regarded, I would suggest, as the Struthious adductor referred to by both Garrod and Beddard, but fused distad with the gluteus anterior, and caudad with the accessory femoro-caudal. A comparison of fig. 6, p. 243, will serve to show the probability of the correctness of this interpretation.

The *semitendinosus* and its accessory in *Casuarius*, *Dromæus*, and *Rhea* are very similar. In *Rhea* the former is inserted on to the tibia by means of a long tendon, in the Cassowary at least of the two former genera it loses itself in the gastrocnemius. In *Struthio* the accessory head is small. In *Apteryx*, according to Beddard, the accessory head shows a slight variation in its relations within the genus. "In *A. australis* the accessory head of the *semitendinosus* was distinctly separated from, though parallel to, the middle head of the gastrocnemius. In *A. haasti* no such separation is obvious."

The *semimembranosus* (ilio-flexorius, Gadow) of *Apteryx* is two-headed, the second head arising from the ischium; between these two heads lies the head of the femorocaudal.

In *Dromæus* the semimembranosus, according to Garrod, is peculiar in that it has an aponeurotic connection with the middle of the linea aspera.

In *Casuarius* it is but feebly developed; it passes rapidly into a thin flat tendon to be inserted into the shaft of the tibia, below the neck. As it passes the middle head of the gastrocnemius it gives off thereto, at right angles, a delicate tendinous band.

In *Rhea* it is small, sharply truncated forwards, terminating distad of the ventral border of the accessory semitendinosus. Its antero-dorsal angle fuses with the tendon of the semitendinosus, distad of its accessory head. Its postero-ventral angle sends downwards a long slender tendon to the gastrocnemius, to be inserted a short distance above the tarsal joint.

In *Struthio*, according to Garrod, the semimembranosus tendon fuses with that of the accessory semitendinosus and then passes down the leg as a long thin tendon to the tendon of the gastrocnemius. Thus closely resembling that of *Rhea.*

The *ambiens* is wanting only, among the *Struthiones*, in *Dromæus*. *Casuarius*, however, is generally regarded as wanting this muscle.

In *Struthio* its origin is peculiar, being from the ilium instead of the pectinal process of the pubis.

In *Apteryx* its origin is from the pectineal process of the pubis; as usual, it is inserted into the flexor perforatus digiti II. It does not, according to Beddard, give off slips to the other two muscles of the perforatus complex. "Furthermore, these small tendinous bands, accompanied by muscle-fibres, and forming a thin, flat sheet of tissue, are continuous with the ambiens tendon above, and appear to be in connection at the other end with the short arm of the biceps sling, and to arise from the fibula. I look upon this sheet of muscle and tendon as a second head of the flexor in question, and as corresponding to the fibular head of birds, such as *Nycticorax*. If this be so, Mitchell's contention that the ligamentous head in question is a rudimentary ambiens is not so certain as it seemed to be, for both occur in *Apteryx*. I found the same state of affairs in *A. haasti.*"

In *Rhea americana*, Gadow [25] found the ambiens to be typically developed. This I am able to confirm from my own dissections.

I would remark that in an adult of this species the ambiens tendon, at the level of the head of the fibula, sent upwards a tendinous slip to the fibrous tissue of the lower border of the tendinous insertion of the crureus and origin of the fl. perf. d. III. and perf. et perf. d. II., and a few fibres to the tendinous portion of the origin of the common belly of the fl. II.–IV. and perf. et perf. III.

In *R. macrorhyncha* he found that "the muscle arose from the latero-dorsal aspect of the pubic spine, and at the same time from the big crural vein, the muscular and aponeurotic fibres of the muscle having firmly got hold of the ventral aspect of this vein. . . . . The tendon of the muscle passed the knee in the typical way.

"In *R. darwini*, ♀, the m. ambiens of either side arose from the pubic spine as usual, but its tendon, before reaching the knee, became flattened out and attached itself with a broad fan-shaped and very thin aponeurosis to the patella, in a similar style as the median additional portion of the m. femoro-tibialis (m. vastus)." In a male *R. darwini* the ambiens of the left thigh stopped at the knee, as in the female, but in the right thigh the muscle was typically developed and passed the knee with a strong tendon.

In *Casuarius* the ambiens, according to Garrod, is wanting. Concerning this, Dr. Gadow, in describing the ambiens of *Rhea*, a portion of which we have just quoted, continues, " This abnormal condition of m. ambiens, which seems to be prevailing in Darwin's *Rhea,* is the intermediate stage between a typically developed m. ambiens and such forms in which, as in *Casuarius*, this muscle has lost still more of its independence, and then only forms an additional head of the median part of the portio media m. femori tibialis s. vasti. Without an elaborate examination and comparison of the formation of these muscles with their nerve-supply, we should, with Garrod, come to the conclusion that *Casuarius* did not possess an ambiens muscle. The assumption of still further reduction of the distal portion of the m. ambiens explains what I have observed in some Passerine birds, *e. g.*, in a specimen of *Lanius bentet*, in which the m. femori tibialis internus, besides being strongly developed, received in its proximal part a thin spindle-shaped semitendinous head from the pubic spine. This additional little slip is probably the last trace of the ambiens muscle, which is now generally lost by the Passerine birds.

" The case above described is one way in which this muscle gets lost; in other cases, e. g., *Ciconia* and *Phœnicopterus*, the reduction does not begin by its tendon becoming attached to the neighbouring tendons in the knee-region, but the whole muscle shows a diminution of its tendon and belly to a mere thread, till at last this also disappears, *e. g.*, in *Abdimia* and *Xenorhynchus*."

The muscle-formulæ of the *Palæognathæ* is as follows:—

Struthio *Apteryx* *Casuarius* *Crypturi*	A . B . X . Y +.
Rhea	B . X . Y +.
Dromæus	B . X . Y −.

The deep flexors of the foot of the *Struthiones* belong to the types II. and IV. of Gadow.

Apteryx alone represents type II. The vinculum is strong, and runs directly downward to join the *flexor profundus.* The *flexor hallucis* tendon is slender.

Struthio, *Rhea*, *Casaurius*, and *Dromæus* all belong to type IV. The separate tendons of the *flexor hallucis longus* and of the *fl. perforans s. profundus* can be distinguished as far as the middle of the tarso-metatarse, when they completely fuse.

Flexor brevis digiti III., which arises from the tendon of the *flexor profundus* and is inserted into digit III., occurs only in *Rhea* amongst the *Struthiones.*

NERVOUS SYSTEM.

The Brain.

Parker has shown that, compared with the brains of many *Neognathæ*—Turkey, Emu, Goose, Pigeon,—the cerebral hemispheres in *Apteryx* are proportionately of large size, and further peculiar is the way they overlap the cerebellum, in this respect bearing a very close resemblance to the Passeres. This overlapping conceals the grooves which mark the anterior region of the cerebellum, the hemispheres extending as far back as the flocculi. The posterior grooves are visible superficially, as in other brains. The pineal peduncle, in consequence of this overlapping, is inclined from the vertical position backwards.

The position of the thalamencephalon is also peculiar, in that this region is tilted backwards, the lamina terminalis looking upwards, the foramen of Monro becoming postero- instead of antero-dorsal.

The Eye.

The pecten is well developed in all the *Palæognathæ*, save *Apteryx*. In *Dromæus* the number of its folds is reduced to four; in *Struthio* the lamellæ are from 14–20 in number.

In *Apteryx* the pecten is generally believed to be wanting in the adult, though present in the embryo. Dr. G. Lindsay Johnson, by a series of drawings recently exhibited at a *soirée* of the Royal Society, has shown that this is not really the case. The pecten is present in *Apteryx*, though it assumes a peculiar form, being columnar, not fan-shaped, and plicated. In all other birds the pecten has two or more plications and is never conical—usually forming a vertical, plicated, densely pigmented septum dividing the disc into a right and left half, although its base expands over it so that very little of the disc is seen. The eye is small. Hence the apex of the pecten penetrates the vitreous to a distance nearly equal to that of the posterior surface of the lens from the retina.

Dr. Johnson's researches in this direction have related almost exclusively to the mammalian eye; and they have been most fruitful in results, enabling him to demonstrate a precisely similar "pecten" in the eyes of several Mammalia, that of the Golden Agouti—as he showed by means of drawings, exhibited at the abovementioned *soirée* in June of this year—bearing a most striking resemblance to that of *Apteryx*.

Jacobson's Cartilages.

These, according to Parker, are represented by a pair of vestigial rods of cartilage lying parallel to, and either immediately dorsad or slightly laterad of, the dorsal edge of the vomer. It can be readily prepared in a well-macerated skull by carefully removing the vomer. It was first described by W. K. Parker [77] in *Rhea.*

THE ALIMENTARY CANAL.

BUCCAL CAVITY.

The buccal cavity of the *Palæognathæ* presents one noticeable feature wherein it differs from that of the *Neognathæ* (Pl. XLV. fig. 1): since, in the former, the posterior nares, or choanæ, form a wide, open, more or less cordiform aperture, divided by a median septum into right and left lateral moities; in the *Neognathæ* the choanæ are slit-like. The Eustachian aperture lies immediately caudad of the choanæ.

In all the *Palæognathæ* the tongue is more or less vestigial. The glottis is also a relatively wider aperture than in the *Neognathæ.* In *Casuarius* the tongue has a denticulate free edge.

THE CONVOLUTIONS OF THE INTESTINE.

Dr. Gadow, in his paper "On the Intestinal Convolutions in Birds" [26], considered the flightless members of the *Palæognathæ* a very heterogeneous group, because of the great diversity in the length and arrangement of the main gut and in the development of the cæca. "In none of these birds has it come to the development of closed and well-developed loops of the mid-gut (with the exception of the duodenum). In this respect they represent the lowest type amongst the recent birds. . . . . Their connections with recent Carinatæ are distant. Nearest of them to the latter comes *Apteryx* through more defined loops, and the *Crypturi* seem to represent the link. . . . All the *Archæopalatinæ* agree with each other in having the second loop right-handed and the third left-handed; this is a feature which occurs again only in the *Crypturi*, *Gallinæ*, *Opisthocomus*, and in the *Cuculidæ*."

Amongst the *Neognathæ*, it will be remembered, Gadow was enabled to demonstrate a greater harmony, the convolutions of the intestines being always referable to one of seven types.

Dr. Gadow's conclusions, it should be remarked, are based upon a study of the coiling of the intestines within the body-cavity.

Mr. Mitchell [60], who approached the study of the intestinal tract from a different point of view, viz., after its removal from the body, and the severance of certain vessels and secondary connections, which reveal the nature of the convolutions of the gut along its attachment to the ventral border of the dorsal mesentery, and the position of the diverticulum cæcum vitelli and its relation to the middle mesenteric vein, entirely confirms Dr. Gadow's conclusions as to the primitive nature of the *Palæognathæ* judged by this standard. He remarks:—"It is plain that, so far as degree of divergence of type in the alimentary canal goes, the Ratites deserve their accepted place at the bottom of the avian scale."

I have been enabled to examine the intestines of all the *Palæognathæ*, save *Struthio*. So far as my material goes it entirely confirms the observations of Gadow, Mitchell, and Beddard.

Casuarius, Dromæus, and *Apteryx* all resemble one another rather closely.

In *Casuarius* and *Dromæus* the duodenal loop is wide, in *Apteryx* narrow. In *Casuarius*, as Mr. Mitchell points out, the pancreatic and hepatic ducts open into a diverticulum of the distal loop. In *Dromæus* and *Apteryx* the duodenum is longer and narrower, and the pancreatic and hepatic ducts open separately into the duodenum. In other genera the small intestine is relatively short, and the convolutions therefore are simple. The rectum is short and straight; in *Casuarius* and *Dromæus* its inner lining is thrown into a number of strongly marked irregular rugous folds.

In *Casuarius* and *Dromæus* the cæca are relatively short, of a uniform thickness throughout, and have a narrow lumen. In *Apteryx* the cæca are relatively much longer, exceeding 6 inches in length, whereas in the two former they do not exceed 5 inches. Furthermore, in *Apteryx* the terminal half becomes suddenly and markedly dilated; each cæcum thus presents a sausage-shaped free end, borne on a narrow tube-like stem.

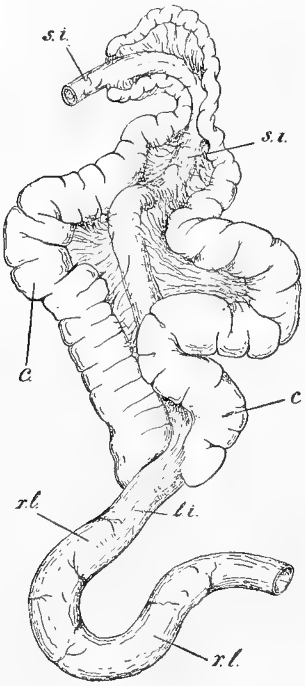
There are no valvular appendages in the cæca of these three forms.

Rhea is intermediate between *Casuarius* on the one hand and *Struthio* on the other. The duodenal loop is narrow and closed. The convolutions of the small intestine resemble *Casuarius*, the posterior rectal portion *Struthio*. The pancreatic and hepatic ducts open separately. The resemblance to *Struthio* consists in the relatively great length of the rectum; but it differs therefrom in that it is only thrown into a single, and not a series of complex loops.

The *cæca* are relatively of enormous length, exceeding those of any other *Palæognathe*. They appear, however, to vary in this respect very considerably. In the series of measurements given by Remouchamps [85] the variations in *R. macrorhyncha* range between 1 foot 4½ inches and 2 feet 9 inches; in *R. americana* between 2 feet 4 inches and 4 feet 8 inches. In a female of this latter species dissected by me they attained a length of 5 feet 3 inches, accompanying the small intestine throughout the greater part of its length. The lumen was sacculated to within a short distance of the extreme end of the cæcum by means of a series of semilunar valves alternating one with another. The position of these valves was indicated on the outside of the cæcum by means of a series of constrictions (fig. 7, p. 250).

The intestinal coils of *Struthio* I have not had the good fortune to examine. I therefore append Mr. Mitchell's description [60]. He writes:—"The first two parts of the intestine and the three great veins were according to type, the yolk-sac diverticulum being conspicuous in the circular loop opposite the end of the median

Fig. 7.



Cæca of *Rhea americana.*

s.i. = small intestine.
c. = cæca.
l.i. = large intestine, forming *r.l.* = rectal loop.

mesenteric vein. The distal limb of the duodenum presented a short lateral diverticulum, and the cæca are relatively longer than in *Casuarius,* and, as has been described frequently, were marked by the attachment of a spiral valve. But the rectal part of the intestine, that supplied by the posterior mesenteric vein, is expanded into an enormous coil swung at the circumference of a semicircular expansion of its mesentery. Only in *Chauna,* and in the Eagles and Petrels, have I found the slightest trace of a convergent resemblance to this feature, but in the latter the subsidiary rectal loops, although supplied by the rectal vessel, lie above the cæca."

According to Beddard the spiral valve of the cæca contains about twenty turns. These cæca, he points out, are furthermore remarkable in that they open into the rectum by a common orifice, thus differing from those of all other birds.

The cæca of the Tinamous resemble those of *Casuarius* ; *Calodromas elegans,* however, affords a remarkable exception, differing as it does in this matter from all other known birds. These cæca have been described and figured by Beddard [6]. They are much wider than usual, and have the outer walls produced into numerous prominent diverticula decreasing in size from behind forwards.

The following table from Beddard [7] will give at a glance the known variations in the proportions of the alimentary canal :—

	Small intestine.		Large intestine.		Cæca.			
	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.
Rhea macrorhyncha, ♀	4	2	1	0	1	4½	1	9
,, ,, ♂	4	5¾	1	11	2	9		
,, ,, ...	5	0	1	4	2	0		
Rhea americana	6	3	1	8	2	4	2	9
,, ,, ♀	9	8	2	2	4	8		
,, ,, (young)	5	10	1	4	2	6	2	8
Struthio camelus, ♀	23	1	32	9	2	8	2	11
,, ,, ♀	23	4	30	8	2	10½		
,, ,, ♀	23	0	29	8	2	7		
,, ,, ♂	24	6	31	8	2	8	3	1
,, ,, ♂	23	0	24	9	1	10		
,, ,, ♀	28	6	33	2	2	7		
Casuarius unappendiculatus, ♀	3	8		10		4½		5
,, *casuarius beccarii*, ♀	4	8	1	0		4½		
,, *picticollis*, ♂	4	0		10		4		
,, *bicarunculatus*	5	0	1	0		7		
,, *bennetti*, ♂	3	10½		11½		3¼		3¾
Dromæus novæ-hollandiæ	10	6	1	0		5		
Apteryx australis	4	4		4¼		7		
,, *oweni*, ♂	3	4¼		4¼		7		

THE LIVER.

The liver, in all the *Palæognathæ*, save *Struthio*, agrees with that of the *Neognathæ* in that it is divided into two lobes.

In *Casuarius* and *Dromæus* the right lobe is larger than the left. A Spigelian lobe is represented.

Both *Casuarius* and *Dromæus* possess a gall-bladder. In the former the gall opens, in common with the pancreatic ducts, into a diverticulum on the distal loop of the duodenum.

In *Apteryx* the left liver-lobe is larger than the right; the gall-bladder is occasionally absent.

In *Rhea* the right and left liver-lobes are equal in size. The gall-bladder is generally wanting.

Struthio is remarkable in that, according to Beddard, the right and left lobes are fused into a single heart-shaped lobe. There is a Spigelian lobe. The gall-bladder is wanting; and there is but a single bile-duct, which opens near the pylorus.

Mr. Beddard found the free edge of the liver in *Rhynchotus rufescens* pierced by three small vessels of the venal portal system—a fact which, as he points out, has a very lizard-like appearance.

RESPIRATORY ORGANS.

a. The Lungs (Pl. XLV. fig. 9).

The costo-pulmonary muscles in *Casuarius* are short, thick, and powerful, five pairs in all; they arise from the thoraco-sternal articulation of the ribs and extended fanwise on to the aponeurosis covering the lung. Those of *Rhea* are relatively longer than in *Casuarius*. In *Apteryx*, according to Huxley [41], they form "broad flat bands," which "take their origin from the vertebral ribs, at some distance below the attachment of the pulmonary aponeurosis, and, proceeding obliquely dorsad and forwards, spread out and are inserted into that part of the aponeurosis which covers the posterior inferior facet.

In the relative size and distribution of the ecto-, ento-, and para-bronchia, and in the size of the vestibule, the flightless members of the *Palæognathæ* do not appear to differ much one from another or from the *Neognathæ*.

In the lungs of a *Casuarius unappendiculatus* the bronchial rings extended backwards as far as the 4th ento-bronchium. The inner border of the anterior and posterior inferior facets of the lung are deeply sculptured by a system of numerous parallel grooves of open tubes, closely packed and running along the surface of the lung from the mesial border outwards so as to converge towards, and open into, a spacious chamber communicating posteriorly and ventrally with the 1st ento-bronchium (Pl. XLV. fig. 9), further forwards and also ventrally into the anterior end of the pre-bronchial ostium. These grooves give the ventral face of the lung, after the removal of the aponeurosis, the appearance of having been bored by Teredos, the groove representing a hemisection. They are crossed and recrossed by transverse strands of tissue and punctured by minute apertures.

They may be divided into two groups according to whether they are fed by a trunk from the 1st or the 3rd ento-bronchium. Thus, as will be seen in fig. 9, all the secondary grooves cephalad of the main trunk marked "ent. I." are fed from this, whilst ento-bronchium III. supplies all the grooves caudad thereof.

These grooves are converted into tubes by the pulmonary aponeurosis.

b. The Air-sacs (Pl. XLV. fig. 8).

In *Casuarius* the *pre-bronchial sac* is paired, and extends forward on each side of the œsophagus for a considerable distance beyond the level of the 1st cervico-thoracic rib.

The *sub-bronchial sac* is divided into right and left loculi, enclosing a median tunnel-like space between them, the roof of which is formed by the trachea. This tunnel can be traced into a large pneumatic cavity in the sternum opening on its anterior border in the middle line between the coracoid grooves.

The intermediate sacs were three in number. A similar subdivision has been described by Beddard in *Podargus* and " one or two Accipitres." In the present instance it would seem that this third sac is due to a subdivision of the anterior intermediate.

The *posterior intermediate* was large. Its roof was pressed inwards by the forward extension of the posterior abdominal.

The posterior abdominal was of considerable size. That of the right side enclosed the right kidney; on the left side the anterior lobe of the kidney was found to lie without the sac and to be enclosed in a separate sac.

The intermediate and posterior abdominal sacs of the right side were markedly smaller than those of the left.

The sacs are fed as follows:—The pre-bronchial and sub-bronchial by a common ostium from ento-bronchium I.; the anterior intermediate (*a*) from ento-bronchium III., and (*b*) from the anterior of two canals arising one immediately behind the other from the ventral floor of the meso-bronchium immediately below the apertures of the III.–IV. ecto-bronchia. The ento-bronchial ostium opens into the anterior, the ecto-bronchial into the posterior loculus. The posterior intermediate by the hinder of the two hinder ecto-bronchial canals. The posterior abdominal by the terminal end of the meso-bronchium—the *ostium posterius.*

The 2nd ento-bronchium does not open, as described by Huxley in *Apteryx*, into the sub-bronchial ostium, but turns upwards and backwards, and terminates cæcally like the 4th.

The air-sacs in *Rhea* differ in no essential respect from those of *Casuarius.*

The sub-bronchial sac is unpaired. In one *Rhea americana* which I dissected the anterior intermediate sac was fed by two ostia widely separated one from another. In a second example the ostium of the anterior intermediate sac of the left side and the septum dividing this sac from the posterior intermediate were both wanting.

The posterior abdominal sacs are much larger than those of the Cassowary.

Apteryx differs from all other birds, as was first pointed out by Huxley, in that, owing to their smaller size, the posterior intermediate and abdominal sacs are enclosed within the sub-pulmonary chamber. In all other birds a great increase in the size of these two has driven out the posterior abdominal sac, so that it projects, like a hernial sac, between the peritoneum and the parietes into the abdominal cavity.

The respiratory organs of the *Palæognathæ* are singularly uniform in character *inter se* and with the *Neognathæ.*

c. The Windpipe.

The most valuable of the numerous treatises on the windpipe of the *Palæognathæ* —from a systematic point of view—is that by Forbes [20]. We are concerned here only with the thoracic end of the trachea, and the degree of specialization which it has reached in the direction of the formation of a "syrinx."

Struthio and *Apteryx*, up to the time of Mr. Beddard's paper [8], have been held to represent the least specialized forms in this particular.

In *Struthio* there are no intrinsic muscles. There is a *membrana tympaniformis interna*, but only a trace of a *membrana semilunaris*. "Internally," according to Forbes, "the mucous membrane of the interior is greatly thickened, forming a vocal cord, in the region of the last three tracheal rings and first two bronchial semirings. The lateral tracheal muscles stop at the point of insertion of the *sterno-tracheales*."

In *Apteryx* there is a broad *membrana tympaniformis interna* and a feeble *membrana semilunaris*. As in *Struthio* there is no *pessulus* and, it was believed, no intrinsic muscles.

Mr. Beddard's dissections, however, showed that these were "especially plainly developed in *Apteryx australis*." In this species he found "a thin band of muscle continuous above with the extrinsic muscle; this passes down the side of the trachea and gradually thins out into fibrous tissue, which seems to die away upon the last tracheal ring, hardly reaching the bronchi. Its state, in fact, is clearly one of degeneration, and very much on a par with the state of the corresponding muscle in the Hoatzin (*Opisthocomus*). In *A. mantelli* the same muscle was visible, but it did not seem . . . . . to be anything like so well developed as it is in the species first referred to."

It appears to be entirely wanting in *A. haastii* and *A. oweni*.

There is a feeble vocal cord, and the lateral muscles stop at the insertion of the *sterno-tracheales*.

Casuarius, as Forbes remarks, shows one interesting peculiarity, the lower end of the trachea becoming slightly dilated above the bronchi. Furthermore, the last tracheal rings are incomplete behind, the median space to which this gives rise being filled up by fibrous and elastic tissue arranged transversely. By the contraction of this, after death, the ends of the rings are drawn inwards, so forming within the tube a low longitudinal ridge, resembling the tracheal septum of certain Petrels and Penguins.

There is no *pessulus*, the *membrana tympaniformis interna* passing over from one bronchus into the other. A very slight thickening of this membrane in the middle line between the two bronchi suggests a *membrana semilunaris*, but, as Forbes remarks, there is nothing that can *properly* be called by this name. The outer vocal cord is well developed.

Forbes describes, but so far I am not able to confirm this, "On the internal wall of the bronchus . . . . . a second much slighter and less prominent fold, slightly concave forwards, running somewhat obliquely backwards and downwards, and supported by the anterior ends of the third and sixth bronchial semirings."

There are no intrinsic muscles. The *sterno-tracheales* in *Casuarius* and in *Dromæus* expand so as to meet in the middle line in front.

The tracheo-bronchial region of the trachea in the adult *Dromæus* has not yet been described. In a young specimen dissected by Forbes there seemed to be no great differences between it and *Casuarius*. The *membrana semilunaris* seemed to be better developed.

The trachea of *Dromæus* is peculiar, in that its front wall is pierced by a long, vertical, slit-like median aperture, caused by the deficiency of certain of the tracheal rings in this region. The lining membrane of the tube projects from this opening and forms a large dilatable sac, which can be filled with air at will. It is probably concerned with the production of the drumming sound which this bird occasionally makes. It has been described in detail and figured by Murie [63]; but seems to have been first discovered and described by Peter Fremery [21] in 1819.

In *Apteryx*, it will be remembered, the syrinx is but feebly developed, and the intrinsic muscles are degenerate. The intrinsic muscles of *Rhea* were first correctly described by Forbes [20]. The last four or five, or even six, tracheal rings fuse more or less completely to form a box. The number of rings involved in this fusion can generally be traced by the interannular sutures, which appear never to be completely obliterated. There is a complete and cartilaginous pessulus and a *membrana semilunaris*. Forbes describes, and I am able to confirm, "on the middle part of the membrana tympaniformis interna a thickened fibro-cartilaginous area." This is triangular in form, its base resting on the pessulus, and its apex terminating near the 4th bronchial semiring. It would be interesting to compare this thickened tissue with certain fibrous pea-shaped pads found in this region in *Sula bassana*, first described by Garrod, and *Catarrhactes chrysocome*, described and figured by Watson in the 'Challenger' Reports.

The broncho-trachealis (intrinsic syringeal) muscle in my dissections, as in Forbes's, arises from the last ten tracheal rings, and passes downwards to be inserted into the anterior ends of the last four or five bronchial semirings and the membrane between. The *sterno-trachealis* terminates just pre-axiad of the origin of the intrinsic muscle.

In the *Casuariidæ*, as Forbes has pointed out, the "terminal part of the trachea tends to develop into an expanded tympanum"; the tracheal rings are softer and become imperfect posteriorly, the junction of the trachea and bronchi is less marked, and the arrangement of the sterno-tracheales is peculiar.

In *Struthio* and *Apteryx* the tendency of the trachea is to become narrower at its termination, and the distinction between this and the bronchi is much sharper than in *Casuarius*.

d. The Choanæ (Pl. XLV. fig. 1).

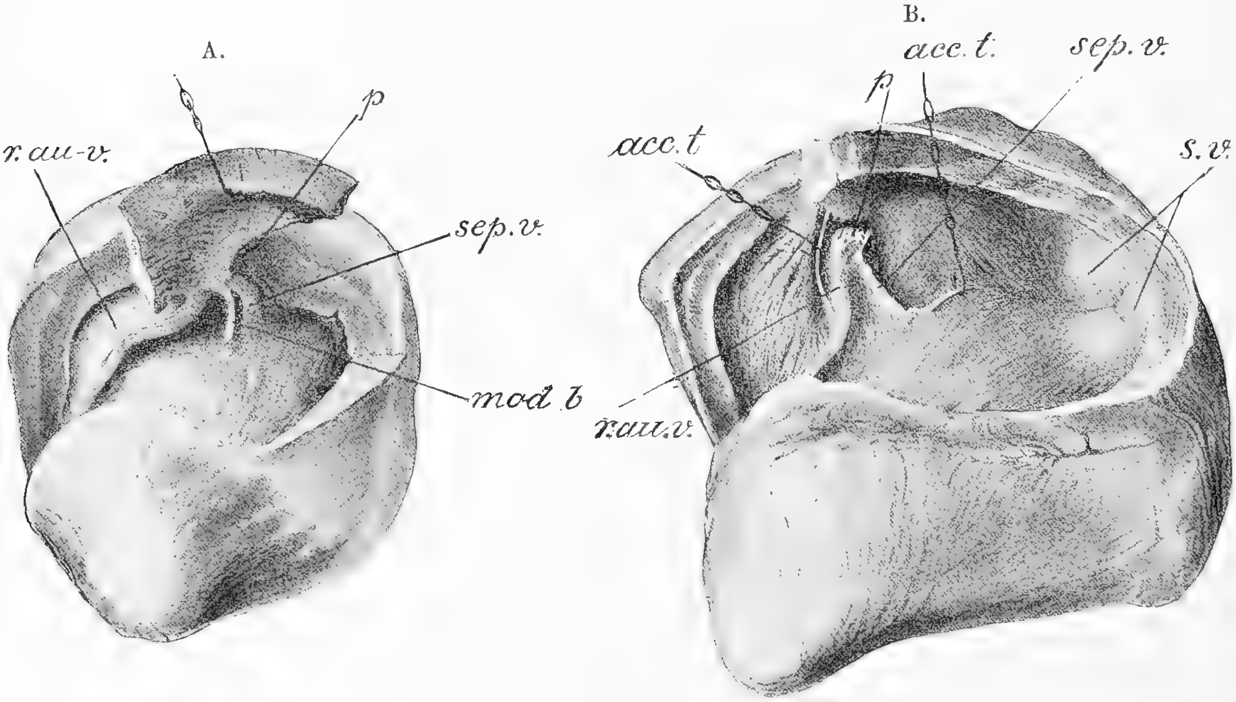
The choanæ of the *Palæognathæ*, it is interesting to remark, differ in form from the *Neognathæ* in their larger size. In all the *Neognathæ* the aperture is slit-like, whilst, as will be seen in the figure, in the *Palæognathæ* it is triangular or cordiform in shape.

CIRCULATORY SYSTEM.

The Heart.

The heart of the *Palæognathæ* does not differ materially in structure from that of the *Neognathæ*. It has been already ably described and its most important features pointed out by Owen [67], Lankester [45, 46], Beddard [5], Rolleston [87], and others, so that little remains for me to say.

Fig. 8.



A.—Dissection of the heart of *Casuarius unappendculatus*, to show the right auriculo-ventricular valve and the "moderator band."

B.—Dissection of the heart of *Rhea americana*, to show the right auriculo-ventricular band and the abnormal septal valve.

acc.t. = accessory tendon.
sep.v. = septal portion of right auriculo-ventricular valve.
s.v. = semilunar valves.
r.au.v. = right auriculo-ventricular valve.
p. = papillary muscle.
mod.b. = moderator band.

My only point concerns the moderator band first described in *Casuarius* by Rolleston. It seems to have been taken for granted by subsequent writers that this was always present, if not in all the *Palæognathæ*, at least in the *Casuariidæ*.

I have only succeeded in finding it *once*, and in the heart of a *Casuarius casuarius salvadorii*, though I have examined specimens of *C. unappendiculatus*, *C. casuarius beccarii*, *C. casuarius violicollis*, *C. casuarius sclateri*, and *Casuarius casuarius*.

In addition to the large papillary muscle binding the right auriculo-ventricular valve to the anterior wall of the ventricle, I find two or more very slender "chordæ tendineæ" extending from the outer surface of the auriculo-ventricular valve to the anterior ventricular wall, recalling the similar structures described and figured by Lankester [45] in the heart of *Ornithorhynchus*. In *Rhea* and *Dromæus* only one of these threads was present. I have, however, only had the opportunity of examining one *Dromæus* for this purpose.

The septal half of the valve in *Casuarius* is thick and fleshy. In *Dromæus* it is relatively somewhat larger, and, in the only adult heart which I have had an opportunity of examining, differs from *Casuarius* in that its free ventral or hinder border is curved forwards at its insertion towards the floor of the left auricle, forming by this means a sort of pocket-like flap on the wall of the inter-ventricular septum.

In *Rhea* this same arrangement occurs again. In one adult which I dissected (fig. 8 B) this was remarkably well developed. The valve was very thin, and the forward pocket-shaped extension into the anterior end of the ventricle was strongly developed and was continued yet further in the form of a narrow slip of muscle attached only at its ends.

In *Dromæus*, in addition to one or two delicate tendinous threads from the outer surface of the auriculo-ventricular valve to the anterior ventricular wall, there were numerous fleshy strands of muscle, interlacing one another, running parallel with the valve, and from it to the anterior wall of the ventricle.

Trabeculæ carneæ were well developed both in *Rhea* and *Dromæus*.

CAROTIDS.

All the *Palæognathæ*, save *Apteryx*, have normally two carotids. Occasionally, in *Rhea*, the left only persists. In *Apteryx* there is only one carotid, the left.

CLOACA, BURSA FABRICII, AND URINO-GENITAL SYSTEM.

a. CLOACA.

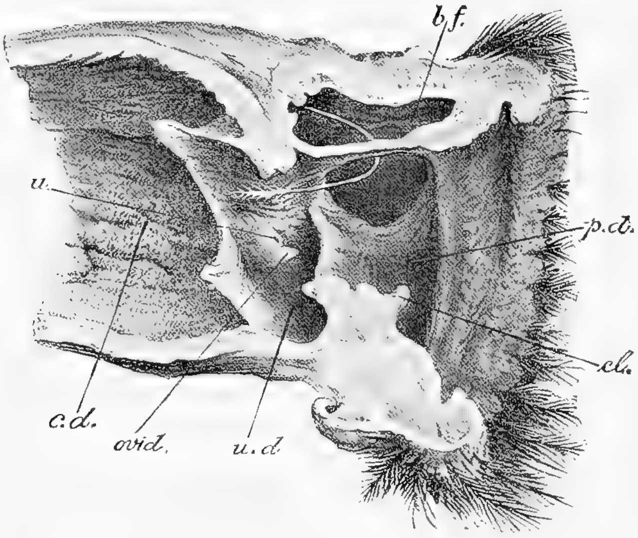
The terminal end of the alimentary canal in the *Palæognathæ*, as in the *Neognathæ*, is divisible into a *copro-*, *uro-*, and *proctodæum*, as defined by Dr. Gadow [24].

In *Casuarius*, *Rhea*, and *Apteryx* the coprodæum passes gradually into the rectum, but in *Struthio* and some *Neognathæ* the *coprodæum* is preceded by an additional chamber, though this is but small and not very sharply defined. In this succession of chambers therefore, as Dr. Gadow has pointed out, *Struthio* resembles some Saurians and young Crocodiles.

In *Struthio*, defæcation and micturition are separate acts, and the urine, instead of passing from the uro- to the coprodæum, is transferred to the *bursa Fabricii*, which, unlike that of all other birds, is of considerable size and remains permanently open. Its function, acting as a physiological dorsal bladder, is unique. A true allantoic bladder, communicating directly with the ureters, is wanting in the *Aves*.

The cloacal aperture of the *Palæognathæ*, as in *Neognathæ*, is round, not transverse as in *Reptilia*.

Fig. 9.



The terminal end of the alimentary canal of *Casuarius violicollis*, to show the cloaca and its divisions into copro-, uro-, and proctodæum and the form and position of the bursa Fabricii.

b.f. = bursa Fabricii.
c.d. = coprodæum.
u.d. = urodæum.
p.d. = proctodæum.
cl. = clitoris.
ovid. = aperture of oviduct.
u. = aperture of ureter.

b. THE BURSA.

The *bursa Fabricii* of the *Palæognathæ* has been very carefully studied by Forbes [20] and Wenckebach [97].

In the *Palæognathæ*—save only in *Apteryx*—as Forbes [20 A] has shown, the bursa in young birds is of considerable size. Furthermore, he held that it differed fundamentally from that of the *Neognathæ*, since in these last it opens by a more or less constricted aperture into the general cavity of the cloaca, whilst in the *Struthiones* the exact opposite was the case, the cloaca opening into the bursa. "From this . . . . . it will be at once evident that the cloaca does *not* open directly to the outer surface, but *indirectly through* the bursa by means of its large posterior and inferior aperture."

I find myself unable to confirm this point, and I think the accompanying figure will justify me. The only difference which I can see between the *Palæo-* and *Neognathæ* in this particular is that in the latter the bursa opens into the roof of the proctodæum by means of a minute aperture, in the former it opens by a very large one, so large as to absorb nearly the whole roof of the proctodæum.

When these parts are dissected from spirit-specimens, in which hardening has taken place *in situ*, Forbes's description seems to be amply verified, as I can testify. The accompanying figure was made from a specimen in which the hinder end of the gut had been removed soon after death, the cloacal aperture set widely open, and the whole plunged into formol and left for two or three days. The wall of one side was then removed and the true relations revealed.

The function of the bursa is yet unknown.

c. Copulatory Organs.

The *Palæognathæ* all possess a well-developed copulatory organ.

That of *Struthio* is a solid grooved organ containing erectile tissue and resembling very nearly that of the *Chelonia* and *Crocodilia*. It can be retracted into a pouch in the floor of the proctodæum. The *m. protractor penis* receives a slip from the *transversus analis*, which descends from the pelvic bones. A pair of *retractores penis* arise from the pelvis and are attached to the ventral aspect of the middle portion of the organ.

In the remaining *Palæognathæ* the penis resembles that of the *Anseres* amongst the *Carinatæ*, being evertible and more or less markedly spirally twisted and grooved dorsally.

The copulatory muscles of the *Palæognathæ*, Dr. Gadow [24] points out, differ from those of the *Neognathæ*, inasmuch as the latter are derived from the *sphincter ani* solely, whilst in the *Palæognathæ* they are partly differentiated from muscles which are still attached to the pelvis, and are therefore skeleto-genital.

DEVELOPMENT.

The egg of the *Palæognathæ*, save in *Apteryx* and perhaps the *Crypturi*, differs from that of the *Neognathæ* in that the pore-canals are branched. In *Apteryx*, as in the *Neognathæ*, they are unbranched.

In *Struthio*, according to Nassonov [64], and *Apteryx*, according to Parker [71], an opercular fold grows backwards from the hyoid arch so as to cover the first and second branchial clefts. This has been noticed in some *Neognathæ*. Sushkin [94] has figured and described it in *Falco tinnunculus*. The first discovery of this operculum appears to have been made by Rathke [84] in 1832.

PHYLOGENY OF THE PALÆOGNATHÆ.

I enter upon the discussion of this subject with very considerable trepidation—not only on account of the difficulty of the problem, but also because it brings me into direct conflict with the opinions of those who speak after deliberation and long experience, and are, for this reason, and rightly, accounted authorities amongst us.

It is now generally admitted that the *Palæognathæ* must be descendants of an Avian proto-carinate form capable of flight.

Parker [71] has given a number of characters which lend the strongest support to this view. To many they will be convincing. The most important of these are:—

> "The fact that the skeleton of the fore limb is that of a true wing."
>
> "The presence of an alar membrane or patagium."
>
> "The presence of remiges and tectrices majores."

The alar membrane is a structure of great significance. According to Parker, it is the remnant of a once extensive scale-covered patagium. As these scales gradually became transformed into feathers the size of the patagium decreased.

As to the mono- or polyphyletic origin of the group there is much divergence of opinion.

Newton and Beddard consider the *Palæognathæ* to be monophyletic; Fürbringer, Gadow, and Parker polyphyletic. With these last I also agree, but not entirely so.

There can be no doubt but that the *Palæognathæ* represent a lower grade than the *Neognathæ*. Nevertheless the latter are closely related thereto.

It is probable that they have been derived as a diverging branch from that stock which gave rise to the *Rheidæ*, *Dinornithidæ*, and *Æpyornithidæ*. The diagram (fig. 10, p. 265) is intended to make this clear.

The very close resemblance of the palate of the *Crypturi* to that of *Rhea* and *Dinornithidæ* and the general resemblance in the form of the pelvis of *Crypturi* and *Dinornithidæ* lend strong support to this view.

The structure of the pelvic arch in the *Palæognathæ* is of considerable interest, inasmuch as it bears upon the relation of this group to the *Neognathæ*.

It retains its most primitive form in *Archæopteryx*, *Dinornis*, *Æpyornis*, *Hesperornis*, *Ichthyornis*, *Apteryx*, and in the *Crypturi*. In all these the ischiadic fissure and free pubes are retained throughout life. In *Neognathæ* the ischiadic fissure becomes converted into a foramen by synchondrosis between the ilium and ischium. In *Struthio* the ischiadic fissure is permanent, but the pubes fuse in the middle line.

In *Rhea* the ischiadic fissure is closed; the ischia, furthermore, meet one another below the vertebral column, and the pubes fuse with them posteriorly. Thus *Struthio* and *Rhea* are each unique in the form of the pelvic arch.

Struthio seems to be a stumbling-block. Thus Prof. Newton writes [65]: "Some systematists think there can be little question of the *Struthiones* being the most specialized and therefore probably the highest type of these Orders" ("*Ratitæ*"). Others, in spite of the great amount of specialization which *Struthio* has undoubtedly undergone, would regard this form as the most primitive, not only of living birds, but of the *Palæognathæ* living and extinct.

According to Fürbringer, on account of the great number of its primaries, its coracoid, and many of its shoulder- and arm-muscles, the form of its pelvis, two-toed foot, "gewisse Eingeweide, etc., entfernen sie weiter von allen anderen lebenden Vögeln, als diese in der Regel unter einander divergiren. Zugleich bietet *Struthio* neben verschiedenen mehr vorgeschritten Specialisirungen progressiver und retrograder Natur eine Anzahl höchst primitiver Charaktere dar, die ihre tiefer als die anderen Ratiten stellen und durch welche diese sehr alte Form Blicke bis in die frühesten Vorzeiten des Vogelstammes thun lässt."

Beddard considers "that *Struthio* is removed far from the *Dinornithidæ*, as well as from other Ratites, by the structure of its palate, which diverges much." He does not, however, go as far as Fürbringer, for he continues further on: "There are really, however, not a large series of characters in which they may be fairly said to be more primitive than some other groups. . . . ." This last statement is evoked in answer to Fürbringer's contention that *Struthio* is really very primitive.

I find myself in agreement with Beddard: more than this, I believe that we have to look to *Dromæus* and NOT to *Struthio* for the most primitive of living birds.

This opinion is based mainly upon a study of the bones of the palate in this and the allied forms. These in *Dromæus* seem to represent the ground type from which, or from some closely allied form, the palates of *Struthio*, *Rhea*, and *Dinornis* may be derived. The palate of *Apteryx* must be considered by itself.

The palate of *Struthio* compared with that of *Dromæus* will be found by no means so fundamentally different as seems to have been supposed. On the contrary, it is contended that the palate of *Struthio* is a specialized and, in some respects, retrograde form of that of *Dromæus.*

The palato-pterygoid connection is similar in both.

The palatine and the forward extension of the maxillo-palatine processes are both considerably longer, both actually and relatively, in *Struthio* than in *Dromæus. Struthio* lacks palatine processes to the premaxilla, and has a degenerate, one might almost say vestigial, vomer. Like all degenerate structures, however, it gives some certain signs of a former perfection. Thus, in a skull which in this paper is attributed to *Struthio meridionalis* the vomerine limbs extend backwards to within a very short distance of the pterygoid. If this proximal extension were carried back sufficiently far to enable the vomer to join the pterygoid the resemblance to the Dromæine type would be really striking.

If we turn now to the palate of *Rhea*, and compare this with that of *Dromæus*, we shall find the differences more decidedly marked. The peculiar and almost complex relations which obtain between the palato-pterygo-vomerine articulations have already been described in these pages (p. 206), and are sufficiently distinct to render further comparisons unnecessary.

But the palate of *Rhea* is curiously similar to that of *Dinornis* and the Tinamous. So similar as to render it probable that these are related more closely one to another than to *Dromæus* or *Struthio*.

The affinity of *Rhea* to the *Dinornithidæ* has already been hinted at by Beddard, though upon different grounds. In discussing the position of *Struthio*, he remarks that though "this is removed far from the *Dinornithidæ*, as well as from other Ratites, by the structure of its palate, which diverges much, ... it is not clear that *Rhea* is so remote; the existence of an apparent homologue of the maxillo-nasal bone . . . . . is a point of somewhat striking likeness to *Emeus*."

Nathusius, again, in studying the egg-shells of *Rhea* and *Dinornis*, was so impressed with the likeness between them that he proposed to unite them in the same genus.

Parker [73], however, strangely enough, remarks: "I know of no character in the skull of *Rhea* by which it definitely approaches the Moas . . . . ." I say strangely enough advisedly, for I feel sure that had Parker's attention been drawn to the points to which attention is directed in this paper he would have grasped its significance and written quite otherwise.

About the palate of *Æpyornis* we as yet know nothing. In the roof of its skull it resembles the *Dinornithidæ*, inasmuch as, just as in this group, there are no outstanding supra-orbital processes to the lachrymal. In some other points it resembles *Struthio*; but since in its pelvis and other points it closely resembles *Dinornithidæ*, I am inclined to place it near this group.

The palate of the Tinamous is truly *Dromæognathous*, but approaches the *Neognathine* type, tending towards schizognathism. In its pterygo-palatine articulation, as I have already pointed out (p. 208), it closely approaches the *Neognathæ*, the palatine having shifted from contact with the body of the pterygoid to form a connection more or less intimate with its tip.

The palate of *Apteryx* in the peculiar forked pterygoid and the complexity of the relations between it and the palatine and vomer seems to differ markedly from all the other *Palæognathæ*, or, indeed, from all living birds.

Here, again, is a conclusion diametrically opposed to that of Parker. Whether or not I failed to appreciate the points of resemblance Parker claims must remain to be seen. This discrepancy is certainly remarkable, and will seem to cast doubt upon the validity of my conclusions rather than his, for those who know his monographs on the development of *Apteryx* and the skull of the *Dinornithidæ* will agree that they are monuments which mark an epoch in the history of this subject. In his work on the skull of the *Dinornithidæ* he wrote: "The marked differences between the Moas and Kiwis are certainly for the most part adaptive. . . . . The real affinities underlying these differences are, however, shown by the striking similarity of the bones of the palate in the two forms."

The skull of *Casuarius*, it may be remarked here, differs in no essential respect from that of *Dromæus*. In whatsoever it differs from *Dromæus* point to specialization, as, for instance, the development of the casque upon the mesethmoid (p. 199, Pl. XLIV. fig. 3) and the small quadrato-jugal fossa.

The skull of *Dromæus*, it would seem, must be regarded as the most generalized of living birds, at least in so far as the bones of the palate are concerned.

Struthio somewhat nearly approaches *Dromæus* in the arrangement of these bones. *Rhea*, the Tinamous, the *Dinornithidæ*, and probably the *Æpyornithidæ* agree more closely one with another than with *Dromæus*.

Apteryx differs from all in the direction of increased complexity of these parts.

We have now *Struthio* and *Dromæus* with *Casuarius* opposed to *Rhea*, *Dinornithidæ*, and *Crypturi*, and possibly *Æpyornis*. These last we may further subdivide by means of the pelvis. This will separate *Rhea* from the remaining forms; inasmuch as in *Rhea* the pelvis is long and narrow, with the post-acetabular ilia meeting in the middle line, as in *Apteryx*.

In the *Dinornithidæ*, *Æpyornis*, and the Tinamous the post-acetabular ilia are separated by the long transverse processes of the synsacrum.

It may seem that this character of the pelvis is a somewhat artificial one, but reflection will show, I think, that it is probably not so. It does not seem to belong to the category of adaptive characters, since *Rhea* and *Apteryx* in the general conformation of the pelvis agree, though their habits are very different, and both bear some similarity to that of *Struthio*—similar in so far as the great length and transverse width are concerned. In the *Tinamidæ*, *Dinornithidæ*, and *Æpyornis* the pelvis owes its great breadth to (1) elongated transverse processes, and (2) the broad dorsal plane of the post-acetabular ilium.

The pelvis of *Struthio* bears an undoubted resemblance to the *Dinornithine* form, inasmuch as, like *Dinornis* or *Æpyornis*, the transverse processes bear the post-acetabular ilia away from all contact with the neural spines of the synsacrum.

Fürbringer's view with regard to the *Dromæidæ* is not exactly in harmony with the views adopted here, but it lends some support thereto nevertheless. He says *Dromæus* and *Casuarius* "bilden zwei sehr nahe verwandte Familien . . . . . welche etwas höher als die *Struthionidæ*, aber tiefer als die *Rheidæ* stehen und im Übrigen sowohl von den anderen *Ratiten* . . . . . als von den *Carinaten* eine entfernte

Stellung einnehmen," and adds: "Ihre Vorgeschichte kommt mir am meisten dunkel vor. . . . ."

By this time the tendency of the foregoing will no doubt have revealed itself. Its intention is to suggest that *Dromæus* and *Casuarius*—the *Dromæidæ*—are to be regarded as the most primitive of the *Palæognathæ*; and that the *Struthionidæ* are most probably the nearest approach thereto, for, in spite of the great specialization which they have undergone, they undoubtedly retain many archaic characters.

The *Rheidæ*, *Dinornithidæ*, *Æypornithidæ*, and *Crypturi* are all probably more nearly related one to another than to the *Dromæidæ*. The *Apterygidæ* are the most aberrant of all, but have affinities with the *Dinornithidæ*.

This implies that the *Palæognathæ* are to be regarded as polyphyletic—probably triphyletic. An attempt to express this relationship is given in the diagram on p. 265.

I propose to discuss the details of this "tree" in so far as concerns the *Neognathæ* elsewhere. Of the *Palæognathæ* I need only say I recognize 7 Orders, viz.:—

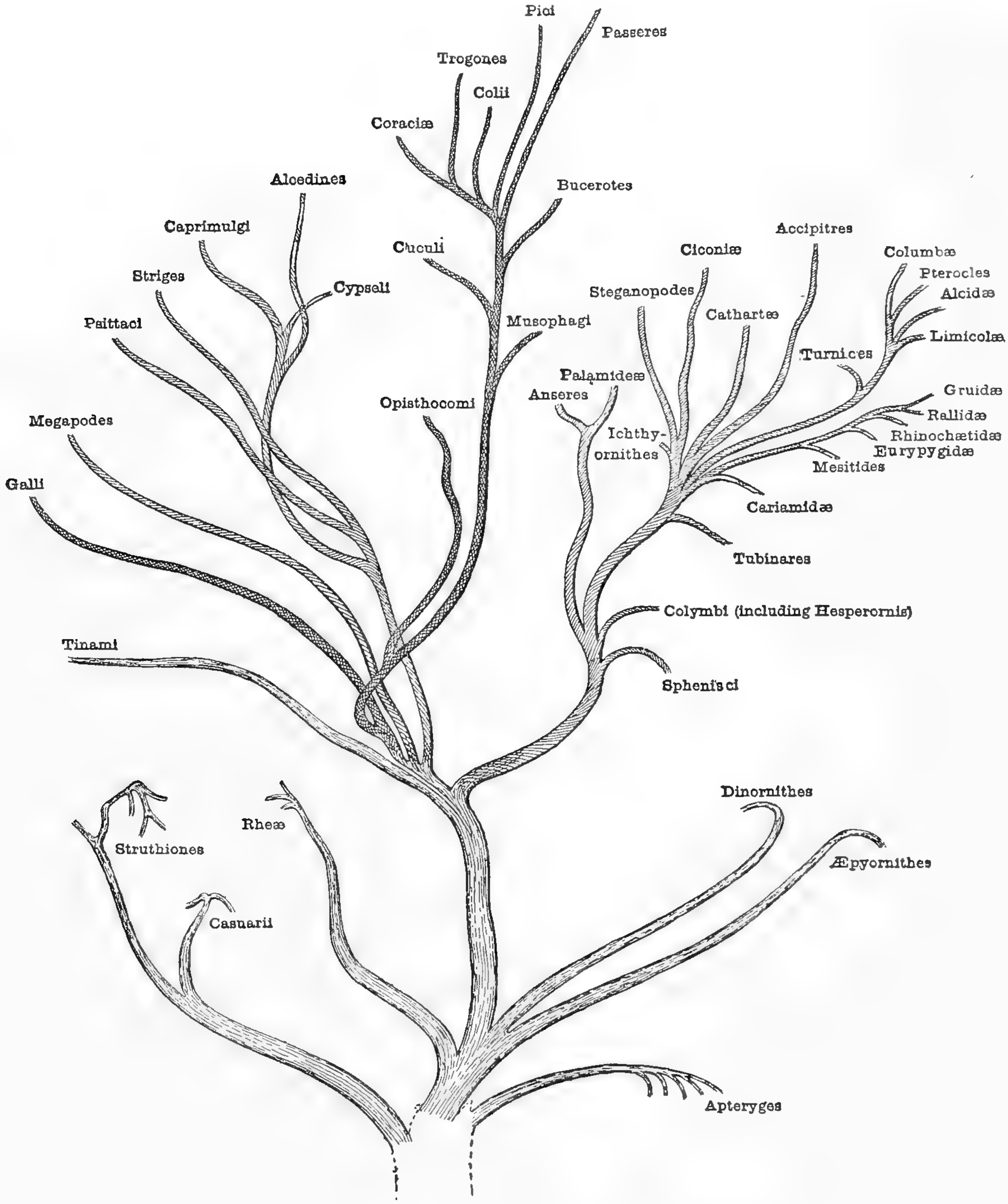
Casuarii.
Struthiones.
Rheæ.
Crypturi.
Dinornithes.
Æpyornithes.
Apteryges.

Their relation to the other members of the Class may be expressed as follows:—

Class AVES.
  Subclass I. ARCHÆORNITHES.
    ,, II. NEORNITHES.
    Grade A. *Palæognathæ*.
      ,, B. *Neognathæ*.

It would have been helpful here to discuss the further evolution of this group to its final end in the various genera and species, but this is unfortunately impossible in the present contribution owing to lack of material. The diagram will give a slight indication of the writer's views on this subject.

Fig. 10.



Phylogenetic diagram showing the probable Relationships of the *Palæo-* and *Neognathæ.*

|||| = Palæognathine stock. ▦ = Eutaxic forms. ▨ = Diastataxic forms

Blank branches indicate eutaxic forms amongst a diastataxic group; blank spaces in a branch that both eu- and diastataxic forms occur in the same genus or family.

SUMMARY.

The group of birds which we collectively designate the "Ratitæ" is the same as that to which this name was originally given by Merrem in 1813 (with the addition of *Apteryx*, then unknown), on account of the fact that all agreed in the absence of a keel to the sternum. They were "raft-breasted," in contradistinction to the Carinatæ, or keel-breasted [1].

Nitzsch, Huxley, Newton, Sclater, and Sharpe have successively adopted Merrem's subdivision of the class Aves—adding the Saururæ, unknown to Merrem.

Other workers, both before and since Merrem, have accorded to the "Ratitæ" no greater prominence than that of an order or suborder of the class Aves. Sometimes even this was considered too great a distinction, and they were reduced to the rank of a Family, including such forms as Bustards, Plovers, &c.

The "Ratitæ" of Merrem were apparently regarded by that author, as well as by Huxley, Newton, Sclater, Sharpe, and other systematists, as a monophyletic group. Fürbringer, Gadow, and Parker stand prominently forward as advocates for a polyphyletic origin.

Gadow's views are admirably set forth in his contribution to Bronn's 'Thier-Reich' [26]. Briefly, he regards the "Ratitæ" as a morphologically monophyletic group, standing in the same relation to the class Aves as the Anthropomorphæ to the rest of the Mammalia.

With this view we entirely agree. We venture further, and include the *Crypturi* within the group. This was done long since by Garrod [30] and Stejneger. Beddard [7], later, has shown a strong inclination to follow suit. Thus, he says:—"It is unquestionably to the *Struthiones* that they showed the greatest number of important likenesses, so much so, indeed, that their inclusion in one great group with them would be by no means an unreasonable way of disposing of them."

The Dromæognathous palate is sufficient justification for such an association. Consent to this, however, renders inoperative the old term "Ratitæ," which at best is but a makeshift; for many of the Carinatæ are Ratite, whilst the Tinamous have a large keel to the sternum.

We propose instead the terms *Palæognathæ* (Ratitæ + Crypturi) and *Neognathæ* (Carinatæ — Crypturi). The adoption of these surmounts the difficulty indicated above.

Gadow regards the Struthiones as a group of primitive forms more nearly representing Proto-Carinatæ than any other living birds. Their retention under the common name "Ratitæ" he regarded as convenient rather than an indication of close affinity.

Similarly we regard the *Palæognathæ* as the unsuccessful descendants of proto-carinate forms, but retaining probably but few of their characteristics unaltered. It would be too much to regard any of the existing *Neognathæ* as the direct descendants of any of the existing or extinct *Palæognathæ* known to us, but it seems not

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[1] Blanchard in 1859 substituted for Merrem's the terms Tropido- and Homalosterni.

improbable that their source may be traced to that stock which gave rise to the Rheo-Dinornithine type of palate and pelvis.

Casuarius, which forms the nucleus of this research, is here regarded as only generically distinct from *Dromæus*. These two forms are, it is here contended, closely allied. *Struthio* is perhaps derived from the same ancestral stock. Hitherto, however, these two forms, *Casuarius* and *Dromæus*, have been regarded as more closely allied to *Dinornis* and *Apteryx* than any other forms. *Apteryx* we regard as quite distinct. The interrelationships of this group are indicated in the diagram (p. 265).

The skeleton of *Dromæus ater*, procured at the last moment, at great trouble, by Mr. Rothschild, has proved of considerable interest in one or two respects. It does not differ much, however, from that of the larger species: wherein it differs it appears to approach the Cassowaries. I have seen no authenticated skeleton of *D. irroratus*.

Skulls of adult *Casuarius* and *Dromæus* are badly needed; as also is the adult skeleton of *Rhea darwini*. It is interesting to note that the characteristic feathered tarso-metatarsus of *R. darwini* is temporarily reproduced in the embryo of *R. americana* (fig. 2 D, p. 155).

Whether the four species of Ostrich indicated in this paper will be further confirmed is a point which time alone will show. It seems probable.

I hope to be able to supply much that is lacking in this paper by a further contribution at no distant date in the shape of an Appendix. Since this was written the British Museum has acquired a hind-limb of *Genyornis*. This is remarkable chiefly on account of the fact that digit II. was becoming absorbed. The proximal phalanx was of great length and slenderness. In this we may trace the early stage in the evolution of a second two-toed Struthious bird. As Messrs. Stirling and Zeitz have shown, *Genyornis* was undoubtedly a near ally of *Dromæus*.

KEY TO THE OSTEOLOGY OF THE PALÆOGNATHÆ,

based on the Characters of the Adult Skeleton.

A. SKULL. (Plates XLII.–XLIV.)

The pterygoid free anteriorly or resting on the paired posterior ends of a large vomer; connected with the palatine either by the opposition of its outer border with the mesial border of the palatine or by squamous suture, or by complete fusion, but *never by means of opposed glenoid surfaces.* The vomer is always present, and paired, and is either fused with or tightly wedged in between the maxillo-palatine processes; basipterygoid processes always present, of great size, seated at the base of the parasphenoidal rostrum, and articulating with the extreme proximal end of the pterygoid; nasal processes of the premaxilla unpaired; parasphenoidal rostrum and mesethmoid continued forward beyond the level of the lachrymal.

A. Beak short or of medium length, never probe-shaped.

a. Vomer deeply cleft posteriorly into widely expanded right and left limbs running directly backwards beneath the pterygoids; palatine articulating *posteriorly by its mesial border with external border of the combined vomer and pterygoid;* vomer of great length, continued forwards beyond the free end of the parasphenoidal rostrum; pterygoid laminate; orbital process of quadrate decurved and articulating with the pterygoid at its base; anterior palatine foramen very small, and lying near the tip of the beak beyond the vomer; anterior narial and lachrymo-nasal fossæ, in dried skull, confluent; mesethmoid with a truncated anterior border; nasal process of premaxilla rod-shaped; nasal with a vestigial external process.

a'. Vomer expanded into a broad flattened plate between the maxillo-palatines, and separated from the parasphenoidal rostrum; beak dorso-ventrally depressed; palatine fenestrated posteriorly, not anchylosed with pterygoid; horizontal plate of mesethmoid appearing on the surface of the skull between nasals, but never inflated to form a casque; lachrymals fusing with nasals and frontals; with long supra-orbital processes . . . . *Dromæus.*

b'. Vomer only very slightly expanded between the maxillo-palatines; beak laterally compressed; palatine unfenestrated and anchylosed with the pterygoid and vomer; horizontal plate of mesethmoid, nasals, and more or less of frontals inflated to form a casque, sometimes of great size; quadrato-jugal fossa not extending forwards to level of antorbital plate . . . . *Casuarius.*

b. Vomer large, trough-shaped, closely investing the parasphenoidal rostrum; distal end of pterygoid and hinder end of vomer hidden (in ventral aspect of skull) by the palatine which underlies them; pterygoid rod-shaped.

c'. Vomer deeply cleft anteriorly, exposing the parasphenoidal rostrum between a pair of long spurs; anterior palatine foramen long and slit-like.

a''. Lachrymo-nasal fossa bounded anteriorly by a bony spike rising upwards from the middle of the external border of maxillo-palatine; with large post-orbital processes; orbital process of quadrate very short, not extending beyond level of articulation with pterygoid; lachrymal with large orbital processes; mesethmoid visible as a lozenge-shaped plate between nasals . . . . *Rhea.*

b''. Lachrymo-nasal fossa bounded anteriorly by a delicate rod articulating above with the nasal and below with the hinder border of the maxillo-palatine plate; no post-orbital processes; orbital process of quadrate moderately long, with a free end projecting beyond articulation with pterygoid; lachrymal without orbital processes; nasal schizorhinal; inter-orbital septum perforate; mesethmoid not visible on surface of skull . . . . *Tinamidæ.*

d'. Vomer truncated anteriorly, not extending so far forward as the end of the parasphenoidal rostrum; anterior palatine foramen small, closed by anterior end of parasphenoidal rostrum; large post-orbital processes; lachrymals fused with frontals and not readily traceable; orbital process of quadrate long, articulating with whole inner border with pterygoid; olfactory cavity of great size . . . . *Dinornithidæ.*

c. Vomer deficient posteriorly, not extending backwards to reach the pterygoid, anteriorly extending forwards, as in *Dromæus,* to conceal the parasphenoidal rostrum; the body of vomer deeply hollowed, fitting closely on to the rostrum, and embraced on either side by the maxillo-palatine processes; maxillo-palatine processes hastate; anterior palatine processes of great size; pterygoid laminate; palatine rod-shaped, fused proximally with external border of pterygoid; premaxilla wanting a palatine process; lachrymals continued backwards to fuse with a chain of supra-orbitals and with the frontals, so as to enclose a supra-orbital foramen; lachrymal with an *osiculum lachrymo-palatinum*; nostrils holorhinal; anterior narial and lachrymo-nasal fossæ confluent; quadrate with long recurved process bearing a well-defined projecting facet for the pterygoid in the middle of its internal ventral border . . . . *Struthio.*

B. Beak elongated, decurved, probe-shaped; anterior narial fossa minute, confined to tip of beak; lachrymo-nasal fossa enormous, extending forwards to within a short distance of tip of beak; skull rounded, without post-orbital processes; lachrymal vestigial; olfactory chamber of great size, extending backwards to optic foramen; vomer passing backwards to fuse with the pterygoid and palatine, and, with these, helping to form the floor of a tubular recess opening inwards . . . . *Apteryx.*

Key to the Species.

STRUTHIO.

a. Maxillo-palatine processes not rising dorsad, the anterior border of the maxillo-palatine process at right angles to the long axis of the skull.

a′. Palatines projecting distad beyond anterior border of maxillo-palatine process; maxillo-palatine processes without any external lateral fenestrated plate . . . . *S. australis.*

b′. Palatines not reaching as far forward as the level of the anterior border of the maxillo-palatine process.

a″. Vomer very short; parasphenoidal rostrum thick; maxillo-palatine processes with an external lateral fenestrated plate . . . . *S. molybdophanes.*

b″. Vomer very long; maxillo-palatine processes without an external lateral fenestrated plate; parasphenoidal rostrum slender; roof of the skull with deep depressions mesiad of the supra-orbital ledges; nasals meeting in the middle line proximad of the nasal process of premaxilla . . . . *S. meridionalis*[1].

b. Maxillo-palatine processes rising dorsad; anterior border of maxillo-palatine processes sloping obliquely backwards; vomer broad, with short, pointed, posterior limbs; palatines projecting distad beyond maxillo-palatine processes . . . . *S. camelus.*

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[1] We believe that *Struthio massaicus* (Neum.) is identical with this bird.—W. R. & W. P. P.

APTERYX.

a. Vomer long, equal to or longer than the width across the paroccipital processes at widest, notched anteriorly, and with the median cleft not extending forwards beyond the middle . . . . *A. australis.*

b. Vomer less than width across paroccipital processes.

  a′. Vomer notched anteriorly, the median anterior portion nearly as long as the paired posterior limbs; paroccipital processes well defined; basitemporal plate bounded antero-laterally by a pair of ridges passing forwards into parasphenoidal rostrum . . . . *A. haastii.*

  b′. Vomer imperfect anteriorly, median portion much shorter than the paired posterior limbs.

    a″. Size not less than 7 inches . . . . *A. a. mantelli.*

    b″. Size not less than $6\frac{1}{4}$ inches . . . . *A. oweni.*

RHEA.

A. Temporal fossa more or less sharply defined and extending backwards to meet the lambdoidal ridge; lachrymal with elongated dorsal processes arching backwards over orbit.

  a. Posterior nares markedly wider anteriorly than posteriorly; anterior vomerine cleft not extending backwards to the level of the hinder angle of the lachrymo-nasal fossa; length of quadrato-jugal fossa less than width across beak measured across the maxillary pillars bounding the lachrymo-nasal fossa anteriorly . . . . *R. americana.*

  b. Posterior nares not wider anteriorly than posteriorly; anterior vomerine cleft extending backwards to the level of the hinder angle of the lachrymo-nasal fossa; length of quadrato-jugal fossa equal to width across beak at the level of the maxillary processes bounding the lachrymo-nasal fossa. *R. macrorhyncha*[1].

B. Temporal fossa not sharply defined and not extending backwards to lambdoidal ridge; lachrymals with short orbital processes; anterior vomerine cleft very short . . . . *R. darwini.*

DROMÆUS.

a. Length not exceeding 7 inches.

  a′. Post-orbital processes short . . . . *D. novæ-hollandiæ.*

  b′. Post-orbital processes long, extending downwards to within a short distance ($\frac{3}{10}$ in.) of quadrato-jugal bar . . . . *D. irroratus.*

b. Size not exceeding 5 inches; roof of skull with a very conspicuous cerebral dome . . . . *D. ater*[2].

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[1] The specific characters of this species have been drawn from a single adult skull, kindly lent me by Mr. Beddard from the Zoological Society's Collection.

[2] This skull is from a skeleton in the Florence Museum. The bones of the palate are missing. The cranium closely resembles that of *D. novæ-hollandiæ*, differing therefrom chiefly on account of its very small size and the prominence of the cerebral dome, whilst in the peculiar form of the inferior limbs of the lachrymal it

B. VERTEBRÆ (not including *Crypturi*)[1].

All the pre-synsacral vertebræ are heterocœlous and free; *all* the synsacral vertebræ develop high neural spines; intercentra are wanting.

A. Hyperapophyses of axis well developed; cervical vertebræ short; cervical diapophysial lamellæ large and conspicuous; at least one lumbo-sacral vertebra; sacro-caudal (post-sacral) vertebræ well ossified.

  a. Hyperapophyses of atlas moderate; neural spine of axis rather high; hyperapophyses of axis well developed; cervical vertebræ rather short; neural spines of cervical vertebræ well developed and greatly excavated postaxially; no neural spines laterally bifurcating; catapophyses commence at about the sixth vertebra, and do not form a ring; hypapophyses well developed, not much produced postaxiad; diapophysial lamella extending towards postzygapophysis, large and conspicuous; cervical ribs moderately long and styliform; thoracic and lumbar neural spines not much axially extended, and not subequal in height; post-sacral vertebræ raised in part, more or less, above ventral margins of acetabula; sacral vertebræ not plainly distinct from post-sacrals; sacral and post-sacral neural spines laterally expanded and separating the post-acetabular ilium; caudal vertebræ eight or nine; pygostyle cylindrical.

    a′. Total number of vertebræ fifty-four; cervical vertebræ seventeen or eighteen; vertebræ with ribs nine; post-sacral vertebræ nine or ten; pre-axial articular surface of atlas moderately notched dorsally; hypapophysis of axis much elongated; hypapophyses developed from the eighteenth or nineteenth to the twenty-third vertebra; a conspicuous fossa on each side of the pre-axial part of the neural spines of dorsal vertebræ; post-sacral vertebræ raised decidedly dorsad of ventral margins of acetabula . . . . *Dromæus.*

    b′. Total number of vertebræ from fifty-five to fifty-nine; cervical vertebræ fifteen or fourteen; vertebræ with (free) ribs eleven or twelve; sacro-caudal (post-sacral) vertebræ eight or nine; pre-axial articular surface of atlas moderate, may become a foramen; hypapophysis of axis extremely long; hypapophyses developed from eighteenth to twentieth vertebra; fossæ beside pre-axial part of neural spines very small; sacro-caudal (post-sacral) vertebra raised scarcely at all dorsad of acetabula . *Casuarius.*

  b. Hyperapophyses of atlas large; neural spine of axis lofty; hyperapophysis of axis moderate or extremely large; cervical vertebræ short; neural spines of cervical vertebræ generally more or less well developed; cata-

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resembles *D. irroratus.* In the conspicuous development of the cerebral dome it differs from both existing species.

I would remark here that the specific characters attributed to *D. irroratus* are based upon an examination of a single unnamed skull in the British Museum Collection; but these appeared to me to be sufficiently marked to justify my determination of this skull as of *D. irroratus.*

[1] This Key is compiled, with modifications, from Mivart's memoir.

pophyses may form a ring; diapophysial lamella extending towards postzygapophysis, large and conspicuous or extremely so; cervical ribs moderate or small; sacro-caudal (post-sacral) slightly raised dorsad of ventral margin of acetabulum; cervical vertebræ fifteen.

c′. Total number of vertebræ from forty-five to forty-seven; post-synsacral vertebræ three; pre-axial articular surface of atlas scarcely at all notched dorsally; hyperapophyses very long; a minute hypapophysis to atlas; no hypapophysis to axis; neural spine of axis very high; hyperapophysis of axis extremely large; catapophyses commence at the fifth vertebra, in the tenth and eleventh vertebræ they form a ring; hypapophyses developed from the twelfth cervical to the third thoracic vertebra; diapophysial lamella extremely large and conspicuous, developing conspicuous postaxially extending processes; cervical styliform ribs small; thoracic and lumbar neural spines exceedingly extended axially and subequal in height; synsacrum with sacral vertebræ plainly distinct from post-sacral; post-sacral bent much ventrad of ilia; free caudal vertebræ seven or nine; pygostyle conical. *Apteryx.*

d′. Hyperapophyses of axis moderate; neural spines of cervical vertebræ well developed and deeply excavated postaxially; neural spines of fourth, fifth, sixth, and seventh cervical vertebræ bifurcating laterally; catapophyses commencing at the fourth vertebra; hypapophyses commence at fifteenth (last cervical) vertebra; diapophysial lamella extending towards postzygapophysis, large and conspicuous; cervical ribs probably moderately long and rather styliform; thoracic and lumbar neural spines not much axially extended, and probably not subequal in height; synsacrum with post-sacrals not bent ventrad of ilia. *Dinornithidæ.*

B. Axis vertebra with a hypapophysis, with or without well-developed hyperapophyses; cervical vertebræ greatly elongated; neural spines of cervical vertebræ small or almost obsolete; catapophyses commencing about the sixth vertebra; catapophysis never forming a ring; diapophysial lamella extending towards posterior zygapophysis, small and inconspicuous; a conspicuous fossa on either side of pre-axial part of neural spines either of cervical or thoracic vertebræ; synsacrum with sacral vertebræ plainly distinct from post-sacral vertebræ.

e′. Total number of vertebræ fifty-six; cervical vertebræ seventeen; vertebræ with ribs ten; no lumbo-sacral vertebræ; synsacrum with eight post-sacral vertebræ; pre-axial articular surface of atlas with a large dorsal notch; hyperapophyses of atlas moderate; hypapophysis of axis rather small; neural spine of axis moderate; neural spines of cervical vertebræ small, but not obsolete; no neural spines bifurcating laterally; no neural spines aborted; hypapophyses developed from the eighteenth (first thoracico-dorsal) to the twenty-first (first thoracic) vertebræ; hypapophyses but little produced pre-axially; a conspicuous fossa on each side of pre-axial part of neural spines of thoracic vertebræ, but not of cervical; cervical ribs long and styliform; thoracic and thoracicolumbar neural spines but little axially extended, but considerably extended dorso-ventrally and not subequal in height; synsacrum with post-sacrals not at all raised dorsad of acetabula, but rather depressed ventrad; *post-sacrals perfectly ossified*; sacral plainly distinct from post-sacral vertebræ; no lumbo-sacral vertebræ; pre-caudal vertebræ ten; pygostyle a laterally compressed plate . . . . *Struthio.*

f'. Total number of vertebræ forty-nine; cervical vertebræ fourteen; pre-axial articular dorsal surface of atlas with only a minute dorsal notch; no hyperapophysis to atlas; hypapophysis of axis not very large; neural spine of axis not very high; hyperapophyses of axis well developed; neural spines of cervical vertebræ almost obsolete, those of fourth to seventh vertebræ abort; neural spines of thirteenth to sixteenth vertebræ bifurcate laterally; hypapophyses developed from last cervical to second dorsal vertebra; hypapophyses narrow and pre-axially produced; a conspicuous fossa on each side of pre-axial part of neural spines from twelfth to the fifteenth inclusive; cervical ribs short and not styliform; free cervical ribs nine; synsacrum with post-sacral vertebræ raised quite dorsad of acetabula, also very imperfectly ossified and much reduced; sacral plainly distinct from post-sacral vertebræ; post-sacrals nine; free caudal vertebræ five; pygostyle small and cylindrical . . . . *Rhea.*

The vertebral formula is :—

Dromæus . . . .

$$\text{Cv. }18 : \text{Cv. Th. }3 : \text{Th. }\overbrace{\underbrace{3+1+2}_{6} : \text{Lb. }6 : \text{Lb. sc. }2 : \text{Sc. }2 : \text{Cd. }\underbrace{9+9}_{18}}^{\text{Synsac.}}=55.$$

Casuarius . . . .

$$\text{Cv. }15 : \text{Cv. Th. }4 : \text{Th. }\overbrace{\underbrace{5+1+3}_{9} : \text{Lb. }5 : \text{Lb. sc. }2 : \text{Sc. }2 : \text{Cd. }\underbrace{9+9}_{18}}^{\text{Synsac.}}=55.$$

Struthio . . . .

$$\text{Cv. }17 : \text{Cv. Th. }3 : \text{Th. }\overbrace{\underbrace{5+2}_{7} : \text{Lb. }8 : \text{Sc. }2 : \text{Cd. }\underbrace{8+10}_{18}}^{\text{Synsac.}} \qquad =55.$$

Rhea . . . .

$$\text{Cv. }14 : \text{Cv. Th. }3 : \text{Th. }\overbrace{\underbrace{3+2+1}_{6} : \text{Lb. }3 : \text{Lb. sc. }4 : \text{Sc. }2 : \text{Cd. }\underbrace{9+8}_{17}}^{\text{Synsac.}}=49.$$

Apteryx . . . .
(*A. a. mantelli.*)

$$\text{Cv. }15 : \text{Cv. Th. }1 : \text{Th. }\overbrace{\underbrace{4+3+1}_{8} : \text{Lb. }4 : \text{Lb. sc. }4 : \text{Sc. }2 : \text{Cd. }\underbrace{3+8}_{11}}^{\text{Synsac.}}=45.$$

C. STERNUM (fig. 4, p. 217) AND PECTORAL ARCH[1].

The sternal plate is keelless; the coracoid anchyloses with the scapula, and lacks the acro-coracoid, the coraco-scapular angle is very wide; furcula vestigial or absent.

A. Coracoid grooves not widely separated.

  a. Metasternum pointed, no posterior lateral processes; pro-coracoid not forming a distinct bar.

    a′. Coracoid grooves and bases of coracoids overlapping; anterior lateral process long, directed upwards and backwards; a pair of short recurved processes lying on the anterior sternal border between the anterior lateral processes; with vestigial clavicles; sternal plate nearly as broad as long; coracoid longer than broad . . . . *Dromæus.*

    b′. Coracoid grooves not overlapping; anterior lateral processes of sternum short or obsolete; no clavicles; sternal plate much longer than broad; coracoid as broad as long . . . . *Casuarius.*

  b. Metasternum more or less pointed, with large posterior lateral processes; pro-coracoid of great size, forming a distinct bar of bone; body of the sternum with a conspicuous ventral prominence; no clavicles; articular surfaces for ribs of great width . . . . *Struthio.*

B. Coracoid grooves widely separated.

  a. Corpus sterni basin-shaped with a marked ventral prominence; posterior lateral processes absent; anterior lateral processes conspicuous, each with a large pneumatic aperture at the base; articular surfaces for ribs crowded together immediately behind the anterior lateral processes; coracoid grooves at the base of the anterior lateral processes and separated one from another by the wide emarginate body of the anterior border of the sternum; coracoids long and slender; pre-coracoid relatively small. *Rhea.*

  b. Sternal plate flat, slightly or not at all pneumatic; metasternal and posterior lateral processes always present; facets for ribs not separated by deep pneumatic pits.

    a′. Articular facets for ribs widely spaced, and lying entirely behind the anterior lateral processes, and not separated by deep pneumatic pits; coracoid nearly as broad as long; pre-coracoid not conspicuous . . . *Apteryx.*

    b′. Facets for ribs crowded, few in number, and partly underlying the base of the anterior lateral processes; coracoid extremely reduced . . . *Dinornithidæ.*

C. Sternal plate flat, pneumatic; metasternal element wanting; facets for ribs separated by deep pits; sternal plate exceedingly narrow from before backwards . . . . *Æpyornis.*

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[1] The sternum and pectoral arch of the *Crypturi* will be found described on pp. 221 & 263.

Key to the Species.

Struthio.

a. Middle region of anterior border straight or slightly arched; length of coracoid groove greater than distance between articulations of sternal ribs 1–5.

  a′. Posterior lateral processes long and spatulate, with an extensively ossified metasternal region between the posterior lateral processes . . . . . *S. molybdophanes.*

  b′. Posterior lateral processes moderately long; ossified metasternal region between posterior lateral processes small . . . . *S. camelus.*

b. Middle region of anterior border of sternum sinuous; posterior lateral processes not spatulate; no projecting metasternal region between the posterior lateral processes; length of coracoid groove less than the distance between the articulations of sternal ribs 1–5.

  c′. Width between the free end of the anterior lateral processes much greater than the width across their bases . . . . *S. meridionalis.*

  d′. Width across free end of posterior lateral processes about equal to the width across their bases . . . . *S. australis.*

Rhea.

a. Anterior border of sternum between the coracoid grooves slightly excavated; width between right and left coracoid grooves greater than length of articular surface for coracoid; articular surfaces for sternal ribs 3 . . . *R. americana.*

b. Outer border of sternum between the coracoid grooves deeply excavated; width between right and left coracoid grooves equal to or less than length of articular surface for coracoid; articular surfaces for sternal ribs 4 . . . *R. macrorhyncha.*

Dromæus.

a. Length $6\frac{1}{2}$ in. Coracoid grooves distinct and the sternal protuberance but slightly developed . . . . *D. novæ-hollandiæ.*

b. Length not exceeding $3\frac{7}{8}$ in.; coracoid grooves obsolete; the ventral lip of right side only represented; sternal protuberance conspicuous . . . . . *D. ater.*

Casuarius.

A. With a pair of low, median, keel-like ridges lying immediately behind a line drawn across the sternum immediately behind the coracoid grooves, without median pneumatic cavity between the coracoid grooves . . . . *C. unappendiculatus.*

B. Without paired median ridges; with large pneumatic cavity between the coracoid grooves.

  a. Coracoid grooves deep, the lower lip strongly marked when seen from above; pneumatic cavity very large, extending backwards into a low swollen protuberance lying in the middle line of the sternum between the coracoid grooves.

a′. Width between inner angles of articulation for last sternal rib less than width across metasternum at widest . . . . *C. casuarius.*

b′. Width between inner angles of articulation for last sternal rib greater than width across metasternum at widest . . . . *C. c. beccarii.*

b. Coracoid grooves shallow, lower lip not strongly marked when seen from above; mouth of the pneumatic aperture produced forward into prominent lips; anterior lateral process short and recurved. Metasternal region very long and narrow.

c′. Width across anterior lateral processes of sternum twice width of metasternum . . . . *C. bennetti.*

d′. Width across anterior lateral process of sternum less than twice width across metasternum . . . . *C. picticollis.*

D. PELVIC ARCH[1]. (Pl. XLIV. fig. 5.)

Synsacral neural spines of great height; sacral vertebræ, and sometimes the last lumbo-sacral, and first and second caudals with conspicuous pleurosteal elements; pre-acetabular ilia always meeting in the mid-dorsal line above the neural spines of the synsacrum; the synsacral neural spines never projecting beyond the level of the post-acetabular ilia; ilio-ischiadic fissure either permanently open or closed only by the fissure of the extreme ends of the ilium and ischium.

A. Pubes remaining permanently free caudad.

a. With the post-acetabular ilia more or less widely separated in the mid-dorsal line; a more or less well-developed supra-trochanteric process.

a′. Post-acetabular ilia separated by the intervention of the synsacral neural spines; ischia bowed inwards towards the middle line, and fused posteriorly with the ilium; perforation of inner wall of acetabulum constricted by ossification.

a″. Post-acetabular longer than pre-acetabular ilium, and tapering gently . . . . *Dromæus.*

b″. Post-acetabular shorter than pre-acetabular ilium, and arched dorsally . . . . *Casuarius.*

b′. Post-acetabular ilia widely separated by means of transverse processes, leaving neural spines in middle of a deep fossa roofed in late in life by a sheet of bone; ischia widely separated one from another and from post-ilia; post-acetabular with a very wide dorsal plane.

c″. Median fossa dividing post-acetabular ilia only imperfectly roofed in, leaving a more or less extensive cleft on either side of a broad, flat neural plate . . . . *Dinornithidæ.*

d″. Median fossa dividing post-acetabular ilia completely roofed by bone, but perforated by a double row of foramina, one on either side of the median line . . . . *Æpyornis.*

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[1] The pelvic arch of the *Crypturi* will be found described on p. 263. There was no need to include it here.

b. Post-acetabular ilia closely approximated, the neural spines at most only barely visible between the closely approximated innominates; no supratrochanteric process; ischia widely separated from post-acetabular ilium; obturator foramen and fissure confluent; post-sacral vertebræ of the synsacrum welded into a large laterally compressed mass, bent down so as to bring the neural crest to the level of the ventral border of the post-ilium . . . . *Apteryx.*

B. Pubes anchylosed caudad with one another or with ischium.

c. Post-acetabular ilia widely separated from ischia, and from one another in the mid-dorsal line; pubes fused caudad (*a*) with the ischia and (*b*) with one another in the mid-ventral line; the synsacral vertebræ appearing below the level of the ventral border of the ilium . . . . *Struthio.*

d. Post-acetabular ilia anchylosed with ischia, and with one another in the mid-dorsal line; pubes anchylosed with ischia caudad; ischia closely united in the middle line one with another throughout almost entire length (unique); the post-sacral vertebræ of the synsacrum atrophied . *Rhea.*

Key to the Species.

RHEA.

a. Pre-ilium not projecting forward beyond the last thoracic vertebra and rib, which forms the limit of the synsacrum cephalad . . . . *R. americana.*

b. Pre-ilium projecting forward conspicuously beyond the last thoracic vertebra and rib . . . . *R. macrorhyncha.*

APTERYX.

A. Width across anti-trochanter equal to or less than the width of pre-acetabular ilium at widest.

a. Pre-acetabular ilium of great width, with a strongly arched dorsal border, and large laterally expanded antero-ventral angles; width across pre-acetabular ilia at widest part = to length of ischium, and far exceeding length of post-acetabular ilium; post-acetabular ilium with a sudden widening at its free end; breadth of pre-ilium at widest = breadth across anti-trochanter . . . . *A. australis.*

B. Width across anti-trochanter always greater than width of pre-acetabular ilium at widest; post-acetabular tapering caudad; breadth of pre-ilium at widest less than breadth of anti-trochanter.

b. Pectineal process large; five lumbar vertebræ.

a′. Post-acetabular ilium with a concave ventral border, and a slight notch immediately behind the anti-trochanter . . . . *A. haasii.*

b′. Post-acetabular ilium with straight or convex ventral border; no notch behind the anti-trochanter . . . . *A. oweni.*

c. Pectoral process small; four lumbar vertebræ . . . . *A. a. mantelli.*

Dromæus.

a. Length 17 in.; pectineal process well developed; dorsal border of pre-ilium much arched; obturator fissure nearly closed; pubo-ischiadic fissure nearly closed . . . . *D. novæ-hollandiæ.*

b. Length $9\frac{1}{2}$ in.; pectineal process obsolete; dorsal border of pre-ilium not arched; obturator fissure wide; pubo-ischiadic fissure very wide . . . . *D. ater.*

E. Pectoral Limb.

A. Extended forearm and hand longer than the humerus; ulnare resembling that of the typical Neognathæ; radius and ulna long, with but a narrow chink between them; distal end of Me. II. flabelliform . . . . *Rhea.*

B. Extended forearm and hand much shorter than the humerus.

a. Humerus with a shallow, but blind subtrochanteric fossa; a very strongly developed linea aspera for the triceps, forming a conspicuous triangular ridge; radius and ulna short and bowed; ulnare a simple nodule; distal end of Me. II. not markedly expanded; manus as in *Rhea*, resembling typical carinate form, though too small for purposes of flight . . . . *Struthio.*

b. Humerus much bowed, without subtrochanteric fossa or indication of pectoral crest; radius and ulna with but a very narrow chink between them; a vestigial radiale and ulnare; a vestigial pollex bearing an unequal phalanx, with the Me. III. incomplete and free distally . . . *Apteryx.*

C. Extended forearm and hand about equal to the length of the humerus; a subtrochanteric fossa; radiale and ulnare anchylosed with metacarpals.

a. Subtrochanteric fossa large; ulnare indistinguishable; radiale anchylosed with radius and carpo-metacarpus, but distinguishable. . . . . *Casuarius.*

b. Subtrochanteric fossa very small; no carpal elements distinguishable; neither pollex nor third digit represented . . . . *Dromæus.*

F. Pelvic Limb.

When the bones are pneumatic only the femur is conspicuously so; save in the *Dinornithidæ* the extensor bridge is wanting; the hallux, when present, is never large.

a. Toes three in number; tarso-metatarsus far exceeding femur in length.

a′. Ectocnemial crest large, rivalling the procnemial in size; ento-condyle with a deep lateral pit; distal extremity of shaft above entocondyle (lateral surface) with a deep groove.

a″. Procnemial crest extending down the shaft; femur with a large pneumatic aperture . . . . *Dromæus.*

b″. Procnemial crest not extending down the shaft; femur non-pneumatic; ungual phalanx of inner toe greatly elongated . . . . *Casuarius.*

b′. Ectocnemial crest small, a mere tubercle of the procnemial; no entocondylar pit or groove on the lateral surface of the shaft; a moderately conspicuous extensor groove; popliteal fossa of the femur very deep; ungual phalanges laterally compressed . . . . *Rhea.*

- *b*. Toes two in number; tarso-metatarsus far exceeding the femur in length.
  - *c'*. Ectocnemial crest small, a mere tubercle on procnemial; fibula extending to level of proximal tarsal mass; extensor groove obsolete; a deep entocondylar pit continued backwards into a groove; the lateral ventral border of ento- and ecto-condyles continued backward and upward to project spur-wise from the shaft . . . . *Struthio.*
- *c*. Toes four; tarso-metatarsus short.
  - *d'*. Extensor bridge wanting.
    - *c''*. Femur long and slender; tibio-tarsus with a deep intercondylar gorge; entocondyle very large, projecting conspicuously in front of shaft in lateral view; none of the phalanges conspicuously shortened . . . *Apteryx.*
    - *d''*. Femur very short and thick, with enormous great trochanter; tibio-tarsus without intercondylar gorge, ento- and ecto-condyles not being clearly distinguishable: Ph. 2. D. I. short; Ph. 2, 3, 4. D. IV. short. *Æpyornis.*
  - *e'*. Extensor bridge present; femur short; ento-condyle of tibio-tarsus large, resembling that of *Apteryx* . . . . *Dinornithidæ.*

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EXPLANATION OF THE PLATES.

PLATE XXII.

Casuarius casuarius. Common Cassowary (p. 113). (Drawn from life from a bird formerly at Tring, now living in Dublin.)

PLATE XXIII.

Casuarius casuarius beccarii. Beccari's Cassowary (p. 116). (Drawn from life from a bird formerly at Tring, now in the Society's Gardens.)

PLATE XXIV.

Casuarius casuarius salvadorii. Salvadori's Cassowary (p. 120). (Drawn from life from a bird formerly alive at Tring, now mounted in the Tring Museum.)

PLATE XXV.

Casuarius casuarius australis. Australian Cassowary (p. 123). (Drawn from life from a bird that lived ten years at Tring, and is now living in the Society's Gardens.)

PLATE XXVI.

Casuarius casuarius violicollis. Mauve-necked Cassowary (p. 122). (Drawn from life from the type specimen formerly at Tring, now living in the Society's Gardens.)

PLATE XXVII.

Casuarius casuarius intensus. Blue-necked Cassowary (p. 121). (Drawn from life from the type specimen formerly at Tring, now mounted in the Tring Museum.)

PLATE XXVIII.

Casuarius bicarunculatus. Two-wattled Cassowary (p. 129). (Drawn from life from a bird formerly at Tring, now living in the Society's Gardens.)

PLATE XXIX.

Casuarius unappendiculatus. One-wattled Cassowary (p. 132). (Drawn from life from a bird in the possession of Mr. Blaauw.)

PLATE XXX.

Casuarius unappendiculatus. One-wattled Cassowary (p. 132). Whole birds, adult and young. (The figure of the adult was made from Mr. Blaauw's bird; the young was drawn from a bird at Tring, the skin of which is preserved in the Tring Museum.)

PLATE XXXI.

Casuarius unappendiculatus occipitalis. Jobi Island Cassowary (p. 135). (The head, neck, and naked parts were drawn from a bird now living in the Society's Gardens, the casque from the mounted specimen in the Paris Museum.)

PLATE XXXII.

Casuarius unappendiculatus aurantiacus. Eastern One-wattled Cassowary (p. 136). (Drawn from life from the type now living in the Berlin Zoological Gardens.)

PLATE XXXIII.

Casuarius philipi. Sclater's Cassowary (p. 138). (Drawn from life from the type now living in the Society's Gardens.)

PLATE XXXIV.

Casuarius papuanus. Westermann's Cassowary (p. 139). (Drawn from life from two specimens formerly at Tring and the Society's Gardens, now preserved in the Tring Museum.)

PLATE XXXV.

Casuarius papuanus edwardsi. Milne-Edwards's Cassowary (p. 141). (Drawn from life from a specimen formerly at Tring, now mounted in the Tring Museum.)

PLATE XXXVI.

Casuarius picticollis. Painted-necked Cassowary (p. 143). (Drawn from the plate in Gould's 'Birds of New Guinea.')

PLATE XXXVII.

Casuarius picticollis hecki. Heck's Cassowary (p. 144). (Drawn from life from the type specimen living in the Berlin Zoological Gardens.)

PLATE XXXVIII.

Casuarius loriæ. Loria's Cassowary (p. 142). (Drawn from a sketch made from a fresh-killed bird by Dr. Loria.)

PLATE XXXIX.

Casuarius bennetti. Bennett's Cassowary (p. 145). (Drawn from life from a bird formerly at Tring, now in the Zoological Society's Gardens.)

PLATE XL.

Map showing the geographical distribution of the six subspecies of *Casuarius casuarius* and of *Casuarius bicarunculatus.*

PLATE XLI.

Map showing the geographical distribution of the three subspecies of *Casuarius unappendiculatus*, two of *Casuarius papuanus*, two of *Casuarius picticollis*, *Casuarius loriæ*, and *Casuarius bennetti.*

PLATE XLII.

The dorsal aspect of the Skull (figs. 1–4).

Fig. 1. The skull of *Rhea americana* (p. 270), to show the form of the temporal fossa, the partly fused mesethmoid plate, the form of the lachrymals and nasals, and the broad nasal process of the premaxilla.

Fig. 2. The skull of *Dromæus novæ-hollandiæ* (p. 270), showing the rod-like nasal process of the premaxilla, the fused lachrymal, broad interorbital region, and widely separated temporal fossæ.

Fig. 3. The skull of *Struthio molybdophanes* (p. 269), showing the supra-orbital ossicles running backwards from the lachrymal to the frontal, and the broad nasal process of the premaxilla. The mesethmoidal suture is obliterated.

Fig. 4. The skull of *Apteryx australis* (p. 269), showing the small size of the lachrymal and the absence of its supra-orbital processes, the complete fusion of the nasal process of the premaxilla, and the rounded form of the frontals, which do not protect the orbit above.

Ventral aspects (figs. 5–8)

Fig. 5. The ventral aspect of fig. 1, showing the large size of the palatine processes of the premaxilla and of the maxillo-palatine processes. The peculiar relations between the vomer, palatine, and pterygoid (described on p. 207), and the anterior end of the parasphenoidal rostrum between the anterior cleft of the vomer.

Fig. 6. Ventral aspect of fig. 2, showing the broad vomer and its continuance backwards on to the pterygoid. The palatines articulate with the external border of the foot of the vomer and external border of the pterygoid. In *Rhea* the articulation between pterygoid and vomer is concealed by the palatine.

Fig. 7. Ventral aspect of fig. 3, showing the vestigial vomer, which does not now articulate with the pterygoid. Note the absence of the palatine processes of the premaxillæ. The palatine has fused with the external pterygoid border.

Fig. 8. Ventral aspect of fig. 4, showing the complete fusion of the vomer, pterygoid, and palatine.

Additional Letters.

ant.b.f. = anterior basi-cranial fontanelle.
ant.h. = antrum.
b.b.p. = basitemporal platform.
b.p. = basipterygoid processes.
hy.for. = hypoglossal foramina, 1, 2, 3.
l. = lachrymal.
l.p. = lachrymo-nasal pillar.
l.r. = lambdoidal ridge.
m.e. = mesethmoid.
mx.p. = maxillo-palatine process.
n.pmx. = nasal process of premaxilla.
n. = nasal.
o.c. = occipital condyle.
pa. = palatine.
pa.r. = parasphenoidal rostrum.
p.pmx. = palatine process of premaxilla.
p.p. = paroccipital process.
pt. = pterygoid.
s. = supra-orbital bones from lachrymal to frontal.
v. = vomer.
vag.for. = vagus foramen.

PLATE XLIII.

The immature Skull.

Fig. 1. Dorsal aspect of the palatine bones of *Apteryx mantelli* (p. 204), to show the sutures, as yet unclosed, between the vomer, pterygoid, and palatine.

Fig. 1 *a*. Ventral aspect of the same, to show similar sutures.

Fig. 2. Sagittal section of skull of *Apteryx australis mantelli*, after Parker, for the purpose of comparison with *Dromæus*. Note the appearance of the squamosal on the inside of the skull in *Apteryx*.

Fig. 3. Ventral aspect of the skull of *Emeus* (p. 270), for the purpose of comparison with *Rhea*. Note the similarity in the relations of the pterygoid and vomer.

Fig. 4. Sagittal section of cranium of embryo *Dromæus novæ-hollandiæ*, to show the separate bones.

Fig. 4 *a*. Outer view of fig. 4. Note how completely the squamosal conceals and protects the pro- and opisthotic bones. In the nestling Penguin the squamosal is deeply emarginate posteriorly and exposes the otic bones.

Fig, 5. Ventral aspect of base of skull of *Rhea americana*, to show sutures.

Fig. 5 *a*. Lateral aspect of skull of *Rhea americana*, to show sutures. Note the vertical spine (lachrymo-nasal pillar) from the maxillo-palatine process, which replaces the maxillary process of the nasal; the remarkably small size of the quadrato-jugal; and the outer and inner views of the lower jaw.

Fig. 5 *b*. Lateral aspect of pterygoid of *Rhea americana* (p. 191), to show its relations with the vomer.

Fig. 5 *c*. Outer aspect of mandible of fig. 5, to show sutures.

Fig. 5 *d*. Inner aspect of mandible of fig. 5, to show sutures.

Fig. 6. Quadrate of *Bubo maximus*, to show double, widely separate, squamosal articular head. Nat. size.

Fig. 7. Quadrate of *Dromæus irroratus*?, posterior aspect, to show single articular head. Nat. size.

Fig. 8. Quadrate of *Apteryx oweni*, posterior aspect, to show double squamosal head.

ADDITIONAL LETTERS.

a. = angulare.
als. = alisphenoid.
ar. = articulare.
ant. = antrum of Highmore.
b.s. = basisphenoid.
d. = dentary.
cor. = coronoid.
ep.o. = epiotic.
ex. = exoccipital.
f.f. = floccular fossa.
fr. = frontal.
m. = meatus internus.
mes. = mesethmoid.
op. = opisthotic.
o.h. = otic head of quadrate.
o.r. = orbital process of quadrate.
p. = parietal.
p.f. = precondylar fossa.
pro. = pro-ötic.
s.a. = supra-angular.
s.o. = supra-occipital.
sp. = splenial.
sq. = squamosal.
sq.h. = squamosal head of quadrate.
vag.f. = vagus foramen.
vo.pr. = vomerine process of premaxilla.
l.p. = lachrymo-nasal process of premaxilla.

PLATE XLIV.

Fig. 1. Dorsal aspect of the skull of an adult *Dromæus ater* (p. 270), to show the conspicuous, embryonic, cerebral prominence and the fused lachrymals.

Fig. 1 *a*. Lateral view of the same skull (fig. 1), showing the cerebral prominence and temporal fossæ.

Fig. 2. Dissection of a skull of a young *Dromæus novæ-hollandiæ*, lateral view, to show the form and position of the mesethmoid for comparison with fig. 3 *et seq.*

Fig. 3. The mesethmoid of a young *Casuarius unappendiculatus* (p. 199), to show the mesethmoid and the large median superposed element forming the centre of the casque of the adult.

Fig. 4. Lateral aspect of a portion of the skull of *Casuarius sclateri*, showing the frontal, nasal, and median elements of the casque.

Fig. 4 *a*. Dorsal aspect of fig. 3 *a*.

Fig. 4 *b*. Dissection of a skull of *Casuarius sclateri*=fig. 3 *a*, showing the mesethmoid and a portion of the ventral border of the median ossification of the casque interpolated between the mesial border of the anterior ends of the frontal.

Fig. 5. Lateral view of the synsacrum of a young *Casuarius unappendiculatus* after removal of the right innominate, to show the great height of the neural spines of the vertebræ.

Fig. 6. Lateral view of the synsacrum of an embryo *Dromæus novæ-hollandiæ* (p. 212), prepared for comparison with fig. 5. Note that at this stage the neural spines have not yet risen above the centra of the vertebræ, but form only a series of lateral wings.

Fig. 6 *a*. Dorsal aspect of a portion of the synsacrum (fig. 6), to show more clearly that the neural spines do *not* rise above the centra as in the adult condition (fig. 5).

Fig. 6 *b*. Lateral view of the same pelvis (fig. 6), to show the separate elements of the innominate.

ADDITIONAL LETTERS.

ant.=anti-trochanter.
f.c.=frontal moiety of casque.
il.=ilium.
il.is.f.=ilio-ischiadic foramen.
is.=ischium.
lb. 1–6=lumbar vertebræ 1–6.
lb. 1–2=lumbo-sacral vertebræ 1–2.
me.c.=median element of casque.
n.c.=nasal element of casque.
ob.=obturator fissure.
o.p.fr.=orbital process of frontal.
p.=pubis.
p.p.=pectineal process.
pubo-isch.f.=pubo-ischiadic fissure.
s.c.=sacral vertebræ 1–2.
s.cd.=sacro-caudal vertebræ.
s.th.=sacro-thoracic ,,
Synsacral vertebræ.
v.=vestigial thoracic rib.
v.me.=ventral border of mesethmoid.

PLATE XLV.

Fig. 1. The buccal cavity of *Rhea americana* (p. 248), to show the large choanæ characteristic of the *Palæognathæ*.

Fig. 2. A neossoptile of *Calodromas elegans* (p. 162), after Pycraft, to show the large aftershaft, equalling the main shaft in size, the complex rami of the main shaft, and their production forwards into horny filaments resembling the grooved ribbon-shaped bands of the young Ostrich (fig. 7).

Fig. 2 *a*. A radius from the distal end of the main shaft.

Fig. 3. A neossoptile of *Rhea americana* (p. 164): neither the main nor the aftershaft have a distinct rhachis. The main shaft is represented by three stiffened rami, produced into filaments as in Tinamous and Ostrich, the aftershaft by numerous slender rami.

Fig. 3 *a*. A portion of a radius from fig. 3 (p. 164). Note the absence of fila.

Fig. 4. A neossoptile of *Dromæus novæ-hollandiæ* (p. 162). The aftershaft is barely distinguishable; the main shaft well developed: compare with figs. 3–7.

Fig. 4 *a*. A portion of a radius of fig. 4. Fila are yet represented but are small.

Fig. 5. A portion of a radius of *Casuarius casuarius*, showing the still further suppression of the fila.

Fig. 6. A neossoptile of *Apteryx mantelli* (p. 163). There is no aftershaft.

Fig. 6 *a*. A portion of a radius of fig. 6. Note that fila are numerous and large, indicating a less degenerate condition than figs. 4 *a* and 5.

Fig. 7. A neossoptile of *Struthio camelus*, showing the three peculiarly modified rami described on p. 164, and representing the main shaft, and the numerous downy rami representing the aftershaft.

Fig. 7 *a*. A portion of a radius of fig. 7. These are flattened as in *Crypturi* (fig. 2). Note the "eye-spots."

Fig. 8. Dissection of the air-sacs of the left side of a *Casuarius unappendiculatus* (p. 252), showing the three divisions of the anterior intermediate sacs and the positions of the ostia throughout. Note the position of the anterior end of the posterior abdominal air-sac—forcing down the roof of the posterior intermediate. The posterior abdominal, furthermore, is seen to take the form of a more or less sausage-shaped sac adherent to the inner wall of the posterior intermediate. It encloses a part of the kidney.

Fig. 9. Dissection of the left lung of *Casuarius unappendiculatus* (p. 252), to show the costo-pulmonary muscle, meso-, ecto-, and ento-bronchia and their ramifications. Note that the ento-bronchia 1 and 3 between them supply all the tubulæ of the ventral surface of the lung described on p. 252. The systems fed by ento-bronchium 1 have been exposed by dissection, those fed by ento-bronchium 2 lie caudad of these and are concealed by the aponeurosis.

Fig. 10. Ventral aspect of a dissection of the wing of an adult *Casuarius casuarius*, to show the hypertrophied calami described on p. 165.

Fig. 11. Dorsal aspect of a preparation of the wing of an Ostrich. *After Wray*.

Fig. 12. Dorsal aspect of a portion of the wing of *Rhea americana* (p. 156), to show the remarkable distribution of the coverts in transversely oblique bundles.

Fig. 13. Ventral aspect of the wing of *Apteryx mantelli* (p. 161), to show the number of remiges and their remarkable resemblance to the young Cassowary described on p. 165.

Fig. 14. A remex of a nestling *Casuarius australis*, dorsal aspect, before the loss of the rhachis described on p. 165.
Fig. 14 *a*. Ventral aspect of fig. 14, to show the peculiar rhachis.
Fig. 14 *b*. Section of the rhachis of figs. 14–14 *a* (p. 165).
Fig. 15. A remex of *Apteryx mantelli* (p. 166), for comparison with that of the young Cassowary described p. 165.

ADDITIONAL LETTERS.

a. = aftershaft.
*a.int.*1–3 = anterior intermediate air-sacs 1–3.
a.s. = ala spuria.
ap. = aponeurosis.
c. = calamus.
c.c. = carpal covert.
ch. = choanæ.
cl. = claw.
c.p.m. = costo-pulmonary muscle.
c.r. = carpal remex.
c.r. = cubital remiges.
* = hypothetical carpal covert.
** = ,, ,, remex.
e. = eye-spots.
ect. = ecto-bronchia.
ent. = ento-bronchia.
eu. = eustachian aperture.
f. = filum.
h. = heart.
k. = kidney.
mb. = meso-bronchium.
m.d.r. = metacarpo-digital remiges.
o. = ostium posterius.
obl.sep. = oblique septa.
o.ent. 3 = ostia of ento-bronchium 3.
o.mb. 1–2 = ostia of outer and inferior lateral branches (1–2) of meso-bronchium.
o.sub. = ostia leading into sub-bronchial sac.
o.p.b.s. = ,, ,, ,, pre-bronchial sac.
p.b. = pre-bronchial air-sac.
p.int. = posterior intermediate air-sac.
p.abd. = posterior abdominal air-sac.
p.a. = pulmonary artery.
para.b. = parabronchia.
p.v. = pulmonary vein.
rd. = radius.
rh. = rhachis.
rh.″ = rhachis of aftershaft.
r.m. = ramus.
r.r. = ribbon-shaped prolongations of rami.
r.g. = rima glottidis.
t. = tongue.
t.f. = terminal filaments of the rami.
t.mj. = tectrices majores.
t.md. = ,, mediæ.
t.m. = ,, minores.
t.ms. = ,, marginales.

3 ← = passage from ento-bronchium 1 to vestibule.
4 → = traverses entire length ento-bronchium 1 to vestibule.
5 → = passes from ento-bronchium 1 to vestibule.
6 → = traverses whole length ento-bronchium 4.
7 → =
8 → = } traverse lateral meso-bronchia into anterior and posterior intermediate air-sacs.

3/5

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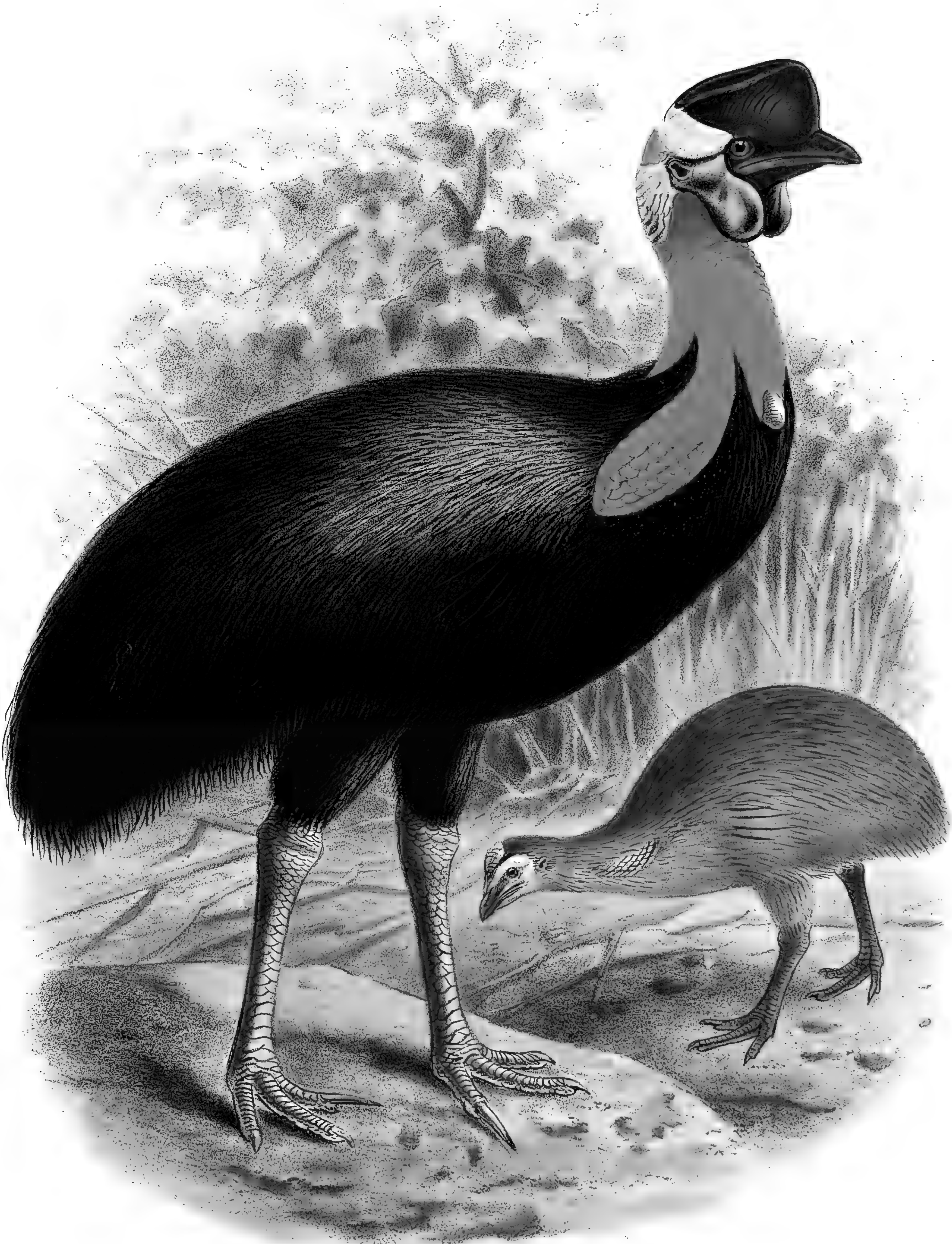

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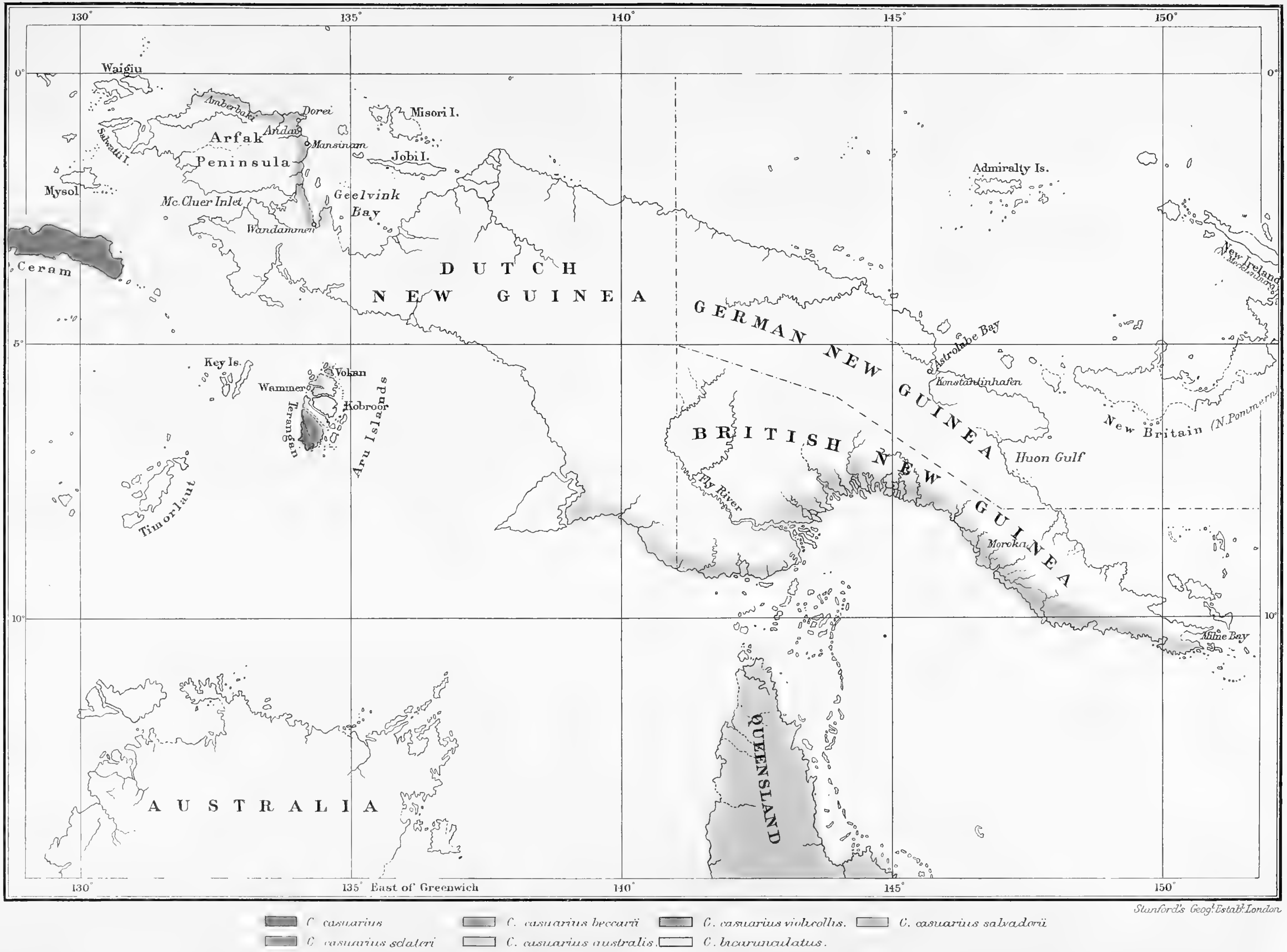

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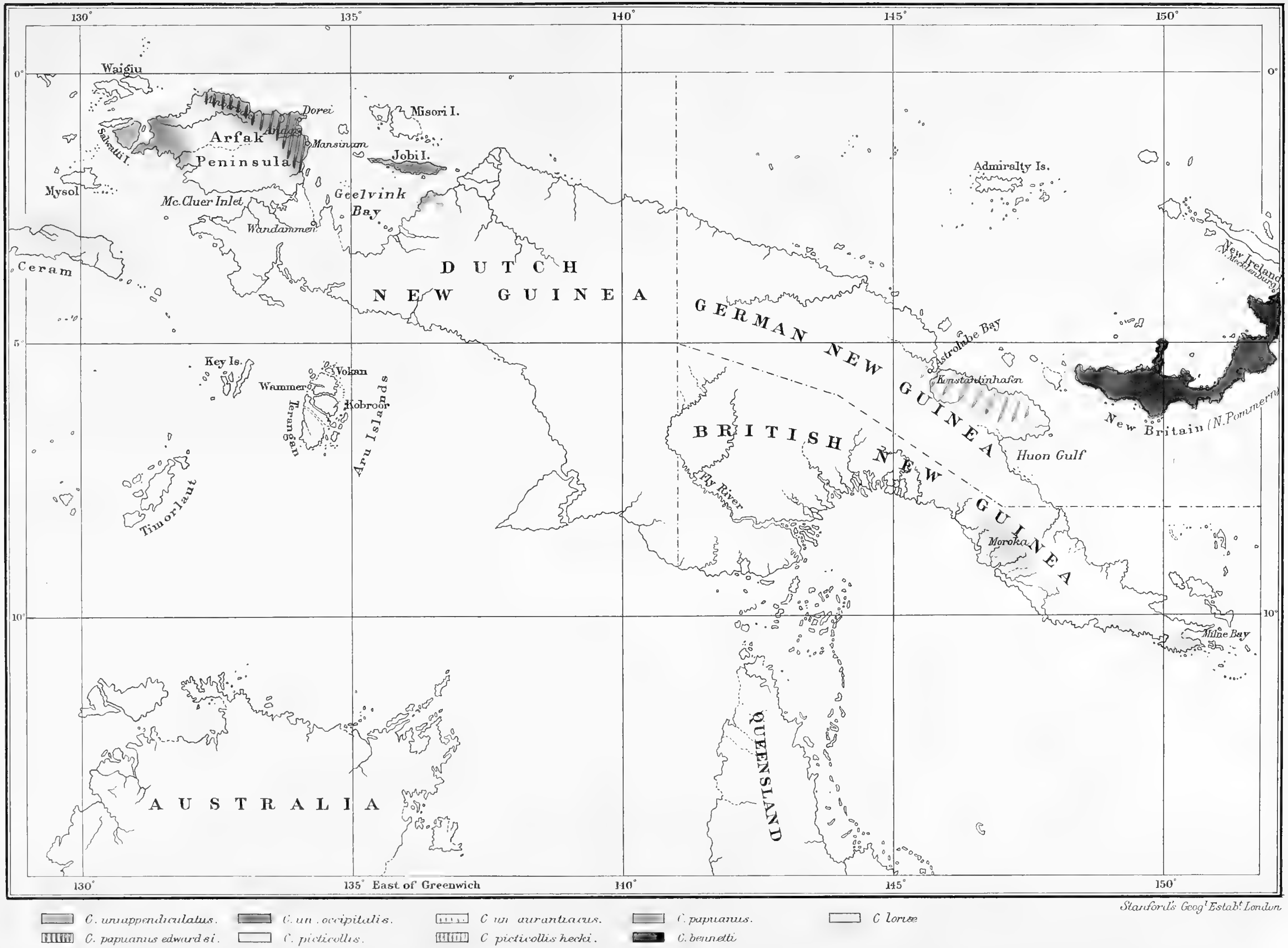

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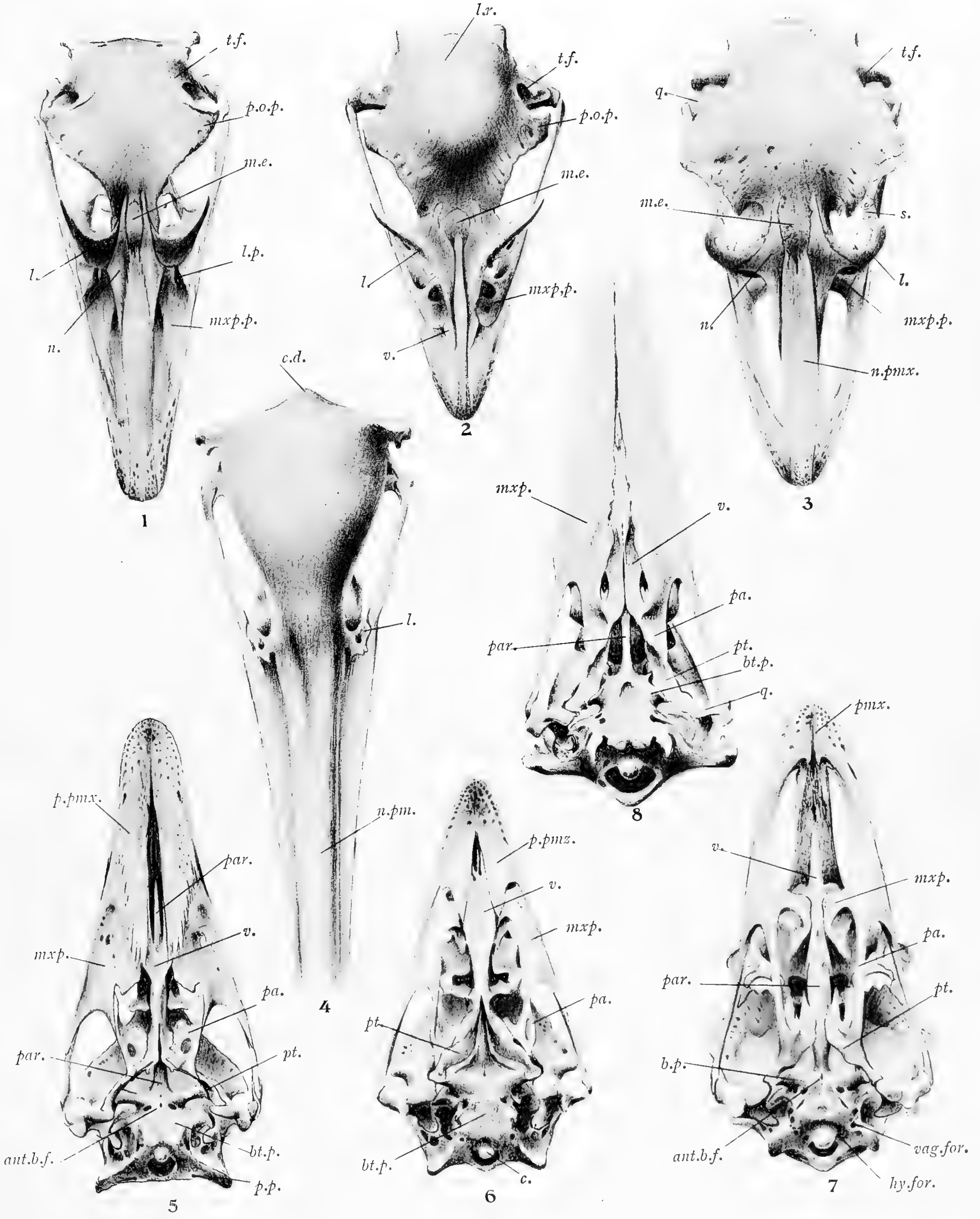

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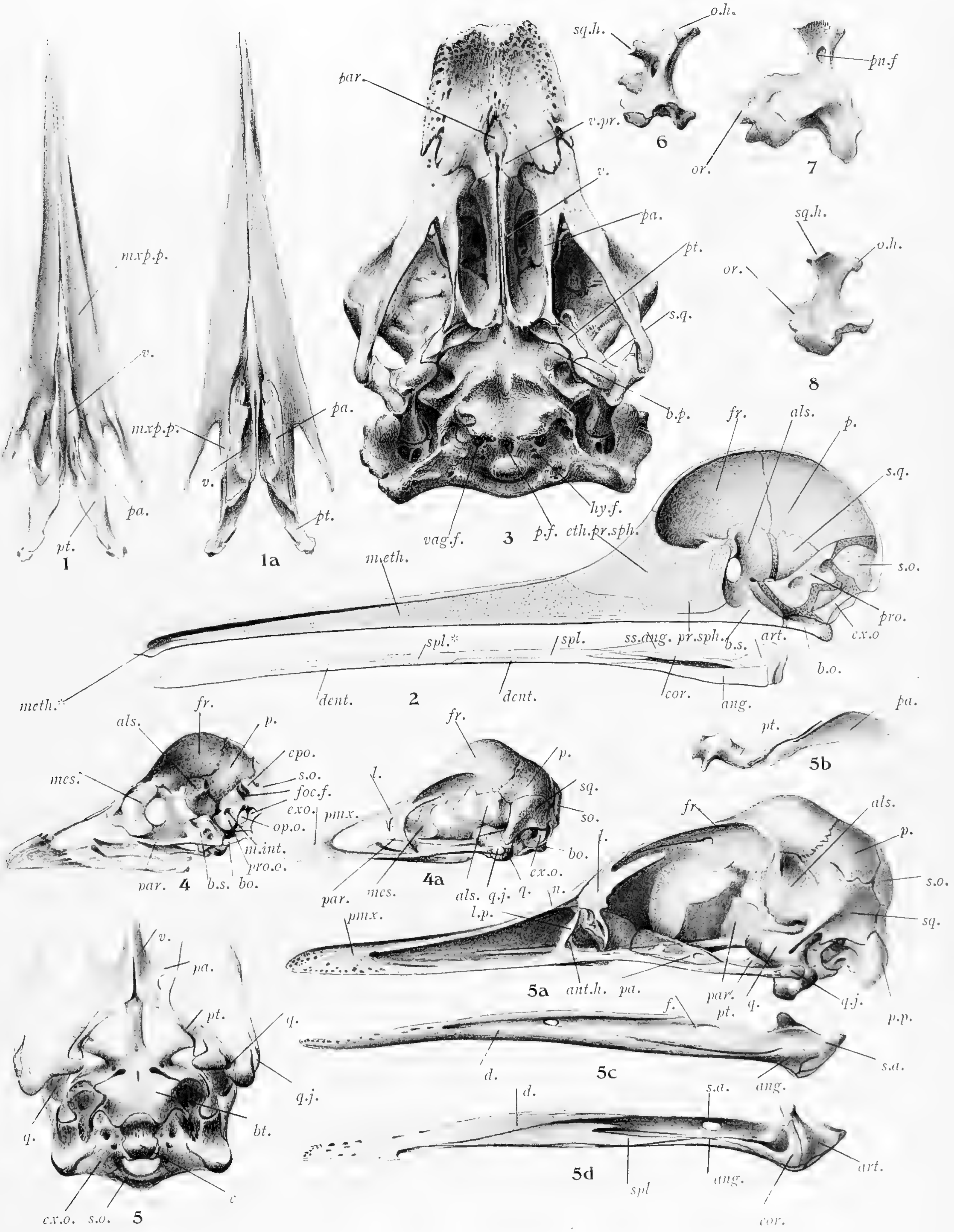

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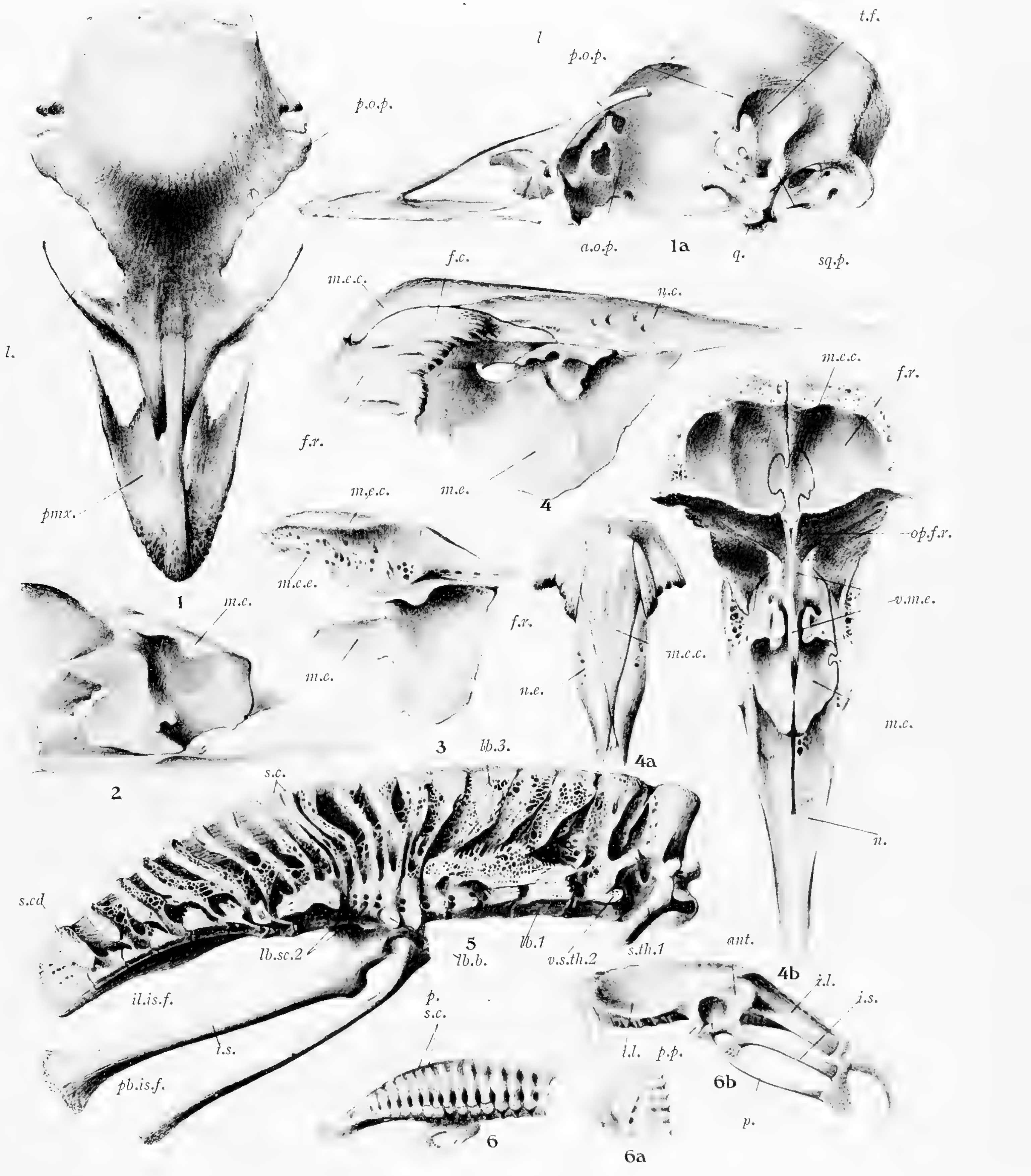

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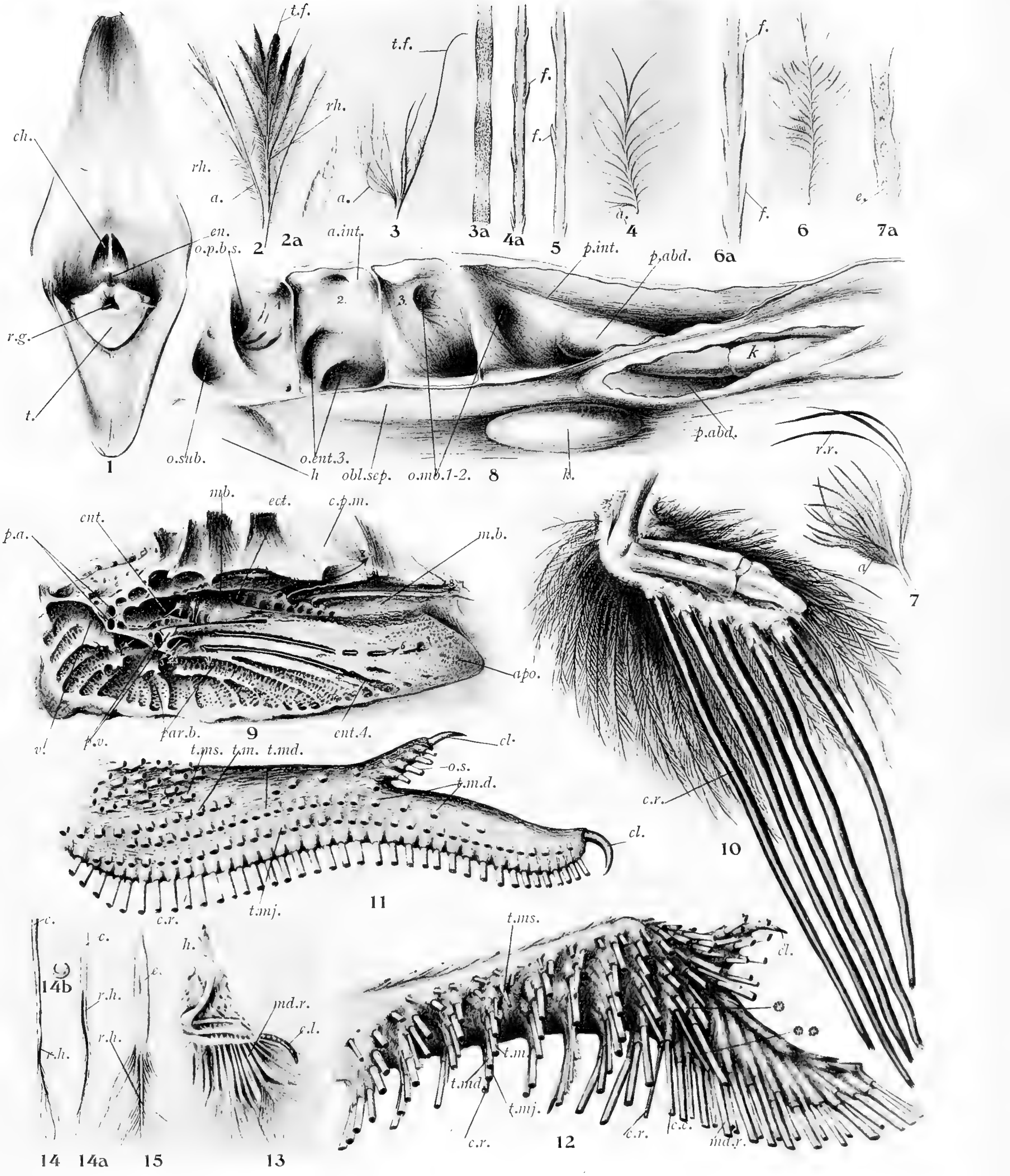

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December 1900.

P. L. SCLATER,
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Continued on page 3 of Wrapper.

VII. *Notes on the Transformations of some South-African Lepidoptera.*
By Lieut.-Colonel J. MALCOLM FAWCETT [1].

Received October 17, 1899, read February 6, 1900.

[PLATES XLVI.-XLIX.]

THE following paper is the result of a collection and observations made during a residence of a year at Ladysmith and Pietermaritzburg, Natal, during which particular attention was paid to the habits and early stages of the Lepidoptera of the district.

CONTENTS.

I.—REMARKS ON THE CLIMATIC AND NATURAL CONDITIONS OF NATAL.

The climate may be described in short as one marked by extreme and rapid changes of temperature, except in what is known as the "Coast Belt." On the higher plateaux, about 3000 feet, a change of wind from west to east has, in the experience of the writer, caused a sudden drop of 22° of the thermometer in one hour; while in the colder months (June to September) the range between day- and night-temperatures is frequently as much as 70°. Such rigorous conditions, taken in conjunction with the want of covert, may account for the extremely poor butterfly-fauna of the higher levels. The rainy season, here coincident with the hotter months, usually begins in November and lasts till the middle of March, and is characterized by exceptionally severe thunderstorms and heavy sea-fogs and rains from the south-east; during the remainder of the year the weather is dry, the days being warm and the nights very cold.

Natal may be divided, for the purpose of these Notes, into three well-defined regions or zones, as the country rises in successive plateaux inland:—

1. The Coast Belt or Zone, from sea-level up to 1000 feet elevation. (Tropical Zone.)
2. The Middle Zone, from 1000 to 5000 feet elevation. (Subtropical Zone.)
3. The High Levels; 5000 feet elevation and over. (Temperate Zone.)

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[1] Communicated by R. TRIMEN, F.R.S., F.Z.S.

1. The Coast Zone, in which Durban is situated, has a tropical climate, and abounds in thick jungles or "bush" (as it is called in South Africa) of virgin forest, the open spaces being mainly under cultivation for tea, pine-apples, sugar-cane, and bananas. In this district Bellevue, some 12 miles out of Durban, and Pinetown are good localities for Butterflies, while a fine tract of virgin forest, called the "Berea," extends to the very outskirts of the city of Durban; but, as a rule, all the bush in this zone is full of Butterflies and Moths of species characteristic of the tropics.

2. The Middle Zone comprises (for the purpose of these Notes) the Maritzburg district. The country here is much more open, and consists of grassy downs with here and there a little mealie cultivation, and a few plantations of wattle (*Elephantorrhiza burchelli*) and blue gum (*Eucalyptus globulus*), imported from Australia.

About 70 miles inland a plateau runs north and south, parallel to the sea, and attaining a height in some places of 5000 feet: on the eastern slopes of this range are the only coverts of virgin forest in this zone; they are known as the "Town Bush" (above Maritzburg) and "Karkloof" (about twenty miles north of it). In these coverts alone are the rarer species of Rhopalocera to be found: the commoner species, the larvæ of which feed on more or less cultivated plants, such as orange, lemon, passion-flower, vine, oak, &c., being found in Maritzburg and its vicinity. It is remarkable, however, how many larvæ in Natal feed on imported plants.

3. The High Levels comprise the country above the 5000 feet plateau above alluded to up to the Transvaal and Orange Free State. It mainly consists of open grassy downs (called "veldt" by the Boers), with here and there rocky knolls ("kopjes" or "koppies") covered with large boulders, entirely devoid of timber, with the exception of a few imported blue gums planted round the farm homesteads; from this district, however, came but few of the forms mentioned below.

II.—Observations on the Rhopalocera.

Most of the species which have been observed are double-brooded, the larvæ of the first brood appearing in November and December, changing to pupæ in January, and the imagines appearing early in February; while the second brood is met with in March, and remains in the pupal stage till the following October. Those which are single-brooded generally appear as imagines in October.

In the case of species which have already been figured and described, merely the writer's experiences and observations in rearing them are recorded, and the reader is referred to the published descriptions and figures.

Mr. J. F. Quekett, Curator of Durban Museum, and Mr. W. Haygarth, of Natal Government Railways, have rendered much valuable assistance in the preparation of these Notes, and have presented many of the larvæ described to the writer.

Mr. J. Medley Wood, Curator of the Durban Botanic Gardens, has kindly identified the various food-plants.

The larvæ are figured natural size, except where stated otherwise.

RHOPALOCERA.

Family NYMPHALIDÆ.

Subfamily Danainæ (Bates).

1. Danais chrysippus (Linnæus).

The *larva* and *pupa* of this well-known species have been already figured by Mr. Trimen, in 'Rhopalocera Africæ Australis,' plate i., 1862.

The South-African larva seems to differ considerably from De Nicéville's description of the Indian form in 'Butterflies of India, Burma, and Ceylon,' where only "two large yellow patches" on the second and third somites are mentioned, and nothing is said of the crimson bases to the "dark retractile (?) horns."

The larvæ reared in Maritzburg fed on "*Gomphocarpus fruticosus*," a common plant in marshy places, and also on the "veldt" in Natal; on being cut the plant exudes a bitter white milky substance, which may account for the bitter taste of the imago, which is said to be its protection. This larva is much infested by the maggots of a very small hymenopterous insect, and out of many examples taken, only two survived to become imagines. I have heard similar experiences detailed by other collectors.

The imago is, however, common all over Natal, and is the only butterfly to be seen on the high levels during the colder months. I have noticed the *alcippus*, but not the *dorippus* form in Natal.

Subfamily Acræinæ (Bates).

2. Acræa acara (Hewitson).

The larva and pupa of this species have been already figured by Mr. Trimen in 'South African Butterflies,' i. plate i. figs. 1, 1 *a*.

Numerous examples of this larva were reared in Maritzburg on a species of *Passiflora*, which is a common plant on the verandahs of houses. The period passed in the pupal stage in January was only 11 days. Some of these larvæ were placed in a box in which some of the same species had already changed into pupæ, and the larvæ proceeded to devour the pupæ, although there was plenty of the food-plant in the box. This is the only species in which I have noticed this carnivorous habit. I have not obtained this species in the coast districts.

3. ACRÆA PETRÆA (Boisduval). (Plate XLVI. fig. 1, larva; figs. 2, 3, pupa.)

Larva. Ground-colour pale golden brown, with a dorsal and lateral black lines, and a black transverse line on each segment bearing two largish white spots and six long branched black spines, those on 3rd, 4th, and 5th segments being longer than the remainder. Head large proportionately to body, black with a white bifid mark on front. Thoracic legs and claspers yellowish. The young larvæ reared were all blackish in colour, and fed in companies on *Oncoba kraussiana* (Planch.).

Pupa appears to be dichromatic, some being pale brown and others ferruginous; in both forms the fine black lines and spots peculiar to *Acræa* pupæ are much reduced. The pupal stage lasted 15 days in January.

The imago is common in the Durban and Maritzburg districts.

4. ACRÆA ENCEDON (Linnæus) = *A. lycia* (Fabricius). (Plate XLVI. figs. 4, 5, larva; fig. 6, pupa.)

Larva. Slaty black, with a yellow lateral line above prolegs and claspers. On each segment three deep black fine transverse lines enclosing two white patches dorsally and two yellow patches laterally. On the centre black line of each segment are placed six black spines (branched). Head, thoracic legs, and claspers black.

Pupa waxy white, with the usual fine black lines on the wing-covers and black spots with orange centres on the abdominal segments.

The larva figured was not fully grown. It became one-fifth longer and proportionately thicker before changing into a pupa.

It feeds on a species of *Commelina,* a common weed in gardens at Maritzburg.

The imago is one of the commonest butterflies in Durban, both on the Berea and in the Back Beach Bush; but is not so often seen in Maritzburg.

5. ACRÆA RAHIRA (Boisduval). (Plate XLVI. fig. 7, larva; figs. 8, 9, pupa.)

Larva. Back and sides blackish; thoracic legs, claspers, and a line above them chrome-yellow. A dorsal white stripe, and on each segment four yellow spots from which spring four branched yellow spines, the lower pair springing from the yellow spiracular line. These spines are shorter than in the majority of *Acræa* larvæ. Head yellow.

Feeds on a species of groundsel, *Erigeron canadense* (Linnæus).

Two figures of the pupa are given: one pupa is waxy white and similar to the pupæ of other *Acrææ*, the other ferruginous. The ferruginous pupæ had nearly always been attacked by ichneumons, with which the larvæ were much infested. The imago is a common butterfly in the coast district.

6. ACRÆA BUXTONI (Butler). (Plate XLVI. fig. 10, larva; figs. 11, 12, pupa.)

Larva. Pale buff dorsally, deepening to pale green on the sides, with a buff lateral spiracular line above thoracic legs and claspers, which are also buff. Two dorsal pale green stripes, interrupted on every segment by a pale yellow transverse stripe bearing four black branched spines; below these are two buff-coloured spines springing from the buff spiracular line. Head yellowish.

Feeds on a species of nettle, locally called "pink hibiscus" (although it is not a hibiscus at all). It is a common plant on the Berea, Durban, where I found the larva, and has been identified for me by Mr. Medley Wood as *Triumfetta rhomboidea* (Jacq.).

The larva is here figured, $\times \frac{6}{4}$, to exhibit the detail.

Pupa waxy white, with the usual fine black lines and spots with orange centres, beautifully gilded; pupæ formed in the dark, however, inside a box, are slaty black.

Imago fairly common in Durban district.

7. PLANEMA ESEBRIA (Hewitson).

This larva and pupa have been figured by Trimen, 'South African Butterflies,' i. pl. i. figs. 2 & 2 *a*. I took it on a species of nettle (*Urtica* sp.), in the covert known as the "Back Beach Bush," near Durban. My specimens resulted in two females of the white variety A. The imago is a very common butterfly in the Durban district.

Subfamily NYMPHALINÆ (Bates).

8. JUNONIA CEBRENE (Trimen). (Plate XLVI. fig. 13, pupa.)

This larva has been already figured by Trimen, 'South African Butterflies,' pl. i. fig. 4.

I reared the larva from an egg which I saw deposited by the female on *Justicia natalensis*, a common plant amongst the grass of the veldt.

Pupa chocolate-brown, with four rows of small yellow spots on each segment, and a submarginal row of white spots round the edge of the wing-covers, with a row of four white spots inside them. The specimens reared passed 13 days in the pupal stage

(23rd Jan. to 4th Feb.). I reared one specimen from the egg which I saw deposited by the female, but regret that I made no notes of the earlier stages, save that the young larvæ were, during the first two moults, lighter and more violaceous in colour, and the spines were proportionately much smaller.

The imago is common everywhere in Natal.

9. Junonia clelia (Cramer). (Plate XLVI. fig. 14, larva; fig. 15, pupa.)

Larva. Dark slaty black, covered with minute yellowish-white atoms, and each segment bearing black branched spines as in the larva of *J. cebrene*, from which it only differs in being lighter coloured and brownish underneath, and in having an interrupted white lateral line above spiracles.

Feeds on *Asystasia coromandeliana.*

Pupa. Dark chocolate-brown; wing-covers lighter; yellowish-white spots on thorax and each segment and wing-covers, as in pupa of *J. cebrene.* Duration of pupal stage 11 days (March 1 to 12).

Imago very common in Durban, more rarely seen in Maritzburg.

10. Pyrameis cardui (Linnæus).

The larva of this well-known species has been so often described that any description here would be superfluous; I will therefore merely state that I reared it on a large species of thistle named *Stobœa discolor* (Harv.). The larva was very similar to that of *Junonia clelia*, but differed in being longer in proportion to its width; the branched spines were yellow instead of black, and the black dorsal line was more defined; the pupa was beautifully gilded.

11. Charaxes candiope (Godart). (Plate XLVI. fig. 16, larva; fig. 17, pupa.)

Larva. Grass-green, irrorated with minute yellow spots, which coalesce into a lateral line below the spiracles, which ends on the 12th segment in a bifid tail. On the 6th and 8th segments are placed three yellow spots with orange centres, one dorsal and two subdorsal, the dorsal spot being larger than the subdorsal spots and more oval in shape. Head dark green in front, brownish to pale yellow at the sides, with four light brown serrated horns, two springing divergently from the top of the head and two from the sides.

Feeds on a species of *Croton*, probably *Croton sylvaticus* (Hochst).

Pupa. Grass-green; very short and thick, suspended by tail to stem of food-plant. I am indebted to Mr. Walter Butcher for a specimen of this larva from the neighbourhood of Durban, where the imago is common on the Berea in the summer months.

Family PAPILIONIDÆ.

Subfamily PIERINÆ (Bates).

12. PIERIS SEVERINA (Cramer). (Plate XLVI. fig. 18, larva; figs. 19, 20, pupa.)

Larva. Dark green on back, covered all over with very fine whitish hairs. Two lighter subdorsal lines, and below them a row of yellow spots, one on each segment, placed in a darker green line. A light yellow lateral line along spiracles above a light green line just above thoracic legs and claspers, which, with under surface, are white. Head dark brown with minute white spots; 1st segment light yellow anteriorly.

Feeds on *Capparis corymbifera.*

Pupa. Bluish green with two yellow spots on each segment subdorsally, and four on each side of thorax. A fine black line along dorsal side of thorax, and two small white tubercles with black bases at angle of wing-covers.

Imago common in Durban and Maritzburg.

This larva is described in 'South African Butterflies' as "Dull reddish sandy on back, with a median longitudinal streak of violaceous grey." It may be dimorphic; but I have never met with a specimen of this colour ('S. African Butterflies,' vol. iii. p. 69)[1].

13. PIERIS HELLICA (Linnæus). (Plate XLVI. fig. 21, larva; fig. 22, pupa.)

Larva. Yellow above, bluish green underneath; a light blue dorsal stripe, and on each side of it a broader greenish stripe, and below these a pale yellow spiracular stripe; body covered by minute black papillæ and some sparse short hairs; head bluish, covered with black dots.

Feeds on a common weed in the grass of the veldt, of which I did not get the name.

Pupa. Yellow above and green underneath, covered with minute black spots.

Pupal stage lasted only 7 days in February.

Common everywhere in Natal.

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[1] "My description (*l. c.*) of this larva was made from numerous Natalian specimens sent alive to me by Colonel Bowker. I observed, on the page quoted, that in its earlier stages the larva is dorsally much tinged with greenish, and it is of interest to find that the green tint commonly persists till the full-grown stage."—R. TRIMEN.

Subfamily PAPILIONINÆ (Bates).

14. PAPILIO POLICENES (Cramer). (Plate XLVI. figs. 23–28, larva; figs. 29, 30, pupa; fig. 31, head of larva with tentacles.)

Larva. 1st stage. Chocolate-brown, each segment with a transverse yellow stripe; three yellow spines on thoracic segments, and a yellow bifid tail consisting of two yellow divergent spines. The larva does not exceed $\frac{1}{4}$ inch in length in this stage.

2nd stage. Ground-colour ferruginous red, with transverse black stripes as follows:—one between each two segments, and two on each segment enclosing a greyish-blue streak between them. 1st and 2nd segments and bifid tail yellow with black points. A black spiracular line divides the ferruginous upper portion of the body from the lower portion, which is violaceous grey. Three thin black spines with scarlet bases on thoracic segments. Head ferruginous, thoracic legs and claspers pale grey.

3rd stage. Ground-colour has become green, fading to yellow at sides above the black lateral line; the black line dividing the segments has become obsolescent, and the two black lines on the segments enclosing the blue streak have become ferruginous. Otherwise as in 2nd stage.

In this stage larva attains its full size.

4th (and final) stage. Entirely green above, with the exception of the three black spines on the thoracic segments, which still retain their scarlet bases, and are joined by transverse black streaks; under surface violaceous grey. Head and Y-shaped tentacular organ pale green.

Larva feeds on *Uvaria caffra*, called by the natives "Maswinda," a common bush in the coverts of the coast-belt.

Pupa green, very broad, and very much flattened, with a very prominent thoracic dorsal projection pointing forward; the lateral projections pale ferruginous; two subdorsal lines of black spots on each side.

One pupa formed in a box was pale pinkish, with the subdorsal region strongly marked with black.

Only the 2nd stage of this larva is described in 'South African Butterflies' (vol. iii. p. 203).

The imago is common in the Durban district.

15. PAPILIO BRASIDAS (Felder). (Plate XLVI. figs. 32–34, larva; figs. 35, 36, pupa.)

Larva. 1st stage. Pale yellowish ferruginous, with reddish diagonal streaks on sides; back of 3rd, 4th, and 5th segments occupied by an olive-green area, with a median dorsal pink stripe from head to tail, bounded by an olive-green stripe on each side. 1st segment reddish brown superiorly, with short tubercles on each side; a pair of short pink tubercles dorso-laterally, bounded inwardly by dark olive-green, and joined by a fine pink transverse line on 2nd and 3rd segments; tail bifid.

2nd stage.—Pale green above, darker green underneath; all the markings described in 1st stage defined by slightly darker green, except the olive-green area on the back of the thoracic segments, which has become dark green in this stage, while the pink median dorsal line and transverse stripes have become a rather startling whitish cross.

3rd (and final) stage. Shortly before changing into a pupa the larva loses all its distinctive marks, and becomes very pale yellow all over, almost diaphanous.

Feeds on *Popovia caffra* (Kaffir name, "small Maswinda"), a common shrub in the coast district.

Pupa. Bright green. On each side of back, from apex of dorso-thoracic projection to anal extremity, a narrow yellow elevated stripe; on summit of back a pair of similar stripes commencing considerably apart near base of dorso-thoracic projection, and converging till they meet at anal extremity. A series of diamond-shaped lozenges down the back, medially, and a series of diagonal streaks subdorsally between the two yellow stripes, and extending beyond them to the cephalic area. Duration of pupal stage 21 days (24th January to 16th February).

Common in Durban and the coast-zone. I have taken the allied species *Papilio leonidas* in the same coverts and at the same time. It is, I should say, doubtful if they are distinct species. *P. brasidas* is the commoner species in the Durban district. I have not met with either in the vicinity of Maritzburg.

16. Papilio morania (Angas). (Plate XLVI. figs. 37–39, larva; fig. 40, pupa.)

Larva (early stage). General colour grass-green on back, incisions of segments pale blue; two dark chocolate-brown lateral stripes above spiracles (which are white). Head, thoracic legs, claspers, and bifid tail brownish yellow. 1st segment yellow dorsally, bearing two short tubercles on each side; 2nd and 3rd segments bearing dorso-laterally a pair of black spines, short, with orange bases, and joined by two broad transverse streaks of chocolate-brown; that on the 2nd segment having three brown spots posteriorly, and that on 3rd segment five brown spots anteriorly, and being much larger than the other, extending posteriorly over part of the next segment; from this three dark brown longitudinal lines, one dorsal and two subdorsal, extend to the 11th segment, where the two subdorsal lines become two chocolate-brown spots joined by fine transverse lines, while the dorsal line (which is much finer than the others) extends to the tail. A double lateral line of black spots along the segments, two on each segment along the upper line, and one on each segment in the lower line.

2nd stage. On casting its last skin, the larva emerges exactly the same as in the early stage; but in a very short time (perhaps half a day) it loses all its distinguishing characters in that stage, and becomes uniform pale green; a yellow lateral line above a darker green line being all that remains to represent the two very distinct brown lateral lines of the early stage, and the under surface, thoracic legs, claspers, and head have all become pale green. The black spines on the thoracic segments, however, remain the same, except that their bases become more reddish. In this stage the larva is very similar to the larva of *P. policenes* in its green stage; but the latter always retains its brown lateral streak and its blue-grey under surface.

3rd (and final) stage. Like the larva of *P. brasidas*, this larva also becomes pale yellow and almost diaphanous just before pupating.

It feeds on *Uvaria caffra* (the large "Maswinda"), like the larva of *P. policenes.*

Pupa. Grass-green and more rounded than in pupa of *P. brasidas.* Dorso-thoracic prominence thicker and pointing more upward; a pair of raised yellow lines from thoracic prominence along the sides to anal extremity, also a second pair of similar lines run subdorsally from base of thoracic prominence to tail, where they converge and meet.

Pupæ formed on 1st February remain over the winter months in this stage.

The imago is common in the vicinity of Durban.

17. PAPILIO DEMODOCUS, Esper. (Plate XLVI. figs. 46–48, larva; figs. 49, 50, pupa; fig. 51, head of larva with tentacles.)

Larva (early stage). Ground-colour black, with short yellow tubercles on the thoracic and 10th, 11th, and 12th segments. Top of 1st segment yellow between the two tubercles; a dorsal line of diamond-shaped lozenges commences grey on the 4th segment, becomes white on 6th and 7th segments, and darkens again to grey and brown on the remaining segments to the tail, where it is obsolescent. On 4th, 5th, and 6th segments are white lateral spots, which converge and meet the dorsal line of lozenges on 5th and 6th segments; similar white lateral spots on 10th, 11th, and 12th segments. Tail bifid and yellow, head reddish. This larva, which apparently mimics the droppings of birds, varies but little in this stage.

Full-grown stage. The ground-colour in this stage varies according to the colour of the lemon-leaves on which the larva is feeding, from pale green almost yellow to dark green; the transverse streaks on the sides also vary from light brown almost ferruginous in the pale specimens to deep velvety black in the dark green examples.

The most common form has a grass-green ground-colour, with velvety black transverse streaks on the three thoracic segments, and black diagonal streaks on the 7th, 8th, and 9th segments, converging till they almost meet dorsally on 8th and 9th segments. Under surface and claspers greyish white, and a broad white lateral line above spiracles. Head and thoracic legs reddish; head surmounted by two reddish tubercles, between which the **Y**-shaped tentacular process is situated. The transverse black streaks on the 2nd and 3rd segments have a line of ferruginous ocellate spots variegated with light blue and yellow. The black diagonal streaks on 7th, 8th, and 9th segments are mottled with rather indistinct purple ocellate markings, and edged outwardly with fine lines of pale yellow. There are also short diagonal streak-like spots on the 9th and 12th segments just above the white spiracular line. Two yellow tubercles over the anal extremity.

The *pupa* also varies in colour according to its surroundings: the most common form is light green, paling to two yellow subdorsal streaks; head and cephalic prominences (which are well-marked) brown, as is also the thoracic prominence posteriorly, from which a broad brown streak extends almost to the anal extremity. Several dark green and brown spots on the segments.

I first bred this larva at Ladysmith, in the high level zone, in April 1898, on a plant named *Clausena inæqualis*; the larvæ began pupating on the 7th April, and the first imago emerged on 12th October, 1898. I noticed that these specimens were smaller than those which I subsequently reared on lemon-leaves at Maritzburg in December and January following; these individuals only averaged a fortnight in the pupal stage.

This is the commonest and most widely distributed *Papilio* in S. Africa.

18. PAPILIO NIREUS (Cramer). (Plate XLVI. figs. 41–44, larva; fig. 45, head of larva with tentacles.)

Larva. 1*st stage.* Ground-colour black, paling to greenish on the sides, the under surface, thoracic legs, and claspers being greenish yellow; head, thoracic, 10th, 11th, and 12th segments surmounted by orange-coloured tubercles in pairs; the pairs on the three thoracic segments being joined by transverse orange lines bearing two to three tubercles each, smaller than those at the extremities. 7th, 8th, and 9th segments ferruginous; 5th, 6th, and 10th segments black superiorly with white sides. In this stage the larva somewhat resembles that of *P. demodocus.* In some individuals the black markings are replaced by very dark green.

2*nd stage.* Ground-colour grass-green superiorly, under surface greyish white. No ferruginous markings on 7th, 8th, and 9th segments, and no lateral white spots on 5th, 6th, and 10th segments, these being replaced by a pale lemon-coloured lateral streak. The tubercles, which have become light lemon-coloured, are confined to the thoracic and 12th segments.

3*rd stage* (*final*). Ground-colour generally dark green, but, like *P. demodocus,* varying according to the colour of the leaves of the food-plant. A wide pale greenish-blue oval area with a thin whitish line across its centre, on the summit of the 3rd and 4th segments, bounded anteriorly and posteriorly by a transverse line of ocellate spots:—the anterior series outlined in black on an ochreous transverse band, the ocelli at the extremity of the band being larger than the rest; the posterior series indistinct: four ocelli in each series have light blue centres. A lateral white stripe along the spiracles from 4th to 12th segments: tubercles on anal segment yellow, well-defined, and joined by a raised yellow pale streak; tubercles on back of 1st segment pale and inconspicuous. The Y-shaped tentacles in this species are bright crimson and much longer than those of *P. demodocus*; the scent emitted is, however, similar.

Pupa. Bright green; point of dorso-thoracic prominence, two spots below it (at abdominal base), and edge of lateral abdominal angles creamy reddish. In shape somewhat attenuated anteriorly, cephalic processes short and directed laterally outward, so that the frontal line of head is widened and but slightly concave. Thoracic lateral angles moderately acute; dorsal prominence also elevated acutely but not inclined forward. Sides of abdomen widely flattened, and so extended as to form a very marked angle on each side of third abdominal segment; whence abdomen narrows very rapidly and greatly to the extremity. Infra-pectoral region, where wing-covers meet, very strongly convex.

A marked constriction dorsally at junction of thorax and abdomen.

In its natural position, attached vertically or nearly so, head uppermost, the anterior portion of this pupa is seen to be very much more bent backward than it is in *P. demodocus.* I have taken this description of the pupa, with some alterations, from 'South African Butterflies,' as I thought it so well describes the peculiarities in shape of the pupa.

The imago is not so often met with as *P. demodocus*, and seems to prefer wooded country more. In its haunts, however, and in the coast district it is one of the commonest species.

III.—OBSERVATIONS ON THE HETEROCERA.

Family SATURNIIDÆ.

1. ACTIAS MIMOSÆ. (Plate XLVII. figs. 1, 2, larva; fig. 3, cocoon.)

Larva. Ground-colour grass-green, with paired dorsal series of long conical humps with yellow apices, surmounted by three or four short black hairs, and the same number of longer yellow hairs, from 2nd to 10th somites inclusive; the 11th somite has only one similar dorsal hump, and the 1st somite no hump, with the black and yellow hairs planted just above the head; a subspiracular line of small tubercles with similar hairs. Between each somite, from 3rd to 11th, a yellow transverse streak folding over a blue transverse streak at the incisions of the somites. Head and thoracic legs ferruginous, spiracles white, with ferruginous centre.

In the early moults this larva is ferruginous, the head and thoracic legs being black. Feeds on *Sclerocarya caffra* (Sond.), called in Natal "the wild mango tree"—a common tree in the coast districts, but not found higher up.

When about to change the larva spins a greyish-white silky cocoon, with a line of ventilation-holes round the exit end, which it attaches longitudinally to a twig of the food-plant. The pupa is chocolate-brown and of the usual shape. This moth appears to be double-brooded, the larva appearing in November and February, and the perfect insects in January and the following October.

Common at Sydenham, near Durban.

2. NUDAURELIA WAHLBERGI (Boisduval). (Plate XLVII. fig. 4, larva; fig. 5, pupa.)

Larva. Ground-colour deep velvety black, each somite bearing four branched ferruginous spines with reddish bases, two subdorsally and two laterally, from 2nd to 12th somite inclusive, the spines on the 2nd somite having black bases. Between the subdorsal and the lateral row of spines are placed a collection of small yellow spots on each somite; the red bases of the subdorsal and lateral spines being joined on 10th and 11th somites. Spiracles white: a subspiracular row of small yellowish tubercles bearing a few whitish hairs, one on each somite. Head and legs concolorous with body.

Feeds on English oak, but has also been taken in large numbers on peach-trees, in gardens in Maritzburg—both these trees being imported species in Natal. When full-fed it burrows underground, where it makes a sort of web [1], inside which it undergoes its transformation. Individuals which changed about 14th March reappeared as imagines on 6th May and subsequent days.

Pupa dark chocolate-brown.

Common in Maritzburg.

3. BUNÆA CAFFRARIA (Stoll). (Plate XLVII. fig. 8, larva.)

Larva. Ground-colour deep velvety black; each somite, from 4th to 12th, bearing eight yellow tubercular processes, two subdorsally, two laterally, and four (in two rows) on each side subspiracularly. The 2nd somite bears four black processes, two subdorsally and two laterally; the 3rd somite bears four black processes, as in the 2nd,

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[1] "The group of *Antheræa* to which this species belongs—*Nudaurelia*—is noted for forming no cocoon, and the closely allied species *A.* (*N.*) *cytherea*, *menippe*, and *tyrrhea*, as well as *Bunæa caffraria*, as far as I have observed, simply bury themselves without any attempt at forming even a 'web.'"—R. TRIMEN.

and two small yellow processes on each side, in line with the subspiracular processes on the other somites. Spiracles red; those on the 4th to 11th somites being surrounded by an irregularly shaped red area. Head and legs concolorous with body.

Larva figured has not attained its full size.

Mr. Quekett writes: "The food-plants of this *Bunæa* are, at Durban, *Celtis kraussiana* (Bernh.), and *Ekebergia meyeri* (Presl), and at and near Maritzburg a species of *Cussonia*, on which I have taken the larvæ in the Botanic Gardens."

This larva, which much resembles that of *N. wahlbergi*, undergoes its transformation underground in a similar manner to that larva, and is double-brooded, the larvæ appearing in November and December, and the second brood in March and April; these latter individuals remain pupæ until the following October, my first specimen emerging on 12th of that month.

Pupa dark reddish brown; very similar to that of *Gynanisa maia* (Klug).

4. GYNANISA MAIA (Klug). (Plate XLVII. fig. 6, larva; fig. 7, pupa.)

Larva. Ground-colour pale green, with paired dorsal series of humps; each somite, from 2nd to 12th, bearing four silver spikes with yellow points inclined backwards, one subdorsally and one laterally on each side; also a number of small silver spots placed irregularly over each somite; the first somite has no spikes, but is raised to a sharp ridge, with a black edge, which may be of assistance to the larva in forcing its way through the ground. Spiracles purple, and immediately beneath them a purple lateral line having on its lower edge a yellow raised lateral line bearing a small orange-coloured tubercle on each somite, and thickening considerably above anal claspers, where it has a series of small black tubercles superiorly. Head green, with black side-streaks defining the eye. Under surface darker green with minute white spots, and a row of small red tubercles, one on each somite just above the claspers, which are green. Thoracic legs pale brown banded with black.

Feeds on the common wattle (*Elephantorrhiza burchellii*, Bth.) and on several species of thorny acacia. When full-fed the larva burrows underground, and there undergoes its transformation, making little or no preparation in the way of a web.

The *pupa* is dark reddish brown, and is remarkable for the large size of the antennæ covers. The moth is double-brooded, the larvæ appearing in November, and the imagines emerging end of January; the second brood of larvæ appearing in March and emerging in the following October. At Fort Napier, Maritzburg, the wattle-trees were completely cleared of their leaves by the March brood this year.

If the collector possesses one female, any number of males can be secured by placing the female in a box on the verandah. The writer has seen as many as twenty males at one time fluttering round the box about 10 P.M. Next morning the verandah was strewn with their wings, a cat, as was subsequently discovered, having caught and devoured them.

5. Pseudaphelia apollinaris (Westwood). (Plate XLVII. figs. 11, 12, larva; fig. 13, pupa.)

Larva. Ground-colour bluish grey, each somite with a broad transverse indented black streak, thickest on 2nd somite, and two finer black transverse lines across the upper part of the body between the somites. Body broader in the middle than anteriorly or posteriorly. Above anal extremity a sharp-pointed black horn—a fine black spiracular line, and immediately below it a broad raised ferruginous line bearing a small black tubercle crowned with some short yellow hairs on each somite. Under surface and abdominal claspers pale yellow. Head, thoracic legs, and anal claspers black. A tuft of short hairs on the summit of the 2nd somite.

Feeds on *Jurrea heterophylla* (Smith), and undergoes its transformation underground; the period passed in pupa state (in March) was 17 days.

Pupa dark red-brown, abdominal somites strongly marked; chiefly remarkable for the long sharply-pointed tail resembling the point of a thorn.

The imago is a common species, flying by day, in the Berea Bush, Durban.

6. Urota sinope (Westwood). (Plate XLVII. fig. 9, larva; fig. 10, pupa.)

Larva. Ground-colour velvety black, with a series of paired pale yellow humps formed by a thick raised transverse yellow streak, bearing a pair of short tubercles crowned with short yellow hairs dorsally on each somite, and a series of similar short tubercles laterally at the lower end of each streak. Spiracles pale yellow, and below them an interrupted, raised, subspiracular line covered with short yellow hairs. Head black, surmounted by a yellow transverse band where it joins 1st somite, and crowned with some yellow hairs. Thoracic legs black, abdominal claspers yellow banded with black, anal claspers and extremity yellow, all covered with yellow hairs.

Feeds in companies on the " Kaffir boom " tree (*Erythrina caffra*, Thb.).

Pupa dark red-brown and of the usual form, with a sharpish spur or horn at the anal extremity. The transformation is carried out underground.

Fairly common in Durban district.

7. Ludia smilax (Westwood). (Plate XLIX. fig. 6, larva; fig. 7, cocoon.)

Larva. Ground-colour rufous, with irregular pale blue spots surrounded by a thin white line. On each somite a short tuft of black hairs, surmounted by a tuft of longer and finer hairs of same colour, and the first five and last somites covered with short yellow hairs. Head, legs, and claspers brown.

This larva, which looks, through a microscope, like a piece of old china ware in colour, is one of the most unpleasant larvæ to handle that I have ever met with. The short black hairs on each somite possess poisonous qualities, which produce on the hand a white rash akin to that produced by a bad stinging from nettles. It forms a cocoon round itself, with its hairs, on the side of the box. Food-plant oak; but I have also reared the larva on Jasmine (*Jasminium pubigerum*).

On quitting South Africa on a short leave of absence home in May 1899, I left two specimens of this larva, in the pupal stage, together with all my larvæ which had not completed their transformations, in the care of a friend who was remaining on in Pietermaritzburg, as I was afraid that, during the voyage, the heat of the tropics would cause them to emerge prematurely; but to prevent, as I thought, the possibility of any mistake in identifying the imagines, I placed each larva or pupa in a different box, with a small ticket, with a reference to the plate and figure of the larva in my sketch-book, which I requested my friend to attach to the pin of the imago when it emerged.

I subsequently returned to South Africa when war broke out, and on the relief of Ladysmith was invalided home; on passing through Pietermaritzburg in March 1900, my box containing the emerged imagines (which had all been placed in a large cork box which I had left with my friend) was returned to me, when I found my ticket referring to the drawing of this larva pinned to an imago of *Ludia smilax* (Westw.). On reaching England I forwarded a figure of the imago to Mr. R. Trimen, and asked him for the name of the moth, as I was unacquainted with it. I was therefore much surprised to receive the following reply from him:—"I know the moth you figure in your note of yesterday very well, it is *Ludia smilax* (Westw.); but I am much surprised to hear that this species resulted from the 'old china' caterpillar figured by you, because I have by me figures of no fewer than *three* quite different larvæ attributed to '*smilax*'—I mean different from each other, as well as entirely different from yours. If you are quite certain about the moth resulting from the old china larva, then this stage of *L. smilax* presents amazing variability. W. D. Gooch and Dr. J. E. Seaman made drawings of this caterpillar; they are rather rough, but those of the apparently more prevalent variety agree in representing a pale greenish larva with broad black rings; Gooch thought that this was the male, but he does not seem to have proved this, though he bred a male from one of this pattern. Gooch's second form of larva is quite like the other in shape, tubercles, hairs, &c., but *the black rings are almost everywhere broken up* into mere scattered spots, and the ground-colour, generally, is *dull yellow*; he thinks this is the female.

"Much more amazing is Dr. Seaman's second form of *smilax* larva; it is *black, marbled with white,* and *with vivid scarlet rings*! There is no doubt that some larvæ seem to vary almost indefinitely, but if *this* is a true case all through, I think it is unsurpassed."

It is therefore with some doubt that I append the description of this larva as the larva of *Ludia smilax* (Westw.), inasmuch as I cannot vouch myself, from personal observation, for its accuracy, though I have no reason to doubt the accuracy of my friend, who is certain that no mistake has been made.

Family SPHINGIDÆ.

Subfamily Acherontiinæ.

8. Acherontia atropos (Linnæus).

No description is necessary of the larva of this well-known species; and I will merely remark that I reared it on a species of *Spathodia*, an imported tree which is often met with in Berea Bush, Durban. The larva underwent its transformation on 14th February, and the imago emerged on 17th March after a pupation of 38 days. This is one of the instances of larvæ feeding on imported trees in Natal.

I also reared the dark form (body uniformly fuscous, first three somites pink subdorsally) at Maritzburg, on *Jasminium pubigerum* (also an imported plant in Natal). This larva underwent its transformation on 5th April, and hibernated in the pupal stage; this form is much rarer than the green and yellow form.

Subfamily Smerinthinæ.

9. Lophostethus dumolinii (Latreille)[1]. (Plate XLVIII. fig. 7, larva; fig. 8, pupa.)

Larva. Ground-colour very pale green, a pair of blue-black steely branched spines with pale yellow bases and basal areas subdorsally on each somite from 2nd to 10th. The 1st somite has no spines, and the 11th has only one spine, thicker than the others and replacing the horn in other species. A lateral row of smaller black spines springing from the upper edge of a spiracular row of large yellow spots; a subspiracular row of small black spines springing from lower edge of above-mentioned spots, and, below these, two spines placed diagonally on the 4th, 6th, 7th, 8th, and 9th somites just above the claspers; the 5th somite having three spines, and the 2nd, 3rd, and 10th somites one spine each in this series. Abdominal claspers yellow, with black extremities, each extremity bearing three short black divergent spines; anal extremity and claspers horny and rufous, with a broad black edging. Head pale green superiorly, pale ferruginous inferiorly; two black vertical stripes on the face, ending with a detached black spot above them. Sides of head black, as in the larva of *Acherontia atropos.* Thoracic legs pale ferruginous, banded with black.

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[1] "A brief description of the extraordinary spiny larva of this Hawk-moth—drawn up by me from a coloured drawing by Mr. W. D. Gooch, and a coloured photograph by the late Dr. J. E. Seaman—was published by Prof. Meldola in his English edition of Weismann's 'Studies in the Theory of Descent,' vol. ii. pp. 527, 528 (1882)."—R. Trimen.

Feeds on *Hibiscus tiliaceus* (Linnæus). When full-fed the larva burrows underground, and forms a sort of chamber with a web, in which it undergoes its transformation.

The *pupa* is dark reddish brown, and only distinguishable from that of *A. atropos* by its greater thickness and the abdominal somites being more horny.

The specimens reared remained in the pupal state from February till the following October.

The imago is not uncommon in Durban and the coast districts.

Subfamily CHÆROCAMPINÆ.

10. CHÆROCAMPA CAPENSIS (Linnæus). (Plate XLVII. figs. 17, 18, larva; fig. 19, pupa.)

Larva. Ground-colour pale green, thickly irrorated subdorsally with darker green diamond-shaped spots, from 5th to 11th somites; these spots coalesce into a series of diagonal streaks along the somites subdorsally and spiracularly. A paler green lateral stripe from 5th to 11th somite, with a dark green stripe along its upper edge; horn very short and pink; a reddish "eye"-like spot edged with white superiorly on 4th somite. Head and claspers green, thoracic legs pink; spiracles red.

When ready for its transformation the larva becomes dull pink flesh-coloured, the lateral line only remaining green; the eye-like spot and diamond-shaped irrorations become black, and the ground-colour of the dorsal region becomes dull yellowish. The figure is taken from a larva in this final stage.

Feeds on common vine.

Pupa. Head, wing-covers, and dorsal region dark brown, with black markings; abdomen pale pink flesh-coloured. Time passed in pupa state about five weeks. When about to change the larva spins a web amongst leaves, &c., on the surface of the ground in some sheltered place, and undergoes its transformation inside.

The imago is fairly common in the evening in flower-gardens in Maritzburg.

I have also reared a red form of this larva, which may be described as follows:—

Ground-colour uniformly ferruginous; a pale subdorsal stripe from 2nd somite to horn, white above, darkening to yellow beneath, bounded inferiorly by dark red diagonal stripes on each somite from 4th to 10th. On 4th somite a conspicuous "eye"-like spot, black superiorly, white inferiorly.

Mr. R. Trimen writes to me of this larva:—"The red form of *C. capensis* larva is, at Cape Town (where the species feeds on the cultivated vine), very much rarer than the green one; the colour of the latter is decidedly protective on the cultivated vine, but that of the red one was not so (except slightly, perhaps, when the larva is on the older woody stems). I imagine, however, from one of the red ones which I found on its native food-plant, the wild Cape vine (*Cissus capensis*), that this tint was probably acquired in relation to the latter plant, which is densely clothed with red down on the younger shoots and underside of the leaves. I have noticed the common Cape Butcher-bird (*Fiscus collaris*) taking *capensis*-larvæ from the cultivated vines at Cape Town and spiking them on thorns; such persecution would seem to show that these larvæ are in need of protective resemblance to their food-plants."

11. Chærocampa osiris (Dalman). (Plate XLVIII. figs. 3, 4, larva; figs. 5, 6, pupa.)

Larva. Ground-colour pale green, thickly irrorated with darker green diamond-shaped spots as in *C. capensis.* A paler green lateral stripe from 5th to 11th somites, ending at a very small yellow horn. Two large "eye"-like spots (green with a light blue centre, on which are placed six minute white spots), surrounded by a narrow light yellow iris, on 4th somite; two smaller round yellow spots on 5th somite. Head, spiracles, and claspers green; mandibles and thoracic legs pink.

When ready for transformation the larva becomes pale reddish brown with a violaceous suffusion; the intersections of the somites and lateral stripe become white, while the diamond-shaped spots become black where they are most thickly placed near the junction of the somites; the large "eye-like" spots become brown with a green iris, while the yellow spot becomes black. The effect of these changes is to give the larva, when viewed dorsally, a very startling resemblance to a snake of the banded Krait species.

Feeds on the common vine.

Pupa light brown dorsally, variegated with black spots and streaks defining head, eyes, antennæ, wing-covers, nervures, and abdominal somites; breast, wing-covers, and underside of abdomen pale pink flesh-coloured.

This pupa is chiefly remarkable for its abnormally long snout, the palpi-covers being produced to form a shield or covering for the haustellum.

The transformation takes place amongst leaves on the surface of the ground, without much attempt at making a chamber with a web, the leaves being loosely strung together by means of a silken thread.

This larva was received from Bellevue, a suburb of Durban; the imago seems to be rather uncommon.

12. Chærocampa balsaminæ (Boisduval). (Plate XLVIII. fig. 1, larva; fig. 2, pupa.)

Larva. Ground-colour bright grass-green; from 6th to 11th somites a brown interrupted dorsal streak, and traces of two double subdorsal streaks mainly formed by small brown spots arranged in transverse rows across the somites. On the 4th somite a pair of black "eye"-like spots with a white iris; on the 5th somite a pair of red "eye"-like spots with a white iris, and between these the dorsal streak above mentioned is continued, green in colour, to the head; thoracic legs pink; head and claspers green; horn light brown and straight, ending in a point.

Feeds on *Jussiœa repens* (Linnæus).

Pupa. Head, thorax, and wing-covers yellowish brown, remainder of body reddish brown, paler dorsally and abdominally; palpi-covers slightly produced and prominent. The pupa is formed in a light web amongst leaves on the surface of the ground, in the usual manner of the larvæ of *Chœrocampinæ.*

The imago emerges in about a fortnight (in February).

Found in Durban district.

13. CHÆROCAMPA IDRICUS (Drury). (Plate XLIX. fig. 1, larva; fig. 2, pupa.)

Larva. Ground-colour pale green; each somite, from 4th to 10th, with a pair of triangular spots, brown superiorly, yellow inferiorly, at its anterior edge. The pair of spots on 11th somite are lengthened into a brown and yellow streak, and end in the horn, which is brown, and sharp-pointed like a thorn. The pair of spots on the 4th somite are larger than the remainder, and bear on their yellow area an oval, black, "eye"-like spot with a white pupil near its upper edge; each spot has three minute white points on its brown area; spiracles white; a pinky-white subspiracular line, and above it a collection of brown points at each intersection of the somites. Head and claspers green, thoracic legs light brown.

Feeds on *Spermacoce natalensis* (Hochst.), a common herb among the grass of the veldt.

Pupa. Pale golden brown, with small black spots defining the nervures on the wing-covers, and sprinkled over the abdominal somites; spiracles black. Period of pupation about 23 days. Habits and transformation similar to other species of the genus.

The imago is very common, hovering over flowers in gardens in Maritzburg, from the early afternoon till dusk.

The larva and pupa are here figured × $\frac{6}{4}$ in size on nature.

14. DAPHNIS NERII (Linnæus).

The transformations of this insect are so well known that figures and detailed descriptions are unnecessary here; but it may be as well to note that numerous specimens were reared from the larva on oleander, which plant is a common shrub in gardens in Maritzburg. The colour of the larva in Natal is very pale green (almost yellow) dorsally, darker below; a white lateral line with numerous small silver-white spots sprinkled over, above, and below it, the lower edge of the line is bounded by a broad light blue area extending downwards as far as the spiracles from 6th to 10th somites. On 3rd somite a pair of large, black, double-pupilled, eye-like spots, the pupils being white, surrounded by a blue and a crimson iris.

Pupa pale ferruginous; habits and transformation similar to those of *C. capensis.*

Duration of pupa state 10th or 11th February to 4th March.

Subfamily SPHINGINÆ.

15. PROTOPARCE MAURITII, Butler. (Plate XLVIII. figs. 9, 10, larva; fig. 11, pupa; fig. 12, larva, dorsal view of 1st four somites.)

I am informed at the British Museum that the name *Macrosila solani*, by which this species is usually known in South Africa, should be applied to the Mascarene form.

Larva. Ground-colour grass-green, under surface darker. Paired humps on 1st and 2nd somites; a purple dorsal stripe from 4th somite to horn; lateral oblique purple stripes from 4th to 10th somites; these stripes join the dorsal stripe on every somite, and are defined inferiorly by parallel narrow white oblique stripes; horn ferruginous, long, and beset with yellowish tubercles; spiracles small, red, with black centres. Head green, with vertical black stripes on the face and sides, as in larva of *A. atropos.* Thoracic legs black, claspers green.

Feeds on *Duranta plumieri*, a common shrub in gardens in Natal; but which, according to Mr. Medley Wood, "is included in the flora of Natal by mistake, and is most certainly not indigenous."

I have also reared a dark form of this larva, which may be described as follows:— Ground-colour very pale brown, the oblique purple stripes of the green form being represented in this form by oblique stripes of dark violaceous grey covered with blackish atoms. Head pink, with lateral and frontal vertical black stripes; first three somites pink subdorsally, surmounted by paired dorsal diamond-shaped fuscous spots. It will be observed from this description that the head and first three somites of this larva bear a striking resemblance to the dark form of the larva of *Acherontia atropos.* Spiracles black; prolegs and claspers pale brown with fuscous bands; horn yellow and serrated.

The specimen figured fed on *Dahlia variabilis* (an imported plant in Natal).

Pupa. Dark reddish brown, with a long external sheath for the proboscis. The transformation is effected underground, where, as in the case of *A. atropos*, the larva constructs a sort of chamber for the pupa.

Mr. Trimen states "the case of *M. solani* seems to me especially interesting, because not only is the larva imitative of that of *A. atropos* in both forms, but the moth also is decidedly imitative of *atropos*-moth, so much so that I have taken it for *atropos* when at rest on a tree-trunk. At Cape Town both the dark forms (of *solani* and *atropos* larvæ) are rare in comparison with the green ones."

Subfamily MACROGLOSSINÆ.

16. CEPHONODES HYLAS (Linnæus). (Plate XLVIII. figs. 13–18, larva; fig. 19, pupa.)

This well-known insect has been reared from six different forms of larva in Natal, which show almost every gradation from an almost wholly green larva with white subdorsal stripes to an almost wholly black one, in which the subdorsal stripes are replaced by very dark grey ones.

The various forms will now be described in detail.

Larva. 1st form. Ground-colour pale green, a white-bordered light blue dorsal line, and a thin white subdorsal line bordered superiorly by a thin carmine line, the combined lines ending in a yellow streak at the base of the horn. Spiracles white, bordered with red edges, that on 11th somite surrounded by a rufous area. Head green, 1st somite beset with yellow tubercles superiorly; thoracic legs and claspers brownish; horn green, curved and pointed, and beset with yellow tubercles. Plate XLVIII. fig. 13.

This seems to be the Indian form described by Hampson in 'Fauna of British India.'

2nd form. Ground-colour pale green; a white-bordered blue dorsal line; a subdorsal white line defined in places superiorly and inferiorly by small black oval spots; under surface, legs, and claspers pale brown. Spiracles white, surrounded by oval red areas; a yellow subspiracular line, interrupted and defined inferiorly with black, which curves up vertically on the posterior half of each somite from 6th to 9th, otherwise as in 1st form. Plate XLVIII. fig. 14.

3rd form. Similar to 2nd form, but differing in the following characters:—The dorsal line is dark grey; the black oval spots defining the white subdorsal line inferiorly are much more numerous and extend downwards between the spiracles till they meet a black subspiracular line. The red areas surrounding the spiracles more enlarged. Plate XLVIII. fig. 15.

4th form. Similar to 3rd form, but differing as follows:—Dorsal line darker, the black oval spots defining the white subdorsal line inferiorly are coalesced into a continuous black lateral line; and the whole body below it is pale brown, with only an isolated patch of green on each somite round the red spiracular areas. 1st somite yellow, covered with small yellow tubercles. Plate XLVIII. fig. 16.

5th form. Dorsal and subdorsal stripes as in 4th form. Ground-colour black; a rufous area round each spiracle, and a few irregular yellow marks on each somite; a few traces of the yellow subspiracular line, and a yellow patch at base of horn; claspers and anal extremity brown; head and 1st somite yellowish. Plate XLVIII. fig. 17.

6th form. Entirely black, with the exception of the red areas surrounding the spiracles, and the head, base of horn, and anal extremity and claspers, which are dull ferruginous; dorsal line black; subdorsal line and 1st somite dark grey. Plate XLVIII. fig. 18.

All these forms of larva were found at the same time feeding on *Gardenia* and also on *Kraussia lanceolata* (Sond.). When ready for their transformations the larvæ burrowed underground, and there underwent their change to pupæ; the perfect insects emerged in from 3 to 4 weeks. In order to test whether all the different forms of larva produced the same imago, each form of larva was placed in a separate box and carefully labelled, but when the imagines emerged it was impossible to detect any difference between them.

Pupa. Dark reddish brown.

The imago seems common all over Natal.

Family ZYGÆNIDÆ.

17. ZYGÆNA (ANTERIS) AMPLA (Walker). (Plate XLIX. figs. 27, 28, larva; fig. 29, cocoon.)

Larva. Ground-colour white, with pink stripes and black spots. A white dorsal line bordered by two subdorsal rows of black spots, two on each somite; beneath these a pink lateral line bordered inferiorly by a white spiracular line, on which is situated a row of smaller black spots in groups of two on each somite. A subspiracular pale fulvous line, and below it an interrupted line of black lunules, one on each somite; under surface and claspers white; head black, with a white bifid frontal stripe.

General form of larva thick in middle, tapering towards extremities, and very similar to larvæ of Lycænidæ in shape.

Feeds on a bush with very large leaves with spiny edges (like holly) of which I have not been able to obtain the name.

The *pupa* is formed in a strongly-woven oval cocoon, usually pale fulvous, and affixed to a leaf of the food-plant; time passed in pupal stage about 25 days (March 3rd or 4th to March 29th, 1899).

Found in large numbers on the food-plant in the Back Beach Bush, Durban.

Family LASIOCAMPIDÆ.

18. GONOMETA POSTICA (Walker). (Plate XLIX. figs. 3, 4, larva; fig. 5, cocoon.)

Larva. There are two common forms of this larva in Natal, one with long grey hair and one with long fulvous hair.

1st form. Ground-colour deep velvety black, thickly covered on sides with long grey hair; a thin black dorsal line and paired black subdorsal patches of short black hairs on each somite from 4th to 12th. Head black, covered with brownish-grey hairs;

spiracles, thoracic legs, and claspers red. The *2nd form* is similar to the 1st, but with the long hairs bright fulvous. Both forms feed on the same food-plant at the same time, grow to the same size, and produce male and female imagines irrespectively.

This larva should not be handled without gloves, as its hair penetrates the skin of the hand and causes much irritation. It appears in great numbers in November and early December, feeding on common wattle (*Elephantorrhiza burchellii*) and also on a species of thorny acacia; the second brood appearing in March and April.

The *pupa* is formed inside a cocoon beset with the hairs of the larva, which cause a very irritating effect to the fingers if it is grasped carelessly, and is affixed to a branch of the food-plant, as shown in the figure.

Pupæ formed in April hybernate in this state, and emerge as imagines in the middle of October.

In common with species of Saturniidæ, the male of this moth seems to possess in a high degree the power of discovering the whereabouts of the female, and the possession of one female will enable a collector to secure a large number of males.

Common and widely distributed in Natal.

Family LYMANTRIDÆ.

19. Dulichia fasciata (Walker). (Plate XLIX. figs. 13, 14, larva.)

Larva. Ground-colour velvety black; dorsal area white, thickly covered with white hairs, except on the 4th, 5th, 11th, and 12th somites, which are surmounted by tufts of long black hairs; a dorsal red spot on the 9th and 10th somites; a spiracular line of red spots, and below this an interrupted white line bearing long white hairs. Head black; thoracic legs and claspers red.

Feeds on species of *Bauhinia*, and also on rose-bushes and oak, the two latter being imported plants in Natal.

When ready for its transformation, the larva forms a silky cocoon with its hairs, inside which it changes and remains as a pupa for about 24 days (Dec. 30th to Jan. 23rd).

Common in gardens in Maritzburg.

20. Dasychira georgiana, sp. n. (Plate XLIX. fig. 19, imago; fig. 20, larva; fig. 21, pupa.)

Allied to *D. horsfieldii.* Head and thorax white; branches of antennæ fulvous. Fore wing white, irrorated with black scales; the antemedial lines more angled than in *D. horsfieldii*; the hind wing white, with some darker hairs on the internal area. Abdomen orange, with a dorsal line of black spots on first four somites. Underside white, no cell-spots.

Larva. Ground-colour velvety black, with very long pale yellow hairs; each somite with two red and four greyish tubercles, from which spring the long silky yellow hairs, except the 4th, 5th, 6th, and 7th somites, on which the two dorsal tubercles coalesce, and from these spring four thick dorsal tufts of shorter grey hairs, and 11th somite, which bears a tuft of shorter blackish hairs. Head red above, black beneath; thoracic legs and claspers red, and a red transverse band on 12th somite.

Feeds on common wattle (*Elephantorrhiza burchelli*).

The *pupa* is formed in a slight web constructed from the hairs of the larva, and is pale fulvous with black markings; wing-covers greyish, with veins delineated by thin black lines. The descriptions are made from two specimens reared in Maritzburg in February and March. There is a female specimen of the imago in the British Museum unnamed.

Family HYPSIDÆ.

21. Hypsa aphidas (Hopffer)=*H. subretracta* (Walker). (Plate XLVII. fig. 16, larva.)

Larva. Chocolate-brown; under surface greyish; an indistinct dark dorsal line. Three red tubercles, one dorsally and two subdorsally, on 1st to 3rd somites; paired red subdorsal tubercles, four on each somite, on a black subdorsal line, from 4th to 12th somite; a broad white spiracular streak on 5th, 6th, 10th, and 11th somites. Head dark brown; thoracic legs and claspers fuscous. A few sparse brown hairs on the body.

Feeds on the common fig, both cultivated and wild; the specimen figured fed on the cultivated fig, but I have reared others which I found as pupæ in hollows on the trunks of the wild fig-trees round the gardens in the square at Durban. When about to change, the larva rolls up a fig-leaf in which it spins a web, and the same process is gone through in the hollows of fig-tree trunks. The specimen figured remained as a pupa from 18th February to 22nd March.

Pupa black, with polished surface.

Imago fairly common in Durban and Maritzburg.

Family ARCTIIDÆ.

22. Spilosoma puella (Druce). (Plate XLIX. fig. 15, larva.)

Larva. Ground-colour dark fuscous, each somite with six large and two small black tubercles surmounted by tufts of black hairs. A pale ferruginous dorsal line, darker on the summit of each somite; under surface paler; head and thoracic legs black, spiracles ferruginous.

Feeds on the Grenadilla passion-flower.

Pupa black, with polished surface, formed inside a cocoon constructed out of the hairs of the larva. The imago emerged in about 17 days (March 8–26).

Common in Maritzburg.

Subfamily ARCTIINÆ.

23. PHISSAMA FLAVA (Walker). (Plate XLIX. fig. 8, larva.)

Larva. Ground-colour pale fuscous, each somite with a red-brown area superiorly, on which is situated a dorsal line of white spots surrounded by black, one on each somite; also a series of black tubercles bearing tufts of black and reddish hairs. Head, thoracic legs, and claspers ferruginous.

Feeds on *Ornithogalum eckloni*, a species of lily, and other plants.

When ready for its transformation the larva weaves a cocoon with its hairs and remains a pupa for about 17 days (1st to 17th December in the case of the specimen figured).

The imago is common in Maritzburg district.

24. PHISSAMA SCREABILE (Walker). (Plate XLIX. fig. 9, larva.)

Larva. Ground-colour greyish white, the somites broadly black transversely and beset with long black and white hairs; the white spaces between the somites traversed by fine black transverse lines; under surface black. Head, thoracic legs, and claspers bright red.

Feeds on *Ornithogalum eckloni*, also on mealie: a larva reared on the latter plant differed from the individual figured in its lighter parts being buff instead of white; this larva produced a female imago.

The *pupa* is formed inside a cocoon constructed with the hairs of the larva. Duration of the pupal stage about three weeks (9th to 29th December, specimen figured).

Imago is common in Maritzburg district.

Subfamily NYCTEOLINÆ.

25. EARIAS INSULANA (Boisduval). (Plate XLIX. fig. 25, larva; fig. 26, cocoon.)

Larva. Ground-colour pale bluish-black, with deep black markings; 1st to 3rd somites pale brown; 4th somite with a white transverse streak; an interrupted white dorsal line from 4th to 8th somite; 9th to 12th somite pale brown dorsally. A subdorsal line of paired short brownish spines with scarlet bases; a lateral line of similar paler spines. Head and legs pale brown.

Feeds on *Hibiscus*.

The *pupa* is formed in a stout thickly-woven cocoon attached to stem of food-plant.

The larva is figured × $\frac{6}{4}$, to get in detail.

Common in gardens in Maritzburg.

Family AGARISTIDÆ.

26. Eusemia butleri (Walker). (Plate XLVII. fig. 14, larva; fig. 15, pupa.)

Larva. Ground-colour light bluish-grey, with fine black transverse stripes and spots on each somite; a reddish spiracular line. Head, thoracic legs, and 1st and 11th somites superiorly reddish ochreous; a few sparse hairs distributed over the somites; thoracic legs fuscous; ventral claspers blue-grey, anal claspers reddish ochreous.

Feeds on common vine (cultivated).

The larva undergoes its transformation underground, and remains a pupa about one month.

Pupa reddish fuscous, very rugged in appearance, the abdominal somites very strongly defined.

The imago has a very strong penetrating scent.

Not uncommon in Maritzburg.

Family NOCTUIDÆ.

Subfamily Trifinæ.

27. Glottula pancratii (Cyr.). (Plate XLIX. fig. 17, larva; fig. 18, stem of food-plant showing hole.)

Larva. Reddish brown, each somite with three small black warty spots, one dorsally, two subdorsally, and two small pale yellow subdorsal spots; between each two somites a transverse row of five oblong pale yellow spots, divided mesially by the intersection of the somites. Head, legs, and claspers ferruginous; a few short fulvous hairs on the somites.

This larva feeds on a species of lily, eating the flowers as well as the stems; also making a burrow inside the stem (as shown in fig. 4 *c*). It can eat its way out of any box, except tin. When full-grown it undergoes its transformation underground.

Pupa red-brown, with strongly-marked somites.

The *imago* is noteworthy owing to its exceedingly small and short pale green haustellum, which would seem to be of little use to it.

28. Agrotis segetis (Schiff.). (Plate XLIX. fig. 16, larva.)

Larva. Ground-colour pale brown, with small black spots placed irregularly on the somites; fuscous dorsal and lateral lines, the former narrow, the latter rather broad and bounded inferiorly by a narrow white spiracular line. Under surface, thoracic legs, and claspers pale fulvous. Head ferruginous, the eyes defined by two crescentic black frontal lines.

Feeds on the cultivated vine, and undergoes its transformation underground.

The pupal stage lasted about one month, in March.

Imago common in Maritzburg in February and March.

Subfamily Quadrifinæ.

29. Polydesma glaucinans (Guen.). (Plate XLIX. fig. 22, larva; fig. 23, pupa in web.)

Larva. Ground-colour bright grass-green, with a broad white dorsal line from head to 12th somite, which bears on its centre a narrow pale blue dorsal line; an interrupted white lunular lateral line, bordered with black superiorly. Head, thoracic legs, and claspers green; the first pair of abdominal claspers aborted; the 12th somite tapering to a point above the anal claspers.

Feeds on wattle (*Elephantorrhiza burchellii*).

Pupa pale brown, formed in a cocoon among the stems of the food-plant.

Imago very common in Maritzburg in March.

30. Tæniopyga sylvina (Stoll). (Plate XLIX. figs. 10, 11, larva; fig. 12, pupa in cocoon.)

Larva (early moults). Ground-colour buff; on each somite, except 1st and 11th, a broad very dark crimson transverse band; on 1st and 11th somites he band is pale ferruginous and bears some small black spots. In the final moult the above-mentioned bands become deep velvety black, with the exception of those on the 1st and 11th somites, which remain the same, the ground-colour becoming pale greenish. Head, legs, and claspers pale ferruginous.

Feeds on *Ornithogalum eckloni* (Sch.), a species of lily common in swampy places. When full-fed the larva burrows underground and constructs a chamber for the pupa, which is surrounded by a strong hard envelope, of a consistency similar to cement, with a small hole at one end for the exit of the imago.

Pupa deep red, with black antemedial and postmedial lines on the wing-covers.

The period of pupation lasts about five weeks.

The imago is not uncommon in Maritzburg in January and February.

Family GEOMETRIDÆ.

31. Boarmia acaciaria (Boisduval). (Plate XLIX. fig. 24, larva.)

Larva. Ground-colour pale reddish brown, inclined to olive-green subdorsally; a pair of dorsal processes with whitish centres on 5th somite, and a pair of dorsal white spots on 11th somite. Head, legs, and claspers reddish.

Feeds on a small species of sunflower, which is a common plant in gardens at Maritzburg.

The transformation to pupa is effected underground.

My specimens of the imago were identified as *B. acaciaria* at the British Museum, but they are much paler and have fewer transverse bands than the examples in that collection, or the specimen figured by Hampson in 'Fauna of British India,' vol. iii. p. 265.

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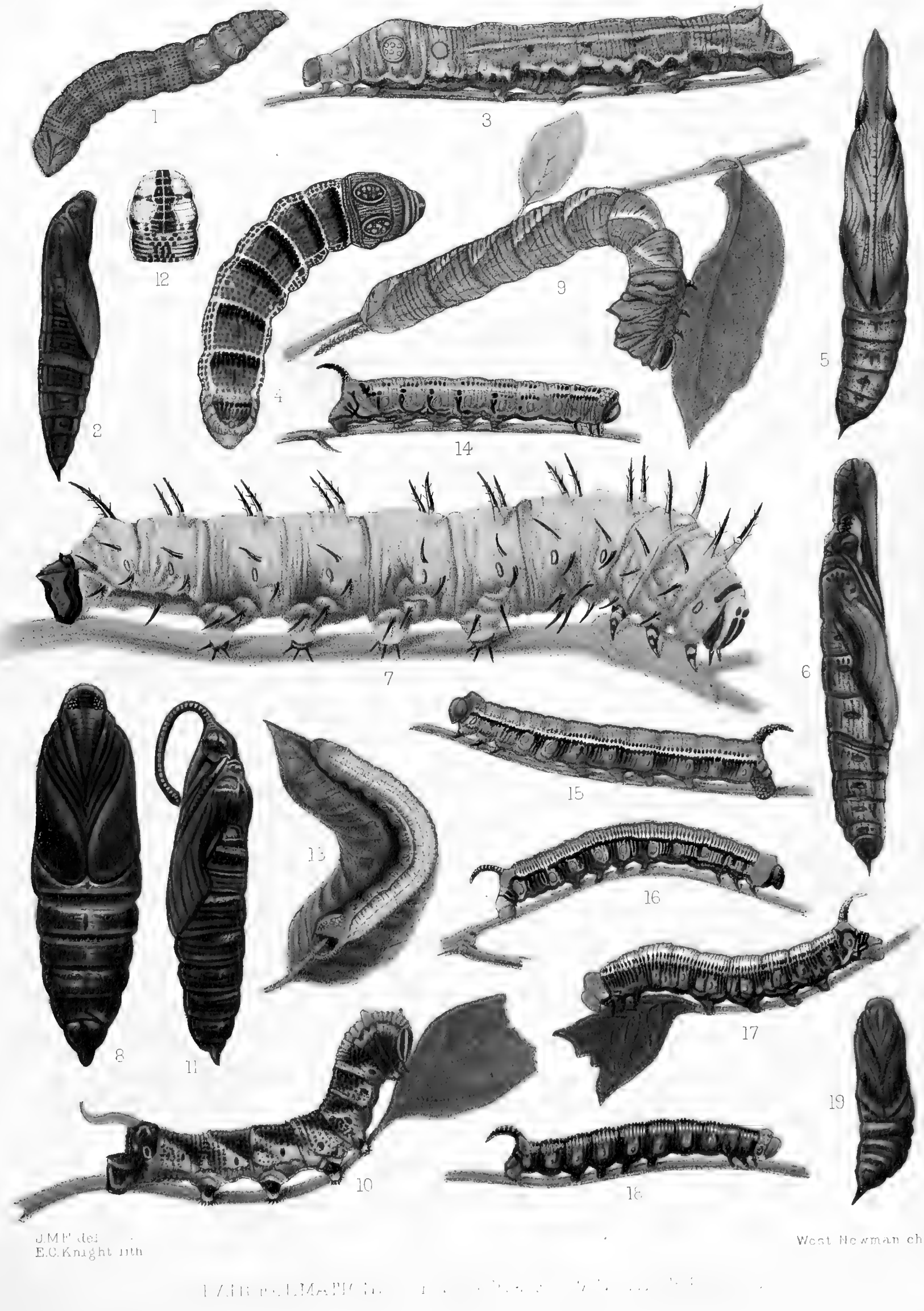

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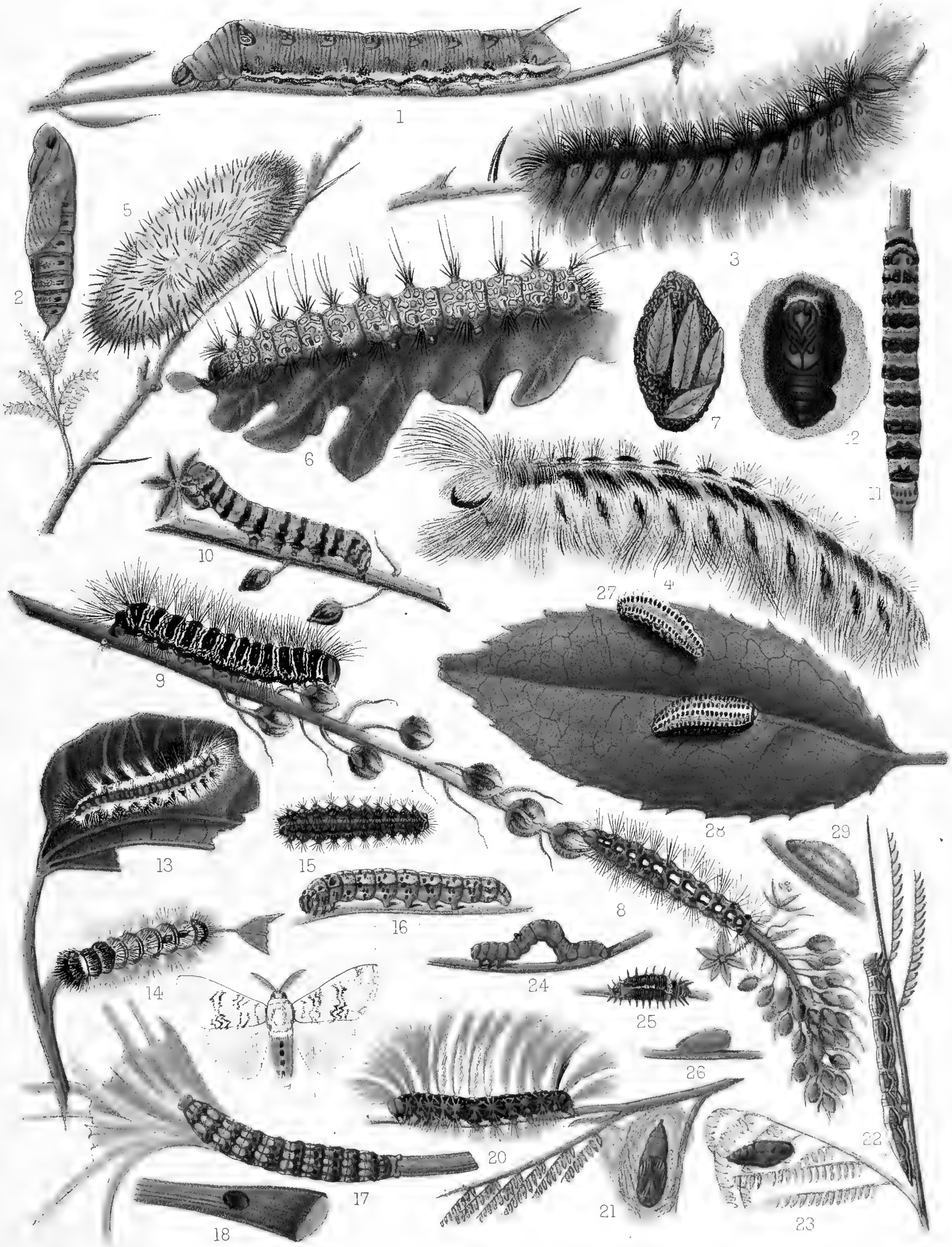

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April, 1901.

P. L. SCLATER,
Secretary.

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OF

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Continued on page 3 of Wrapper.

VIII. *On some Points in the Anatomy of* Polypterus.

By J. S. Budgett, *M.A., F.Z.S., Trinity College, Cambridge.*

Received and read May 8, 1900.

[Plates L.-LII.]

Contents.

I. *Introduction.*

HAVING obtained a large amount of material of both the species of *Polypterus* found in the Gambia, in the spring of 1899, I have thought it advisable to attempt to fill up some gaps in our knowledge of the anatomy of this most interesting of fishes.

A great deal of work has already been done in this direction by such eminent zoologists as Agassiz, Geoffroy St.-Hilaire, Joh. Müller, Leydig, and Hyrtl, as well as by numerous other authors in recent years. The anatomy of the head of *Polypterus* has been described in detail by Pollard, the brain by Waldschmidt, the skull by Traquair and by Bridge, while Hyrtl has described the blood-supply of the external gill. The foundation of this work of recent years had been laid, however, by Joh. Müller in his 'Bau und Grenzen der Ganoiden.'

In the present paper I have, I believe for the first time, described in detail the urinogenital system of the male and female *Polypterus*, together with the later stages in the development of these organs. I have also added some observations upon the vascular system, the external gill, the abdominal pores, the anal fin, and the skull.

II. *The Male Organs.*

The following observations have been made on adult male specimens of *Polypterus senegalus* and *P. lapradei* taken at the commencement of the breeding-season. Series of the urinogenital organs of the young *P. senegalus*, 13 cm. and 9 cm. in length, have also been carefully studied.

In the adult male a ridge of testicular tubules extends the entire length of the body, lying parallel to and directly over the kidney on either side (Pl. L. figs. 2, 3, *t.r.*). Each testis-ridge is enlarged towards its anterior end, forming a conspicuous lobulated testis (fig. 3, *t.*): that on the left side is situated more anteriorly than that on the right.

The testis and testis-ridge are covered by peritoneum, the two folds of which are approximated at the base of the testis to form a mesorchium, in which spermatic veins pass to the cardinals (fig. 3, *sp.v.*).

The tubules of the testis and testis-ridge open by very numerous short ducts into a longitudinal canal extending the whole length of the gland lying in the mesorchium at the base of the testis, and further back between the testis-ridge and the kidney (Pl. L. fig. 3, *t.d.*; Pl. LI. figs. 10, 11, *t.d.*). Posteriorly this duct leaves the testis-ridge as the vas deferens (Pl. L. figs. 5, 6, *v.d.*), and passing backwards in the same sheath of connective-tissue as the ureter, opens upon a papilla into the narrow neck of the urinogenital sinus just before it opens to the exterior (Pl. L. fig. 5; Pl. LI. figs. 12, 14, *g.ap.*).

This duct is of even calibre throughout the greater part of its length, but is somewhat dilated in the region of the lobulated testis.

The tubules of the adult ripe testis are very numerous, and dilated with spermatozoa and what appear to be sperm mother-cells. The tubules are embedded in lymphoid tissue with deeply-staining nuclei (Pl. LI. fig. 10, *t.*). The spermatozoa are very small, about the diameter of a red corpuscle in length, thickened anteriorly and tapered posteriorly (Pl. LI. fig. 13).

The arrangement of the tubules of the testis-ridge is a simplification of that of the testis-tubules. Here three or four longitudinal tubules are connected by numerous transverse tubules with the testis-duct (Pl. LI. fig. 15, *t.r.tbs.*). The walls of these tubules are lined with columnar epithelium, and are not surrounded by lymphoid tissue as are the tubules of the testis, but by dense connective-tissue.

The tubules of this testis-ridge do not appear to be functional testis-tubules, although amongst them were found what appeared to be traces of spermatozoa. It seems possible that the tubules of this ridge assist in carrying away the sperm from the testis to the vas deferens, but do not themselves actually produce spermatozoa.

In the young Polypterus senegalus, 13 cm. in length, the tubules of the testis which are embedded in lymphoid tissue are lined by a single layer of large-celled columnar epithelium, while the lumina are small (Pl. LI. fig. 16, *t.tbs.*). The tubules of the testis-ridge differ little from those of the adult male (Pl. LI. figs. 15, 17, *t.r.tbs.*); the tubules, however, are smaller as compared with the testis-duct in the young than in the adult. It is noteworthy also that the vas deferens, which in the young is very thick-walled and has a larger lumen, is much larger as compared with the ureter in the young than in the mature individual (Pl. LI. figs. 14, 18, *v.d.*).

In the young *Polypterus* the duct of the testis runs forward a short distance anteriorly to the testis. This portion of the duct could not be traced with certainty in the adult. No opening in the young male was found, however, into the body-cavity.

In the very young male, 9 cm. in length, the tubules of the testis are foreshadowed by the nuclei being arranged in double rows, but there are no lumina; the duct, however, has a wide lumen and is well formed (Pl. LII. fig. 19, *t.d.*). At this stage the tubules of the testis-ridge are not yet developed; the duct, however, is here well formed, as opposite the testis. Posteriorly the vasa deferentia end blindly in the wall of the ureter (Pl. LII. fig. 20, *w.v.u.*).

III. *The Female Organs.*

The following observations have been made on adult female specimens of *P. senegalus* and *P. lapradei* taken at all times of the year, and also upon specimens of the young female *P. senegalus* 9 cm. in length.

The funnel-like opening of the oviducts into the body-cavity (Pl. L. fig. 1, *p.ap.od.*) were mentioned and figured by Joh. Müller; the ducts were figured in more detail by Hyrtl, and the ovaries were described. My own observations, however, do not in some respects agree with those of the latter author. According to Hyrtl the two oviducts unite to form a urinogenital sinus, into which the two ureters open by a common mid-dorsal aperture.

I have carefully studied the adults of both species found in the Gambia, and I find that the ureters are dilated posteriorly, lying closely approximated to each other, but not communicating, except immediately before opening to the exterior (Pl. L. figs. 1, 4, *u.*; fig. 4, *s.u.g.s.*). Shortly before the ureters open to the exterior the oviducts open into their lateral walls precisely as do the vasa deferentia in the male (Pl. L. fig. 4, *g.ap.*). Further, in the young female 9 cm. in length the course of these ducts has exactly the same relation to the ureter as in the male, only that the oviducts are considerably more dilated; they lie immediately over the genital ridge, which anteriorly is developed into the ovary (Pl. LII. figs. 21, 22, 23, *mes.o.*).

The great difference between the sets of organs in the male and female is that in the male the genital gland discharges directly into the duct, whereas in the female the genital products are shed free into the body-cavity, and thence find their way to the mouth of the duct. Were the outer wall of the duct in the female carried forwards to enclose that side of the ovary from which the ova are shed, or were the testis-duct in the male open anteriorly to receive the products of the testis from the body-cavity, the arrangement would be precisely analogous in the male and female.

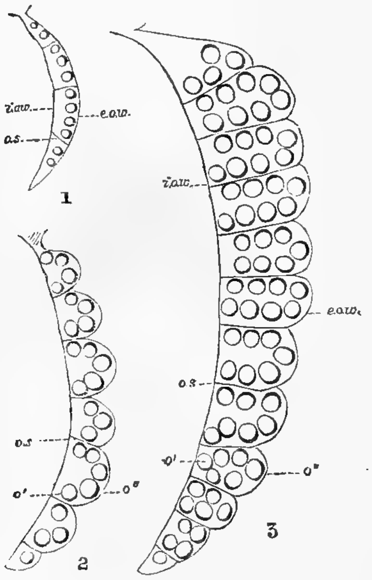
The latter appears actually to be the case in *Polyodon folium*, where, according to Hyrtl, the duct of the testis, as well as the duct of the ovary, opens into the body-cavity by means of a peritoneal funnel.

At what stage the opening of the oviduct into the cœlom is acquired in *Polypterus* I cannot definitely say. It was, however, open in my youngest specimen 9 cm. in length (Pl. LII. fig. 22, *p.ap.od.*).

In young females 9 cm. in length the genital ducts have not a free opening into the ureter, but, as in the male, the ducts end blindly in the wall of the latter (Pl. LII. fig. 24, *w.o.u.*). The communication is complete, however, by the time the young *Polypterus* is 12 cm. in length.

Though it would be unwise to form any definite opinion as to the significance of these ducts until their primary origin shall have been made clear, yet, seeing that very immature specimens have been examined, it seems worth while suggesting that the very high development of the genital ducts at an early stage in both sexes, and their similar arrangements, point to their being homologous with one another and also with the embryonic Müllerian duct. The discussion of the *à priori* objections and the consequences of this conclusion need not here be discussed, in view of the probability of the question being settled by a study of the early development of *Polypterus*.

Figs. 1–3.



Ovary of *Polypterus*.

Fig. 1.—Diagrammatic representation of the developing ovary.

Fig. 2.—The outer wall of the ovary between each septum beginning to bulge.

Fig. 3.—The outer wall thrown into deep folds, as in the ripe ovary.

e.o.w., external wall of ovary ; *i.o.w.*, internal median wall of ovary ; *o'*, white side of ovum ; *o''*., black side of ovum ; *o.s.*, septum dividing ovary into compartments.

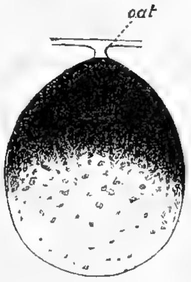
The ovary in *Polypterus* develops as a genital ridge lying along the ventral surface of the kidney, and separated from it posteriorly by the genital duct (Pl. LII. figs. 21, 22, 23).

A large vein and artery traverse the median wall of the ovary (Pl. LII. fig. 21, *b.v.*). The ovary becomes divided into numerous compartments, on the outer wall of which the ova are developed (Pl. LII. fig. 21, *o.at.*, and text-fig. 1, p. 326).

With increased development of the ova in size and number, the outer wall becomes greatly enlarged in surface, while the median wall is not thus enlarged (text-fig. 2). It thus happens that the outer wall bulges out into great folds between the septa (text-fig. 3).

As the ova develop they become deeply pigmented upon the pole of the ovum which is attached to the outer wall of the ovary. Although the outer wall becomes so much folded, nevertheless the ova retain their original "orientation" at the extremities of each fold, so that, when ripe, through the median wall of the ovary, which is a thin smooth sheet, only the pigmentless poles are seen (text-fig. 3, *o′*), while through the external much-folded wall only the pigmented poles are seen (text-fig. 3, *o″*). It has been stated that the outer wall of the ovary of *Polypterus* is without a covering of peritoneum. It will be understood from the above-given description of the growth of the ovary, and from the examination of text-fig. 4, that this is not strictly correct.

Fig. 4.



The ovarian ovum of *Polypterus*, with attachment (*o.at.*) to the outer wall of a compartment of the ovary.

IV. *The Kidneys.*

The kidneys are similar in male and female. They consist of two bands of excretory tubules, glomeruli, and embedding lymphoid tissue (Pl. LI. figs. 10, 11, 16) lying on either side of the vertebral column between the peritoneum and the muscles of the body-wall, and are constricted metamerically by the projecting myocommata. The kidneys of the two sides do not unite (Pl. L. figs. 2, 3, *k.*).

The minute structure of the kidney of the young *Calamoichthys* has been described by Lebedinsky. His description of the arrangement of the tubules in *Calamoichthys* will answer perfectly for that in *Polypterus*, except that in my youngest specimen 9 cm. in length I can find no trace of the nephrostomes opening into the cœlom described by him in "larvæ" 12 cm. in length. It seems, then, that *Calamoichthys*, which is so much smaller in the adult than *Polypterus*, is in a more larval condition at 12 cm. length than is the *Polypterus* at 9 cm.

It is possible that the nephrostomes never entirely close in *Calamoichthys*. However this may be, I have found in *Polypterus* no trace of nephrostomes opening into the cœlom.

In my youngest specimens the uriniferous tubules were arranged in distinct metameric masses, the metamerism disappearing in older specimens. The glomeruli did not appear to be thus arranged, there being a very indefinite number of these structures to each metamere (Pl. LI. figs. 10, 16, *m.cps.*). The openings of the tubules into the ureter are far more numerous and irregular in the adult than in the young.

V. *The Ureters.*

The ureters lie along the whole length of the kidney between the outer ventral edge of the latter and the body-wall (Pl. L. figs. 2, 3; Pl. LI. figs. 10, 11, *u.*) (text-figs. 5, 6). They receive the kidney-ductules. The ureter on passing ventralwards from the hind end of the kidney becomes dilated, and, in the male, joining its fellow of the opposite side, forms a large urinary sinus (Pl. L. figs. 2, 5, 6; Pl. LI. fig. 12, *u.s.*). The urinary sinus still passing ventralwards to a position just dorsal to the rectum becomes constricted to a narrow neck and, just before opening to the exterior, receives on either lateral wall the opening of the genital duct, then opens to the exterior in a depression just posterior to the anus (Pl. L. figs. 6, 7, 8, *u.g.ap.*).

In the female the ureters do not become confluent until immediately before they open by a slit-like aperture just posterior to the anus. Otherwise they resemble entirely those of the male (text-fig. 6, p. 329).

VI. *General Considerations on the Structure and Growth of the Urinogenital Organs.*

It having been shown by Balfour and Parker and also by Semon that the testis of *Lepidosteus*, and perhaps also of *Acipenser*, was connected with the kidney-tubules, it was of extreme interest to see whether this were the case also in *Polypterus*, in many respects the most archaic of recent Teleostomes.

No such connections as a matter of fact exist. The products of the testis pass out by a well-developed duct, which, running the same course as the ureter, opens into the lateral wall of the latter close to its termination (text-fig. 5).

It is well known that the oviduct of the female *Polypterus* is short and is open anteriorly by a wide peritoneal funnel, the ova being shed through the external wall of the ovary into the body-cavity. This duct in the female runs a course similar to the genital duct in the male, opening into the ureter on its lateral wall shortly before its termination (text-fig. 6).

The resemblance of these ducts in the male and female is brought out still more strongly by a study of the quite young fish 9 cm. in length. Apart from the fact that the oviduct opens into the body-cavity, the arrangements in the two sexes are identical.

Fig. 5.

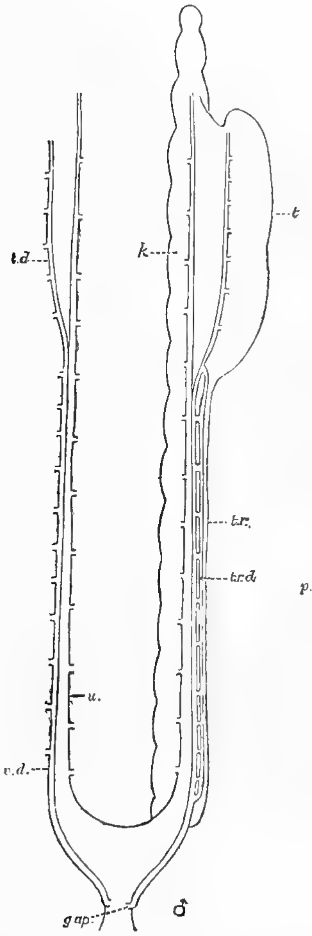


Fig. 6.

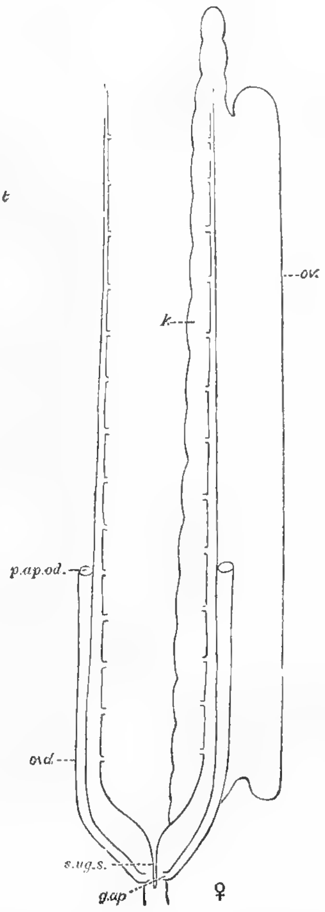


Fig. 5.—Diagram of the urinogenital organs in the male *Polypterus*.
Fig. 6.—Diagram of the urinogenital organs in the female *Polypterus*.

g.ap., genital aperture; *k.*, kidney; *ov.*, ovary; *ovd.*, oviduct; *p.ap.od.*, peritoneal aperture of oviduct; *s.ug.s.*, septum of urinogenital sinus; *t.*, testis; *t.d.*, testis-duct; *t.r.*, testis-ridge; *t.r.d.*, duct of testis-ridge; *u.*, ureter; *v.d.*, vas deferens.

The question as to whether these ducts are both homologous with the Müllerian ducts of Elasmobranchs, Amphibia, and Amniota can of course only be settled by a knowledge of their actual origin.

The fact remains, however, that in this most primitive fish the arrangement of the genital ducts is nearly identical in the two sexes, and would seem to substantiate the view which was latterly held by Balfour that primitively the testis had a duct of its own, derived either from a Müllerian duct like that of the female Elasmobranch, or a structure *sui generis*, as held by Howes and Max Weber, and that, on the other hand, the connection of the testis with the tubules of the kidney found in the male Elasmobranch, Amphibian, and Amniot is a secondary one.

There is, however, a difficulty with regard to the latter view in the fact that *Lepidosteus*, the Ganoid fish which, as regards its ovary and oviduct, most closely resembles the Teleostean arrangement, in having a closed ovary continuous with its duct, is the very one which shows this supposed secondary connection of testis with kidney.

It is possible, however, that this acquirement is confined to *Lepidosteus*, while other Ganoids retain the primitive condition; and it may be that it is a feature which has been frequently acquired independently. So that the Elasmobranch, Amphibian, and Amniot are not necessarily a separate evolutionary line from the Crossopterygian, Dipnoon, Ganoid, and Teleost, but the Amphibia may have acquired the Elasmobranch arrangement after they split off from the Dipnoi, which have not acquired it.

That the arrangement in *Lepidosteus* is not primitive seems probable from the fact that the testis-tubules open into a well-marked longitudinal collecting-duct, which lies along the ureter in the same position as the testis-duct in *Polypterus*, and it is from this longitudinal duct that the transverse tubules pass to the kidney.

That the arrangement in *Polypterus* is not secondary seems probable from the fact that not only is it the simpler method of conveying the testis-products outwards, but is, on the whole, closely similar to the arrangement in the female *Polypterus*, and we can hardly suppose that in the primitive vertebrate the ova and spermatozoa found exit by totally different means.

VII. *Abdominal Pores.*

In both male and female, abdominal pores are present in *Polypterus*. They have been correctly described in the adult as fine canals opening to the exterior on either side of the vent (Pl. L. figs. 7, 8). In the young female 9 cm. in length there is a very fine nucleated diaphragm cutting off the communication of the cœlom with the exterior. This is, however, extremely delicate (Pl. L. fig. 9, *ab.p.*).

In the young male 9 cm. in length the cœlom is completely shut off from the exterior, the abdominal pores not being yet formed.

VIII. *The Anal Fin.*

Traquair has already noted in *Calamoichthys* that the males have an enlarged anal fin. In *Polypterus*, during the breeding-season at least, this difference is not merely one of size but also of shape and form, as shown in Pl. L., figs. 1 & 2.

The anal fin in the female is narrow and pointed, while in the male it is twice as deep as in the female, and its surface is thrown into deep folds between the successive fin-rays. The muscle of the anal fin is greatly enlarged in the male, protruding as a rounded mass into the cœlom. It is this mass which causes the ureters and genital ducts to turn so abruptly ventralwards in the male (Pl. L. figs. 2, 5, 6, *an.f.m.*).

I may mention that in an abnormal male specimen in which the anal fin was absent this muscle was completely absent, and the excretory and genital ducts ran backwards into an extension of the cœlom, then forwards ventrally to open in the normal position behind the vent.

This sexual character almost entirely disappears out of the breeding-season.

Leydig has suggested that there is internal fertilization in *Polypterus* from the fact that in the cœlom of a female *Polypterus* he found masses of filaments which he took for spermatozoa. That these filaments are not spermatozoa can at once be seen by comparing the figure he has given with my figure of spermatozoa from the ripe testis (Pl. LI. fig. 13).

When the arrangement of the oviducts is considered, it seems extremely improbable that the spermatozoa would find their way into a duct which opens into the urinogenital sinus upon a papilla. It remains to be seen to what use the male *Polypterus* puts this modified anal fin.

IX. *The Vascular System.*

The blood-supply to the external gill has been worked out by Hyrtl, while the main roots of the arterial system were described by Joh. Müller. I would call attention, however, to a few additional details. Having injected a male specimen with salt-solution when killed, it was re-injected with a coloured gelatine in the laboratory. The specimen was adult and had no external gill. The details of the blood-supply to the external gill were made out on a young specimen in which it was possible to inject the hyoidean artery with a coloured fluid. The figure of the arterial system was made by a combination of these two dissections.

As Hyrtl has shown, the hyoidean artery arises at the anterior end of the ventral aorta immediately in front of the first afferent branchial artery, and passes to the base of the operculum, at the centre of which it meets the efferent hyoidean artery, to run with the latter to the posterior edge of the operculum and thence to the external gill.

The point I wish to call attention to is that the afferent and efferent arteries at the extremity of the gill are continuous one with another, forming a drawn-out loop. From the afferent limb branches run to the pinnæ, at the extremity of which they loop back to the main efferent limb; similar tertiary loops pass into the pinnules.

At the root of the external gill there is a dorsal and a ventral muscle; towards the extremity of the gill these break up into numerous isolated bundles (Pl. LII. figs. 25, 26, 27). The whole arrangement is quite similar to that of an Amphibian or Dipnoan external gill.

Hyrtl, from the arrangement of the main blood-supply to the external gill, argues that this must be homologous with the pseudobranch of *Acipenser*, which has the same structure as the succeeding gills.

The external gills of larval batrachians are borne upon the first two or three gill-arches, there being to each of these arches an external epidermal gill and an internal, probably endodermal, gill.

Kerr has shown that in larval Dipnoi which possess external gills there is to each arch an internal, probably endodermal, gill and an external epidermal gill, both being supplied by the same afferent artery.

It appears probable therefore that in the external gill of the hyoid arch in *Polypterus* we have not the homologue of the internal endodermal pseudobranch of *Acipenser*, but of the external epidermal gill of Dipnoi and Amphibia.

Moreover there is in *Polypterus* at the base of the operculum a stout branch from the efferent artery (Pl. LII. fig. 25, *hy.eff.'*) which runs parallel with the afferent artery. The presence of this branch is suggestive, as indicating the position of the pseudobranch, corresponding to the pseudobranch of *Acipenser*, of which in *Polypterus* there is no further trace.

Pollard states that he could find no trace of a connection between the last efferent branchial artery and the dorsal aorta, the blood from the last hemibranch passing only to the air-bladder. Part of the blood from this gill does, however, pass to a branch joining the third efferent artery, which on the right side meets the cœliac artery (*br.IV.eff.*). The main part of the blood from the hemibranch of the IVth arch passes to the air-bladder on either side and is returned from them by veins passing to the hepatic veins, as shown by Joh. Müller. The vein on the right side is of great size, corresponding to the size of the right air-bladder, and posteriorly unites with the caudal vein.

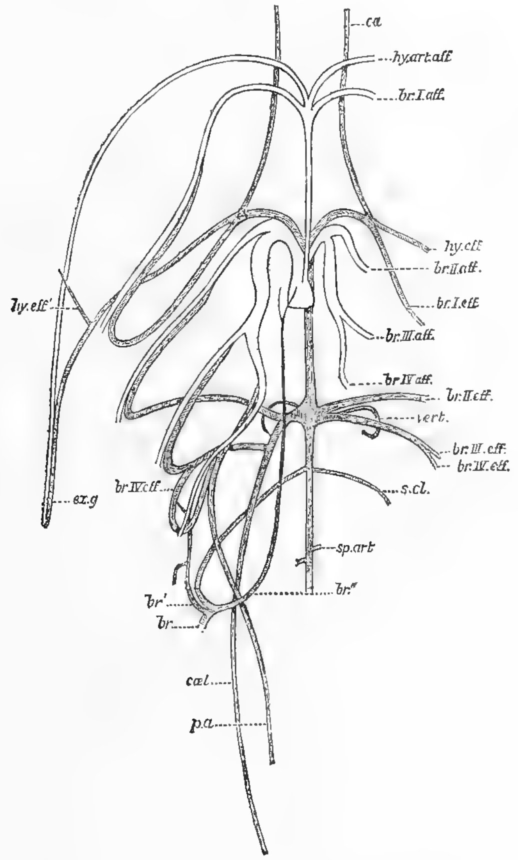
It is difficult to see how these air-bladder veins in *Polypterus* could get converted into the pulmonary veins in Amphibia. It seems more probable that the great vein of the right air-bladder corresponds to the anterior abdominal vein of Amphibia, though it is notorious that veins frequently make secondary connections.

The subclavian artery of *Polypterus* passes outwards dorsal to the vagus and the cœliac and pulmonary arteries, and curving ventralwards gives off, near the pericardium, a branch on either side (text-fig. 7, *br.''*). The posterior branch, the brachial, is a stout artery passing to the pectoral fin; the anterior branch runs dorsally again parallel with the main subclavian, and divides to supply the muscles of the shoulder-girdle (text-fig. 7, *br.'*). After giving off these two branches, the subclavian is continued as a small coronary artery along the sides of the pericardium, at the anterior end of which it passes to the walls of the conus and ventricle (text-fig. 7, *br.''*).

The blood from the conus and ventricle is returned to the ductus Cuvieri by a thick-walled, deeply-pigmented, coronary vein, which runs free in the pericardial chamber from the ventricle to the ductus Cuvieri.

From the dorsal side of the dorsal aorta just behind the junction with it of the second efferent branchial artery there passes outwards on either side a small vertebral artery, which curving dorsally round the spinal column appears to enter the spinal canal.

Fig. 7.



The arterial system of *Polypterus*.

br., brachial; *br.'*, branch of subclavian to shoulder-girdle; *br.''*, branch of subclavian which becomes the coronary artery; *br. I. II. III. IV. aff.*, branchial afferent I., II., III., IV.; *br. I. II. III. IV. eff.*, branchial efferent I., II., III., IV.; *ca.*, carotid; *cœl.*, cœliac; *ex.g.*, external gill; *hy.aff.*, hyoidean afferent; *hy.eff.*, hyoidean efferent; *hy.eff.'*, hyoidean efferent branch; *p.a.*, pulmonary; *s.cl.* subclavian; *sp.*, spermatic.

Pollard has pointed out the extremely primitive condition of the dorsal arterial system in *Polypterus*. The single efferent vessel from each gill-arch uniting with a median dorsal aorta, resembles most the condition found in *Chlamydoselachus* and the embryos of other Selachians.

X. *The Cranium.*

In this paper I have no intention of dealing with the anatomy of the head and cranium of *Polypterus*, except that I wish to mention that the peculiar differences in the condition of the sphenoid bone which Bridge has described in two specimens which he examined, and called specimen A and specimen B, have been found to be specific in the two species from the Gambia. The sphenoid bone of Bridge's specimen A, resembling that figured by Traquair, in which the lateral wings of the sphenoid did not curve inwards and fuse anteriorly in the frontal region, resembles exactly that of *Polypterus senegalus*, Cuv. The sphenoid (or "sphenethmoid") bone of Bridge's specimen B, which he suspected of being *Polypterus lapradei*, Steind., resembles exactly that species[1].

XI. *Conclusion.*

If in this paper I have occasionally reiterated facts which have long been known, I trust such has not been done without adding at least some details of interest. In any case I hope I have always acknowledged the authority.

I feel that no apology is needed for having entered into minute details in some cases, for an accurate knowledge of the anatomy of a creature of such surpassing interest as the *Polypterus* seems to me in every way desirable.

In obtaining my material for this investigation I have been aided by a grant of £50 from the Balfour Fund of the University of Cambridge. The work has been done in Mr. Adam Sedgwick's laboratory. To Mr. Sedgwick, Mr. Graham Kerr, and Prof. Howes my thanks are due for much help and advice in my work.

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[1] Since this paper was read, I have examined a young specimen of *P. lapradei* 12 cm. in length, and find that at this age the sphenoid has not yet developed its specific character, but resembles that of the adult *P. senegalus*.

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XIII. EXPLANATION OF THE PLATES.

PLATE L.

Fig. 1. General side view of the posterior part of the viscera in a female *Polypterus lapradei* (p. 325), showing the course of the oviducts and the anal fin of a female in the breeding-season.

Fig. 2. General side view of the posterior part of the viscera in a male *Polypterus lapradei* (p. 324) in which the ureters have been injected blue, showing the testis-ridge and duct running along the ventral external wall of the ureter. The anal fin of a male in the breeding-season is also shown with the anal-fin muscle projecting into the posterior part of the cœlom.

Fig. 3. A median ventral view of the testis, the kidney, and their ducts of the same male specimen dissected out (p. 324). The ureter, as in fig. 2, is injected blue. Figs. 2 & 3 together give a complete view of the urinogenital organs in the male.

Fig. 4. Ventral view of the urinogenital sinus in the female (pp. 325, 330), showing the openings of the oviducts upon papillæ, the septum of the urinogenital sinus, the narrowness of the anal fin in the female, and the corresponding

smallness in size of the anal-fin muscle. The rectum has been partially cut away and the ventral wall of the urinogenital sinus removed.

Fig. 5. A similar view of the urinogenital sinus in the male (pp. 324, 331), showing the genital aperture, the narrow neck of the urinogenital sinus, the great width of the base of the anal fin and the great development of its muscle.

Fig. 6. View from the right side of the urinogenital sinus in a large male (p. 324), the anal fin and its muscle, showing the course of the vas deferens; these organs, together with the rectum, having been dissected from the body.

Fig. 7. View from below of the anal region in a female (pp. 328, 330), showing the slit-like urinogenital aperture and the abdominal pores.

Fig. 8. A similar view in a male (pp. 328, 330), showing the wide urinogenital aperture.

Fig. 9. A vertical section of a very young female *Polypterus senegalus*, 9 cm. in length (p. 330), passing through the abdominal pores, showing a thin nucleated diaphragm closing the abdominal pores, at the same time showing an exudation of the cœlomic fluid. The caudal vein and abdominal vein are cut through just anterior to their junction.

PLATE LI.

Fig. 10. A vertical section through the testis and kidney of an adult male (pp. 324, 327, 328). The ureter is injected blue. The testis-tubules are shown opening into the testis-duct, and a kidney-ductule opening into the ureter. The magnification is 6 diameters.

Fig. 11. A similar section behind the testis (pp. 324, 327, 328), showing the relation of the testis-ridge and duct to the ureter in an adult male.

Fig. 12. A similar section in the region of the urinogenital sinus (pp. 324, 328), showing the duct of the testis opening upon a papilla into the urinogenital sinus.

Fig. 13. Spermatozoa compared with a blood-corpuscle (pp. 324, 331). Zeiss ocular 3, objective E.

Fig. 14. An enlarged drawing of the right half of fig. 12 (pp. 324, 325), showing the stout columnar epithelial lining of the vas deferens.

Figs. 14 to 24 are all magnified about 70 diameters.

Fig. 15. An enlarged drawing of the testis-ridge of fig. 11 (p. 324), showing the similar appearance of the ductules of the ridge and the main testis-duct. They are lined by a large-celled epithelium and embedded in connective-tissue with a few small blood-vessels.

Fig. 16. A vertical section through the kidney and testis of a young male *P. senegalus*, 13 cm. in length (pp. 324, 327, 328), showing the minute structure of the testis. The tubules are lined by large glandular cells, and are embedded in lymphoid tissue similar in appearance to the lymphoid tissue of the

kidney. The section shows also the similar appearance of the testis-duct and ureter. The uriniferous tubules of the kidney are embedded in a mass of lymphoid tissue.

Fig. 17. A similar section passing behind the testis (p. 325). When compared with fig. 15 the figure shows the relatively great development of the main duct of the testis-ridge, the small development of the ductules of the ridge in number and size, and the small relative size of the ureter.

Fig. 18. A similar section in the region of the urinogenital sinus (p. 325), showing the opening of the vas deferens into the latter and its lining of large columnar cells. The large relative size of the vas deferens is seen on comparing with fig. 14.

PLATE LII.

Fig. 19. A vertical section through the testis and ureters of a very young male *P. senegalus*, 9 cm. in length (p. 325), showing the precocious development of the testis-duct, the tubules of the testis not being yet formed.

Fig. 20. A similar section through the posterior termination of the testis-ducts (p. 325), showing that they are only just acquiring their connection with the urinogenital sinus.

Fig. 21. A vertical section through the developing ovary and ureter of a very young female *P. senegalus*, 9 cm. in length (pp. 325, 326, 327), showing the ova developing from the external wall of the ovary, the ovary divided into a number of loculi, and the artery and vein in the median wall.

Fig. 22. A similar section behind the ovary passing through the peritoneal opening of the oviduct (pp. 325, 326).

Fig. 23. A similar section behind the peritoneal opening of the oviduct (pp. 325, 326), showing the oviduct lying between the mesoarium or female genital ridge and the ureter. To be compared with fig. 17.

Fig. 24. A similar section through the posterior termination of the oviduct (p. 326), showing that they have not yet acquired their connection with the urinogenital sinus. To be compared with fig. 20.

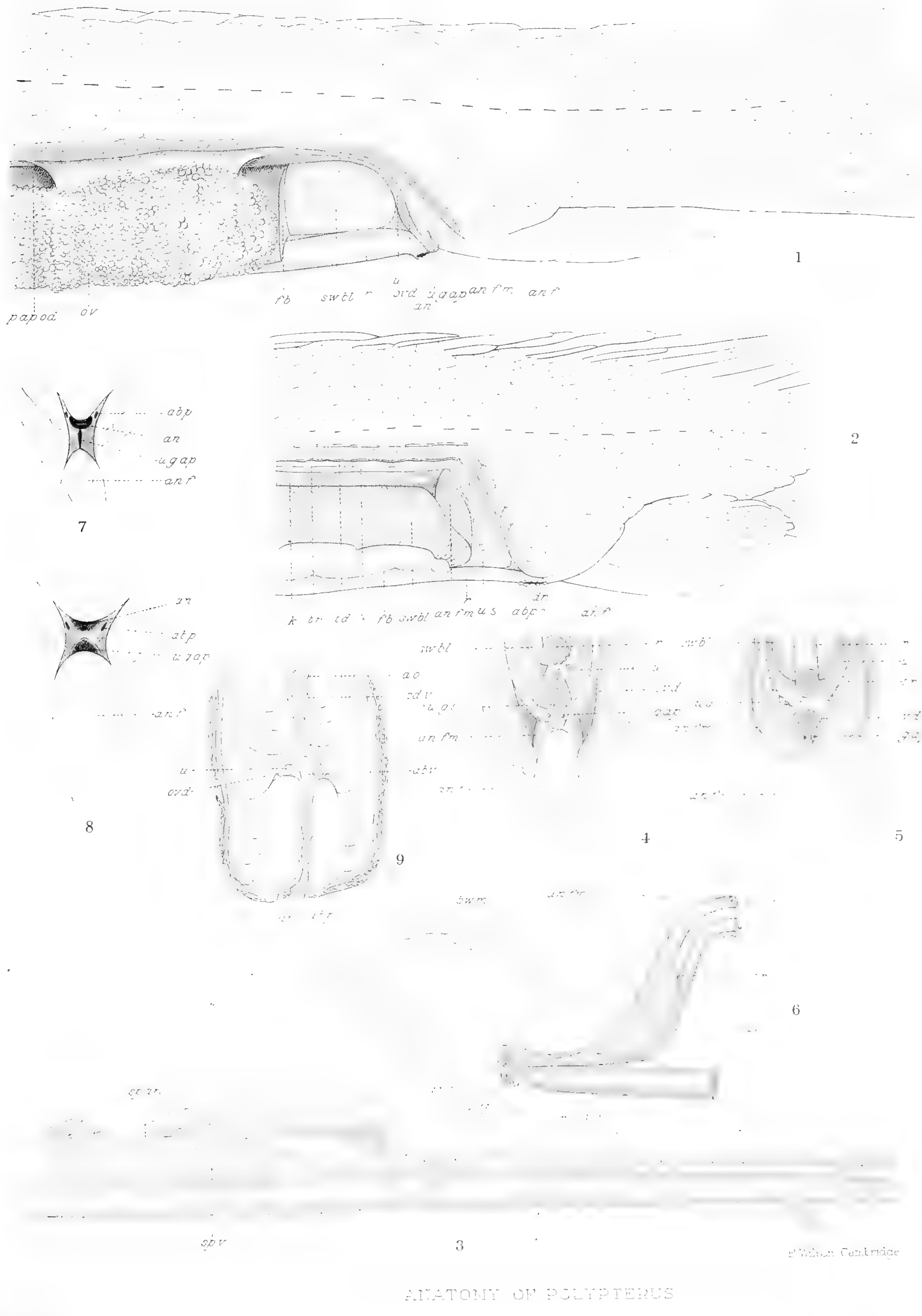
Fig. 25. Left operculum bearing external gill of *Polypterus lapradei*, 30 cm. in length (pp. 331, 332), showing the blood-supply to the gill and the efferent artery giving off a branch which runs parallel with the afferent artery. The muscles of the operculum and the gill are also shown.

Fig. 26. An enlarged drawing of the tip of the external gill (pp. 331, 332), showing its minute structure and the continuation of the afferent into the efferent artery at the end of the gill.

Fig. 27. A pinnule of the external gill highly magnified (p. 331).

XIV. Explanation of the Lettering of the Figures.

ab.p.	Abdominal pore.
ab.p.c.	Abdominal pore-canal.
ab.v.	Abdominal vein.
aff.art.	Afferent artery.
an.f.	Anal fin.
an.f.m.	Anal-fin muscle.
ao.	Aorta.
b.c.	Blood-corpuscle.
b.v.	Blood-vessel.
b.w.m.	Body-wall muscle.
c.v.	Cardinal vein.
cd.v.	Caudal vein.
con.tis.	Connective-tissue.
d.m.	Dorsal muscle.
e.ov.w.	External wall of ovary.
eff.art.	Efferent artery.
f.b.	Fat-body.
g.ap.	Genital aperture.
g.p.	Genital papilla.
m.ov.w.	Median wall of ovary.
k.	Kidney.
k.v.	Kidney-vein.
l.t.	Lymphoid tissue.
m.cps.	Malpighian corpuscles.
mes.o.	Mesoarium.
mes.t.	Mesorchium.
n.o.	Nucleus of ovum.
o.	Ovum.
o.at.	Attachment of ovum.
op.m.	Opercular muscle.
ov.	Ovary.
ov.d.	Oviduct.
ovd.ep.	Epithelium of oviduct.
p.ep.	Peritoneal epithelium.
pl.	Pinnule.
pn.	Pinna.
r.	Rectum.
sp.	Spermatozoa.
sp.art.	Spermatic artery.
sp.ep.	Spermatic epithelium.
sp.v.	Spermatic vein.
sw.bl.	Swim-bladder.
t.	Testis.
t.d.	Testis-duct.
t.d.ep.	Epithelium of duct of testis.
t.d.sh.	Testis-duct sheath.
t.r.	Testis-ridge.
t.r.tbs.	Testis-ridge tubules.
t.tbs.	Testis-tubules.
u.	Ureter.
u.ep.	Epithelium of ureter.
u.g.ap.	Urinogenital aperture.
u.g.s.	Urinogenital sinus.
u.s.	Urinary sinus.
u.sh.	Sheath of ureter.
u.tbs.	Uriniferous tubules.
v.d.	Vas deferens.
v.d.ep.	Epithelium of vas deferens.
v.m.	Ventral muscle.
w.o.u.	Point where oviduct ends in wall of ureter.
w.v.u.	Point where vas deferens ends in wall of ureter.



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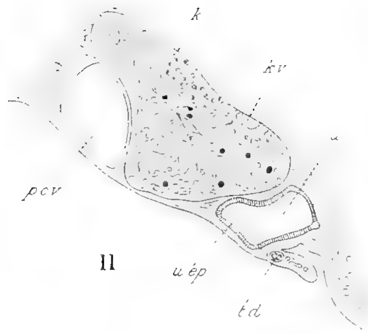

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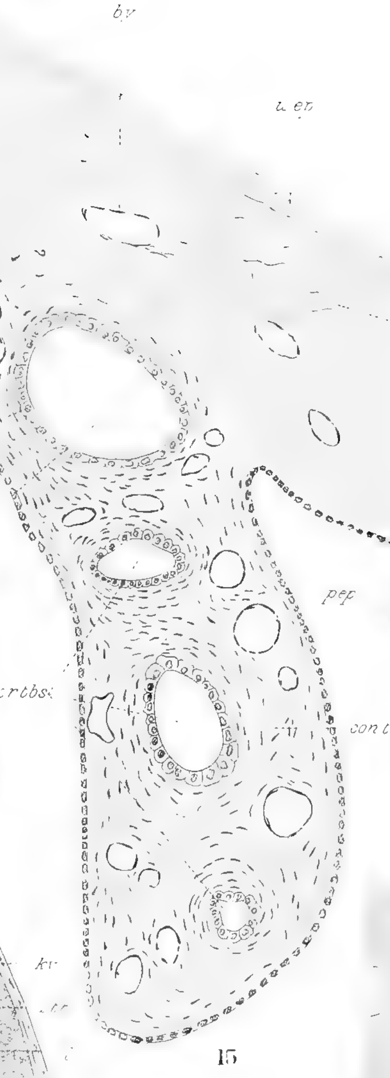

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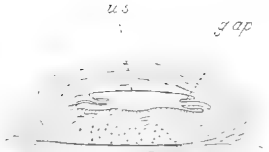

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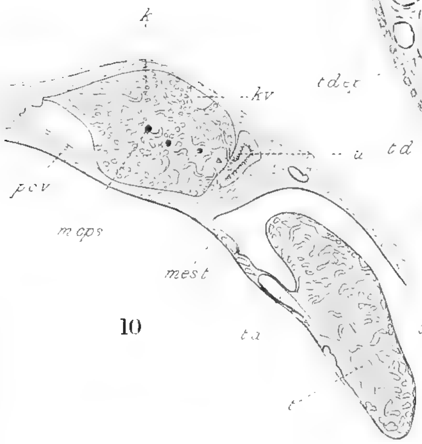

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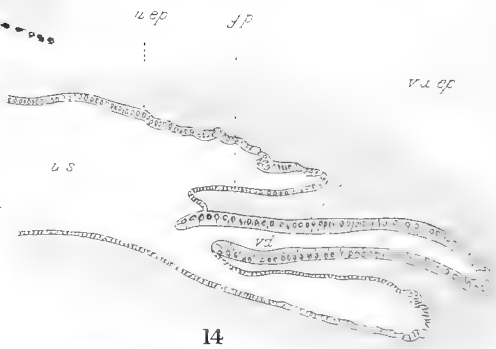

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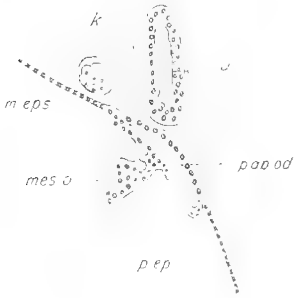

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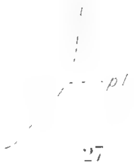

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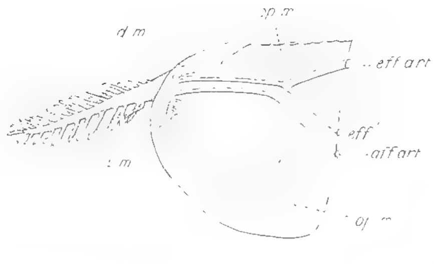

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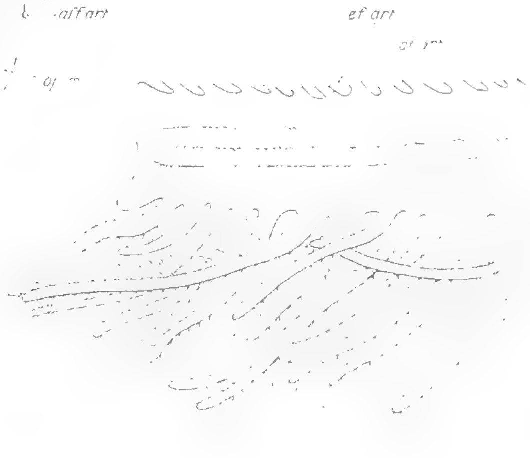

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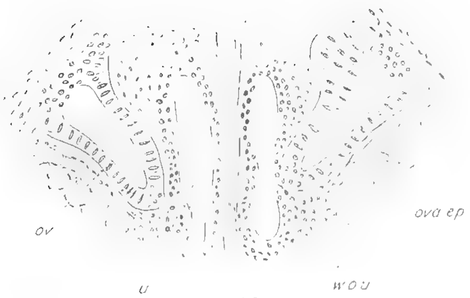

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