PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Researches on the Structure, Organization, and Classification of the Fossil Reptilia. V. On Associated Bones of a Small Anomodont Reptile, Keirognathus cordylus (Seeley), Showing the Relative Dimensions of the Anterior Parts of the Skeleton, and Structure of the Fore-Limb and Shoulder Girdle

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Phil. Trans. R. Soc. Lond. B 1888 **179**, 487-501
doi: 10.1098/rstb.1888.0018

XVIII. *Researches on the Structure, Organization, and Classification of the Fossil Reptilia.—V. On Associated Bones of a Small Anomodont Reptile,* Keirognathus cordylus (Seeley), *showing the Relative Dimensions of the Anterior Parts of the Skeleton, and Structure of the Fore-limb and Shoulder Girdle.*

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Received April 5,—Read April 26, 1888.

[Plates 75, 76.]

The Dicynodont remains hitherto described are nearly all isolated portions of different skeletons, which give no definite idea of the form of body or proportions of the limbs of the animals comprised in the group. The skulls described have been separated from the vertebræ; there has been an absence of matrix to connect either with the limb bones or the shoulder girdle; and, though the pelvis has been found associated with the sacrum, there is no means of judging of its relative size as compared with the head or limbs. Although the Anomodontia are among the most interesting of Reptiles in osteological structure, knowledge of the individual animals is indefinite, and no restoration of the skeleton has been possible.

There is one specimen (Plate 75), however, in the British Museum which contributes materially towards the desired knowledge. It is a small slab of grey-green calcareous shale, numbered 49,413, collected by Mr. Thomas Bain at Klipfontein, Fraserberg, and placed in the National Collection in May, 1878. It is in the worst possible preservation, owing to fracture through the remains, and absence of the counterpart slab, but exhibits the skull, a few vertebræ, ribs, the shoulder girdle, and bones of the fore-limb of a small species of a genus closely allied to *Dicynodon*. The limbs prove to have been unexpectedly short, and, notwithstanding the Mammalian form of pelvis, in other specimens referred to the genus *Dicynodon*, justify the inference that the proportions of the body were rather those of a short-tailed Salamander or Seal than of a Dinosaur or long-limbed Mammal.

The Head.

The skull is exposed in side view with the lower jaw in contact. The extreme antero-posterior length of the head is 10 centims., but this extent is due to the posterior lateral expansion of the squamosal bones at the back of the head, for the

measurement from the occipital condyle to the extremity of the snout is 8·5 centims. The vertical measurement from the condyle of the quadrate bone to the summit of the skull is 6 centims., and it is 7 centims. from the infra-articular angle of the lower jaw. The lateral contour of the skull closely approaches that of *Dicynodon feliceps;* but that species has the squamosal bone longer, the lower jaw deeper, the maxillary tooth larger, and the back of the head apparently less elevated. *Dicynodon dubius* has the tooth as small as in this specimen, but its root enlarges in the skull, in a way to which this species shows no approximation. Only in *Dicynodon recurvidens* is so small a tooth found as appears to characterize this fossil; but the skull of that species has little in common with these remains. Hence I conclude that the head upon the slab belongs to an undescribed species, with the facial contour of *D. feliceps;* a short vertical quadrate region, as in *D. dubius;* and small teeth, like those of *D. recurvidens,* which, however, were directed downward and forward instead of downward and backward. The scapula shows it to be related to *Kistecephalus;* but the humerus distinguishes it from other genera.

From the back of the head the contour line steadily descends as it extends forward, till over the anterior border of the narine the descent to the alveolar margin becomes rapid. The shape and size of the narine are badly indicated, but its dimensions as preserved are about 17 millims. long by 13 millims. high; hence, the form of the aperture was probably transversely ovate, and its size smaller than the present fractured limits of its margin. It approached near to the roof of the snout, and its superior margin was about 23 millims. above the margin of the jaw, at the point where the tooth crosses it. The orbit appears to have been relatively small, less than 1·5 centim. in diameter. It is separated from the narine by a bar which is less wide than the narine, and is undefined posteriorly, since the post-orbital bar is broken away, leaving a long transversely ovate vacuity, which extends over the temporal region, and measures about 4·5 centims. long by 2·7 centims. deep.

The alveolar margin of the jaw forms a sigmoid curve, being concave from the quadrate bone forward, then convex, with the convexity terminating behind the extremity of the jaw. The small tooth, of which only a fragment is preserved *in situ,* is in advance of the middle of the convexity at 2·5 centims. behind the imperfect anterior extremity of the jaw. By the side of the anterior extremity of the lower jaw is what I take to be an impression of a tooth, which is 3 millims. wide and 17 millims. long. The tooth itself may have been longer and wider. These remains may be parts of the same tooth, with a crown fully 2 centims. long; they give no evidence of expansion of the root to a wide pulp cavity, as in *Dicynodon.*

The vertical depth of the head between the orbit and narine is about 4 centims. in the anterior convex part of the alveolar border; and the depth is about the same in the middle of the posterior concave part of the border. This curved outline of the border of the jaw probably results from the breaking away of the maxillary bone, for the pterygoid bone is exposed posteriorly, and is seen to extend downward and unite

with the quadrate. The quadrate bone is vertical, and the depth of the skull at the quadrate articulation is 6 centims. This bone is short, as in the true Dicynodons, but not so short as in the Oudenodons. A canal in the sphenoidal region, such as the cochlea might be, is shown in section to be four-sided, with the angles prolonged so as to make its sides concave, and situate far above the upper extremity of the quadrate bone. The lateral expansion and divergence of the squamosal bones outward and backward forms a concavity at the back of the head.

The anterior end of the snout appears to have been rounded and steeply inclined, with an inflation at the anterior corner of the narine; so that the lateral contour of the head approximates to that of the common Turtle.

The lower jaw is 7·5 centims. long. It is short and moderately deep, and terminates anteriorly in a sharp beak, below which the bone retreats in the oblique manner common to Chelonians. The superior and inferior borders are sub-parallel for three-fifths of their length, gently convex above and concave below, with a depth of 1·9 centim., and then its hinder extremity bends downward to the articulation; but the superior border descends more rapidly than the inferior border, so that the vertical measurement narrows posteriorly, and at the articulation the vertical measurement is only 7 millims. The articular bone extends obliquely downward and backward, but the extension of the jaw behind this bone is slight.

The preservation of the remains does not warrant a detailed description of the head, and those features which are of interest in it will be better elucidated in remains of other Anomodonts.

The Shoulder Girdle.

The scapular arch of this Dicynodont proves to be made up of many elements. Sir Richard Owen found the scapula and clavicle in the allied genus *Kistecephalus*;* and in another specimen, which was classed as "Dicynodont,"† the scapula is shown to unite with the coracoid and pre-coracoid. The present specimen adds to these elements a very large inter-clavicle and a sternum; and shows the relations of the bones to each other. The preservation of the bones, however, leaves much to be desired, and I offer the following description and restoration with diffidence, which the imperfect condition of the bones may justify, but with some confirmatory evidence from other remains in the British Museum.

The Scapula.

The scapula is formed on the plan of the scapula of *Kistecephalus* (British Museum, No. 17,071), which it closely resembles in form. It has an elongated blade, a distinct acromion, and a transverse articulation, not much expanded, for the head of the

* 'Catalogue of the Fossil Reptilia of South Africa,' Plate 69, fig. 8, p. 63.

† *Loc. cit.*, Plate 69, figs. 5, 6, p. 55.

humerus. It is badly preserved, and at the proximal end is only indicated by an impression from which the bone is lost, while its free end is imperfect. Its length, as preserved, is 4·5 centims. It is thin throughout the length, which is somewhat curved, is 7 millims. wide towards the distal end, and contracts apparently to about half this width in the middle of the shaft. The anterior border is the more concave, because the bone widens proximally towards the acromion process, which is short, blunt, and directed proximally, as in *Kistecephalus*. It widens the bone to 7 millims. Below the acromion the bone is necessarily constricted, or rather notched out, on the anterior side, so that the transverse measurement is 4 millims. And then the proximal end widens to 8 millims. at the articulation, and the bone increases in thickness so as to form a flattened articular surface with a sharp margin. The elongated bladelike extension of the bone gives it almost an Avian character; but the acromion process makes it more like the scapula of an Iguanodont. There are no Lizards in which the scapula is similarly elongated and expanded. The Chameleon makes, perhaps, the nearest approximation in relative length, but has not the same distal expansion, nor has it an acromion process. The scapula of *Hatteria* is compressed, but it is short, and is differently connected with the coracoid, as though it were connate with the pre-coracoid. It has a slight tubercle on the anterior margin representing the acromion. In Ornithischia the scapula is relatively longer than in *Hatteria*, but has not the expanded form of the free end seen in the fossil, though the acromion may be well marked.* The differences from Ornithosaurs are of a similar nature. The scapula in *Ornithorhynchus* is wider, and relatively less elongated, but resembles the fossil in the articular end, in the supra-articular emargination, and in the extent and direction of the acromion process, which characters may be regarded as Mammalian.

The Coracoid and Pre-coracoid.

Both coracoid and pre-coracoid are developed as moderately large elements in the shoulder girdle, but are represented in the slab by faint impressions, with scarcely a trace of bony tissue. The pre-coracoid appears to have been excluded from the humeral articulation, and to have extended between the scapula and the inter-clavicle. The impression indicates that it may have extended as far forward as the acromial process of the scapula. Its internal border was convex, corresponding with the concavity of the anterior lateral part of the inter-clavicle. Its anterior border is badly defined externally towards the scapula. The extreme transverse width over this pre-coracoid area, below the acromion, is about 1·8 centim.; its antero-posterior extent is about 1·2 centim. There is a small oblong ossification on its anterior border, which is more likely to be part of the expanded plate of the pre-coracoid than part of the clavicle, if the condition of the clavicle in this specimen may be inferred from that

* Scapula of *Cratæomus*, "Reptile Fauna of the Gosau Formation," 'Geol. Soc. Quart. Journ.,' vol. 37, 1881, p. 656.

in *Kistecephalus*,* in which the scapula is similar. A narrow space, about 2 millims. wide, separates the pre-coracoid from the inter-clavicle, and may indicate an unossified band of the pre-coracoid cartilage, but is a defined separation between these sternal elements.

The coracoid has its chief extent in the antero-posterior direction. It is overlapped posteriorly by the sternum; and the head of the displaced humerus appears to abut against its lateral border. It contributes almost equally with the scapula to form the glenoid cavity for the head of the humerus. Its surface is smooth. The internal border abuts against the inter-clavicle; and the anterior border, which is straight and transverse, meets the pre-coracoid by a transverse suture which extends into the middle of the glenoid cavity, just meeting the anterior margin of the articular border of the scapula. The bone is vertically oblong, and measures 17 millims. in the antero-posterior direction to the border overlapped by the sternum, while transversely its measurement exceeds 1 centim. It contributes 6 millims. to the articular cup for the humerus. Its external lateral border below the articulation is concave; and the posterior border is unknown, but probably curves convexly towards the sternum and inter-clavicle. Where the internal lateral border of the coracoid and pre-coracoid meet there is a concavity, which fits against a corresponding convexity of the inter-clavicle.

In *Salamandra maculosa* Professor W. K. Parker, F.R.S., has shown† that when the animal is nearly adult both coracoid and pre-coracoid elements of the shoulder girdle are present, in addition to the scapula, but neither scapula nor pre-coracoid appears to reach the glenoid cavity, which is formed by the coracoid; and, as no inter-clavicle is present, the type obviously has no near relation to the fossil. The absence of an inter-clavicle is one of the more singular characteristics of the living Amphibia. I am not aware that the pre-coracoid is ever ossified separately in the Lacertilia. The cartilage which is so named never occupies the position, anterior to the coracoid and posterior to the transverse bar of the inter-clavicle, which the pre-coracoid has in this genus. The nearest approach to the condition seen in the fossil is found in the Monotreme Mammals, where a pre-coracoid extends anterior to the coracoid, but it does not unite with the scapula, and extends behind the inter-clavicle, instead of meeting its lateral margin. If the coracoid and pre-coracoid were united, the bone would resemble the coracoid of an Ornithischian. The coracoid approximates to the bone in a Monotreme, and in a less degree to *Hatteria*.

Sir Richard Owen has figured‡ a remarkable fragment, which is described as parts of the mutilated scapular arch of a small Dicynodont, which may possibly belong to the same genus as the specimen now described, and indicates an animal with a skull probably about a foot long, if its proportions were those of this species. The

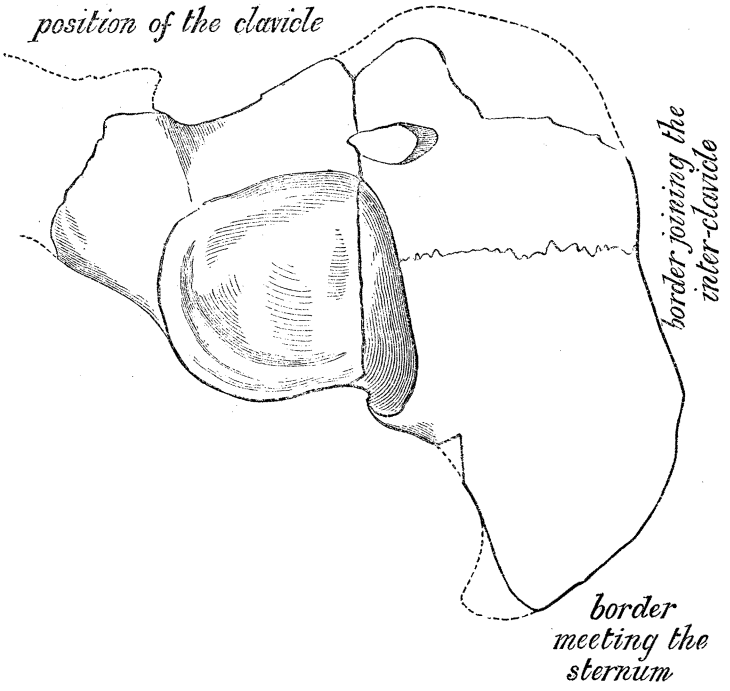
* The bone which Sir R. Owen describes and figures as episternum in *Kistecephalus* ('Cat. Rept. South Afric.' Plate 69, p. 63) I regard as being the clavicle.

† Ray Society, 'Shoulder Girdle,' p. 65, Plate 4, fig. 7.

‡ 'Cat. Rept. South Afric.,' Plate 69, figs. 5, 6.

acromion of the scapula appears to me to be lost with the fracture (fig. 1) which has removed the greater part of the bone, and the anterior margin of the pre-coracoid is also imperfect; but, otherwise, it affords, when turned round into its natural position, a remarkable confirmation of the natural association of the bones now described. Not the least curious coincidence in structure is furnished by the lateral concavity where the coracoid and pre-coracoid meet on the internal border, showing that the inter-

Fig. 1.



No. 36,287, Brit. Museum.

clavicle in that species also had a convexity on the side of the median bar, like that which has been described in this species.

The Clavicle.

The clavicle extended along the anterior edge of the scapula as a narrow straight bar running from the acromion to the extremity of the bone. At the acromion it probably made an angular bend, so as to extend along the pre-coracoid to the horn of the inter-clavicle, conforming to the plan of the bone in *Kistecephalus*.*

The Inter-clavicle.

The inter-clavicle, if I am right in thus determining the bone, differs from this element of the skeleton in every vertebrate type, apparently in being placed not in

* 'Cat. Rept. South Afric.,' Plate 69, fig. 8, *b*, *h*.

front of the coracoids so as to overlap them, but so that they meet its lateral margins. I do not think there is any probability of error in observation on this point, though the bones are badly preserved and only seen on one side of the body. The bone occupies the position of a sternum, but I regard it as the inter-clavicle because its posterior end lies in front of a sternum, because its form is that of the inter-clavicle, and because this interpretation harmonizes with the general construction of the remainder of the shoulder girdle.

It is placed like the inter-clavicle in *Iguana*, *Psammosaurus*, and *Stellio*, and is a modification of the T-shaped form seen in those Lizards, in *Ichthyosaurus*, and *Ornithorhynchus*; but it is fundamentally different in form, proportions, and osteological relations from the inter-clavicle of the Pareiasauria. As preserved, it is 3·7 centims. long, is wide, with sinuous lateral margins, and transversely truncated anteriorly, where it terminates in a straight border, 1·8 centim. wide. The two sides are not quite symmetrical, owing apparently to fracture. Behind the anterior border the bone contracts with concave lateral curves, so as to define the cross-bar of the T. This reduces the transverse width to half a centimetre, and there is then a transverse expansion, with convex lateral borders, widening the vertical staff to nearly a centimetre in the anterior half of its length. Then the sides slowly converge, being almost parallel as far as the middle of the sternum, but there are some evidences of irregular transverse expansions near the distal end. The convex expansion in the middle of the vertical staff apparently marks the transverse division between the coracoid and pre-coracoid. The bone is flat, thin, perfectly smooth on its ventral aspect, which is exposed, and apparently lies in one plane.

Its wide staff is its most distinctive character, by which it is distinguished from the inter-clavicle of Lizards. In *Stellio* the bone is relatively short, but perhaps makes as near an approach to it in plan as is to be found in the Lacertilia. The inter-clavicle of Chelonians does not admit of comparison, because its relations with the pre-coracoid and coracoid are not quite the same. In no Amphibian is there any comparable condition of the inter-clavicle; but in Monotreme Mammals the bone, though relatively shorter in the longitudinal staff, has similar relations to the coracoid, pre-coracoid, and sternum, though in both *Ornithorhynchus* and *Echidna* the anterior element in the sternum is very small. A somewhat intermediate condition is found in the Permian genus *Stereorachis* of Gaudry.

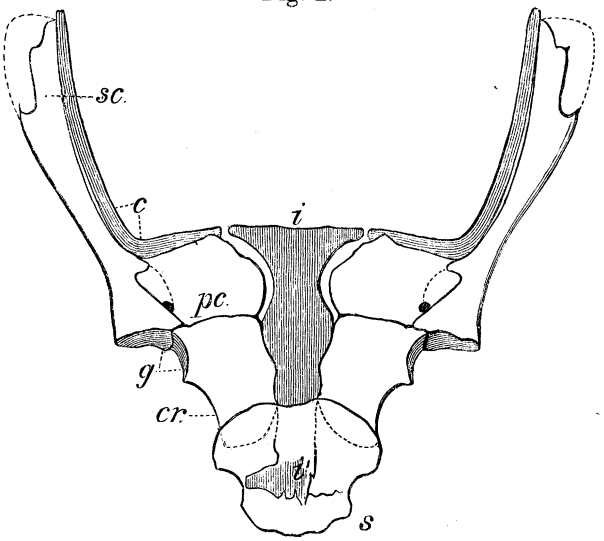
The Sternum.

The sternum is badly preserved, but its imperfection displays the inter-clavicle extending in front of it almost to its posterior border, though there is some reason for suspecting that the sternum may have been displaced a little forward so as to underlap the posterior borders of the coracoids.

The bone is a thin transversely ovate subhexagonal plate, which is 2·3 centims. wide anteriorly, and 1·7 centim. long, There is no definite boundary between the

sides, which all merge into each other by convexities, which correspond with the angles of a hexagon. The anterior border is slightly concave, and about 1·3 centim. long. The antero-lateral borders are about 1 centim. long, and slightly convex. I think it probable that they may have given attachment to the coracoids, since those bones are thus articulated in Lizards and Monotreme Mammals. The posterior-lateral outlines are concave, and more than a centimetre long, and the posterior transverse outline is of similar length, rather convex, and irregular. Only the internal aspect of the bone is seen; its transverse width exceeds the measurement over the distal ends of the coracoids. There is no certain evidence of attachment of ribs to the posterior sternal border, as among Lizards, and they were not articulated to the posterior-lateral border, as in *Hatteria*. Its general form, however, is Lacertilian; and in some Lizards, like *Hemidactylus*, there is a slight posterior-lateral emargination of the bone, which is more marked in *Chamæleo*. In *Ornithorhynchus* the sternum is formed on the typical Mammalian plan, and is, therefore, not comparable with the fossil, and its anterior cartilage with which the coracoids articulate is so small as to be entirely hidden behind the inter-clavicle. The only fossil which it at all resembles is the sternum of *Cetiosaurus*, figured by Professor PHILLIPS,* which he regarded as a transversely ovate bone.

Fig. 2.



Restoration of the shoulder girdle, natural size.

i., inter-clavicle; *i'.*, inter-clavicle seen through a break in the sternum; *s.*, sternum; *sc.*, scapula; *c.*, clavicle; *pc.*, pre-coracoid; *cr.*, coracoid; *g.*, glenoid cavity.

The points on which there is some deficiency of evidence in this restoration (fig. 2) are: first, as to the form of the clavicles; fragments of them are found along the whole of the anterior border of the scapula, they are present in *Kistecephalus*, which is nearly allied to this type of Dicynodont, and on the basis of their form in that genus

* 'Geology of Oxford,' 1871, p. 268.

I have introduced the bones as having an L-shape, with one limb resting on the scapula, and the other extending transversely in front of the pre-coracoid to the angles of the transverse border of the inter-clavicle. Secondly, it is possible that there may be a foramen on the anterior border of the pre-coracoid; but I attach no importance to the indication, because the character is absent from the other specimens. Thirdly, the sternum may have been a little more posterior in position. I have made the restoration by drawing one side of the girdle from the specimen, and then repeating it on the other side, to make the structure symmetrical.

From the description, it is evident that this shoulder girdle belongs to an ordinal type, which is distinct from all known animals. It is intermediate in many respects between *Ichthyosaurus* and *Ornithorhynchus*, but differs from both groups in the presence or relations of the pre-coracoids, sternum, and inter-clavicle. The Ichthyosaurs have neither pre-coracoid nor sternum, and the inter-clavicle overlaps the median union of the coracoids. In the Monotremes the pre-coracoids and coracoids extend behind the inter-clavicle, instead of meeting its lateral borders; but that may be a difference of degree rather than of plan, so that the arrangement in this, as in other respects, comes nearer to *Ornithorhynchus* than to *Ichthyosaurus*. The elongation of the inter-clavicle and size of the sternum are Lacertilian characters, and in Lizards the pre-coracoid element of cartilage does not extend behind the inter-clavicle so that the right and left elements overlap, as among Urodeles and Monotremes. Hence from such a type, the Lacertilian shoulder girdle may be derived by loss of the individuality of the pre-coracoid, while that of the Monotreme would result from transverse expansion of the pre-coracoid, shortening of the inter-clavicle, and reduced size of the sternum. On the whole, the Monotreme characters in this shoulder girdle may be regarded as the more remarkable, but they are blended with Lacertilian characters. I do not, however, think that the latter features are approximations to Lizards, so much as a generalized Reptilian inheritance which suggests the Lizard type; and that, on the whole, the Chelonian shoulder girdle may be nearer to Anomodonts than the Lizard's. For the Chelonian stock, before it developed a plastron and lost the separation of the pre-coracoid from the scapula, may well have developed a shoulder girdle in substantial harmony with that which is here restored.

The Humerus.

The humerus is 4·3 centims. long. It is exposed so as to show the width of the proximal end, with the size, form, and position of its radial crest; while distally it shows the transverse thickness of the shaft.

The distal extremity has the articular surface moderately convex from back to front, where the thickness of the bone is about half a centimetre. A little above the articular extremity the shaft contracts somewhat, so as to give a rounded aspect to both sides of the condylar extremity, and makes the thickness of the shaft, where it

rises at the articulation, about 3 millims. The shaft widens steadily as it extends proximally, being 1 centim. wide at 2·5 centims. from the distal end. The inferior lateral or anterior outline of the bone is nearly straight, becoming very slightly concave towards the proximal end, though the concavity is not more marked than that shown at the distal end. The superior lateral or posterior outline, for 2·5 centims. towards the distal end, is so gently concave as to be approximately straight; but beyond this point the radial crest widens the bone rapidly, so that at 2·9 centims. from the distal end the transverse measurement is 1·7 centim., and then the width contracts towards the articular head; but the radial crest is separated from the articular head by a concave area, which suggests a condition of connection between crest and head like that seen in the Crocodiles. The margin of the crest has two sides, which are inclined to each other at a right angle, the longer side proximal, the shorter distal and sub-parallel to the head; but the angle where the sides meet is rounded.

The head of the bone is very imperfectly preserved. It is 1 centim. wide, and gently convex from the ulnar to the radial side. The articular surface of the head is directed forward, and apparently makes an obtuse angle with the straight external inferior side of the bone. The shaft appears to have made an angle with the radial crest, but the two parts of the bone are now flattened so as to lie nearly in the same plane.

This humerus approximates in size to that of *Kistecephalus microrhinus* (Owen) (Brit. Mus., No. 47,071), but the proximal half of that bone, which is alone preserved, shows important generic differences in a much less development of the radial crest, which is more proximal in position, and continuous with the articular head of the bone; and, judging from the position of the foramen in the shaft, the humerus of *Kistecephalus* was probably shorter than that of *Dicynodon*.

As the bone is so imperfectly exposed, it may be convenient to defer full examination of its affinities, for there can be no doubt its shape was as substantially Anomodont as the bone in other genera, though the radial crest is obviously large, and there is less indication of lateral expansion of the distal end. In these smaller and lighter bodied Anomodonts the limb bones were relatively elongated and slender; and, just as a type like *Cynodraco* has the extremities of the humerus less expanded than in *Galesaurus* and *Cynochampsa*, so it would seem that the distal expansion of the bone may be reduced in this more elongated type. There is no approximation to known Monotreme genera in the humerus. But the bone as exposed is rather suggestive of the humerus of an Ornithosaur, but apparently with the ends less twisted. The epicondylar foramen is not seen; and, on the whole, the form of the bone shows less divergence from the humerus of a Lizard than might have been expected from extreme forms which the Anomodont humerus assumes.

The Ulna and Radius.

The ulna is 3·4 centims. long. It is exposed so as to show the lateral contour, which is typical of all Anomodont Reptiles, being massive at the proximal end, wide at the olecranon, with an oblique concave articulation for the humerus, limited anteriorly by a slender process, below which the shaft contracts, with slightly concave sides, before it expands slightly at the distal end to form the rounded distal extremity.

The distal condyle is nearly 6 millims. wide, with a convex rounding, which is as well marked laterally as at the base. It extends proximally for 3 millims., when the shaft is narrowed to half its width. The shaft retains this width for half its length, when it begins to widen proximally, chiefly by a posterior expansion. Below the articular surface for the humerus its width is 8 millims. below the proximal extremity. Then a slender process extends horizontally forward so as to widen the bone to nearly 11 millims. The antero-posterior measurement of this process is hardly more than a millimetre. Its proximal aspect forms the border of the proximal articulation of the bone; its distal aspect is concave. The concave articular surface is oblique, about 7 millims. wide from below upward, so that as it ascends it somewhat reduces the width of the proximal part of the bone, which terminates in a truncated surface 6 millims. wide, somewhat obliquely inclined backward, being at right angles with the upper part of the articular surface, and rounding into the posterior surface. The proximal end of the bone appears to be but little disturbed from its natural connection with the radius, since the anterior process of the proximal articulation rests upon the radius; and this indicates that the ulna was excavated proximally to receive the radius, as in all other Anomodonts, and in a way to which some Saurischia approximate.

The radius is a shorter bone than the ulna, with the sides concave, the articular ends truncated, and the proximal end rather larger than the distal end.

The length of the bone is 3·1 centims. Its proximal end is 9 millims. wide, with the middle section of the articulation slightly convex from behind forward. The sides of the shaft approximate evenly towards each other, so that in the middle length the transverse measurement is reduced to 4 millims. The proximal half of the shaft has the external surface well rounded, but the distal end is evidently more flattened. The width of the bone at the distal end is fully 7 millims., with the anterior corner more pointed than the posterior corner, where the articular surface forms rather more than a right angle with the posterior side.

So much as is preserved of the bony tissue appears to demonstrate that these bones of the fore arm were solid, like the humerus, though in all three the external layer is thick and dense, while the middle of the shaft is more or less loose and cellular.

The humerus is flexed at rather less than a right angle to the ulna and radius, and

the convexity of its distal articulation is parallel to the proximal articular concavity of the ulna, from which an interspace 3 millims. wide separates it.

It is difficult to affirm affinities from these bones. They have much resemblance to the ulna and radius among Lizards and Chelonians, but their size is too small, and exposure too imperfect, to satisfactorily demonstrate their relations to the same bones in other animals.

The Carpus.

On the left side the elements of the carpus are in natural association; on the right side they are scattered, because the ulna, with one digit and part of the carpus, has been separated from the remainder of the foot by a large sub-triangular bone. It is difficult to identify the scattered bones, which appear to number about 14, while in the articulated carpus I can count but 12.

The carpus comprises three rows of bones. In the left limb there are three bones in the proximal row, such as are commonly named radiale, intermedium, and ulnare. The intermedium separates the distal ends of the ulna and radius. The radiale I regard as representing the scapho-lunar; the ulnare may be the pisiform. The second row of bones is on the radial side, and consists of three elements in linear series, which I regard as centralia; one is below the intermedium, the other two are below the impression of the radiale. In the distal row there are five or six bones. It is not possible to be sure of the exact number, for, although there are six impressions of bones, it is possible that owing to irregularity of form the appearance may be deceptive, and that two of the seemingly distinct ossifications may belong to one bone. A similar explanation would account for the apparently larger number of bones in the carpus of the right limb.

Commencing with the proximal row, the radial element is represented in the left carpus by an impression, or rather a marking on the level of the surface of the slab. It is 8 millims. wide, and extends transversely beyond the radius on the inner side, and is 1 to 2 millims. deep; but in the right carpus the bone in contact with the radius is deeper, measuring about half a centimetre, by nearly a centimetre wide.

The intermedium in the left carpus is an obliquely oval sub-angular element, 6 millims. wide by 4 millims. in the vertical direction. In the right carpus the same element is recognized a little to the right of the ulna. The ulnar carpal in the left carpus appears as a narrow ossification, 6 millims. in vertical measurement by 3 millims. in width at the proximal end, with the middle constricted, it is directed downward and inward as preserved. In the right carpus it is wider proximally, but its vertical extent as preserved is less. These differences in the forms of the bones are probably due to conditions of fossilization, but similar irregularities on the two sides of the body are sometimes found in the carpus and tarsus of Urodeles.

Below the intermedium, and in close contact with it is a small, nearly circular ossification, 3 millims. in diameter, which I regard as No. 1 of the central series.

No. 2, which is below the inner side of the radiale, is a polygonal and transversely oval bone, 5 millims. wide, and 4 millims. in vertical measurement. No. 3 extends further on the radial side than the radiale, so that the carpus widens distally. This element is only indicated by a marking on the stone, about 6 millims. long by 3 millims. vertically. On the scattered right carpus there is a bone below the ulnare which may be No. 1; a larger bone below the intermedium may be No. 2; while an obviously displaced bone or two at the left upper corner of the radiale may be No. 3.

The distal row of the carpus is more obscure, and may include only the normal four bones, though the number appears to be more. In the left carpus the element which corresponds in position with the trapezium appears to be ossified from more than one centre, but this appearance may be a result of fracture. It is transversely oblong, 6 millims. long, with a portion directed downward under the trapezoid. The trapezoid element is of similar form and size, though concave superiorly, and becoming narrower towards the magnum. Between these elements is a small circular ossification, 2 millims. in diameter, which is probably a portion of one or the other. The magnum is a four-sided bone, nearly square, placed obliquely, 4 millims. in diameter, articulating proximally with the ulnare and centrale No. 1. The unciform is a smaller bone, 3 millims. in vertical diameter by 2 millims. in width, but it is probably imperfectly preserved. In the right limb the forms of the distal carpal bones are different, and, though they appear to be more numerous, may perhaps only number four.

Owing to the condition of the bones, it is not easy to make an accurate comparison of this carpus with the same region in other animals; but on the whole it is probably best compared with that of *Hatteria* and the Tortoises. The presence of centralia makes its near resemblance to the South African fossil Mammal *Theriodesmus* interesting, as a modification which is in harmony with the Mammalian character of the shoulder girdle.

The Digits.

In the left limb there is no trace of the metacarpus or digits. But on the right side, in which the ulna and radius are separated by a large bone which is possibly one of the hyoid elements, three digits lie in connection with the radius, and one with the ulna. It is possible that the first digit is imbedded in the matrix, for there appear to be indications of the first metacarpal in the slab. Nevertheless, only four digits are preserved in *Platypodosaurus*;* and the only South African fossil in which there are five digits preserved is the impression of the fore-limb figured by Sir R. Owen† as Dicynodont, and subsequently referred with doubt to *Dicynodon*.‡

* 'Geol. Soc. Quart. Journ.', vol. 36, Plate 17, "Description of Parts of the Skeleton of an Anomodont Reptile, *Platypodosaurus robustus* (Ow.), from the Trias of Graaf Reinet, S. Africa," by Professor Owen, C.B., F.G.S.

† In his 'Catalogue of South African Reptilia' (Plate 52, figs. 2, 3).

‡ 'Geol. Soc. Quart. Journ.', vol. 36, 1880, p. 424.

That specimen I regard as indicating a new genus, because the form of the humerus is distinctive, and, instead of being longer than the radius, as in other known Anomodonts, it is relatively shorter. It may be referred to as *Eurycarpus Oweni*. The number of digits is variable in other orders of Reptilia; and therefore the question must remain open whether Dicynodonts had four or five.

If the first metacarpal is present, only its proximal end is exposed in near union with the radiale: a circular osseous point in advance of it might then indicate its distal end; while a somewhat larger circle prolonging the line inward would indicate the first phalange. These identifications, however, rest upon too shadowy a foundation of fact to be evidence that the digit existed.

The remaining digits are remarkable for showing a reduced number of phalanges. There are, apparently, three in the middle digit on the radial side, but only two in each of the other digits, as in terrestrial Chelonians. I number the digits 2, 3, 4, 5. The metacarpal of digit II. has a dice-box form, with large extremities. It is 8 to 9 millims. long, 5 millims. wide proximally, and slightly wider distally. The third metacarpal is of similar form, about 7 millims. long; and the fourth is rather shorter, but its extremities are worn. The articular extremities appear to be more convex on the under side than on the upper side, and the proximal end is usually rather larger than the distal end.

The first phalange of digit II. is much stronger than the corresponding bones in the other digits, which decrease in size towards the ulnar side. All the bones appear to be sub-cylindrical, and contracted in the middle like the metacarpals, but are much smaller at the distal end than at the proximal end; the latter is flattened, and the former more convex. The claw phalanges are comparatively large, and as long as the phalanges which they follow; they are flattened from above downward with the superior surface convex, and apparently two grooves at the sides, such as are seen in *Iguanodon*.

If this specimen may be relied upon as a type of the Anomodontia, it makes known a very remarkable characteristic in the small number of phalangeal bones, and the small size of the foot.

The accompanying restoration of the skeleton (Plate 76) is based in its anterior part upon the bones now described, and in the vertebral column and hind limb upon fragmentary evidences from Anomodonts in the British Museum. It represents the maximum elevation of the body above the ground, such as might occur in water; but, as a rule, I regard the animal, when at rest, as lying on the ground like a Crocodile.

I would express my grateful thanks to Dr. Henry Woodward, F.R.S., for the facilities afforded me in making these studies, and for permission to describe and figure the remains.

Explanation of Plates.

PLATE 75.

Slab in the British Museum (No. 49,413) showing the skull, vertebræ, ribs, scapular arch and sternal apparatus, and fore-limbs of a Dicynodont Reptile, *Keirognathus cordylus*.

Skull: *T.*, temporal fossa; *O.*, orbit; *N.*, narine; *t.*, tooth; *pt.*, pterygoid; *q.*, quad-bone; *a.*, articular bone in the mandible.

c.r., cervical ribs in contact with cervical vertebræ.

d.r., dorsal ribs.

d.v., dorsal vertebra.

Scapular arch: *s.*, scapula; *cl.*, clavicle; *ic.*, inter-clavicle; *st.*, sternum; *c.*, coracoid; *pc.*, pre-coracoid; *g.*, glenoid cavity.

Fore-limb (left): *h.*, humerus; *u.*, ulna; *r.*, radius; *cs.*, carpus; the three proximal bones are regarded as ulnare, intermedium, and radiale; the three centralia are indicated as c^1, c^2, c^3; and the distal row, *Tm.*, *T.*, *m.*, *u.*, is interpreted as trapezium, trapezoid, magnum, and unciform.

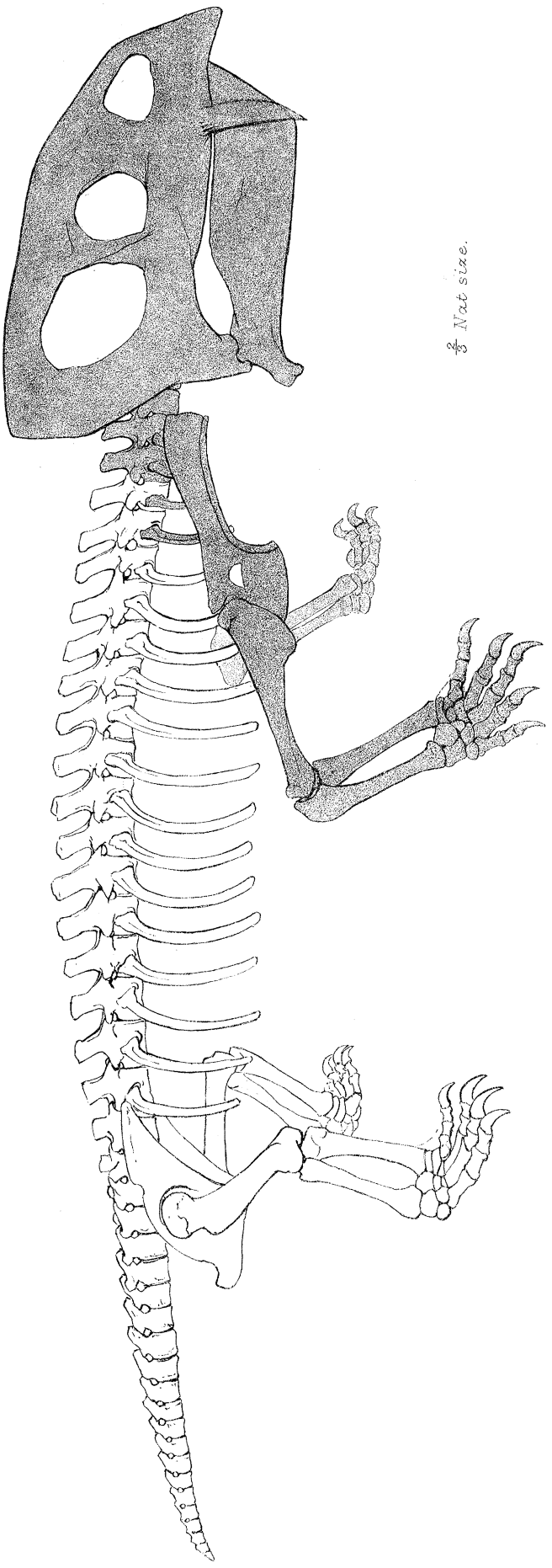
The digits are only preserved in the right limb, where three are connected with the radius and one with the ulna, the bones of the fore-arm being separated by an undetermined bone (?) possibly the hyoid.

PLATE 76.

Restoration of *Keirognathus cordylus*, based upon the evidence of the preceding figure. The dark tint indicates the parts shown in that slab. The large size of the tooth is not quite established. The hind-limbs may have been relatively longer than is here indicated. The light parts are based upon Russian and South African evidences of Anomodont structures. When at rest the animal is regarded as having been supported upon the lower jaw, scapular arch, ribs, and pelvic bones.

nat. size.

Skull and fore limbs of Keirognathus cordylus.



⅔ Nat size.

Restoration of Keirogonathus cordylus.

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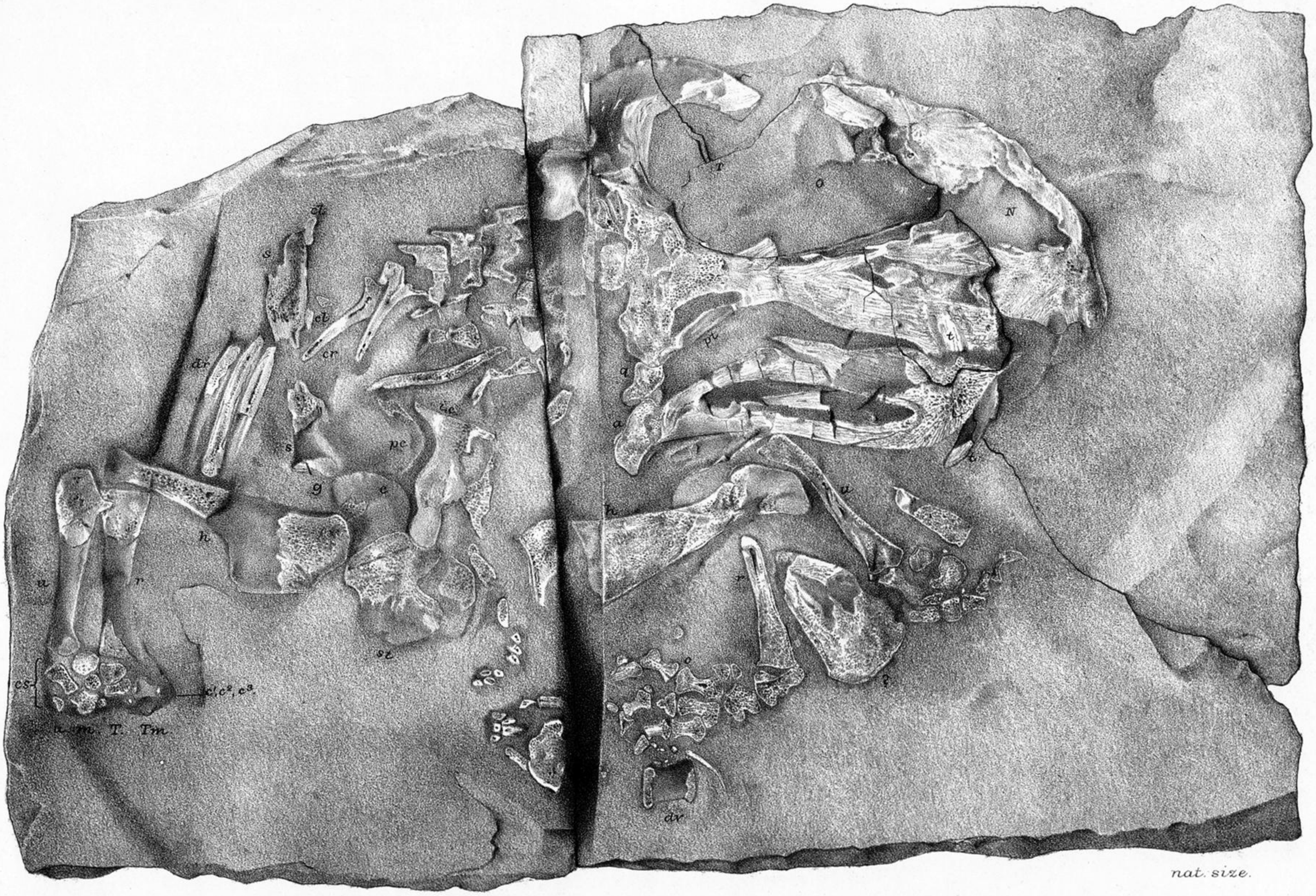

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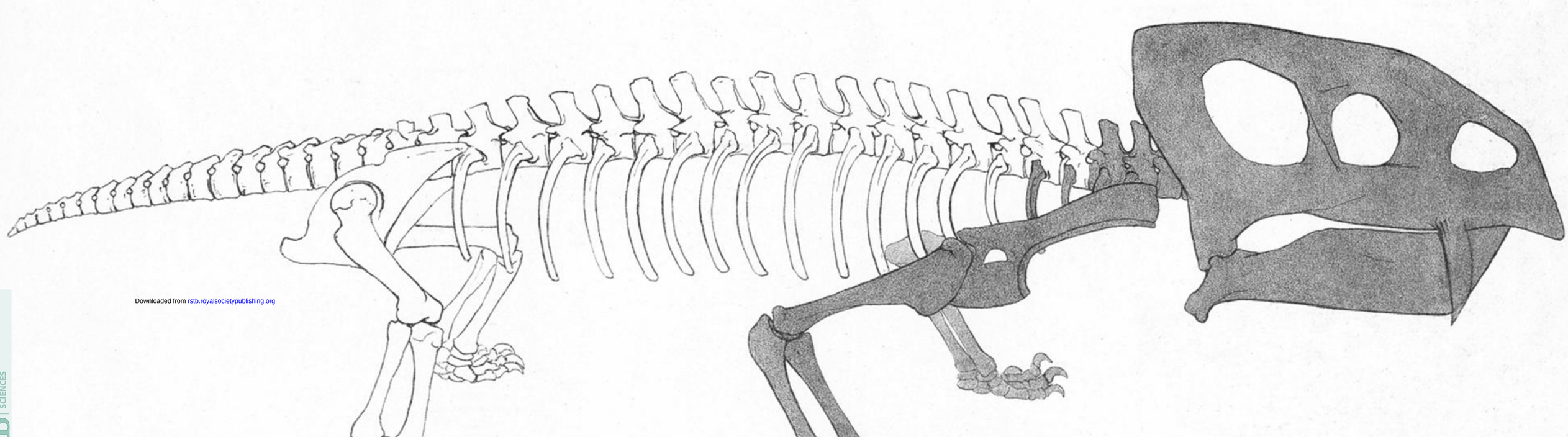

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