Supplementary Note on the Vertebræ of Ornithopsis, Seeley,= Eucamerotous, Hulke

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4. Supplementary Note *on the* Vertebræ *of* Ornithopsis, *Seeley*,= Eucamerotus, *Hulke*. By J. W. Hulke, Esq., F.R.S., F.G.S. (Read November 19, 1879.)

[Plates III. & IV.]

At the close of last session I brought before the Society some additional evidence of the existence in our Wealden times of a huge Dinosaur whose vertebræ were characterized by marvellous lightness; and I endeavoured to show, by an examination of all the material at that time available for comparison, that although the vertebræ of this Saurian (*Ornithopsis*, Seeley, *Eucamerotus*, Hulke; *Bothriospondylus*, in part, *Chondrosteosaurus*, Owen) exhibited correspondences with those of certain newly discovered American forms (some of which had been recently noticed by Prof. Owen) which indicated affinity with these, yet there coexisted such differences as seemed to me to disprove their generic identity.

The liberality of the Rev. W. Fox now enables me to place before you photographs and drawings which, for the first time, afford complete information respecting the structure of the vertebral column in the neck and trunk of this remarkable animal.

Neck.—Three cervical vertebræ in Mr. Fox's possession show the centrum in this region to be strongly opisthocœlous. The articular ball in this region is a larger portion of a sphere than in the trunk, and the cup is correspondingly deeper. The under surface of the centrum is singularly flat, a character which disappears in passing backwards and is little apparent in the trunk. The neural canal is very capacious. The præzygapophyses project considerably forward beyond the front of the neural arch, overhanging here the ball. Their articulating surface is large, of a roughly oblong form, and directed upwards and inwards. It is a single surface for each præzygapophysis; and the notch between the præzygapophyses is non-articular. The additional articular surface forming the zygantral arrangement present in dorsal centra is here absent; and the associated zygosphenal bolt dependent from the confluent inner ends of the postzygapophyses is necessarily also wanting in the neck. The neural arch in all Mr. Fox's specimens referable to the neck is devoid of spinous process. From the root of each præzygapophysis a lofty crest curves upwards, backwards, and inwards, and then diverges and declines posteriorly, where it ends in a stout postzygapophysial process bearing on its under and outer surface the articular facet. The crests of opposite sides are separated by a mesial groove very deep in front. There are two transverse processes, a lower on the body and an upper on the arch. The lower transverse process (parapophysis) springs from the side of the centrum towards the front, a constriction separating it from the articular ball. From the parapophysis a projecting ledge-like plate passes backwards along the centrum to its posterior border. The upper transverse process

(diapophysis) springs from the arch vertically over the lower, towards which it inclines; and both processes are joined by the branches of a short forked riblet, which assist to enclose a large foramen. The only riblet preserved is mutilated; but it is evident that its unattached, free, distal border was extended forwards and backwards in a direction nearly parallel with the vertebral column in an ordinary manner. From the root of the diapophysis another projecting ledge-like plate descends along the side of the arch towards the junction of this with the centrum near the posterior border of this latter, thus taking a direction approximately parallel with the lower plate. Between these two plates, and much overhung by the upper one, the side of the centrum is impressed with a long narrow pit, crossed slantingly and imperfectly subdivided by ridges. From each of the neural crests, where these diverge behind, a prominent ridge runs downwards and forwards towards the root of the diapophysis of the same side, and another wider ridge descends nearly vertically towards the centrum, its posterior margin forming the lateral boundary of the posterior opening of the neural canal. Between these two ridges, and above the diapophysial ledge-plate which bounds it below, is a large very conspicuous depression. The average length of the three cervical centra was probably not under 28 centim., which is about the length of the centrum I brought before the Society last June. The large extent of the articular surfaces, the crests and ridges, and the great length of the vertebræ indicate a very long, extremely mobile, strongly muscular neck. In the singular flatness of the under surface of the centrum there is a striking resemblance to that of *Apteryx Mantelli*.

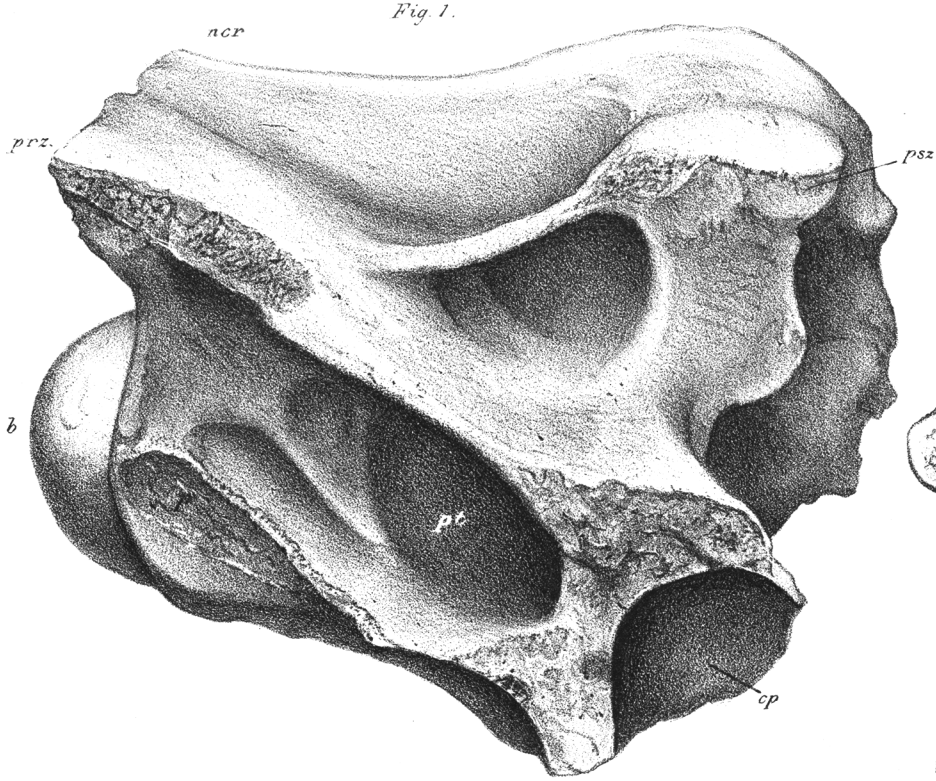
Trunk-Vertebræ.—The best-preserved vertebra in Mr. Fox's collection (Pl. III. figs. 4, 5) referable to the trunk is, I believe, from nearly the same situation as the neural arch I brought under the Society's notice in 1870. When placed on a plane surface, its height, taken from this to the top of its spinous process, is about 62 centim. The centrum is opisthocœlous; but the prominence of the articular ball is less than in the neck. The horizontal diameter of the ball is greater than the vertical diameter, the actual measurements being 22·5 centim. and 14·6 centim. The length of the centrum taken along the side from the base of the ball to the edge of the cup is, in the present state of the fossil, 17·5 centim.; but before abrasion it was probably not less than 20 centim. The under surface of the centrum is flattened transversely, but to a much smaller degree than in the neck. Longitudinally it is rendered very concave by the swelling of the articular ends. It is marked by a low median ridge. In the side of the centrum is the conspicuous opening of the large internal chamber, described more particularly in my last note. It is of an oval form, with the larger end in front. Its length is 13·5 centim., and its greatest vertical diameter is 5·4 centim. The chambers of opposite sides are separated only by a very thin median partition. The neurapophyses have an extensive attachment to the centrum, their antero-posterior extent nearly equalling that of the latter. They then contract to 13 centim. at a height of 1·5 centim.

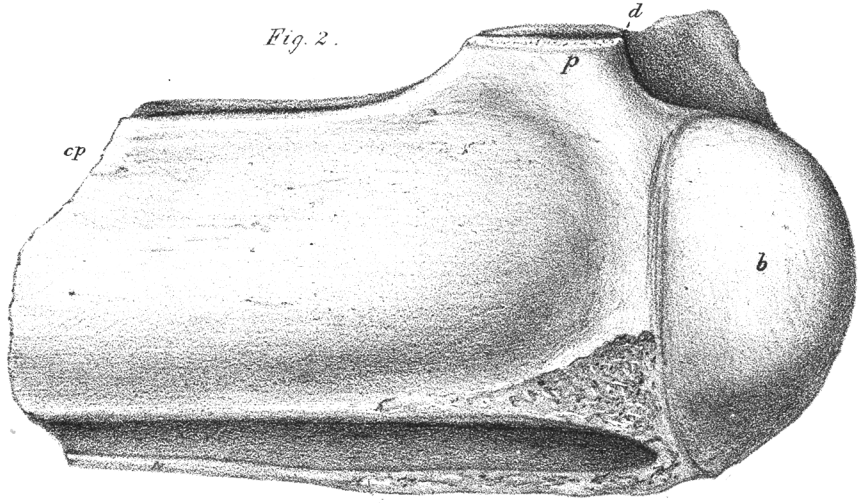
to 2 centim. above the floor of the neural canal, and above this again rapidly increase. The arch and processes exhibit the singularly complex structure, less perfectly shown in my first fossil, shown here in 1870. The inner aspect of each præzygapophysis has an additional articular surface which, prolonged into the bottom of the deep notch that separates the pair of præzygapophyses, forms with this a zygantral arrangement. In correspondence with this a vertical zygosphenal bolt-plate depends from the confluent inner ends of the postzygapophyses. From the bottom of this zygosphenal plate two sheets of bone descend upon the neurapophyses, roofing in, after the fashion of an eave, the posterior opening of the neural canal. The præ- and postzygapophyses are connected by a platform continued along the neural arch in the level of its crown. This platform is produced outwards and upwards in the form of a strong and rather long transverse process, the free end of which is stout and clubbed as for the attachment of a rib-tubercle. Below, a thin vertical plate descends from the transverse process and platform upon the side of the neural arch, on which it is lost slightly below the mid height of the latter. Above, a similar thin plate connects the platform with the neural spine. The articular surface for the rib-head is just outside the præzygapophysis. Under the platform are very deep cavern-like recesses. The neural spine arises by two pairs of plates, of which the front are thinner, and spring from the crown of the very lofty arch close to the præzygapophyses. Below, these anterior plates are separated by a deep mesial groove. Above, they gradually approach, the separating groove lessens till they meet, when they again diverge and lose themselves in the anterior aspect of the transversely extended free end of the spinous process. The posterior pair, stouter, more pillar-like, arise directly over the postzygapophyses. They are not traceable so high as the anterior pair. Below, between them, immediately above the zygosphenal plate, is a deep pit. Above this they are separated by a narrow median crest which ascends nearly to the top of the spinous process, and served for the attachment of an interspinous ligament. The transverse expansion of the free end of the spinous process, so that the direction of its greatest measurement here crosses the axis of the vertebral column, and its deep sculpturing, are two remarkable features.

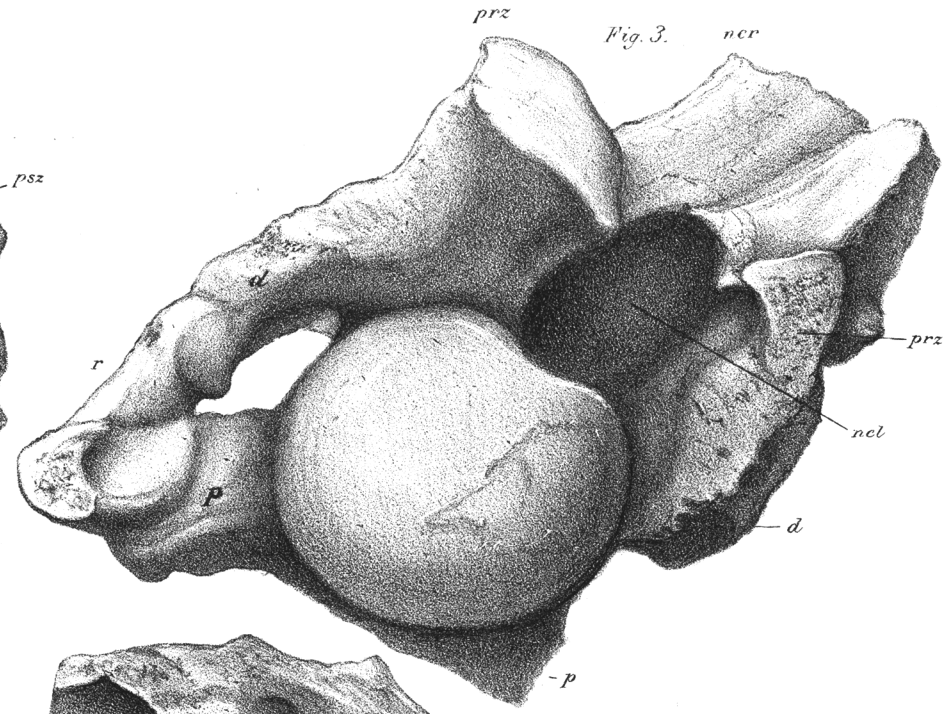
Until now our ideas of the form of these singular vertebræ had been drawn constructively from fragments of detached arches and centra. The association of arch and centrum, which in 1870 I felt justified in affirming, on the evidence of such fragments, is here first actually demonstrated in this magnificent fossil. Another centrum, apparently from the same part of the vertebral column as that just described, is 24 centim. long. The articular ball is 22 centim. in its vertical diameter, and 16 centim. in the horizontal. The under surface of the centrum is somewhat flattened. The chambers and their lateral openings are very large. A third centrum, about 23 centim. long, has a more cylindroid

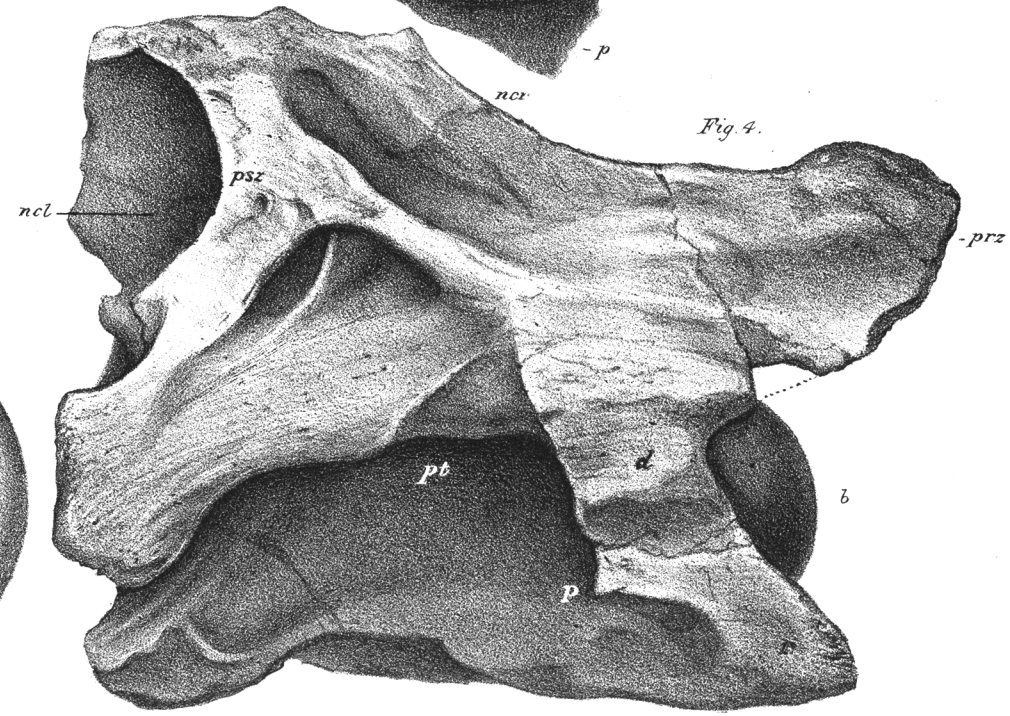
figure; the under surface is only very slightly flattened. The lateral opening and the chamber are smaller. I am inclined to regard this centrum as having occupied a position in the vertebral column posterior to the two just described. The form of the articulations and the superadded zygosphenal arrangement are calculated to greatly limit the mobility of the vertebræ on one another in this region. With respect to the orifice of the large-sided chambers in these vertebræ, Prof. Seeley, finding them paralleled in birds and Pterosauria, regarded them as pneumatic. Prof. Owen, on the other hand, thinks that they were more probably filled with chondrine; and in a recent discussion he supported this view by a reference to the vertebræ of fish. On this hypothesis it is not apparent to me why the chambers should attain their maximum development in the fore part of the trunk, be absent from the neck, and lessen towards the loins. Why should such a connective substance as chondrine be thus limited in its skeletal distribution? Rather does not such limitation strengthen the opinion of their being air-chambers? In Birds, particularly those endowed with great powers of flight, *e. g.* Albatross, the pneumatic opening in the side of the vertebral centrum is largest precisely in the same situation as in *Eucamerotus*; it is also wanting in the neck, and it rapidly lessens towards the sacrum. In noticing this parallel I would, however, not be understood to affirm that *Eucamerotus* was capable of flight.

Tail.—All the vertebræ yet discovered which I can confidently refer to the animal belong to the neck and trunk. I know of none which bear chevron facets or other marks whereby to assign them to the tail, a circumstance which is not without significance when we consider the large number of vertebræ in most reptilian tails. May its caudal vertebræ be, like those described in certain of the new American forms, unchambered and relatively solid? In the same Wealden beds which have yielded these cervical and dorsal vertebræ caudal vertebræ not unfrequently occur. Of these, the most common are those laterally flattened forms which are correctly assigned to *Iguanodon*. Next in frequency are two types which have usually been given to *Ceteosauri*. Of these, one I have good reason to place in the tail of *Iguanodon* immediately behind the spot where the transverse process disappears. The other, which often attains much larger dimensions than in *Iguanodon*, is also relatively shorter and of coarser texture. May these belong to *Eucamerotus*? Not long since I should have rejected this conjecture as unworthy of attention; but the late Colorado discoveries show that it would not be safe to do so.









C. Berjeau lith.

VERTEBRÆ OF ORNITHOPSIS.

Hanhart imp

Fig. 7.

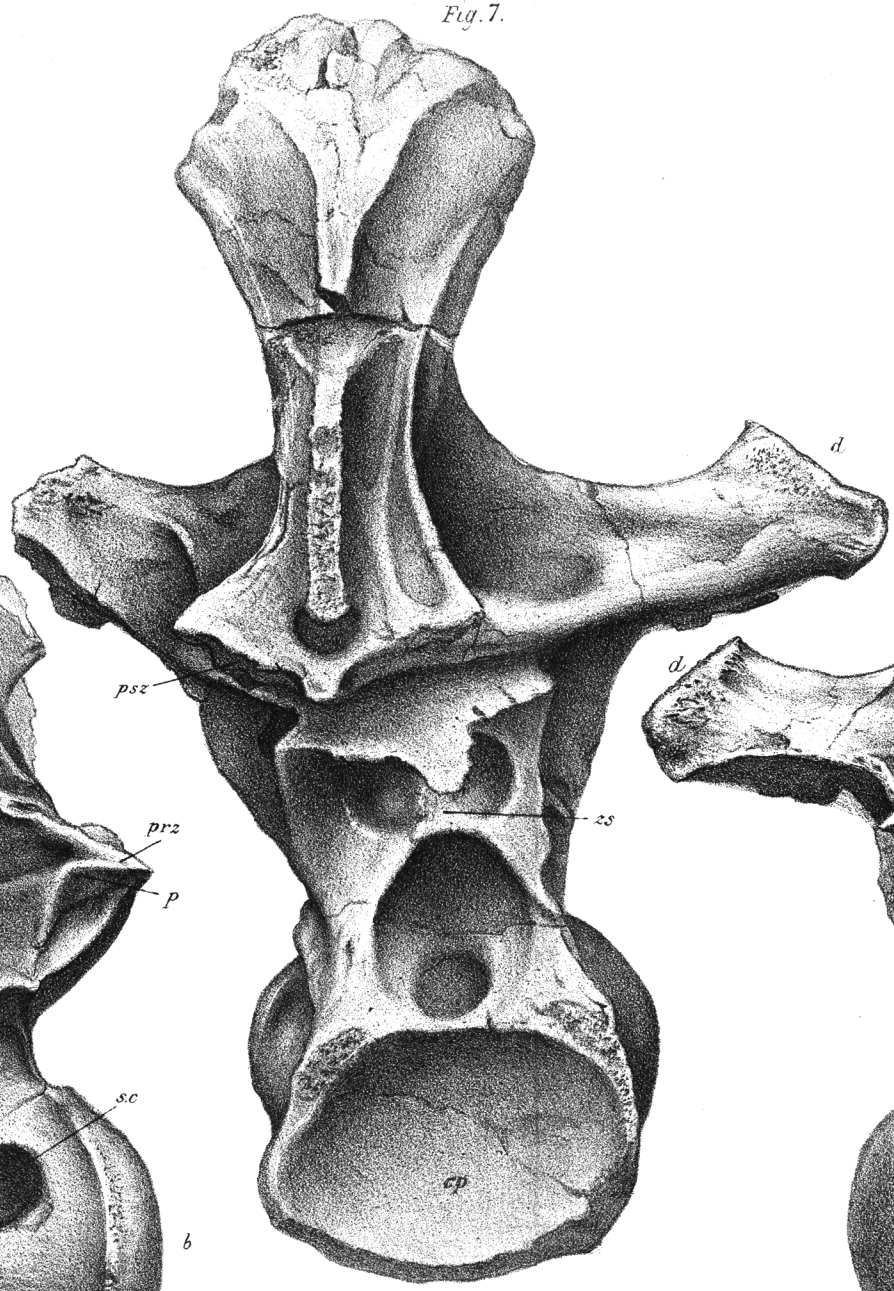


Fig. 6.

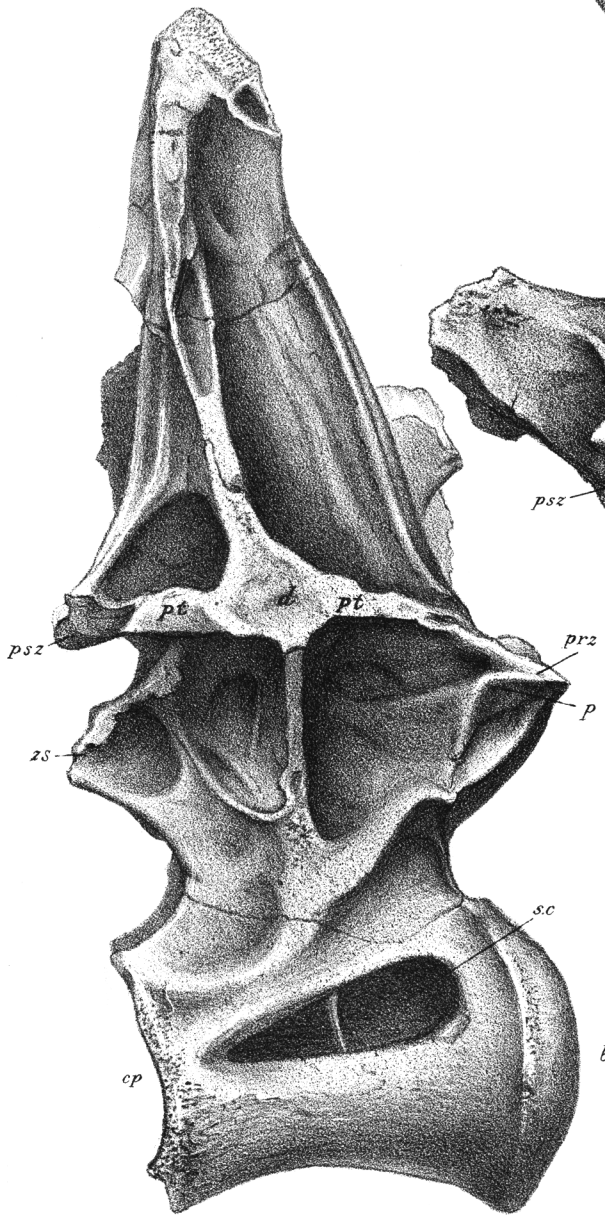
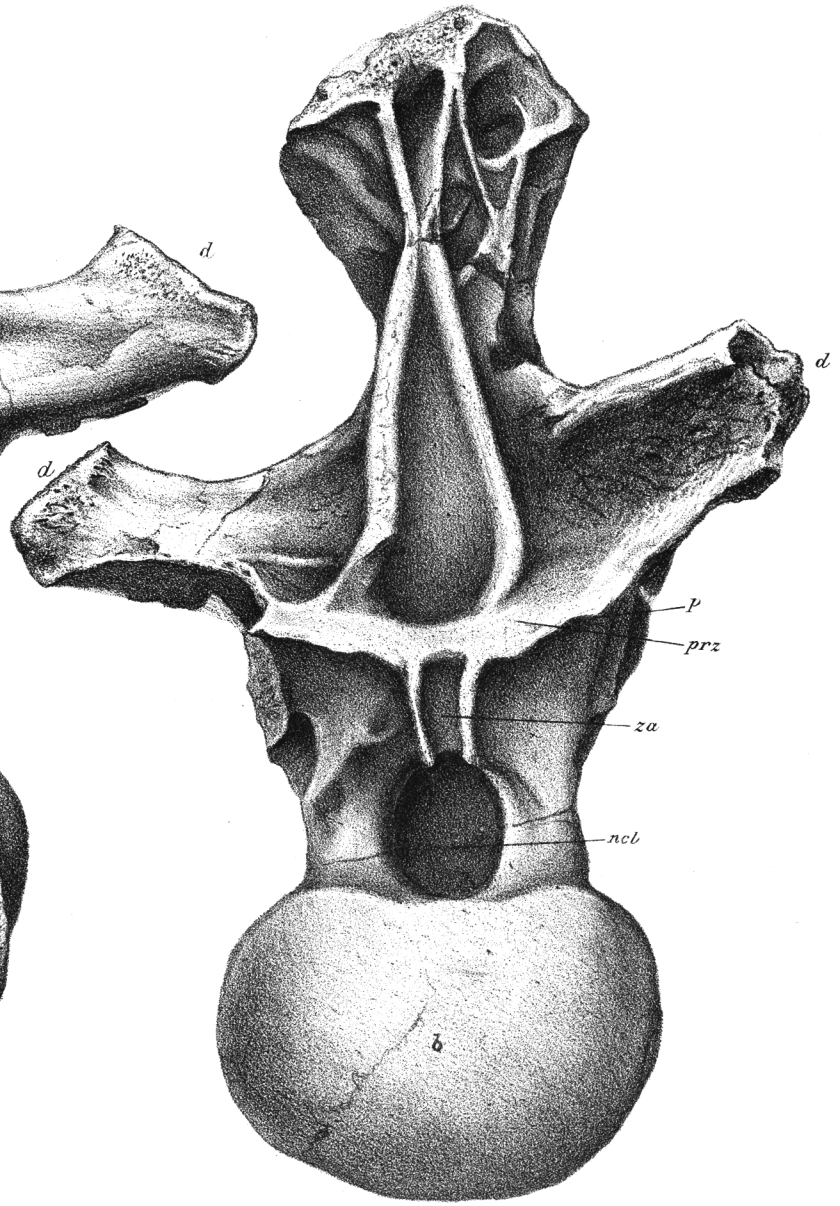


Fig. 5.



VERTEBRÆ OF ORNITHOPSIS.

C. Berjeau lith.

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EXPLANATION OF PLATES III. & IV.

All the figures are about one fourth the natural size.

Fig. 1. Side view of cervical vertebra. (No. II. 4, Mr. Fox's Catal.) (The præzygapophyses, the dia- and parapophysis and a piece of the border of the posterior articular cup have been broken off.)
Fig. 2. Under surface of another cervical vertebra. (No. II. 6, Mr. Fox's Catal.)
Fig. 3. Front view of another cervical vertebra. It is somewhat distorted by pressure, and the left præzygapophysis, dia- and parapophysis have been broken off. (No. II. 3, Mr. Fox's Catal.)
Fig. 4. Side view of the same (postzygapophysis broken off).
Fig. 5. Front view of trunk-vertebra.
Fig. 6. Side view of trunk-vertebra. (The free extremity of the diapophysis is detached.)
Fig. 7. Back view of trunk-vertebra. (No. II. 1, Mr. Fox's Catal.).

In all the figures the letters have the following signification:—

prz, præzygapophysis.
psz, postzygapophysis.
za, zygantrum.
zs, zypospheue.
p, parapophysis.
d, diapophysis.
b, ball.
c, cup.
s.c, side chamber.
n.cl, neural canal.
n.cr, neural crest.
pt, side pit.
r, riblet.

Discussion.

Prof. Seeley supported the view of the pneumatic character of the vertebral cavities in this genus by reference to the Chelonians and Birds, and believed that the tissue of the dorsal vertebræ had been excavated and absorbed owing to the pressure of an air-sac upon the vertebræ, due to a sacculate condition of the lungs. He pointed out the value of the new evidence obtained with regard to the neural arch; and (if we may accept the evidence of the American genera as to the carpus and tarsals) we seem to have proofs in these animals of the existence of a suborder of Dinosaurs in which peculiar skeletal modifications are associated with a pneumatic skeleton.

Dr. Meryon took exception to the explanation given by Prof. Seeley as to the absorption of portions of the vertebræ. He suggested that the analogies were with the Sharks and Rays rather than with Birds.

Mr. Hulke replied to Dr. Meryon that while the cervical vertebræ indicate great mobility, the dorsal vertebræ are very firmly locked together. Against the view that the parallel of the singular chambered structure was to be found in the Sharks and Rays, he pointed out that this structure is, in *Ornithopsis*, confined to the dorsal region, and does not extend through the whole length of the vertebral column, as is the case with cartilaginous fishes.