

III. "Observations on the Anatomy and Development of *Apteryx*." By T. JEFFERY PARKER, B.Sc., F.R.S., Professor of Biology in the University of Otago, Dunedin, New Zealand. Received March 20, 1890.

(Abstract.)

The chief materials for the present investigation consist of a number of embryos of the three common species of *Apteryx*, which naturally group themselves into ten stages (A—K); an eleventh stage (L) is furnished by a bird a few weeks old, a twelfth (M) by the skeleton of an adolescent specimen, and a thirteenth (N) and fourteenth (O) by odd bones of young birds; the adult may be considered as constituting a fifteenth stage.

The embryos were, for the most part, well preserved, but not sufficiently well for the purposes of exact histological study. The single embryo belonging to stage A corresponds in most respects to a chick of the fourth day.

The author returns his sincere thanks to the Council of the Royal Society for the grant from which the expenses of the investigation were defrayed, and also to those who have assisted him in various ways. His paper is illustrated with seventeen plates, depicting the external form and anatomy of the various stages, and a number of new terms are proposed in the description of the skeleton.

The following account is abstracted from the author's summary of results:—

*External Characters.*—In stage C, corresponding with a sixth-day chick, there is a well-marked operculum growing backwards from the hyoidean fold, and covering the third (? and fourth) visceral cleft. A rudiment of this structure is seen in the preceding stage.

In stage A, the limbs have already attained their permanent position, so that, if the backward shifting of the appendages so noticeable in the chick occurs in *Apteryx*, it must take place at an unusually early period.

From the first appearance of the feather papillæ there are well-marked pterygæ and apteria, most of which can be made out with tolerable distinctness in the adult.

The wing of the adult has a well-marked pre- and post-patagium, and amongst its feathers may be distinguished nine or ten cubitals, two or three metacarpals, one mid-digital, and a row of tectrices majores. The barbicels of the feathers are slightly curved.

The fore-limb passes through a stage in which it is a tridactyle paw with subequal digits, followed by one in which it is a typical

wing with hypertrophied second and partially atrophied first and third digits.

The nostril has acquired its final position at the end of the beak in stage E; up to the middle of incubation the whole respiratory region of the olfactory chamber, from the anterior nares to the commencement of the turbinals, is filled with a solid mass of epithelial cells, through which a passage is formed at a later period.

At no stage is there any trace of the caruncle or "egg-breaker" at the end of the beak.

*The Law of Growth.*—A number of details are given with respect to the various proportions of the different parts at different ages.

*The Specific and Sexual differences* observable in the three species are described.

*The Skull.*—In stages A and B the only cranial rudiments present are the parachordal plates, continued cephalad into the prochordal plate, and the visceral arches.

In stage C the trabeculæ have appeared, and are continuous with the parachordals; the prochordal plate sends off paired processes directly upwards in the mesencephalic flexure and laterad of the third nerves.

In stages E and F the pituitary fossa is pierced by three apertures in longitudinal series—the anterior, middle, and posterior basi-cranial fontanelles. The middle fontanelle has disappeared in stage G, but the anterior and posterior are still recognisable in stages H and I. Through the anterior fontanelle the pituitary radicle passes.

The medio-dorsal portion of the dorsum sellæ arises as a distinct chondrite, the prochordal cartilage, which in stages F and G is quite separate both from the trabecular and from the parachordal regions of the skull.

None of the stages show a separate prenasal cartilage or inter-trabecular; if present as a distinct chondrite it certainly does not extend further backwards than the anterior presphenoidal region; the posterior presphenoidal region is clearly formed from the trabeculæ.

In stages D, E, and F the presphenoid is a vertical plate of considerable antero-posterior extent, and gives origin to a pair of large orbitosphenoids. In stage A the orbitosphenoids have begun to atrophy, and in later stages are reduced to narrow bars of cartilage, the presphenoid at the same time undergoing a great diminution in antero-posterior extent.

The olfactory capsules extend backwards to the optic foramina mesiad of the eyes; there is at no stage an interorbital septum.

The turbinals are unusually well developed, and are divisible into anterior, middle, posterior, anterior accessory, ventral accessory, and mesoturbinal folds. Alone amongst these, the anterior accessory turbinal is formed as a hollow invagination of the wall of the olfactory capsule,

not as a plate-like ingrowth; its cavity contains a prolongation of the antrum of Highmore.

There are paired, rod-like Jacobson's cartilages, lying one on each side of the rostrum in the vomerine region.

In late embryonic life, and even in the adult, the quadrate articulates with the roof of the tympanic cavity by a double articular surface.

The hyoidean portion of the tongue-bone chondrifies late—subsequently to stage G—and never ossifies.

*The Vertebral Column.*—As in other Birds, the atlas arises from a post-occipital intercentrum and a pair of neurochondrites. The axis consists originally of seven pieces. In both vertebræ each of these elements ossifies separately.

The way in which the notochord is constricted by the ingrowing centrochondrites differs greatly in the various regions.

The atlas and axis in a newly-hatched embryo differ far less than in the adult from those of the other Ratitæ.

Two intercentra are described in the caudal region.

A new method of writing the vertebral formula of birds is adopted.

*The Sternum and Ribs.*\*—The development of these parts seems to show that the costal sternum does not originate by the union of all four sternal ribs, but that it extends backwards independently of the third and fourth ribs, meeting them in turn and becoming united with them by joints.

In some adult specimens the sternum bears a low, median ridge, probably to be looked upon as a vestigial keel.

The form of the adult sternum is very variable.

*The Shoulder Girdle.*—Up to stage H the shoulder girdle is a single cartilage; during that stage the procoracoid and coracoid are differentiated by fenestration. The procoracoid degenerates into a ligament, which is sometimes present in the adult. The coracoid fenestra may persist or may be filled up by a preaxial extension of the coracoid.

Acromial, procoracoid, and acrocoracoid tuberosities are present.

The coraco-scapular angle varies from  $150^{\circ}$  to  $122^{\circ}$ . In stage E the scapula is curved backwards over the ribs. In the same stage the coraco-vertebral angle is  $35^{\circ}$ ; by stage H it has increased to  $90^{\circ}$ .

The adult shoulder girdle is subject to great variation, both in form and size.

*The Fore-limb.*—In the carpus a radiale, an ulnare, and the three

\* It is mentioned by the author that uncinatæ processes (or "uncinates") are present in the ribs of *Dinornis*, some points in the structure of the foot of which bird are also described.

preaxial distalia are distinguishable in early stages. The distalia usually coneresce with the second and third metacarpals to form a carpo-metacarpus, with which the radiale and ulnare may or may not become united.

The pollex usually atrophies at an early stage, but a vestige of it may persist.

The manus is fairly constant in structure in *A. australis* and *A. Oweni*, but is very variable in *A. Bulleri*.

*The Pelvic Girdle.*—The pubis and ischium are nearly vertical in stages D and E, and gradually become rotated backwards.

The post-ilium is already fully formed in stage D, the pre-ilium not until stage G.

The pectineal process is ossified equally from the ilium and the pubis.

*The Hind-limb.*—In the tarsus a tibiale, a fibulare, and a single distale are distinguishable in stages D and E. In F a post-axial centrale appears in the rudiment of the mesotarsal articular pad; in G it becomes chondrified, and in the adult ossified. A smaller pre-axial centrale is first seen as a distinct chondrite in stage L; in the adult of *A. australis* and *A. Haasti* (?) it was observed as a separate bone in the preaxial moiety of the mesotarsal pad.

In stage D the fifth digit is represented by an elongated metatarsal; in E this has diminished in size, and in F undergone almost complete atrophy.

*Muscles of the Wing.*—The following muscles are present in the wing in addition to those described by Owen:—Brachialis anticus, supinator, pronator, anconeus, flexor profundus internus, extensor carpi ulnaris, extensor metacarpi radialis brevis, extensor indicis proprius, and flexor digitorum profundus. There may also be a brachialis anticus accessorius, an interosseus dorsalis, and probably a flexor carpi radialis.

The biceps arises from the acrocoracoid, the triceps by a long head from the scapula and by a short head from the humerus.

*The Brain.*—The mesencephal is unusually small from the first; in stages D—F the optic lobes are dorsal; in G they become lateral by the transverse extension of the optic commissure or median portion of the roof of the mesocœle; in H they are already ventral, although larger proportionally than in the adult.

The diencephal becomes tilted backwards in later stages, its dorsal wall becoming posterior and the foramen of Monro postero-dorsal instead of antero-dorsal.

The anterior commissure and corpus callosum are large.

The cerebral hemispheres are of unusual proportional length, and partly cover the cerebellum.

*The Eye.*—A pecten is present during late embryonic life.

*Phylogeny.*—The following characters support the view that *Apteryx* is derived from a typical avian form capable of flight:—

- (a.) The presence of an alar membrane or patagium.
- (b.) The presence of pterylæ and apteria.
- (c.) The presence of remiges and of tectrices majores.
- (d.) The attitude assumed during sleep.
- (e.) The presence of two articular facets on the head of the quadrate.
- (f.) The presence of a pygostyle.
- (g.) The extreme variability of the sternum, shoulder girdle, and wing, indicating degeneration.
- (h.) The occasional occurrence of a median longitudinal ridge or vestigial keel on the sternum.
- (i.) The position of the shoulder girdle and sternum in stage E.
- (j.) The presence of vestigial acromial, procoracoid, and acrocoracoid processes.
- (k.) The fact that the skeleton of the fore-limb is that of a true wing in stage F.
- (l.) The early assumption of undoubted avian characters in the pelvis.
- (m.) The typically avian characters, both as to structure and development, of the vertebral column and hind-limb.
- (n.) The fact that the brain passes through a typical avian stage with lateral optic lobes.
- (o.) The relations of the subclavian muscle.

On the other hand, the total absence of rectrices tells against this view.

The following characters indicate derivation from a more generalised type than existing birds:—

- (a.) The characters of the chondrocranium, especially in the earlier stages. Many of these peculiarities, *e.g.*, the absence of an interorbital septum, may, however, be adaptive, and correlated with the diminished eyes and the enlarged olfactory organs.
- (b.) The presence of an operculum in early stages. As, however, this structure has not been described in Reptiles, it either proves nothing or too much.
- (c.) The presence of a well-marked procoracoid in comparatively late embryonic life.
- (d.) The characters of the pelvis.

On the other hand, in the following characters, *Apteryx* exhibits greater specialisation than other birds:—

- (a.) The early assumption of their permanent position by the limbs.
- (b.) The late appearance and obviously degraded character of the hyoid portion of the tongue-bone.
- (c.) The position of the nostrils and the peculiar mode of development of the respiratory section of the nasal chamber.
- (d.) The total absence of clavicles.

Such characters as the position of the basi-pterygoid processes, the broad vomer, and the presence of Jacobson's cartilages, being paralleled in existing *Carinatae*, some of them even in *Passerines*, can hardly be considered as of fundamental importance, since they may be derived from a proto-carinate or from an early typical carinate stock.

Before considering the peculiarities in the development of the sternum as of fundamental importance, it will be necessary to study that of the flightless *Carinatae*, and especially of *Stringops*.

The general balance of evidence seems to point to the derivation of both *Ratitae* and *Carinatae* from an early group of typical flying birds or *Proto-Carinatae*.

IV. "Notes on some peculiar Relations which appear in the Great Pyramid from the precise Measurements of Mr. Flinders Petrie." By Capt. DOWNING, R.A. Communicated by Sir F. ABEL, F.R.S. Received March 13, 1890.

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