## 17. *On a* Sacrum, *apparently indicating a new type of* Bird, Ornithodesmus cluniculus, *Seeley, from the* Wealden *of* Brook.

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[Plate XII.]

The discovery of the pneumatic condition of the vertebræ in Ornithosaurs and certain Dinosaurs showed that they diverge from Reptiles in structural characters which are typically Ornithic. The augmented number of vertebræ in the sacrum in both those groups also shows a divergence from existing Reptiles, which is markedly Avian. On the other hand, the small number of sacral vertebræ found in the *Archæopteryx* has proved that a bird may have the sacrum no more complex than in Ornithosaurs and Dinosaurs. The bird's sacrum formerly had a simpler structure, just as the intervertebral articulation was simpler; and we expect to find some of the distinctive osteological attributes of existing birds wanting among earlier representatives of the class. This would also be a fair inference from Prof. Huxley's exposition of the sacrum of the fowl. Sacral vertebræ are defined by their nerves uniting to form the sacral plexus; judged by this test, the fowl has five sacral vertebræ. But ossification has extended beyond them, so as to incorporate in the sacrum the four anterior vertebræ which were originally dorso-lumbar, and the five posterior vertebræ which were originally caudal. When the number of vertebræ is reduced, the structure of the sacrum may be simplified. At the present day the most striking character of a bird's sacrum is the absence of transverse processes extending outward from the bases of the true sacral vertebræ, so that deep depressions are formed in its middle region, comparable to the entire sacrum in some Ornithosaurs. These depressions contain the middle lobes of the kidneys, and therefore may be presumed to be due to the way in which the development of those organs governed the ossification. Hence the presence or absence of this osteological character would imply no more than a slight difference in the deep-seated condition of the kidney; so that the renal recess might be wanting, without implying any important difference in organization.

The specimen which I am about to describe wants the modified renal recesses of the sacral vertebræ of the sacrum (Pl. XII. figs. 2, 3), the typically Avian saddle-shaped intervertebral articulation (fig. 4), and the large number of vertebræ commonly found in a sacrum in existing birds. It is in the Fox collection of the British Museum, and is distinguished by the number $\frac{R}{187}$.

This sacrum is 9·6 centimetres long and slightly curved, so as to be concave in length on the ventral aspect (fig. 3), though the original curvature may have been less than the specimen now shows.

The bodies of the vertebræ and neural arches are both higher in the anterior part of the specimen than in the posterior part, towards which the depression steadily augments (fig. 3).

Anteriorly the articular face of the first centrum is transversely ovate, as among many birds, fully 15 millim. deep, and 20 millim. wide, as preserved (fig. 4). It is in the main flattened, apparently slightly concave from above downward, with a sharp peripheral edge, now a little broken and showing fine cellular tissue.

The posterior articular face is much smaller, and is also extended transversely (fig. 5). It measures over 15 millim. wide at the base, and is much narrower below the neural canal, towards which the sides converge upward. It is over 9 millim. deep. There are two small abraded tubercles which look downward, placed at the outer angles of the base. The articular surface of the centrum is flattened, but slightly concave, and has a small prominence extending backward below the neural canal; the whole surface is inclined obliquely forward so as to look obliquely backward and upward. The small articulation for the caudal vertebra, as compared with the intervertebral articulation in the dorsal region, is a character which has not been found in Dinosauria, and, like the transverse extension, is Avian, though the latter character is also found among some Ornithosaurs. The small caudal articulation implies a small tail; and it will subsequently be seen that we are entitled to infer that this tail was of the type which characterizes existing birds.

The sacrum includes six vertebræ, which are perfectly anchylosed together (figs. 1, 2, 3).

The transverse processes (figs. 1, 2, 3, *t*) are given off at the junction of the centrums. They extend from their origin on the sides of the vertebræ up to the neural platform, which is a horizontal lamina, formed by the blending of the neural arches, extending along the sacrum on each side of the neural spine. This platform (fig. 3, *np*) in its anterior part is directed outward and slightly upward; in the hinder part it is horizontal. The height from the base of the centrum to the neural platform at the junction of the first and second vertebræ is 2·2 centim.; at the junction of the fourth and fifth vertebræ the corresponding measurement is 14 millim. The neural platform does not appear to extend to the sixth vertebra. The width of the neural platform at the second vertebra is 14 millim.; at the fourth vertebra it is about 2 millim. wider. The neural spine is broken (fig. 3, *ns*), but appears to form a thin continuous vertical plate from the second to the fifth vertebra (fig. 1, *ns*). Its base is 3 millim. wide in front, but it is stronger in front than behind. As preserved, it is only half a centimetre high in front, and its height posteriorly was less.

The posterior aspect of the sixth neural arch is worn, so that the zygapophyses are lost, but the neural spine is seen to be vertically grooved. The first vertebra has its zygapophysial facets preserved; they have the characteristic oblique, curved, Avian position resting flat upon the neural arch (fig. 4, *z*).

The sides of the centrums are compressed, and the first two show

long concave lateral depressions, in which are impressed ovate apertures of a pneumatic character (fig. 3, *pn*).

The vertebral centrums are nearly equal in length, but become slightly shorter posteriorly, and the sixth is conspicuously short (fig. 2). The first has a length of 17 millim., the second of 16 millim., the third, fourth, and fifth are slightly shorter, and the sixth measures 13 millim.

The general aspect of the underside of the centrum is flattened, with the flattening augmenting posteriorly. The first centrum is decidedly convex from side to side and concave in length, but the longitudinal concavity becomes obliterated with the next vertebra. The transverse measurement is from 12 to 13 millim. In the second vertebra the centrum is a little wider and flatter, and it widens posteriorly because the transverse process descends almost to the level of the base of the centrum, and widens transversely in a direction nearly horizontal. In the third vertebra the width is nearly 15 millim.; in the fourth it is 16 millim., and in the fifth and sixth it is 13 millim.

The first transverse process (fig. 3, *t*) is on the neural arch; but in the succeeding vertebræ they descend, till the base of the fourth process is on a level with the base of the centrum; their antero-posterior extent gradually increases as they extend backward. The sixth vertebra is at first less conspicuous than the others, because its transverse process does not descend to the base of the centrum, from which it is defined by an emargination. All the transverse processes, except the last, are broken (fig. 2), and the measurement across them and the intervening vertebra, as preserved, in no case exceeds 3 centim.; but the abrasion is probably slight, since the processes are as long as in many existing birds, and in some cases the correspondence with birds in contour and length of the processes is absolute.

The side of the sacrum below the neural platform and between the transverse processes appears in all cases to be excavated. The transverse process between the first and second vertebræ is vertical, 15 millim. high and 6 millim. from front to back. The other processes have some resemblances with *Megalosaurus*, but appear to be vertical (fig. 3, *t*) and constricted in the middle, except the last, which is sub-ovate, but little elevated, 12 millim. high and 10 millim. wide.

The neural canal is wider than high (figs. 4, 5).

The only extinct animals with which this type of sacrum can be compared are Dinosaurs and Ornithosaurs. With described Dinosaurs, notwithstanding many general points of resemblance, it has comparatively little in common. No genus approaches it more nearly than *Hypsilophodon*, in which the character of the sacrum is altogether different in the transverse processes of the first sacral being given off on a level with the base of the centrum, while in the later vertebræ these processes originate higher up on the sides of the centrum. Mr. Hulke has described a shallow median groove as occupying the ventral surface of the centrums of the sacrum in that genus; but it is very different in character from the vascular groove

(fig. 2, *vc*) seen in the median line of this fossil, which is better compared with the similar groove seen on the sacral centra in Vultures and *Ichthyornis victor*. If we were to say that the general analogy with Dinosaurs is such as to give a reasonable probability that some member of the group will be found to resemble it, the prediction would not seem inadmissible; but it would only be another mode of recognizing the approximation of the sacrum in Dinosaurs towards that structure in birds. Unfortunately nothing is known of the sacrum in British Dinosaurs with pneumatic vertebræ; but if the American types which are thus characterized may be taken in evidence, the sacrum has nothing in common with the sacrum described which would tend to affiliate it to the Dinosauria.

The sacral vertebræ in Ornithosaurs are also united into a sacrum. Von Meyer has stated the number of vertebræ in species from the Solenhofen Slate at from 5 to 6. They are anchylosed at a sufficiently late period for the vertebræ not to show the diminished length seen in the sacrum of a bird. There is a resemblance to the fossil in the transverse form of the articular face of the centrum, a less resemblance to the concave articular surface of the first sacral vertebra, and no resemblance to the flat or concave articulation of its last vertebra, which in Cretaceous Ornithosaurs is convex. There is a general resemblance in the pneumatic character of the bones; but I am not aware that any Ornithosaur has the foramina similarly situate, or that the structure of the sacrum is such as this fossil shows.

Turning to birds, the form of the articular face of the first sacral vertebra is variable, so that the Gannet, which has the lower dorsal vertebræ almost biconcave, has the articular face flat, with a central pit in the first vertebra of the sacral mass, which cannot be termed sacral, since it carries ribs. There is therefore no insuperable difficulty in the absence of the typical Avian articulation of the first vertebra in interpreting the sacrum as that of a bird, since the Avian articulation has already been found to be absent in the sacrum of *Enaliornis* from the Cambridge Greensand, and in that of *Ichthyornis*, figured by Professor Marsh.

In *Ichthyornis dispar* * there are ten vertebræ in the sacrum; but the specimen forms an interesting link with our fossil, in differing from existing birds by not having the transverse processes of the middle sacral vertebræ elevated from the centrum on to the neural arch. It is true that they rise a little on the last three sacral vertebræ of *Ichthyornis dispar*, but then there are more vertebræ in the sacrum than in this fossil. *Ichthyornis*, however, is no near ally.

Among existing birds, I was led to seek an elucidation of the fossil among the Penguins rather than any other type, because their dorsal vertebræ present the opisthocœlous deviation from the Avian articulation, which has already offered a suggestive explanation of the opisthocœlous articulation in certain vertebræ of some Dinosaurs, towards which the sacrum may approximate in a general way. The sacrum of *Aptenodytes*, however, is typically Avian. Yet in the

* *Ichthyornis victor* may be generically distinct.

large *A. Forsteri*, which is not dissimilar in size, there is enough in common with the fossil to make some comparisons instructive.

In the skeleton of *Aptenodytes Forsteri*, in the Osteological Collection of the British Museum, numbered 1197 *b*, the presacral vertebra is imperfectly anchylosed to the sacrum, and comes away leaving a rugose surface, which is slightly convex from the ventral margin to the neural canal. This is the converse condition to that seen in the fossil. But just as birds have the vertebræ biconcave, flat, and opisthocœlous, as well as saddle-shaped in the intercentral articulation, there is no antecedent improbability in an extinct bird having the articulation procœlous.

This Penguin's sacrum contains ten vertebræ, and differs from the fossil in many details. It has not the median ventral canal, nor the pneumatic pits; but the Penguin is exceptional among water-birds in that respect. The transverse processes of the early sacral vertebræ of the Penguin are inclined forward as they ascend from the centrum to the neural platform, so that the process rises from one centrum to the neural arch in front of it; whereas in the fossil the processes are vertical, and given off at the junction of two centrums. The middle three sacral vertebræ of the Penguin, have the character already discussed as typical of existing birds, the attachments for the ilium being given off from the neural arch, and this is an important difference from the fossil. But the posterior widening of the transverse processes seen in the Penguin is well marked in the fossil. And the last vertebra has the vertically ovate tubercle for the ilium upon its own centrum, and is conditioned in every respect in the same way in the Penguin (fig. 6) and the fossil (fig. 5). The correspondence is almost as close in the character of the transverse processes and zygapophyses of the first sacral vertebra. The resemblances further include the flattened neural platform, which is better developed in the fossil than in the Penguin. The neural spine in the fossil is thinner, more as in ordinary birds, and apparently lower than in the Penguin. Another resemblance is in the descent of the transverse processes from the neural platform in the first vertebra to the base of the centrum in the fourth vertebra, in consequence of which the first two vertebræ have their bodies compressed from side to side (fig. 3). In both types the bodies of these vertebræ are of similar form, the first rather flattened on the underside and concave in length, the second widening as it extends posteriorly. Though the centrums in the fossil are approximately of equal length, their length diminishes in the middle of the sacrum in a way which is Avian, though the shortening is less than in existing birds. From the Avian form of the last sacral vertebra it may perhaps be legitimately inferred that the tail was not unlike that of a Penguin.

From this comparison it is manifest that the differences which the fossil shows from existing birds are three: first, the small number of vertebræ in the sacrum; secondly, the absence of the sacral recesses for the middle lobes of the kidneys; and, thirdly, the form of the articular face of the first sacral vertebra. Fossil birds lessen the importance of these differences: first the *Archæopteryx* has as

few vertebræ in the sacrum; while *Ichthyornis dispar* has no renal recesses in the middle of the sacrum; and the Gannet makes a sufficiently near approximation to the form of the articulation to remove any improbability as to its being a modified Avian form.

I therefore venture to submit, on the evidence of the resemblances and considerations which have been discussed, that *Ornithodesmus* is probably a bird; but it differs from existing birds, so as to suggest that it is a link towards lower forms. It cannot be placed in any existing division of the class, but approximates towards Dinosaurs in a way of which no bird had previously given evidence.

I am indebted to Dr. Henry Woodward, F.R.S., for facilities afforded me in making this study.

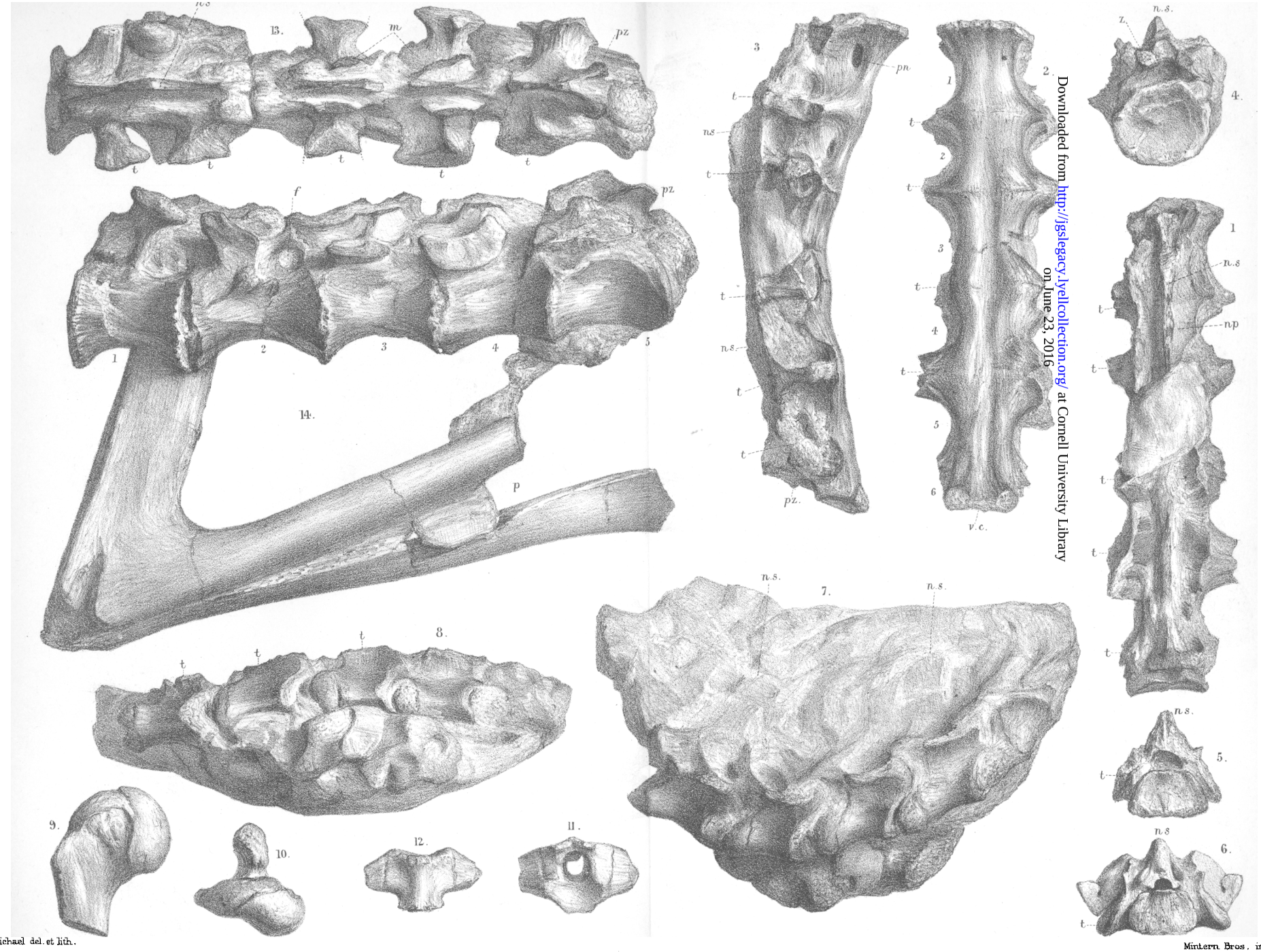
## EXPLANATION OF FIGURES.

### Plate XII.

*ns*, neural spine; *t*, transverse process; *z*, prezygapophysis; *pz*, postzygapophysis; *np*, neural platform; *pn*, pneumatic foramen; *vc*, vascular groove.

Fig. 1. Dorsal view of sacrum of *Ornithodesmus cluniculus*.
2. Ventral view of sacrum.
3. Lateral view of sacrum.
4. Anterior articular end of first sacral vertebra.
5. Posterior articular end of last sacral vertebra.
6. Posterior articular face of last sacral vertebra of *Aptenodytes Forsteri*.

(For the Discussion on this paper, see p. 219.)






F. H. Michael del. et lith.

ORNITHODESMUS, HETEROSUCHUS, PATRICOSAURUS AND ARISTOSUCHUS.

Mintern Bros. imp.