

I shall finish this paper with one more instance. In most birds the true sacrales have only the upper transverse processes, or diapophyses; the lower bars, or arrested "pleuroids," are entirely gone in the adult, but small prickles remain, often more on one side than on the other. Thus the spaces for the large sacral nerves and their ganglia, and for the lobes of the kidneys, are not quite cleared. In the Tiger-Bittern (*Tigrisoma leucolophum*), a Neotropical member of the "Ardeidæ," there is no vertebra in the sacrum, until we come to the last three uro-sacrales, that has not its inferior or "pleuroid" bars.

The sacrum of this bird is composed of fifteen vertebræ, the first has developed ribs, with imperfect sternal pieces, the next two have small ankylosed ribs, separated for some distance from the diapophyses. Then come three with stout generalised pre-iliac buttresses. The next *six* have inferior rib-bars, those of the last four are strong, those of the first two weak. On the left side the second of these rods is membranous for a short extent; on the right side it is imperfect in its outer part, it is a mere prickle growing from the centrum. Except on the atlas this bird has ribs or rudiments of ribs up to the twelfth sacral. I suspect that if the ancestral form from which the Tiger-bittern arose could be put face to face with its stilted descendant, the two would differ as much as the vermiform larva of *Tipula oleracea* differs from its winged and stilted imago.

V. "Second Preliminary Note on the Development of *Apteryx*."

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The materials for the present investigation consist of embryos of the three common species of *Apteryx*, viz., *A. australis*, *A. oweni*, and *A. mantelli*. Most of them, including all the earlier stages, were collected for me by Mr. R. Henry, of Lake Te Anau; a nearly ripe embryo of *A. mantelli* was obtained from Mr. A. Reischek: and I am indebted to Mme. Müller for a half-ripe specimen of *A. oweni*, and to Sir Walter Buller for two, somewhat older, of *A. mantelli*.

I desire to record my sincere thanks to the Council of the Royal Society for the grant which has enabled me to defray the expenses of the investigation.

My observations are far from complete, and deal only with comparatively late stages. The eggs of *Apteryx* are at all times difficult to obtain, as evidenced by their high market value, and Mr. Henry is bird dissected by me in having the pre-ilia buttressed by *seven* pairs of massive processes instead of *six*, by having only *one* true sacral, and by showing strong costal bars on both the first and second "uro-sacral."

the only collector I have yet met with who was willing to give his time not only to collecting the eggs, but to removing and preserving the embryos. I have, unfortunately, never been able to leave Dunedin during the breeding season so as to try and procure the earlier stages, the removal and preservation of which could not be entrusted to a collector.

My first Stage (A) corresponds roughly with a chick embryo of the fourth day of incubation: the full number of mesoblastic somites—about 44—has already appeared. Stage B is apparently only a few hours older: Stage C corresponds very nearly with a fifth day chick, except that the limbs are in a less advanced condition.

Stage D is in about the same state of development as a chick of the 7th day; it was unfortunately damaged by the collector during removal from the egg, both fore-limbs being destroyed. Avian characters are now definitely assumed, the head being produced into a short beak very like that of a chick at the corresponding period. The hind-limbs are still in the primitive position, *i.e.*, stretched out at right angles to the long axis of the body, but their extremities are dilated into flattened paw-like feet which distinctly show the three principal digits and a small knob-like hallux.

Stage E is a little later than D, and is chiefly interesting for the condition of the fore-limb, which is terminated by a tridactyle paw with sub-equal digits. In the hind-limb the cnemial flexure has appeared, but not the mesotarsal flexure, so that the combined crus and pes are directed backwards.

In Stage F the characteristic features of the genus *Apteryx* are assumed, the beak having undergone a great increase in length and bearing the nostrils at the tip. The fore-limb is now a true wing, the manus being supported mainly by the second digit, but presenting blunt projections on the pre- and post-axial borders of the wrist which indicate respectively the positions of the reduced first and third digits. In the hind-limb the mesotarsal flexure has appeared, and the pes has nearly assumed its adult characters. The feather-papillæ appear first in this stage.

In Stage G the feather-papillæ have become larger and more widely distributed; the beak and the hind-limbs have further increased in length, and the wing shows no trace externally of either the first or the third digit. In all the remaining stages the adult form is assumed and the body covered with feathers.

Contrary to the usual statements as to the pterylosis of the *Ratitæ*, *Apteryx* has distinct apteria, which are especially noticeable in the earlier stages.* In Stage F, in which the feather-papillæ first appear, they are arranged in fairly distinct dorsal, humeral, and femoral

* Pterylae and apteria are figured in the embryo ostrich and referred to in the description of the figures by Miss B. Lindsay, 'Zool. Soc. Proc.,' 1885, Pl. XLIII.

tracts; the ventral tract appears in Stage G. In the ripe embryo and even in the adult, besides the narrow ventral space recognised by Nitzsch, there are well-marked lateral spaces separating the dorsal and ventral, and the dorsal and femoro-crural tracts from one another.

In the full paper a table and diagrams will be given showing the length of important parts of the body (head, beak, limbs, &c.), in the various stages, expressed as percentages of length of vertebral column. The table shows that while the wings attain their maximum relative size in Stage F, the legs continue to increase in proportional length some time after hatching. The brain-case, also, undergoes from Stage G onwards a proportional diminution in size, while the beak increases steadily up to adult life.

The greater part of the full paper will deal with the skeleton: a detailed description will be given of the entire skeleton at about the time of hatching, when all the more important ossifications have appeared and but little ankylosis has taken place.

The vertebral formula is—

$$\text{Cv. 16. Th. } 5+3 : \overbrace{\text{L. 8 : S. 3 : Cd. 3}+6-8}.$$

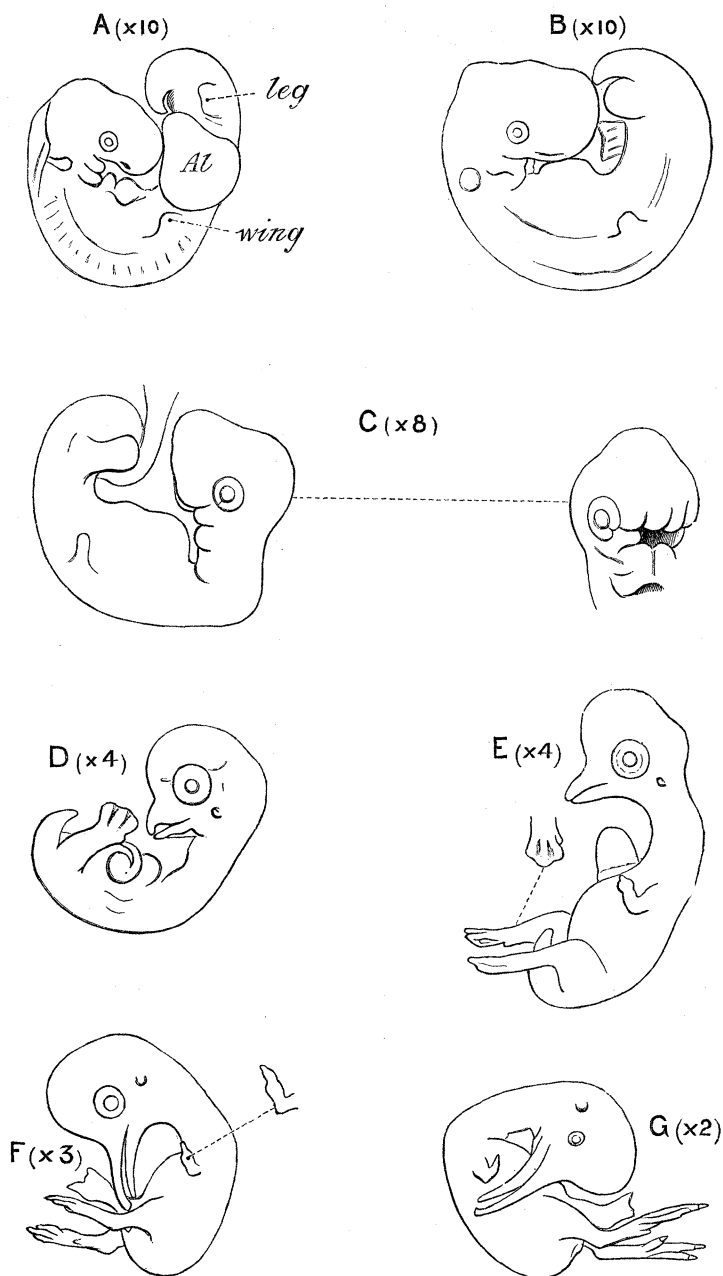
The bracket indicates that the last three thoracic, all the lumbar and sacral, and the first three caudal vertebræ are united to form the compound sacrum of the adult.

The axis vertebra is ossified by five centres, the additional one occurring in the antero-ventral region of the body, below the odontoid; this evidently represents an inter-centrum or inter-vertebral wedge-bone.

The cervical ribs appear to chondrify separately from the rest of the vertebræ; but further observations are needed on this point, as well as on the autogenously ossified transverse processes of the sacral vertebræ which in the youngest specimen hitherto examined are continuous with the vertebræ.

The skull differs so little except in details from that of other birds, that there is little to be said about it in an abstract. The chondrocranium of the ripe embryo and the separate membrane bones will be fully described and figured. As in other birds, I find no trace of Jacobson's organ; the capsule of the organ is, however, represented by a distinct (paired) rod of cartilage in the vomerine region, as in *Rhea*.

In Stages D—G the shoulder-girdle consists of a solid piece of cartilage having much the same shape as the adult bone. In Stage H an ossification appears in the scapular region, and another in the post-axial moiety of the coracoid region. In Stage I a fenestra appears, immediately pre-axial of the coracoid ossification, dividing the ventral portion of the shoulder-girdle into procoracoid and coracoid

*Apteryx australis* and *oweni*.

regions. The resemblance at this stage to the shoulder-girdle of the ostrich is very close, but the late occurrence of the distinction between coracoid and procoracoid, and their formation by fenestration of a continuous cartilage, are remarkable. In Stage K the procoracoid has degenerated into a ligament which now forms the sole pre-axial boundary of the coracoid fenestra. Later, the coracoid ossification extends pre-axiad until the membrane of the fenestra is replaced by bone, but even in the adult the position of the fenestra is marked by the thin, often emarginate plate which forms the inner or pre-axial portion of the coracoid. The small aperture situated mesio-ventrad of the glenoid cavity, and sometimes described as the coracoid fenestra, serves for the transmission of a nerve.

In Stage E the manus contains three well-chondrified sub-equal digits; the carpals are not yet chondrified, and are only indicated by a concentration of nuclei in the blastema. In Stage F the second digit has increased out of all proportion to the first and third. In Stage G the pollex has degenerated, and its position is indicated only by a concentration of nuclei in the mesoblast; two well-marked carpals have appeared, one of which—the radiale—lies pre-axiad and slightly proximad of the other, which gives attachment to the second and third metacarpals. In Stage H the radiale lies entirely proximad of the second or distal carpal, which is closely applied to the proximal ends of the two metacarpals. In the newly-hatched bird the second and third metacarpals have ankylosed with one another and with the distal carpal, the radiale remaining separate.

In Stage G the pubis closely resembles that of a chick of the 6th day, the pubis being vertical and the ilium comparatively short. In Stage E the ilium has lengthened greatly, and the pubis forms an angle of 20° with the vertical. In G the adult form is assumed, and in H ossification has begun.

In Stage D the tarsus consists of three elements, tibiale, fibulare, and a single cartilage representing the five distalia. Besides the three functional digits of the adult, and the pollex, which at this stage has its normal connexion with the tarsus, there is a distinct vestige of the fifth metatarsal in the form of a rod-like cartilage, 0.4 mm. long. In Stage E the foot has elongated; the pollex has shifted distalwards, and is now attached to the pre-axial edge of the second metatarsal at about the middle of its length. The fifth metatarsal is still distinct, but has not increased in size; the tibiale and fibulare have united.

In Stage F the foot has nearly attained its adult form. The united tibiale and fibulare instead of being, as in the preceding stage, in close contact with the combined distalia, are separated from them by a narrow in-growth of connective tissue, the rudiment of the mesotarsal semilunar pad. The fifth metatarsal is still visible, but has

undergone distinct retrogression, being only 0·15 mm. in length, and formed of indifferent tissue instead of hyaline cartilage. From this it would appear that the fifth metatarsal actually disappears in *Apteryx* instead of fusing with the fourth as in the chick.

In Stage G the proximal tarsals are closely applied to but have not yet united with the tibia; the distalia also are still distinct from the metatarsals. The rudiment of the mesotarsal semilunar pad has increased considerably, and in the centre of it a rounded nodule of hyaline cartilage has appeared, which I take to be the representative of the centrale tarsi, an element not hitherto recognised in birds.* In a recently-hatched specimen of *Apteryx australis*, it is a perfectly distinct cartilage about 2 mm. in diameter, imbedded in the fibrous tissue of the semilunar pad; in the adult it becomes ossified, attaining a diameter, in *A. owenii*, of about 5 mm.

As the scientific libraries to which I have access are small and imperfect, I take this opportunity of saying that I shall be extremely grateful to the authors of papers bearing upon the subjects of the present investigation who will favour me with separate copies.

[Note.—In no stage is there any trace of the hard knob on the beak which in birds generally assists the embryo to break the egg-shell.—March 21, 1888.]

The Society then adjourned over the Easter Recess to Thursday, April 12th.

Presents, March 22, 1888.

Transactions.

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* It was figured, but not described, by Morse ("On the Intermedium," 'Anniversary Mem. Boston Soc. Nat. Hist.,' 1880, Plate I); and is figured and described as *naviculare vel* "centrale" by me in my paper "On the Morphology of Birds." (See Abstract, 'Roy. Soc. Proc.,' vol. 42, 1887, p. 58.)—W. K. P.