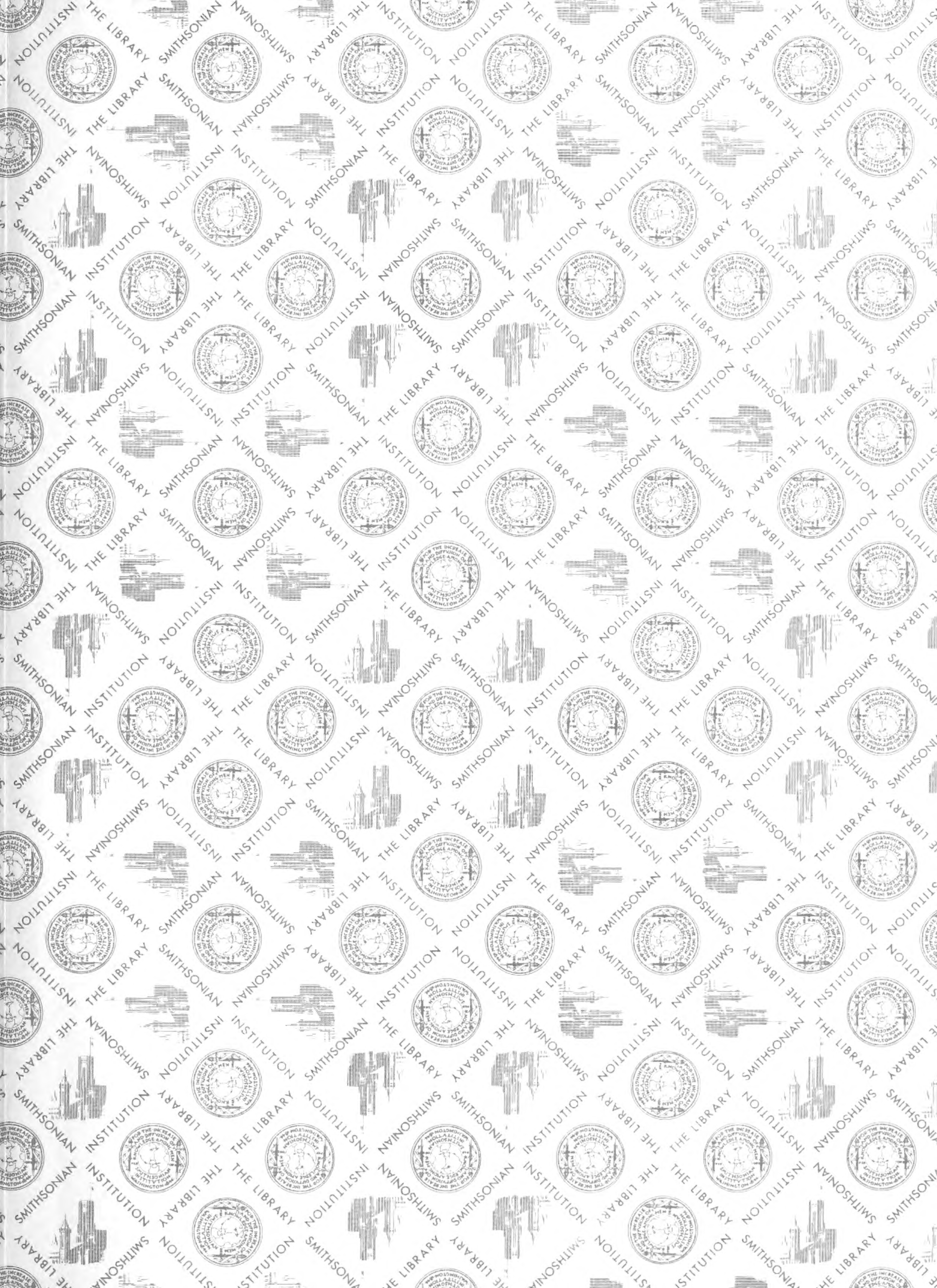
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[*From* 'THE TRANSACTIONS *of the* ZOOLOGICAL SOCIETY *of* LONDON',—Vol. xv. Part v., *December* 1900.]

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 caruneulated 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 1½ 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 paleari-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 1½ 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 × 2¼ 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. 318 (critical note on Diggles);
1869. Krefft, Ibis, p. 318 (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 1⅔ 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 $1\frac{1}{2}$ 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. 81, 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, 614 (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.

TABLE OF CONTENTS.

Page

Pterylosis

Osteology.

Myology.

Page

Nervous System and Sensory Organs.

Alimentary Canal and Appendages.

Respiratory Organs.

Circulatory System.

Cloaca, Bursa Fabricii, and Urino-genital System.

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

VOL. XV.—PART V. No. 6.—*December*, 1900.

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 ½ 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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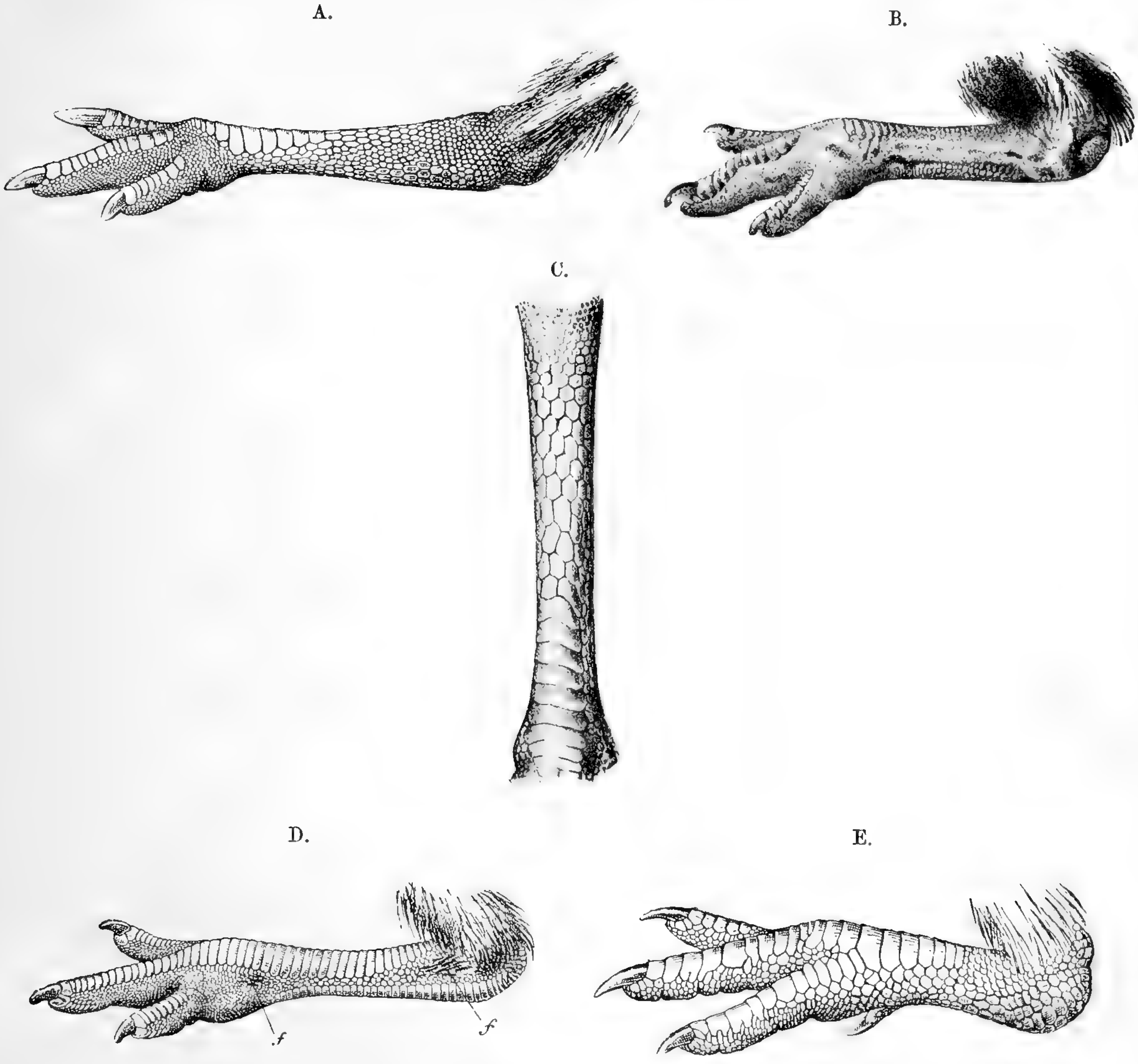
[1] Figures in brackets refer to Bibliography at end of paper.

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 $3\frac{3}{4}$ in. long and 2 in. wide. Immediately caudad of this callosity the space narrows to $1\frac{1}{4}$ in., and again to about $\frac{1}{2}$ 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.

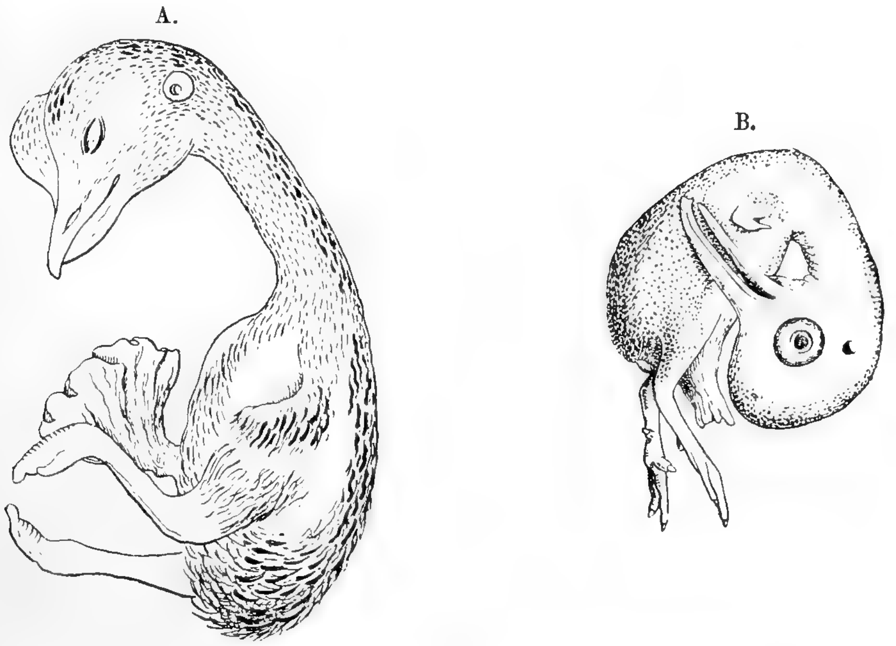
I find no trace of an "egg-tooth" in the ripe embryo, which I myself removed from the egg. This is also wanting in the embryo *Dromæus* and the nestling *Casuarius.* Concerning *Dromæus*, however, see p. 154. The late Prof. Jeffery Parker failed to find it in *Apteryx* at any stage of its growth.

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 and 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, ecto-ethmoidal 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. In 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.

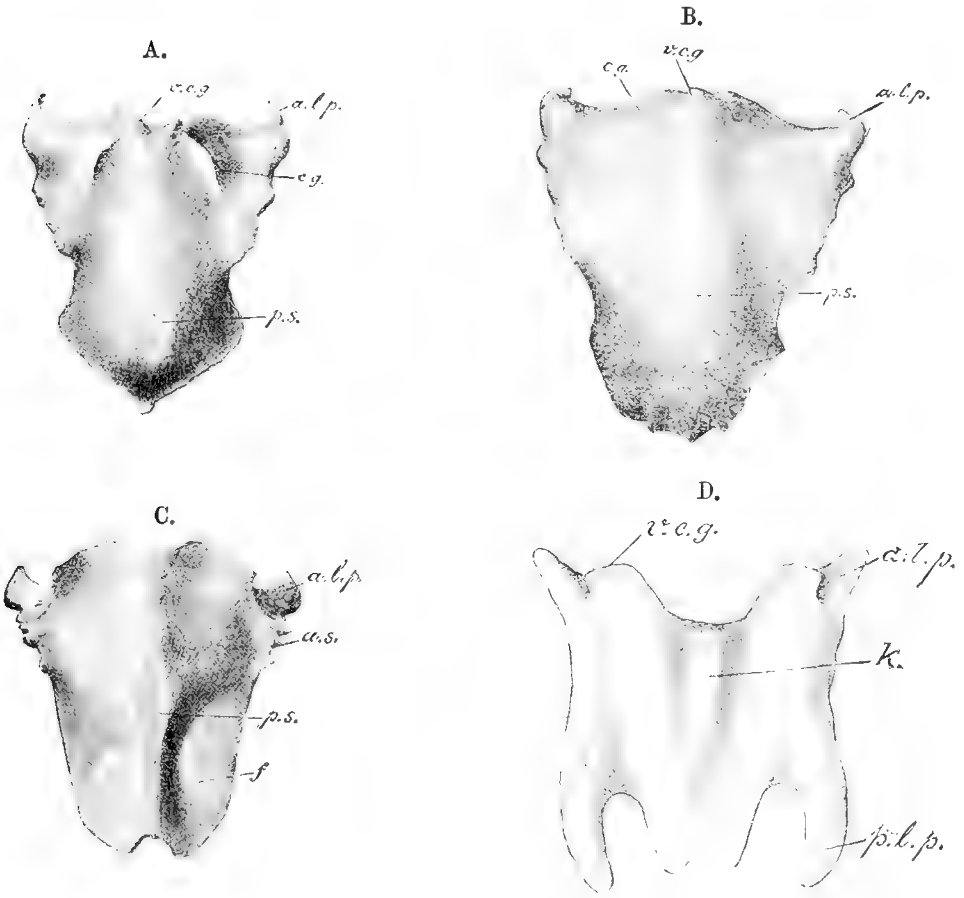
a. *The Sternum.*

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 procoracoid, 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 *Podicipidæ* 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 permanent 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. There 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.*

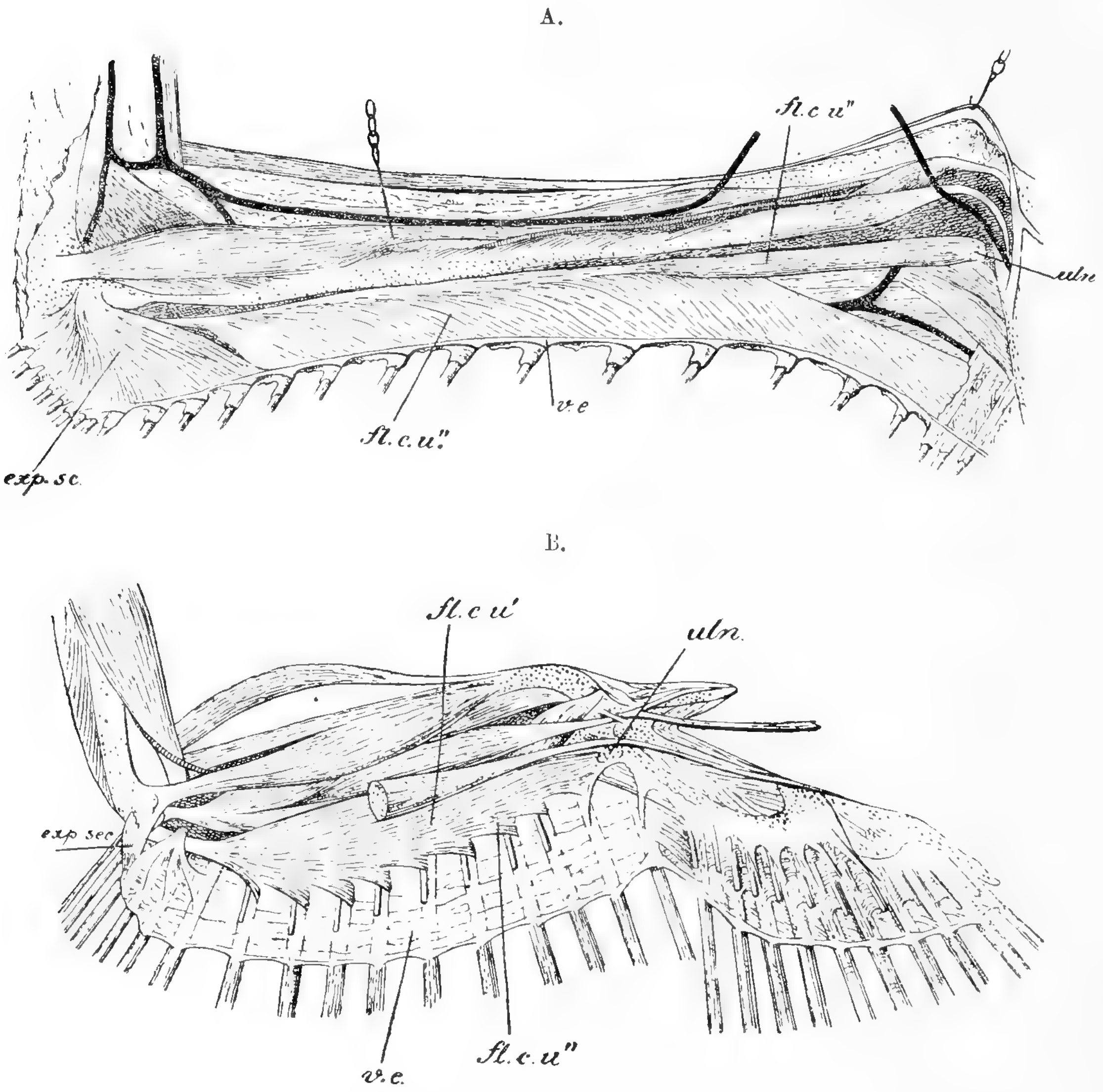
"The *extensor indicis* is only represented by the belly arising from the wrist. The *flexor sublimis* may possibly be represented by a slip of muscle arising from the tendinous edge of the *flexor metacarpi ulnaris* . . . .

"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.

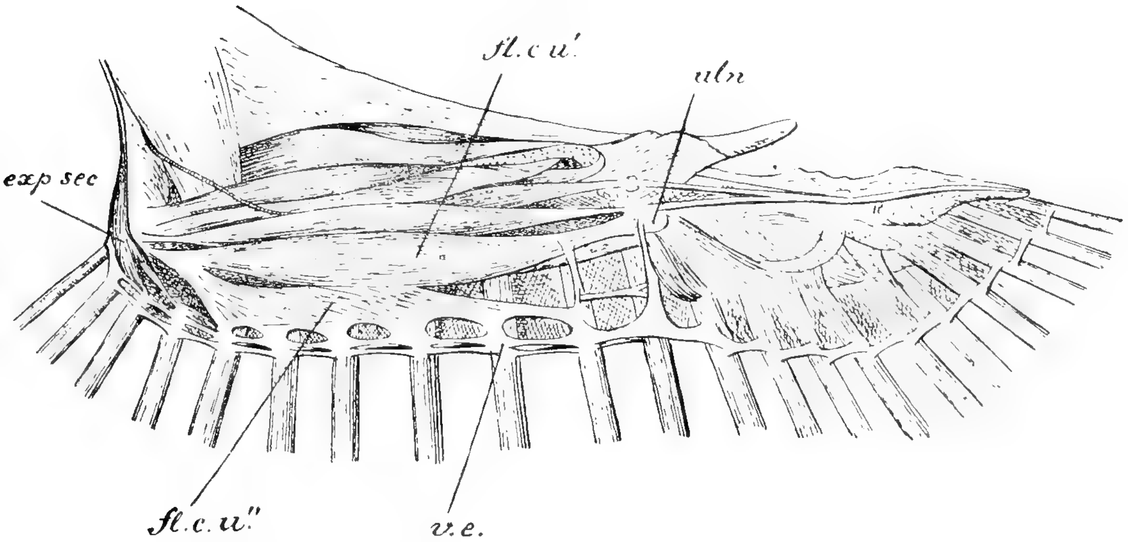


conjoined flexors digitorum is highly suggestive of a walking or climbing animal. It seems to be conceivable that the Ostrich branched off from the avian stem before the power of flight was perfectly established.

"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*.

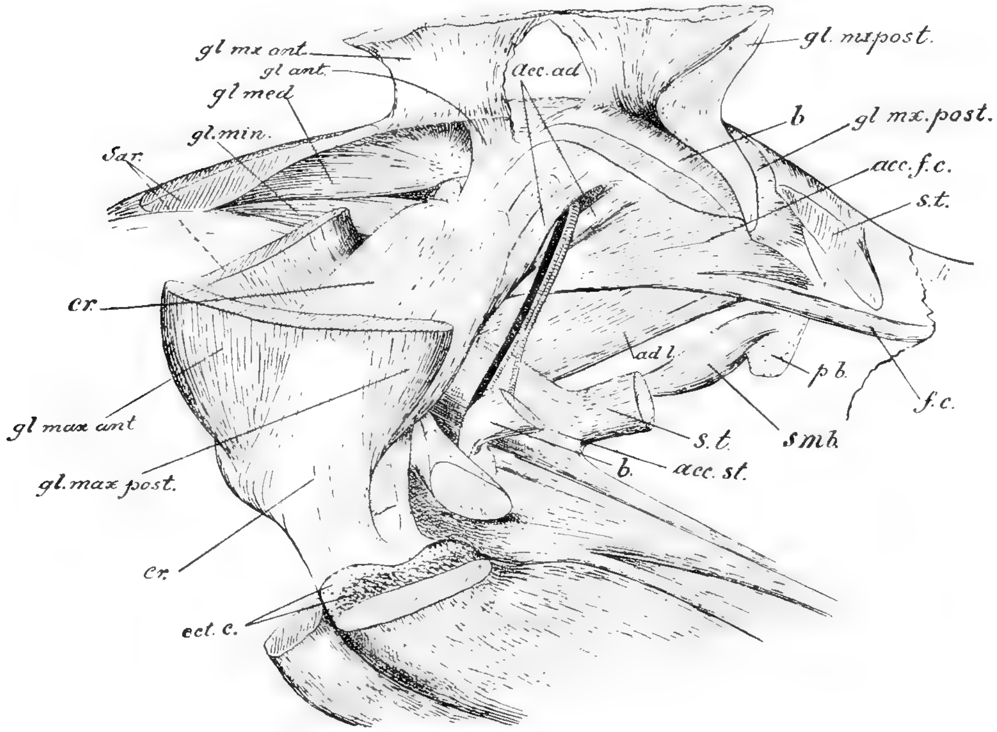
THIGH- AND LEG-MUSCLES.

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 *Dromæus* 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 femoro-caudal.

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	A . B . X . Y +.
Apteryx	
Casuarius	
Crypturi	
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.

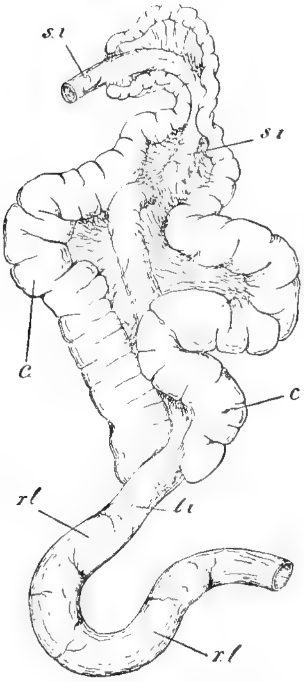
There are no valvular appendages in the cæca of these three forms.

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 *Palæognathæ*. 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.		Caeca.			
	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).

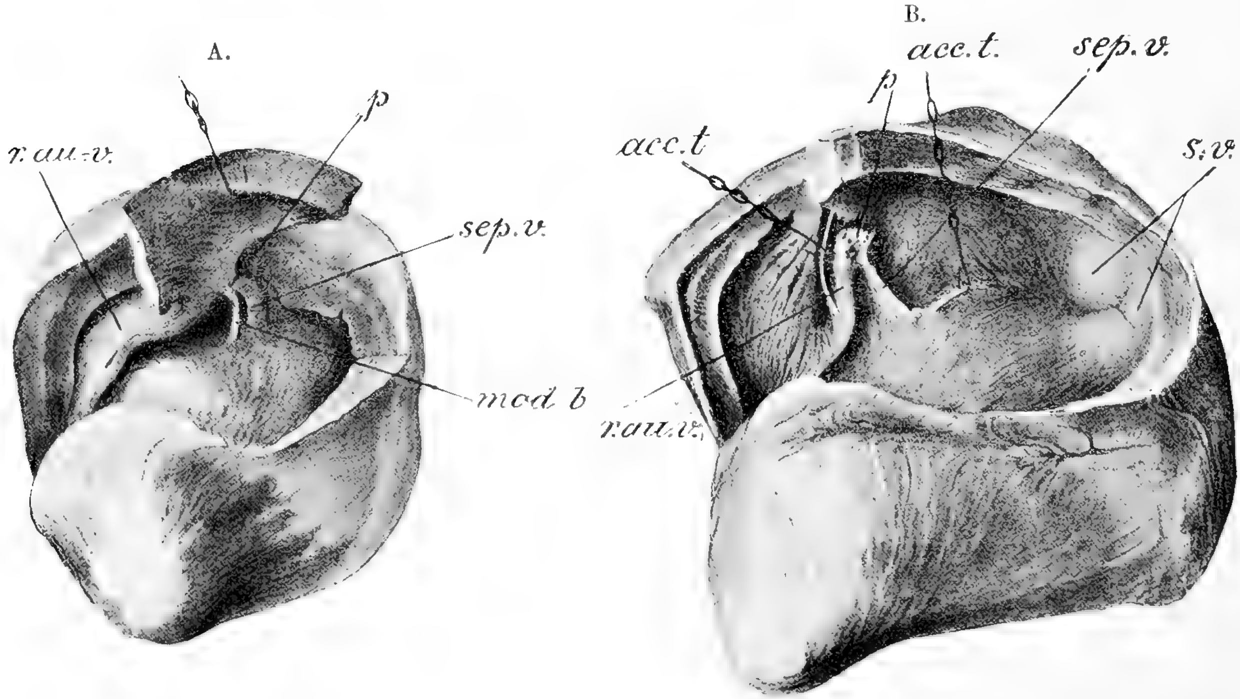
The choanæ of the *Palæognathæ*, it is interesting to remark, differ in form from the *Neognathæ* in their larger size. In all the *Neognathæ* the aperture is slit-like, whilst, as will be seen in the figure, in the *Palæognathæ* it is triangular or cordiform in shape.

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.

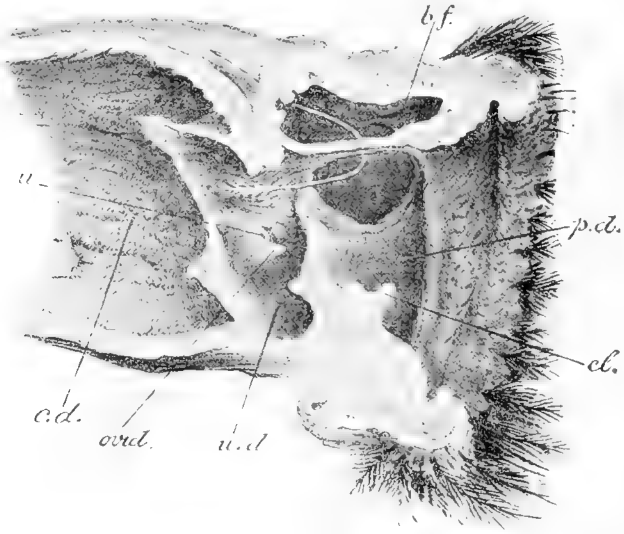
The terminal end of the alimentary canal in the *Palæognathæ*, as in the *Neognathæ*, is divisible into a *copro-*, *uro-*, and *proctodæum*, as defined by Dr. Gadow [24].

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*, *Æpyornithidæ*, 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.:—

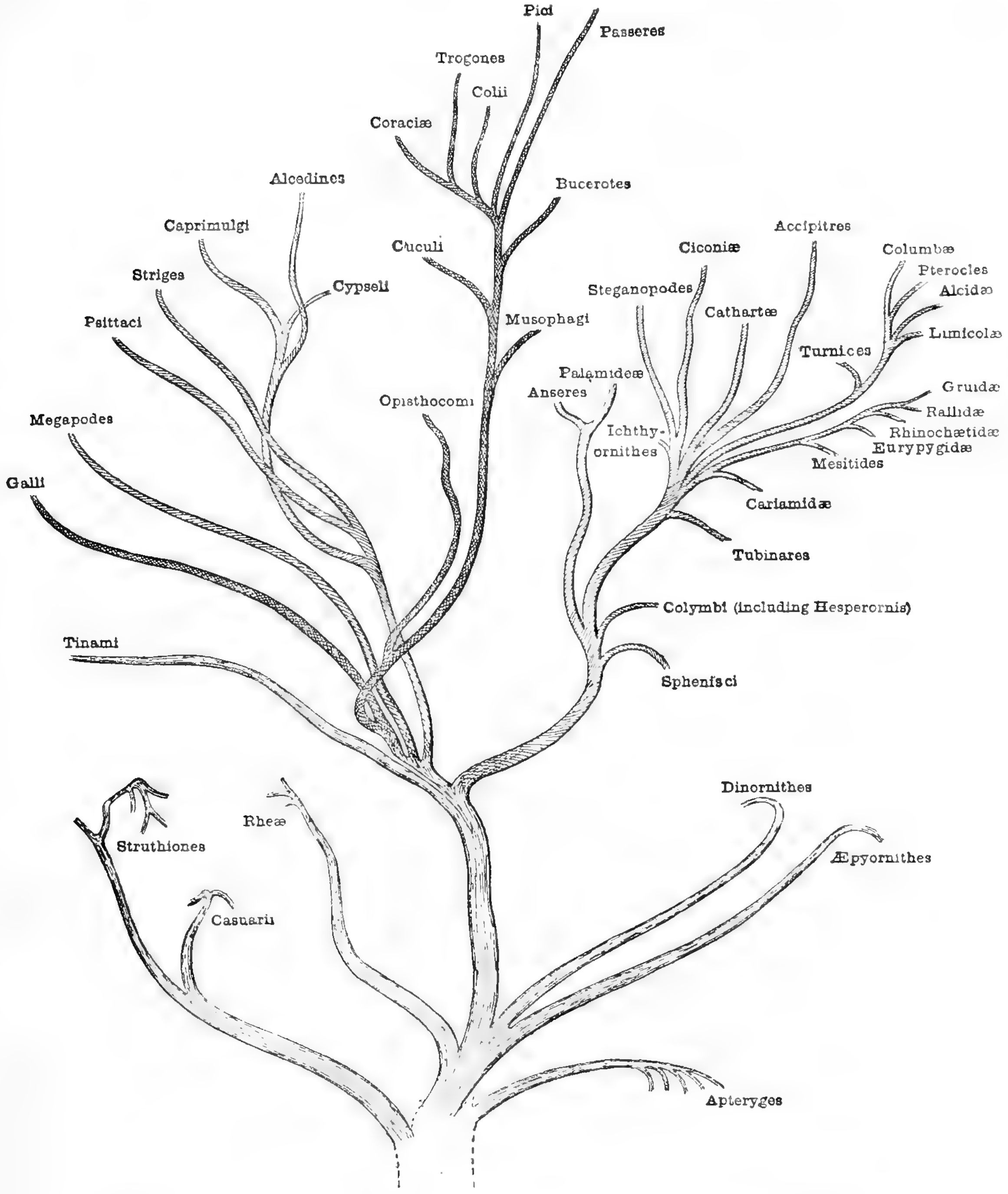
Casuarii.
Struthiones.
Rheæ.
Crypturi.
Dinornithes.
Æpyornithes.
Apteryges.

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 protocarinate 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* .

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 . . . .

$$\text{Cv. }18:\ \text{Cv. Th. }3:\ \text{Th. }\underbrace{3+1+2}_{6}\overbrace{:\ \text{Lb. }6:\ \text{Lb. sc. }2:\ \text{Sc. }2:\ \text{Cd.}}^{\text{Synsac.}}\ \underbrace{9+9}_{18}=55.$$

Casuarius . . . .

$$\text{Cv. }15:\ \text{Cv. Th. }4:\ \text{Th. }\underbrace{5+1+3}_{9}\overbrace{:\ \text{Lb. }5:\ \text{Lb. sc. }2:\ \text{Sc. }2:\ \text{Cd.}}^{\text{Synsac.}}\ \underbrace{9+9}_{18}=55.$$

Struthio . . . .

$$\text{Cv. }17:\ \text{Cv. Th. }3:\ \text{Th. }\underbrace{5+2}_{7}\overbrace{:\ \text{Lb. }8:\ \text{Sc. }2:\ \text{Cd.}}^{\text{Synsac.}}\ \underbrace{8+10}_{18}\qquad=55.$$

Rhea . . . .

$$\text{Cv. }14:\ \text{Cv. Th. }3:\ \text{Th. }\underbrace{3+2+1}_{6}\overbrace{:\ \text{Lb. }3:\ \text{Lb. sc. }4:\ \text{Sc. }2:\ \text{Cd.}}^{\text{Synsac.}}\ \underbrace{9+8}_{17}=49.$$

Apteryx . . . .
(*A. a. mantelli.*)

$$\text{Cv. }15:\ \text{Cv. Th. }1:\ \text{Th. }\underbrace{4+3+1}_{8}\overbrace{:\ \text{Lb. }4:\ \text{Lb. sc. }4:\ \text{Sc. }2:\ \text{Cd.}}^{\text{Synsac.}}\ \underbrace{3+8}_{11}=45.$$

C. Sternum (fig. 4, p. 217) and Pectoral Arch[1].

The sternal plate is keelless; the coracoid anchyloses with the scapula, and lacks the acrocoracoid, 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 9½ 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; tibiotarsus 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.

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CASUARIUS [illegible]

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CASUARIUS CASUARIUS SALVADORII

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CASUARIUS CASUARIUS AUSTRALIS

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CASUARIUS CASUARIUS VIOLICOLLIS

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CASUARIUS CASUARIUS INTENSUS

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CASUARIUS BICARUNCULATUS

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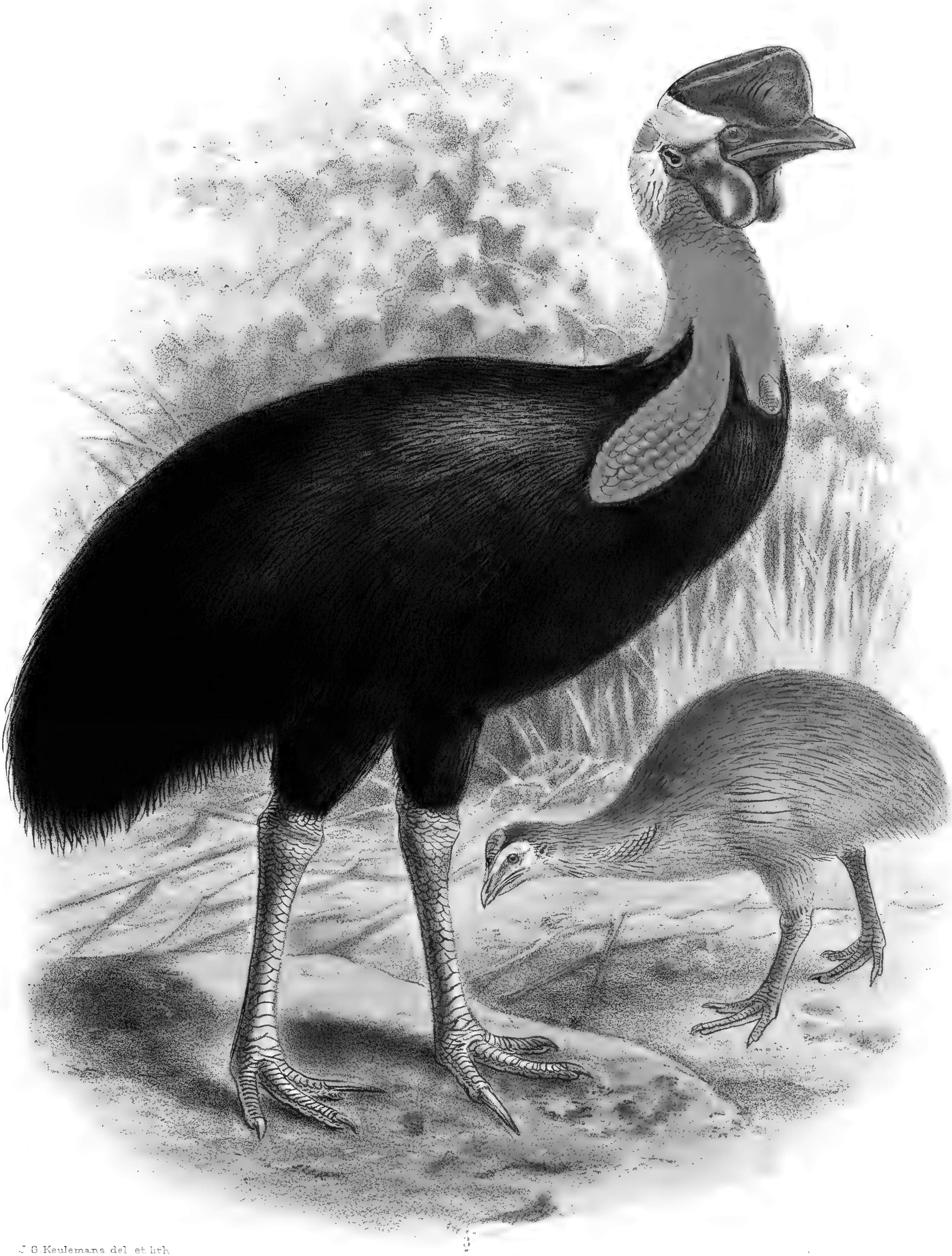
CASUARIUS UNIAPPENDICULATUS



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CASUARIUS UNIAPPENDICULATUS OCCIPITALIS

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J. G. Keulemans del. et lith.

Mintern Bros imp.

CASUARIUS UNIAPPENDICULATUS AURANTIACUS

J. G. Keulemans del. et lith.

Mintern Bros. imp.

CASUARIUS PHILIPI.

$\frac{3}{5}$

J G Keulemans del. et lith

Mintern Bros imp

CASUARIUS PAPUANUS

J. Smit del. et lith.

Mintern Bros. imp.

CASUARIUS PAPUANUS EDWARDSI.

$\frac{3}{5}$

J. G. Keulemans del. et lith.

Mintern Bros. imp.

CASUARIUS PICTICOLLIS

J. G. Keulemans del. et lith.

Mintern Bros. imp.

CASUARIUS PICTICOLLIS HECKI

J G Keulemans del. et lith.

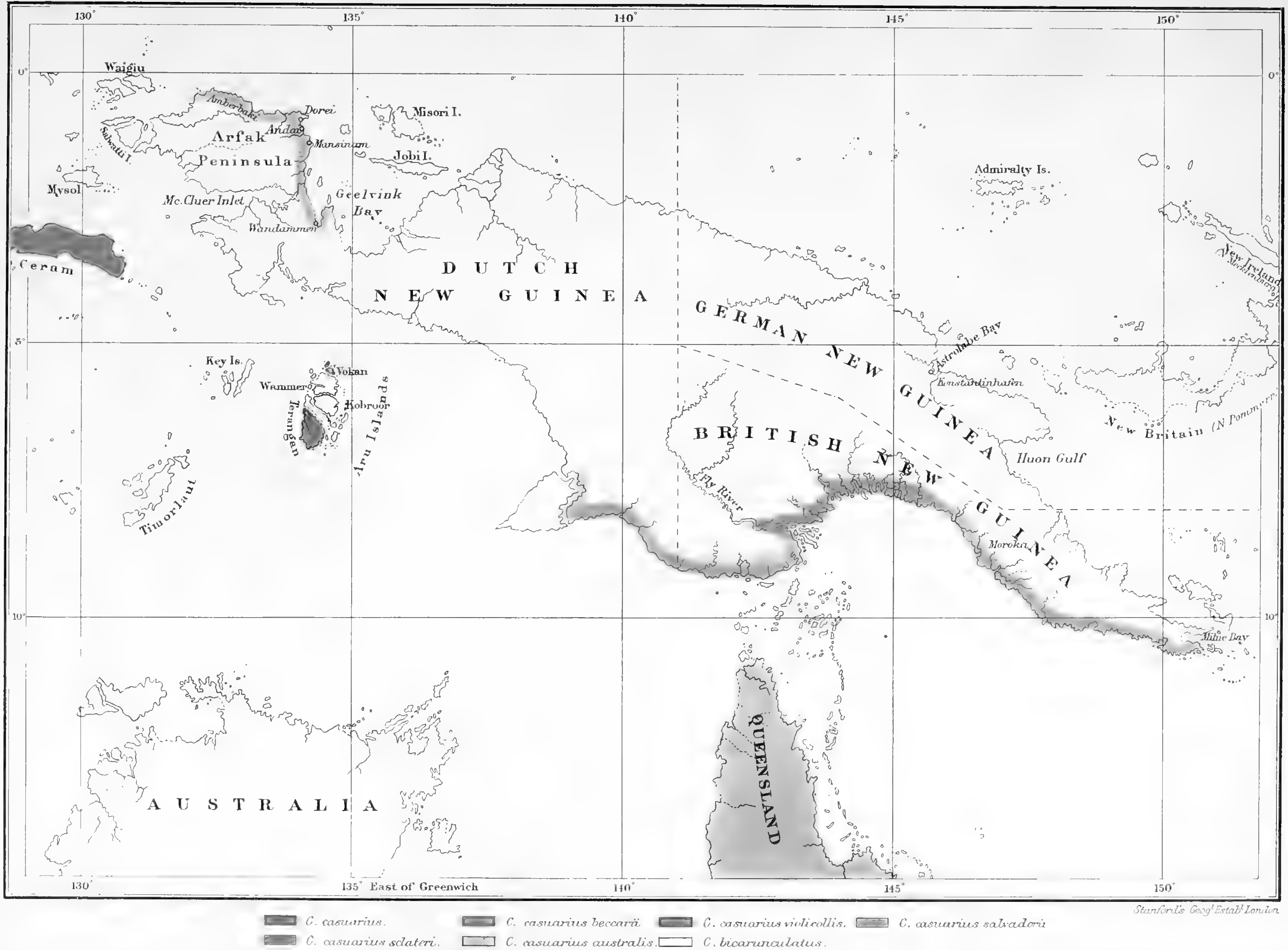
Mintern Bros. imp.

[illegible]

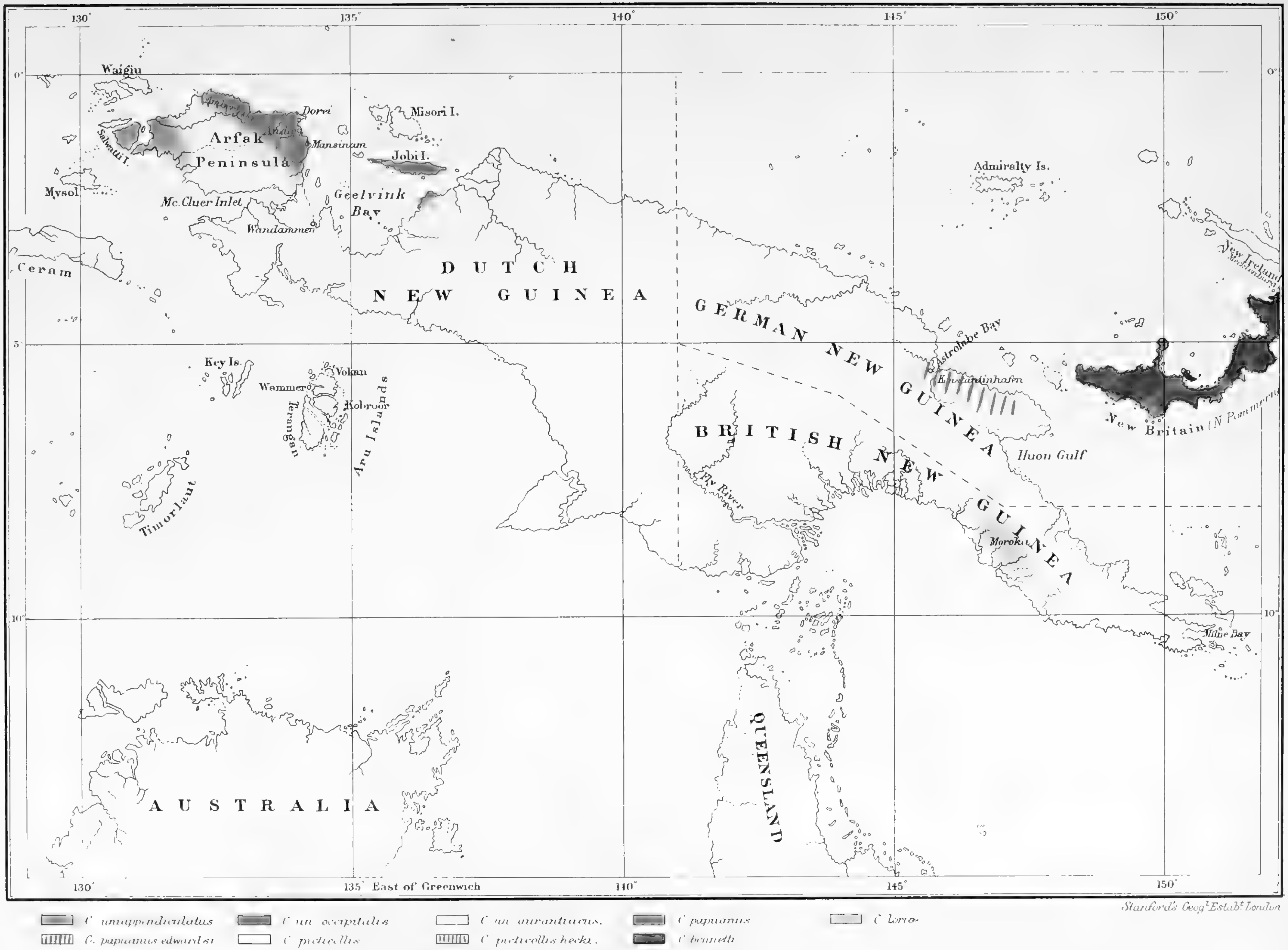
J. G. Keulemans lith.

Mintern Bros. imp.

CASUARIUS BENNETTI

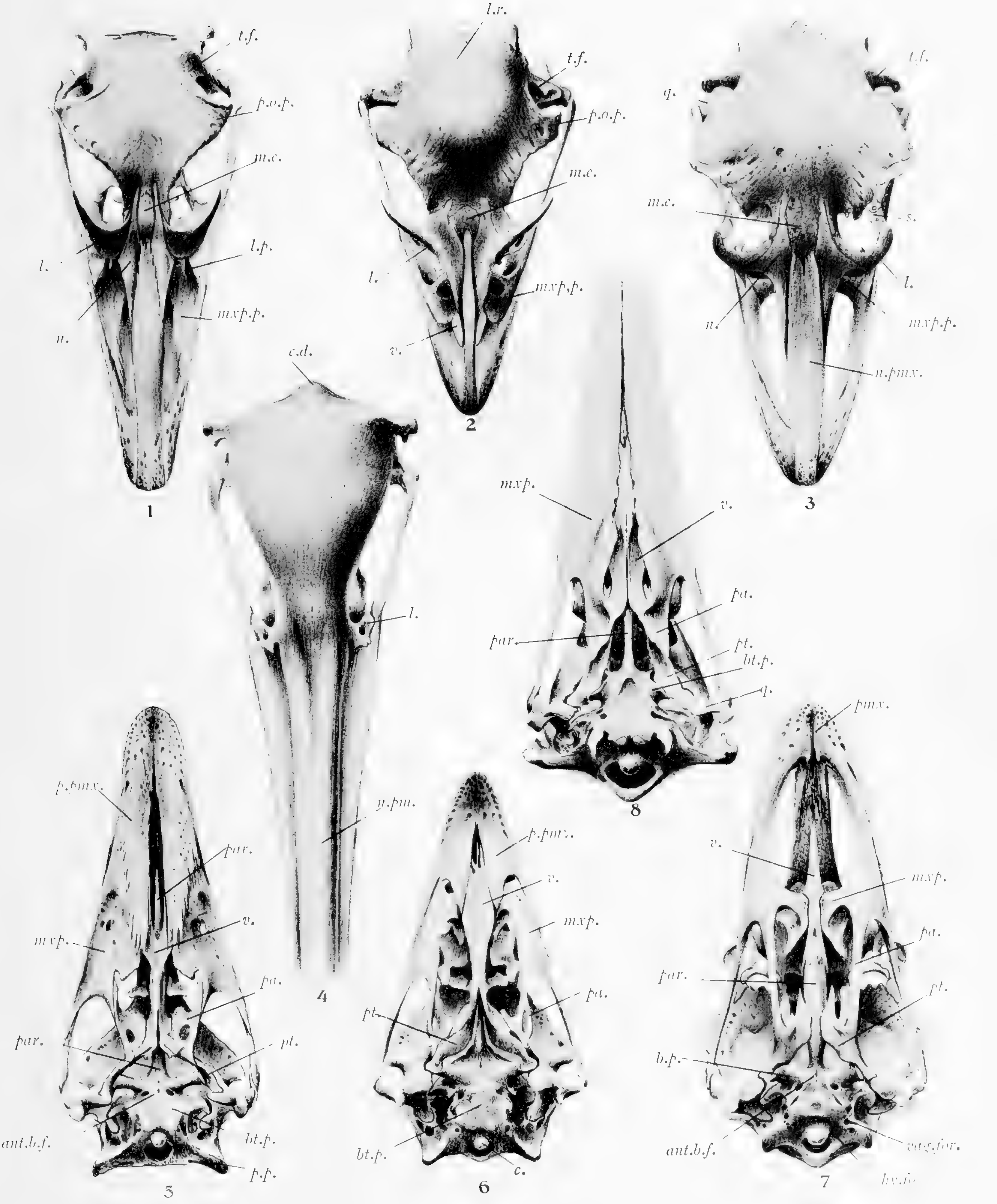


DISTRIBUTION OF THE CASSOWARIES. 1.



Stanford's Geog.l Estab.t London

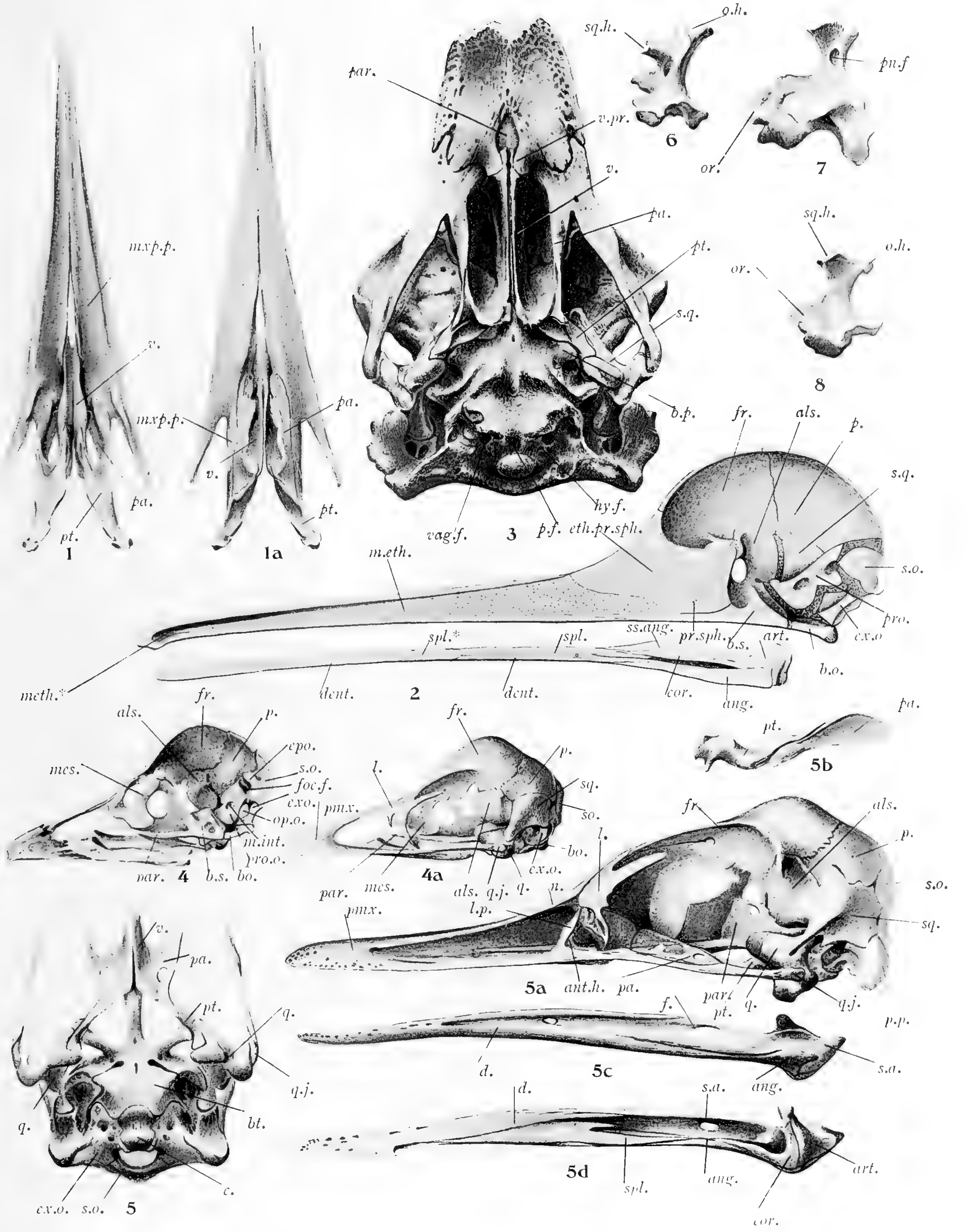
DISTRIBUTION OF THE CASSOWARIES. II.



H Grönvold del

STRUCTURE OF THE PALÆOGNATHÆ

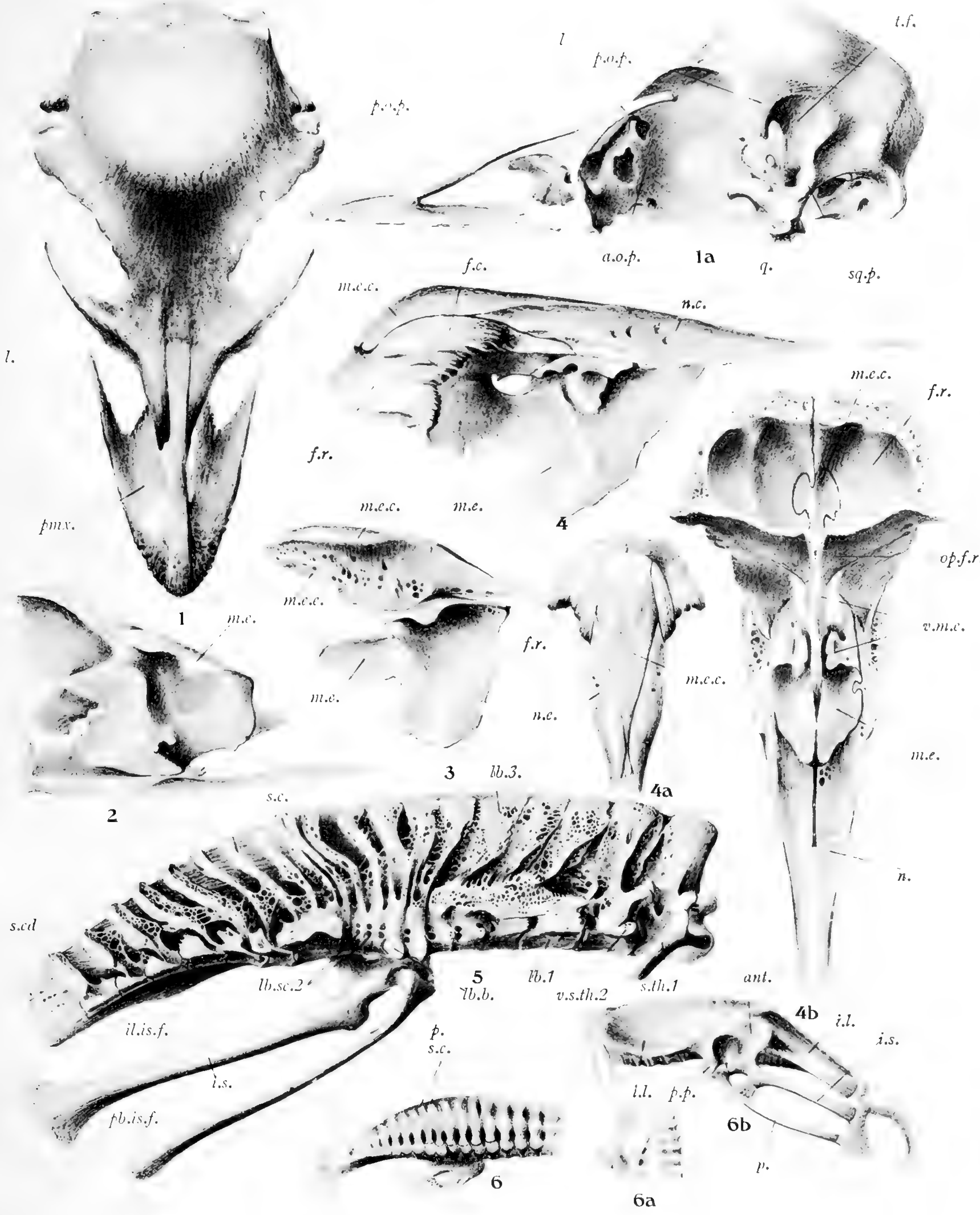
Photoprint by [illegible] Danielsson Ltd



H. Grönvold. del.

STRUCTURE OF THE PALÆOGNATHÆ.

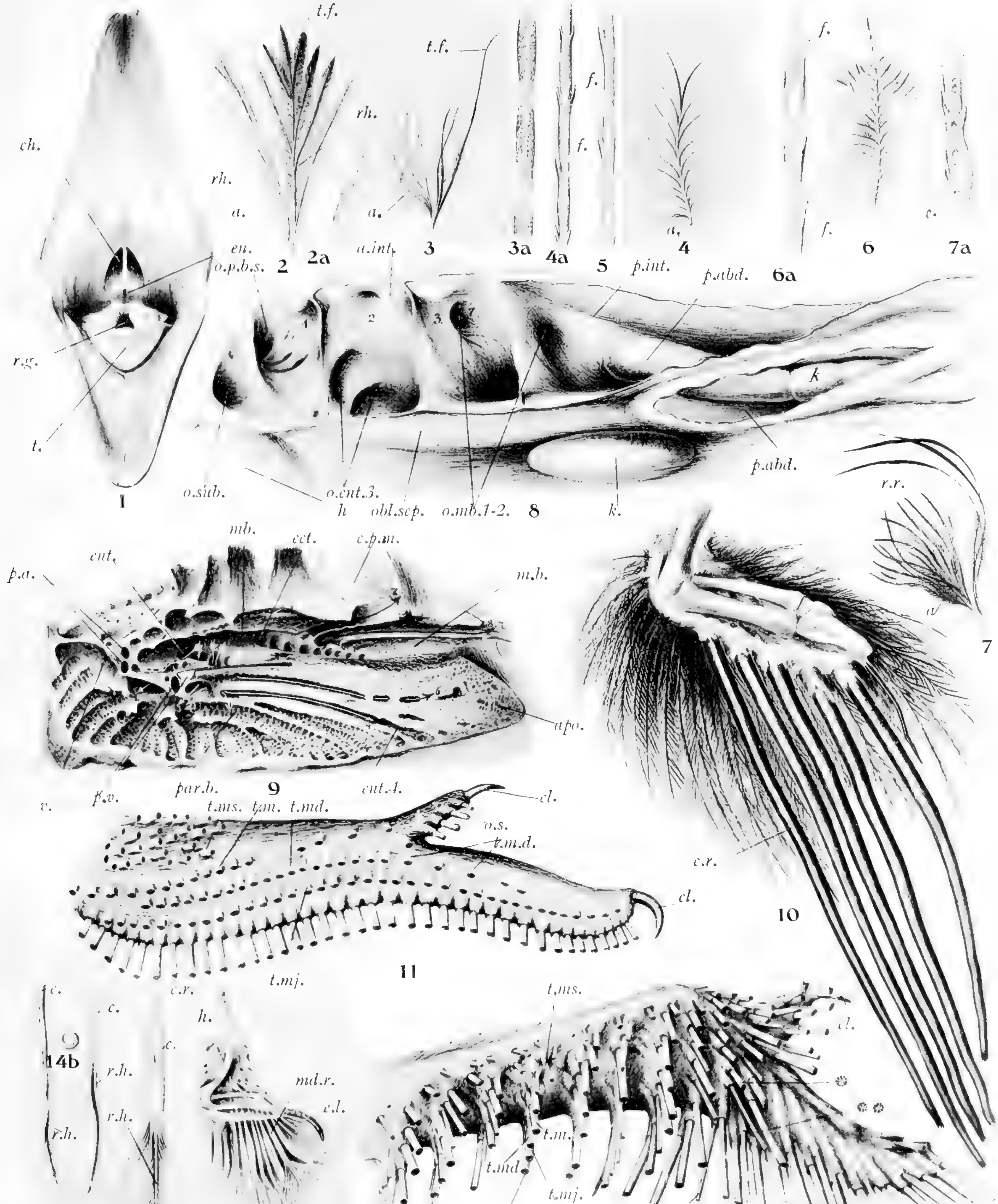
Photoprint by Bale & Danielsson Ltd



H. Grönvold. del

STRUCTURE OF THE PALÆOGNATHÆ.

Photoprint by Bale & Danielsson Ltd



H. Gronvold. del.

STRUCTURE OF THE PALÆOGNATHÆ.

Photoprint by Bale & Danielsson L^td