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(fig. 6, *S.*, *A.P.*). There are also three pairs of minute postanal papillæ (*P.*).

I have placed this species in the same genus as the first-described form, in spite of the peculiar structure of the mouth-cavity, because in most respects the two are so closely similar that I do not feel justified in separating them generically.

LII.—*A Note on the Parasphenoid of a Palæoniscoid.* By HENRY DAY, M.Sc., Geological Department, The University, Manchester.

WHILST engaged in the determination of a number of fish-remains collected by the late Mr. Binney of Manchester, and labelled merely as "fish-remains," I came across two excellent examples of the bone which has been called "parasphenoid" by Traquair (1) speaking of *Gonatodus*, and similarly by Fritsch (2) for *Trissolepis*, *Sceletophorus*, *Amblypterus*, and *Acrolepis*. This particular bone of the fish cranium is very rarely found, however, in any very complete state of preservation; in fact, the one found by Traquair in *Gonatodus*, and described and figured by him (1, p. 16, pl. ii. fig. 5), was the only one he encountered in his work on the Palæoniscidæ.

Traquair's example is apparently only moderately well preserved, although he speaks of it as "a well-developed parasphenoid," but Fritsch was more fortunate in finding good examples in association with determinable fish-remains.

In addition to the above two specimens from the Pendleton Colliery, in the Binney collection, a third specimen came to light in association with other fish-remains, from Ashton Moss Colliery, and obviously incorrectly determined as "*Acanthodes*."

It is now proposed to describe these specimens in some detail since they exhibit several very interesting features, which throw light on the homology of this element.

All three specimens agree in general form and size with Traquair's figured example, and would therefore in all probability have belonged to fishes of about four or five inches in length.

Actual specific determination is difficult, but two of the specimens are associated with other remains. One of the Pendleton examples is associated with typical Palæoniscoid

scales, and the example from Ashton Moss Colliery is associated with the disarticulated skull-bones of a Palæoniscoid fish, in association with scales which can be generically identified as those of *Rhadimichthys*—probably *R. monensis*, judging by the scale ornament. The second Pendleton example exactly resembles the Ashton one, and probably belongs to the same, or closely allied species. The three specimens combined give an excellent idea of both dorsal and ventral views of the bone.

For convenience they will be described under the letters A, B, and C. A gives us a dorsal view of the bone; B is in part a ventral view, but anteriorly is merely cast; and C is an almost perfect cast of the dorsal surface, and supplements the facts observed in A.

The bone consists essentially of a posterior rounded expanded portion and an anterior rostrum or shaft. The posterior portion possesses two pairs of lateral processes or wings—an anterior pair situated at the junction of the shaft and posterior expansion, and a posterior pair from the posterolateral margins of the expansion.

Dorsal View. (Specimen A.)

In the greater part of specimen A the actual bony material is preserved, and an excellent view is given of the main features of the dorsal surface.

Anteriorly there is the long shaft which presents a rounded convex surface to the observer (*i. e.*, is dorsally convex). It is constricted behind and expands anteriorly to give a slightly club-shaped anterior extremity. The actual anterior extremity in all three specimens exhibits distinct evidence of having been forked, resembling in this respect the compound para-basisphenoid of the common snake and the parasphenoid of certain living and extinct Amphibia.

The shaft, for its posterior two-thirds, is bounded by a pair of wings closely applied to it. These wings are broad behind, and, gradually tapering anteriorly, pass into the shaft about one-third from its anterior extremity. Posteriorly they pass into the broadened posterior part of the bone at the point where the anterior pair of processes come off. These wings, the bony material of which is actually preserved, each present a concavity to the observer (*i. e.*, dorsally concave); hence in specimens B and C, in which the shaft and side-wings are represented as casts, we have the shaft represented (except for adherent fragments of bone) as a concavity to the observer, whilst the side-wings stand out as convexities.

Coming now to the posterior expanded part of the bone, we find on the centre line of the specimen, and immediately behind the posterior termination of the shaft and wings, a distinct, rounded, slightly oval depression, which is marked out by a definite raised rim, broken in part by splintering of the bone. This pituitary region—depression and rim—is even better marked out in the cast C of this dorsal surface.

By the side of the pituitary depression we have the right anterior lateral process preserved, passing outwards and very

Fig. 1.

Dorsal view of the compound para-basisphenoid bone of *Rhadinichthys monensis*. (Specimen A.) $\times 7.6$ diams. No. L 10820. M. M.

slightly forwards. This process is apparently of the nature of a thick flange of bone, constricted near the base, rounded off at its outer and rather wider extremity, and bearing on its dorsal surface two or three well-defined ridges. The corresponding process of the left side is cut off by the broken edge of the rock, whilst the posterior pair of processes is also missing.

A broad well-defined ridge runs outwards and backwards on each side from the region of the pituitary depression, and the whole of the expanded region of the bone posterior to

these ridges and the pituitary depression has the form of a shallow basin-shaped hollow, with a circular outline posteriorly. The whole of this basin is floored by the actual bony material, but for a few splinters flaked off on the posterior margin. The surface of this hollow is almost smooth, only a few faint radiating ridges and grooves being visible.

Immediately anterior to the broad ridge on each side, mentioned above, there is a shallow depression, followed anteriorly by a slight prominence. These appear as reversed features on specimen C.

Ventral View. (Specimen B.)

This specimen, as regards outline, is practically complete. It exhibits anteriorly the long shaft described in specimen A, and expands posteriorly as in that specimen. Both antero-lateral processes are well preserved and will be described below, and, in addition, we have also preserved in this case the posterior pair of processes, which are of a wing-like nature and extend outwards and backwards.

The anterior shaft and its side-wings as described in specimen A are here represented as cast, with the exception of a small fragment of bone at the extreme anterior end of the shaft. Hence, since the shape of the dorsal surface of the shaft has been described as convex, the present specimen simply exhibits the concavity in which it lay, and the side-wings, which in dorsal view are concave, are represented as convex surfaces.

The posterior expanded part of the bone is extremely well preserved, and gives us a ventral view of the bone whose dorsal surface has been described in A. The portion preserved includes a short stump of the shaft, which is broken off by a transverse fracture just in front of the posterior termination of its side-wings. The shaft from this fracture passes backwards and merges into a well-defined, raised, diamond-shaped area, lying in the centre of the more or less semicircular posterior expanded part of the bone. This raised area must correspond with the shallow basin-shaped area of the dorsal view. No trace is shown of a raised boss corresponding to the depression for the pituitary body, seen in dorsal view. There is, however, nothing extraordinary in this, since, even in the common snake, the extremely deep pituitary depression on the dorsal surface of the compound para-basisphenoid is not represented in ventral view by any boss or tubercle. Antero-laterally the diamond-shaped raised central area is bordered on each side by a deep

valley which separates it from the anterior lateral process of each side. This valley passes outwards and backwards on the posterior flange-like side-process, where it flattens out and disappears.

Coming now to a consideration of the preserved part of the shaft, we find that it exhibits a practically flat surface, with posteriorly a rather greater prominence, and possesses numerous well-defined denticle-like prickles, best shown in

Fig. 2.

Ventral view of the compound para-basisphenoid bone of *Rhadinichthys* sp. (Specimen B.) $\times 7.6$ diams. No. L 10821. M. M.

that part of the shaft immediately anterior to its posterior diamond-shaped expansion. On this latter expansion there is apparently a tendency for the prickles to fuse into longitudinal, slightly diverging ridges. Numerous denticles also occur in the antero-lateral valleys mentioned above, with some slight tendency towards a linear arrangement.

It now remains to consider the two pairs of lateral processes. The anterior pair pass almost directly outwards,

slightly dumb-bell shaped in form—broad-based, then constricting, to expand again and end in what appears to be definite articulating facets. These anterior processes, which are stout flattened rod-like structures, are to be regarded as “basipterygoid” processes, and are of great interest on account of their articulating facets, the interest of which will be apparent when we come to deal with the homologies of this bone.

Fig. 2.

Cast of the dorsal surface of the compound para-basisphenoid bone of *Rhadinichthys monensis* showing the well-defined pituitary region. (Specimen C.) $\times 7.6$ diams. No. L 10822. M. M.

The posterior pair of lateral processes are flat thin flanges of bone which project outwards and backwards, and possess on their surface a few indefinite ridges.

This completes the account of the dorsal and ventral views of the bone, but a few remarks may be added on specimen C. This is an almost complete cast of the dorsal surface of the bone, only a few small fragments of actual bony material being still adherent. The dorsal surface has already been

described from A, but this specimen is interesting in giving us an excellent cast of the complete pituitary region, appearing as a well-defined boss, surrounded by a sharp depressed ring, *i. e.* the reverse of the actual features. Immediately in front of the pituitary region the cast exhibits a well-defined, symmetrically disposed, shallow V-shaped line, which may possibly represent the line of junction, on the dorsal surface, of the para- and basi-sphenoids. The anterior pair of lateral processes is only fairly well preserved in impression, but the posterior pair is much more perfectly cast, the extremity of the right-hand process being accurately shown, a feature not definitely shown in specimen B.

Having described the three specimens, it now remains to consider their homologies. Are they simply "parasphenoids" in the restricted sense of the term—as applied to the so-called "membrane" bone of that name—or do they represent a fusion of membranous parasphenoid elements with one or more cartilaginous elements of the basis cranii?

This question is best approached by comparing the present specimens with the structures to be observed in other fishes, and also in the Amphibia and Reptilia.

When we make such a comparison, we find that the contours of the above-described specimens are more or less completely imitated by those of the corresponding bone of certain Fishes, Amphibians, and Reptiles. All three groups possess a bone on the ventral surface of the cranium, having anteriorly a narrow pointed shaft, which expands posteriorly to form a more or less square plate, which possesses usually two pairs of lateral processes.

In living fishes and Amphibia this is a definite, very well-defined membrane-bone, and there is no distinct ossified basisphenoid, although rudimentary ossified structures have been found in several Teleosts, and in *Amia* only amongst the Ganoids, indicating the presence of paired basisphenoids.

In living reptiles the bone which has an exactly similar configuration to the "parasphenoid" of the lower groups is termed the basisphenoid. The general statement made is "that the parasphenoid bone, so characteristic of the Amphibia, is for the most part very much reduced in reptiles or it may be entirely wanting." Now there are only two possible solutions to fit the case in reptiles, both of which may be correct, however. One is that the parasphenoid is a degenerating structure, as the above general statement might lead one to expect; the second, that the parasphenoid may have fused with the basisphenoid.

It certainly seems remarkable that, although the parasphenoid is regarded as a disappearing bone in Reptilia, yet it is replaced by a bone—the basisphenoid—which is practically identical with the parasphenoid of Fishes and Amphibia, as applied especially to fossil representatives of these groups. This would lead one to expect a fusion of the basisphenoid with the parasphenoid, rather than a degeneration of the latter bone.

Now this fusion can actually be traced in the development of reptiles, *e. g.* the primitive *Sphenodon*, snakes, &c.

Swinnerton and Howes (3) indicate that in *Sphenodon* a fusion of basisphenoid and parasphenoid takes place to form one bone, which in the adult resembles the “basisphenoid” of snakes. At their development stage T the parasphenoidal splint is still independent of the overlying pre-sphenoidal cartilage, but presumably this latter is finally completely overlaid or even embraced by extension of the parasphenoidal shaft.

Parker (4) shows that in the common snake the parasphenoid arises as “a long styloid tract of granular tissue wedged between the trabeculæ and reaches the pituitary body by its broad hinder end,” *i. e.* this tract is situated in the fore-half of the basis cranii, and later becomes a sharp style of bone which broadens out under the pituitary space. At Parker's Stage 4 the basisphenoid is seen to arise as “paired symmetrical films of bone, on the outer margin of the trabeculæ where the latter pass into the basal plate.” At Stage 5 these films “have grown inwards to meet and form one large bone, the basisphenoid proper.” It occupies the roots of the trabeculæ, but stops in front opposite the end of the parasphenoid. At Stage 8 “the basisphenoid is now a compound bone, it was made from the two proper basisphenoid centres and has gained a bulging floor and a large carinate rostrum from the parasphenoid. But neither the parasphenoid nor the basisphenoid directly floor the cranial cavity.” In this case there is no pre-sphenoidal cartilage.

In the above-quoted cases, therefore, it is evident that, in the basisphenoid, we are dealing with a compound parasphenoid.

Dealing now with the fossil Reptilia, we find that the parasphenoid is best developed in the Plesiosaurs, where it extends forwards from the basisphenoid between the pterygoids, and, as usual, the parasphenoid partly underlies the basisphenoid to which it is adherent.

In the Squamata, Ichthyosauria, and most early reptiles,

the parasphenoid appears as a more or less slender shaft or process in front of the basisphenoid. For the Ichthyosauria the para-basisphenoid of *Ophthalmosaurus* (5) may be taken as a type, and for the Sauropterygia that of *Tricleidus* (5).

Thus there is a characteristic form amongst the Reptilia for the compound para-basisphenoid bone, compound as we know from a study of fossil and recent types.

Coming now to a consideration of the Amphibia, we find that the living Amphibia are much too specialised to be of much assistance. All the Anura possess a characteristic T-shaped bone termed the parasphenoid, with the cross of the T directed posteriorly. There is no trace apparently of any basisphenoid.

When we turn to the fossil Amphibia, we find a much more satisfactory state of affairs. Watson (6), speaking of *Loxomma*, says: "the basisphenoid, parasphenoid, and ethmoid are fused together and only their lower surface is well seen. The back of the basisphenoid is recessed for the anterior end of the basi-occipital, and what is presumably the posterior end of the parasphenoid projects backwards covering the lower surface of the latter bone." This backward projection of the parasphenoid (though not to underlie the basi-occipital) is exactly paralleled in *Ophthalmosaurus*, certain of the Sauropterygii, and even in *Sphenodon* itself. Further, "the sides of the basisphenoid slope upwards, passing imperceptibly into the opisthotic and pro-tic. On each side of the bone in the region of the pituitary fossa is a powerful process, the processus basiptyergoideus, which has a well-marked, smooth, articulating surface on its antero-lateral side: deeply impressed on the bone on the inner side of each of these processes is a groove which leads round from the side of the basis cranii to open in front into a foramen passing through the bone, which is undoubtedly the carotid foramen." Anteriorly to this the bone takes the form of a narrow pointed splint exactly like those of the reptiles quoted above: hence the general form of this bone in *Loxomma* is exactly like that to be found in the reptiles. *Pteroplaea*, in the same paper by Watson, is stated to have a very similar basis cranii. Finally, Fritsch (7) figures numerous bones in the Branchiosauridæ, &c., of the same general form as the compound para-basisphenoid of the snake, and to these applies the term "parasphenoid."

Coming now to the fishes themselves, and the primitive Teleostomes in particular, we find that Watson (6), speaking of *Megalichthys*, says: "the basisphenoid of *Megalichthys* has sometimes carotid foramina just as in *Loxomma*. It has

small but distinct basiptyergoid processes which are, however, not provided with articulating surfaces but with sutural ones. The long parasphenoid extends forwards to the premaxillæ as it may do in *Pteroplax*, and its lateral borders are in contact with the pterygoids to which they afford support."

Here, again, the para-basisphenoid elements have apparently the characteristic form with which we are dealing; and once having assumed that in *Loxomma* the posterior expansion is basisphenoid, the assumption is also made in the case of a similar expansion with processes and foramina in *Megalichthys*. That the assumption is correct in the case of *Loxomma* there can be little doubt, from a consideration of primitive Reptilian structures.

Bones of the basi-cranial axis in fishes are rarely preserved, however; in fact, the present specimens, so far as can be ascertained, are almost unique in their perfect preservation. Even the examples found by Fritsch lacked the side-processes in every case, judging by his figures; but, nevertheless, the specimens were well enough preserved to cause Fritsch on several occasions to comment on their remarkable resemblance to the parasphenoid of the Branchiosaeria, by which, presumably, he would mean the compound para-basisphenoid as described by Watson for *Loxomma* and *Pteroplax*.

One definite fact seems to emerge from a consideration of the above points, and that is, that certain primitive fossil fishes of the Ganoid group, certain of the primitive fossil Amphibia—the Branchiosaeria in particular,—and both living and fossil Reptilia, exhibit a bone on the ventral surface of the cranium, possessing the same general form, the same relationships, and all agreeing, as will be gathered from the above, in representing in each group a compound para-basisphenoid, the parasphenoid in each case having a broadened posterior extension underlying the basisphenoid. *Megalichthys* stands as a type for the fishes, *Loxomma* and *Pteroplax* for the early Amphibia, *Ophthalmosaurus* and *Tricleidus* for the fossil, and the Common Snake and *Spheonodon* for the recent reptiles.

The present specimens make the case even more conclusive, since in A and C we have the pituitary region well marked out as already described. Now the pituitary body always comes into relationship with that part of the cartilaginous basis cranii which later ossifies to form the basisphenoid. Hence, in the present specimens we must assume that in A, in the pituitary region, we have the actual dorsal surface of the basisphenoid preserved. The depression for the pituitary body does not affect the ventral surface of specimen B,

because the actual basisphenoid is underlaid by a posterior broadened extension of the anterior shaft, which shaft and extension we must recognize as the parasphenoid on account of the dentate surface already described, and also by analogy with the structures described above for Fishes, Amphibia, and Reptiles.

I think the evidence may be accepted as conclusive that specimens A, B, and C are actually compound bones built up of a posterior basisphenoid and an anterior shaft-like parasphenoid, which, however, has a posterior extension underlying the basisphenoid and fused with it; and so we arrive at the homology existing between the above specimens and the similar bone in such types as *Megalichthys*, *Loxomma*, *Ophthalmosaurus*, and the snake.

Only one other point remains to be dealt with, and that is a consideration of the anterior lateral processes of the present specimens, which exhibit definite articulating facets. The bones with which these processes articulated are unfortunately not sufficiently preserved to allow of their characters being determined, but there is little doubt but that they are the pterygoids.

These anterior lateral processes have an interesting bearing on the question of the autostylic and hyostylic modes of suspension of the jaws.

Parker (8) and Swinnerton (9) have shown that *Lepidosteus* and *Amia* possess similar processes from the trabeculæ which articulate with a process (the "pedicle") of the palato-quadrate bar. Swinnerton discusses fully the importance of this connexion between the basis cranii and the palato-quadrate bar. Dealing with the Teleostomi, he shows that there has been in the Teleosts a gradual reduction in the metapterygoid region of the palato-quadrate bar, concurrently with an increase in the importance of the hyomandibular. He also notes that in those lowly forms in which the metapterygoid region is large, a pedicle is sent off from its upper border towards the trabeculæ, and the trabeculæ have on each side a projecting process to meet this pedicle.

The evidence, Swinnerton says, "suggests that at some former time an actual connection or articulation must have existed between the pedicle [of the palato-quadrate bar] and the trabeculæ." As already noted, Parker indicates that such a condition exists in *Lepidosteus*, in which at all stages from the embryo, two-thirds of an inch long, up to the adult condition, there is a strongly developed pedicle forming an articulation with the "basipterygoid" process. He says: "the proximal part of each trabecula has developed an

oblong facet of cartilage for articulating with the pedicle of the suspensorium."

Swinnerton notes that Smith Woodward has discovered that in *Lepidotus* there is a stout process of the metapterygoid which bears a large facet which may have articulated with a lateral element in the cranium. Swinnerton believes that this process is the homologue of the pedicle of the palato-quadrate bar in *Lepidosteus*. After a consideration of Smith Woodward's description and figures (10) it becomes difficult, however, to suppose that the "lateral element in the cranium," mentioned by him, can represent the basipterygoid processes as in *Lepidosteus*, since in *Lepidotus* he figures well-developed basipterygoid processes of the "parasphenoid" which apparently have sutural terminations, and therefore could not have been apposed to the facet which is found on the anterior process of the metapterygoid, though there can be little doubt that these basipterygoid processes united with the pterygoid region.

Watson has shown that *Megalichthys* has similar processes from the basisphenoid region of the basis cranii, and that these have a sutural union with the pterygoid region, and that *Loxomma* and *Pteroplax* also possess exactly similar processes of the "basisphenoid" articulating with the same region. In the present specimens the basipterygoid or anterior lateral processes bear articulating faces, and, we may take it, correspond with those of *Lepidosteus*, *Lepidotus*, and *Megalichthys* amongst fishes, and with the similar processes of the basisphenoid region as described by Watson in *Loxomma*, *Pteroplax*, and *Batrachiderpeton* amongst the fossil Amphibia, and in which the articulation is by facet with the pterygoid region.

It appears, then, that the additional pedicular articulation of the palato-quadrate region with the trabeculæ is simply continued in an homologous form in the union of pterygoid region with the basipterygoid processes, a union by facet or suture.

Swinnerton notes that in the Selachii also there is a constant recurrence of this pedicle of the palato-quadrate region, pointing back to an ancestor "which certainly possessed that feature."

In that case, on the evidence brought forward above, we have a line passing from the Selachii through the primitive Teleostomes to the primitive Amphibia and Reptilia, on which line there is this characteristic pedicular connexion between the palato-quadrate region and the trabeculæ of the chondrocranium, and hence these groups all agree in possess-

ing this distinctive type of "autostyly." This points very strongly to an affinity along this line and to a derivation of the Tetrapoda from some group of primitive Teleostomes.

It is to be noted also that this characteristic "autostyly" we have traced, is not the "autostyly" of the Dipnoi, nor does it agree with the condition in the Tetrapoda to which that term is usually applied. In the former group the quadrate region of the palato-quadrate bar is directly fused to the auditory capsule; in the latter the primitive mode of attachment, as Watson has shown for *Loxomma*, *Batrachiderpeton*, &c., is for the quadrate region to come into connexion, not with the auditory capsule, but with the dermal cheek-bones—the squamosals.

We have therefore three distinct methods by which the palato-quadrate bar has come to possess an "autostylic" suspension, and, since this same term has been applied indiscriminately to all three, considerable confusion exists in consequence.

The foregoing observations have thus supported two strong arguments in favour of a primitive Teleostome, and against a Dipnoan, derivation of the Tetrapoda:—

(1) The compound para-basisphenoid bone has a similar form in primitive Teleostomes and all primitive Tetrapoda, while the corresponding bone of the Dipnoi is totally different.

(2) In both primitive Teleostomes and Tetrapoda the palato-quadrate has a "pedicular" autostylic suspension, while the type of autostyly present in Dipnoi is not found in Tetrapoda.

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LIII.—*Notes on Fossorial Hymenoptera*.—XVIII. *On the Australian Species of Bembex*. By ROWLAND E. TURNER, F.Z.S., F.E.S.

So little was known of the Australian species of *Bembex* at the time of Handlirsch's fine monograph of the genus (1893), that I think a key including the species since described, and also those described by Smith, most of which were not known to Handlirsch, may be useful. The genus is not so well represented in Australian collections as should be the case; probably this is due to the extreme rapidity of flight rendering capture difficult, for in sandy localities many of the species are very common. They burrow in sand, often in colonies—that is, a number of specimens form burrows close together in suitable localities. Little is known of the habits of Australian species, but in other countries the burrows are often left open and fresh flies supplied to the larva daily. Further collecting will doubtless result in the discovery of more species.

Key to the Australian Species of Bembex.

♂♂.

1. Anterior femora serrate	<i>B. egens</i> , Handl.
Anterior femora not serrate	2.
2. Spur of fore tibia much dilated and flattened	3.
Spur of fore tibia not roundly dilated ..	4.
3. Bands of apical dorsal segments interrupted	<i>B. calcarina</i> , Handl.
Bands of apical dorsal segments continuous	<i>B. flaviventris</i> , Sm.
4. Second ventral segment with a small tubercle on each side of the large median tubercle	<i>B. lobimana</i> , Handl.
Second ventral segment without lateral tubercles	5.
5. Basal joint of fore tarsus strongly dilated.	6.
Basal joint of fore tarsus not dilated. . . .	9.