Some Points in the Morphology of the Palate of the *Neognathæ*.

By W. P. Pycraft, A.L.S., F.Z.S.

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(Plates 31 & 32.)

In a recent memoir on the Struthious birds (Trans. Zool. Soc 1900, vol. xv.), I dealt at some considerable length with the arrangement of the bones of the palate, and instituted some comparisons between this arrangement and that prevailing amongst the "Carinatæ." In this same memoir I proposed to adopt the characters of the palatal bones as a more convenient and more exact distinguishing feature than the characters of the sternum, which have done duty ever since their introduction by Merrem in 1813. In accordance with the characters of the palate, the Tinamous are to be divorced from the "Carinatæ" with which they are generally associated, and placed with the Struthious birds. The Struthious birds and Tinamous constitute a group by themselves—the Palæognathæ; whilst the remaining forms made up a second group—the Neognathæ.

The contention that the Struthious (Palæognathine) palate is of a more ancient type than the Neognathine is admitted by all. The typical Palæognathine palate is that of *Dromæus*; and as this is to serve as a standard of comparison with the palatal bones now to be discussed, we may briefly enumerate its salient features.

The vomer (Pl. 31. fig. 1) is of great size, flattened dorso-ventrally, extending far forwards as a broad, median, grooved plate to beyond the middle of the beak; and backwards, to terminate in a pair of rami beneath the pterygoids, with which they ultimately fuse. The palatines are comparatively short, flattened, and slightly twisted bones. They run forwards, tapering as they go, to terminate in a slender rod, closely approximated to the mesial border of the very large maxillo-palatine process: they extend backwards to the level of the orbital process of the quadrate. The proximal half of the palatine (*pa.*) is relatively broad, *and its mesial border is applied to the outer border of the fused vomero-pterygoid bar.*

To this vomero-pterygoid bar and its relation to the palatine, attention is now specially directed. At the same time, it would be well also to carefully examine the form of the palatines and

their relation one to another, and to the maxillo-palatine process, in the accompanying figures.

In the palate of *Rhea* (Pl. 31. fig. 2) the vomer is relatively smaller than in *Dromæus*. It is deeply cleft anteriorly, thereby exposing the parasphenoidal rostrum, which is concealed in *Dromæus* when the skull is viewed ventrally, and posteriorly it terminates in a pair of broad "feet" closely approximated. Furthermore, the vomer is peculiar in that it is trough-shaped, the parasphenoid being received into the trough. The feet of the vomer, if further examined from the ventral aspect of the skull, will be found to be partly concealed by the palatines. Thus the primitive position of the palatines, which obtains in *Dromæus*, has in *Rhea* undergone a change. They have moved, from their original position *outside* the vomero-pterygoid bar, *towards the middle line*, and in doing so have come to underlie this bar.

This movement of the palatines inwards, and their connection with the distal end of the pterygoid, has played a very important part in the evolution of the avian palate.

We may trace the early stages in this movement of the palatines in the skull of the Tinamous.

The palate of the Tinamous, as I have already pointed out, closely resembles that of *Rhea*. This close resemblance being undeniable, we need only concern ourselves here with the differences between the two skulls. The most important of these differences for the present connection are concerned with the vomer, palatine, and pterygoid.

The pterygoid, in the Tinamous, appears to be relatively longer than in *Rhea*. This appearance is deceptive, and is really due to the fact that the vomer and palatines have shifted considerably forwards, whereby the vomer terminates much further forward along the parasphenoidal rostrum—so much so, that the choanæ (which are narrower than in *Rhea*) lie almost entirely in front of, instead of almost entirely behind the ant-orbital plate (prefrontal), terminating immediately beneath the bony style (lachrymo-nasal pillar), taking the place of the maxillary process of the nasal. In other words, the choanæ extend forwards as far as the anterior limit of the lachrymo-nasal fossa.

The palatines of the Tinamous have become more rod-shaped.

Seen from the ventral aspect of the skull, the proximal end of each, instead of expanding into a broad plate to underlie the base of the vomer, and extending backwards in a spike-shaped fashion along the pterygoid to within a short distance of the basipterygoid process, as in *Rhea*,—on the contrary, cross the pterygo-vomerine bar obliquely, as a narrow flattened lamina, attached merely by its mesial border. The palatine of the Tinamou, then, is confined to the distal end of the pterygoid, instead of extending back to within a short distance of the basipterygoid process as in *Rhea*.

The vomer, as we have already remarked, has shifted relatively further forwards; it also appears to have undergone a slight relative reduction in size.

The most important features in all this are: (1) the forward shifting of the palatine to the distal end of the pterygoid; and (2) the inward shifting towards the middle line. Compare figs. 1–5, pl. 31. But it would be well to pause for a few moments to survey briefly one or two other features of the Tinamine palate before passing on.

Compared with that of *Rhea*, it will be remarked at once that in the Tinamous the maxillo-palatine processes have undergone a great reduction, though they are still of considerable size. In *Rhea*, these processes extend inwards and backwards, in the form of a pair of broad, plate-like, more or less fenestrated laminæ. The postero-internal angle of the plate is continued backwards in the form of a long and delicate rod, closely approximated to the outer border of the palatine, and terminating beyond the middle of that bone. The great size of the maxillo-palatine process restricts the forward extension of the quadrato-jugal fossa to the level of the antorbital plate.

In the Tinamous the maxillo-palatine processes—though, as we have just remarked, of considerable size—are relatively much smaller than in *Rhea*. The backward extension (the palatine process) may be described as having the form of a narrow, concavo-convex band tapering to a point, and terminating at about the middle of the outer border of the palatine, which it supports as in *Rhea*. The furthest point of this maxillo-palatine process lies immediately behind and below the antorbital plate. This reduction of the maxillo-palatine process has extended the length of the quadrato-jugal fossa, which now

reaches as far forward as the anterior limit of the choanæ, and terminates immediately below the level of the anterior limit of the lachrymo-nasal fossa.

The anterior end of the palatine in *Rhea* is widely separated from the palatal process of the premaxilla, while in the Tinamous the anterior end of the palatine just touches the free end of the palatal process of this. This connection is brought about, partly by the forward shifting of the palatine, and partly by the narrowing of the beak, consequent upon the lateral reduction of the maxillo-palatine process.

We are now in a position to summarize the facts herein set down, and to select therefrom such as directly illustrate the transition from the Palæognathine to the Neognathine palate, which is the object of this paper.

The most primitive arrangement of the Avian palatal bones is to be found in the skull of *Dromæus*. The vomer is here of great size, terminating posteriorly in a pair of rami, continued directly backwards beneath, and fusing with, the pterygoids. *The palatines are connected, caudad, with the outer border of this vomero-pterygoid bar, and are widely separated one from another.* Anteriorly the palatines are connected solely w the maxillo-palatine processes.

In *Rhea* the vomer is relatively smaller, and the paired extremities are closely approximated, but are continued backwards as in *Dromæus*, beneath the pterygoids. The palatines have shifted inwards, losing their original connection with the outer border of the vomero-pterygoid bar, and, taking up a new position beneath this bar, have formed therewith a squamous suture. The approximation of the rami of the vomer towards the middle line has brought the distal end of the pterygoid into relation with the parasphenoidal rostrum. The distal extremity of the palatine is far removed from the palatal process of the premaxilla, and is connected wholly with the mesial border of the maxillo-palatine process.

In the Tinamous, the vomer is still relatively further reduced, and does not embrace the parasphenoidal rostrum so completely as in *Rhea*. The relations between vomer and pterygoid are much as in *Rhea*. The palatines bound the feet of the vomer externally, and will be found to be connected with the pterygoid by an oblique and scarcely perceptible suture. By the reduction in

the size of the maxillo-palatine processes, they begin to come into contact with the palatal process of the premaxilla: the one touching the other by the tip only. The shifting forward of the palatine and vomer is a feature of great importance, as thereby an approach is made towards the Neognathine palate. The approximation of the palatines to the palatal process of the premaxilla is another Neognathine feature.

Some confusion seems to exist, even now, as to the nature of the palate in the Struthious birds. Thus, in so recent and authoritative a work as the 'Dictionary of Birds' (article Skull) the palates of *Struthio*, *Apteryx*, and the *Crypturi* are said to be *Schizognathous*, whilst the palate of *Dromæus* is described as *Desmognathous*. Now Huxley, who introduced these terms, added yet another—*Dromæognathous*, for the special purpose of expressing the fact that the palate of certain "Carinate" birds—the Crypturi—was Struthious in type, and could not therefore be included amongst his Schizognathous forms.

The palate of the Palæognathæ might be described as Desmognathous; but certainly there are no members of this group in which it is Schizognathous. It would be better to adopt the term Huxley coined for the Crypturi—Dromæognathous. This form of palate is not Desmognathous in the sense in which Huxley used this term.

In the Dromæognathous palate the palatines never meet one another caudad, in the middle line, and never overlap the palatal process of the premaxilla anteriorly. The pterygoid is never segmented, and consequently is never free, but is immovably united with the vomer, vomer and palatines, or palatines only—as in *Struthio*.

We may now pass on to consider the peculiarities of the Neognathine palate, and the changes which it undergoes within this group. This, indeed, is the avowed purpose of the present contribution. At the same time, so far as is possible, we shall attempt to show how the Neognathine has arisen out of the older Palæognathine form.

The Neognathine form may be briefly characterized as that in which the palatines meet one another in the middle line, caudad. If, for working purposes, we confine our description to adult skulls, we might define the Neognathine skull, in all but a few cases to be dealt with presently, as that in which the

palatines meet one another in the middle line caudad, and support the vomer between them, whilst the pterygoids join the palatines not by suture, but by a true joint.

The Schizognathous skull of any adult Gull or Plover will admirably illustrate the differences between the Palæo- and Neognathæ. The changed form and relations of the palatines are here almost diagrammatically emphasized. Anteriorly, they are seen to be quite independent of the maxillo-palatine processes, passing below them, and forwards, to fuse with the palatine processes of the premaxillæ. Behind, they touch one another and join the long pterygoids by a joint. On both ventral and dorsal aspects strong keels have been developed. The inner ventral keels have grown downwards so as to enclose the vomer in a deep, cavern-like hollow. The vomer itself is seen to be held in position by the embrace of the mesial dorsal border of the palatines. In size it is now relatively greatly reduced, but has developed a strong blade-like keel * passing backwards into a pair of rami attached to the dorsal border of the palatines as we have just indicated. The maxillo-palatine processes are not unlike those of the Tinamous, being shell-like scrolls of bone. They do not, however, extend so far backwards, afford support to the palatines, nor embrace the vomer. The pterygoids are long, rod-shaped, and articulate with the palatines by a true joint. Basipterygoid processes for the support of the pterygoids, caudad, have been dispensed with.

The pterygoid, in some Lari, is keeled dorsally; and this keel increases in height from before backwards, so that immediately behind the pterygo-palatine articulation it has attained a considerable height, rising to embrace the parasphenoidal rostrum on either side. It is possible that modifications in the form of the pterygoid, to be discussed presently, may be traceable to the excessive development of this terminal portion of the pterygoid keel.

The adult skull in the Neognathæ, it has just been remarked, differs from that of the Palæognathæ, amongst other things, in that the pterygoid is a free bone, articulating at the one end with the quadrate, at the other with the palatine.

This being so, it follows that the relations between the vomer

* The vomer in many forms, e. g. *Cariama*, is represented only by a blade-like lamina; in others this is reduced to a mere spicule, *e. g.* some Galli whilst in many forms it is entirely wanting.

and pterygoid must be quite other than those which obtain in the Palæognathæ. A comparison of adult skulls will show that this is the case: that the palate in the two forms is quite different in this respect, the vomer in the Neognathous palate being supported by the palatines.

But the skull of the young bird throws quite a different light upon the nature of the relations between pterygoid, vomer, and palatine. Care must be taken, however, to select favourable types for study, specialization having, in the skulls of many forms, obliterated more or less completely the evidence for the facts which follow.

If the nestling skull, preferably of some Schizognathous form, such as of the Lari, Charadrii, Otidæ, Sphenisci, or Colymbi, be examined, the pterygoid will be found to be continued forward into a sharp point, which either slightly overlaps or just touches the bifid end of the azygos vomer. That is to say, the right and left pterygoids are connected with the right and left limbs of an originally paired vomer—as in the Palæognathæ. The palatines, which, as we have already remarked, have moved inwards to meet one another in the middle line, underlie the distal ends of these pointed pterygoids. Immediately behind the palatines the pterygoids segment, the segmentation at first resembling a fracture, but later this fracture becomes transformed into a true joint. By this time the terminal ends of the segmented pterygoids have become perfectly ossified, and simultaneously have begun to effect a union with the underlying palatines, the distinction between pterygoid and palatine being marked by a fine suture. Eventually all trace of the suture disappears, and with it the evidence of the pterygo-vomerine connection. The existence of the distal end of this segmented pterygoid is entirely obliterated, so that there is nothing to show that this joint is not a true articulation between two distinct bones—pterygoid and palatine. In other words, there is no indication of the fact that this joint is formed by segmentation of the pterygoid, and the fusion of its segmented portion with the palatine to form a palato-pterygoid articulation. In some skulls the palatine extends backwards below the segmented portion of the pterygoid to join with it in forming the articulation (Pl. 32. fig. 2). This segmented portion of the pterygoid I have elsewhere called the hemipterygoid; it is the mesopterygoid of W. K. Parker.

This hemipterygoid varies greatly in its relative size in different groups. In some it has become so greatly reduced that it ceases to segment off from the main body, and remains as a kind of peg projecting from the antero-dorsal angle of the pterygoid trunk. This is the case in the Galli and Anseres. In these groups the vomer, when present, is therefore supported entirely by the palatines.

In the Falconidæ, amongst the Accipitres, again it has entirely disappeared, the support of the vomer being undertaken by the palatines.

As a consequence, then, of the inward movement of the palatines, the hemipterygoid element is slowly undergoing suppression. In some cases, as we have just remarked, only the merest vestige remains. In the majority of cases its connection with the vomer is but of the slightest. The support of this element has practically been transferred to the palatines.

The nature of this support is seen with almost diagrammatic clearness in the Penguins. Herein the palatines, caudad, are plate-shaped. The mesial border of each runs at first beneath the hemipterygoid, then beyond this upward and forward for a considerable distance. The whole of this region beyond the hemipterygoid is applied to the dorsal border of the vomer, which only just reaches back to the tip of the hemipterygoid.

Numerous stages in the decay of the disappearing hemipterygoid are to be found. The skull of an immature *Tetrapteryx paradisea* in the British Museum collection affords an admirable object-lesson in this degeneracy. Here (Pl. **32**. fig. 4) the free end of the hemipterygoid fails to reach the vomer, which is now entirely supported by the palatine in the manner just described.

The vomer, like the hemipterygoid, is also in many cases completely suppressed.

Attention must now be directed to the palatal bones of certain Coraciomorphæ (*Gadow*).

Lack of suitable material (in the shape of embryos or nestlings) has greatly hampered me in the investigation of these groups; but enough has come to light to enable me to deal therewith in the present contribution. It is to be hoped that help in this matter will come to hand shortly. We should be very grateful at the Natural History Museum for ripe embryos and nestlings

to make up the blanks, which are many, in the collections. When this has been done, one or two very interesting points can be definitely settled.

The Cuculi and Psittaci may be dismissed in a few words. The former have the typical Neognathine palate; the pterygoid being segmented, and the hemipterygoid fusing with the palatines, and forming a joint with the main body of the pterygoid. The pterygoid in the Psittaci also forms a joint at its distal end, but nothing is yet known concerning the presence or absence of the hemipterygoid—we do not know whether it is present and fuses with the palatine, or has been lost by atrophy as in the Galli or Anseres. Certain of the Coraciiformes and Passeriformes afford us some interesting modifications of the type.

Briefly, these modifications seem to show that the forms in question differ from all the remaining Neognathæ in that the pterygoid does not segment, but is continued forward directly on to the vomer when present, as in Palæognathæ. That is to say, the hemipterygoid element has not been lost by atrophy, but remains permanently in connection with the main pterygoid body. Between this and the normal Neognathine type are many gradations. The most extreme forms of this modification are perhaps to be found in the Capitonidæ and Bucconidæ.

In *Megalæma marshallorum*, one of the Capitonidæ (Pl. 32. fig. 7) the pterygoid is continued directly forward on to the vomer, terminating in a sharp point running obliquely over the dorsal border of its right and left limbs. This connection between the vomer and an unsegmented pterygoid is of course a Palæognathine character. Moreover, the palatine, as will be seen in the figure (*pa.*), is confined to the ventral border of the pterygoid, and in no way comes into relation with the vomer. It is significant, however, that in this skull the region of the pterygoid shaft that corresponds to the hemipterygoid is not a direct continuation of the shaft, but a curved plate rising somewhat suddenly from the distal end of the pterygoid shaft immediately above the free end of the palatine. This latter fits into the curved hemipterygoid border and abuts against the antero-ventral extremity of the pterygoid (fig. 7). On this account, from the ventral aspect of the skull, the pterygo-palatine connection appears to be by means of a joint, as in all the other Neognathæ. This joint is

continued upwards and forwards beneath the hemipterygoid for some distance. All this seems to imply that this unsegmented pterygoid is really not a primitive but a secondary character—an approximation to the original type.

The suggestion that the unsegmented pterygoid of the species described above is a secondary and not a primitive character, is confirmed by what obtains in *Cyanops asiatica*. Here the form of the pterygoid, its hemipterygoid plate, and its relations to the vomer, are precisely similar to what obtains in *M. marshallorum*, *but the hemipterygoid is cut off from the main shaft, and fuses by its distal end with the palatine.* Except that the fusion of the hemipterygoid with the palatine is not so complete as usual, this is a perfectly normal Neognathine palate.

There is one particular, however, in which the hemipterygoids of these two species differs from the normal type, and that is their relatively greater size and close approximation to the parasphenoidal rostrum, which is held by them in close embrace.

Another well-marked type of palatal modification is afforded by the Passeriformes. Foreshadowings of this occur in the Pici, and many modifications thereof occur amongst the Passeriformes. The evolution of these modifications I propose to deal with in a further contribution to this subject, wherein the morphology of the palate in the whole of the Coraciomorphæ will be, as completely as possible, set forth.

In this Passerine type, which has perhaps reached the high-water mark of specialization in the Corvidæ, the hemipterygoid (Pl. 32. fig. 6) is split off, not by transverse fracture, but by a very oblique segmentation extending from the ventral border of the distal end of the shaft forwards and upwards. The vomer is in contact with the distal end of this reduced hemipterygoid. The main shaft of the pterygoid, immediately behind the hemipterygoid, expands into a slipper-shaped plate, which is closely applied to the parasphenoidal rostrum on either side. The palatines run along beneath the hemipterygoid, but instead of terminating at the proximal end of this segment, run backwards to articulate with so much of the ventral border of the distal end of the shaft of the pterygoid as is applied to the parasphenoidal rostrum. From the ventral aspect of the skull the proximal ends of the palatines appear to lie in a groove hollowed out of the ventral border of the parasphenoidal pterygoid plate.

The peculiarly modified distal extremity of the free pterygoid the adult skull and the connection of this extremity with the fused hemipterygoid and palatine are features of great interest. The resultant oblique joint appears to be one which allows of but little motion. A comparison of the figures will make the peculiarities of this palate easier to understand.

It has been suggested (p. 348) that the dorsal keel of the pterygoid in the Lari might have some significance. We would remark here that it is possibly by the segmentation of a strongly keeled pterygoid that the large plate-like hemipterygoid of such forms as *Megalæma*, for instance, may have been derived. Later on in development the keel of the shaft of the pterygoid may have been lost.

Before closing this paper, I would draw attention to the modifications of the pterygoid in certain of the Caprimulgi.

Steatornis affords a most perfect illustration of the segmentation of the pterygoid. In a nestling in the Museum Collection, this bone (Pl. 32. fig. 5) is continued forward as an unbroken and completely ossified rod to terminate in a sharp point above a vestigial vomer. The palatines have met together mesially beneath these pointed pterygoid extremities, which as yet remain one with the main shaft. In the adult (fig. 5 *a*) segmentation has taken place, not immediately behind, but some distance distad of, the extreme posterior ends of the palatines. The hemipterygoid fusing with the palatine, an oblique palato-pterygoid joint is formed (*cf.* fig. 5 *b*).

The other Caprimulgine forms to which allusion has been made are mentioned here, not on account of the hemipterygoid, about which I can at present say nothing, but because of the peculiar modification which the palato-pterygoid articulation undergoes.

In *Caprimulgus europæus* the pterygo-palatine articulation is a perfectly normal (Neognathine) one; the pterygoid shaft articulating by a joint with the extremity of the palatine. In *Eurostopus nigripennis* the pterygoid articulation is as in *Caprimulgus*, but the palatines send backwards on to the pterygoids two minute processes, one on either side. In *Nyctibius* this backward extension of the palatines has encroached still further upon the pterygoids so as to underfloor these for a considerable extent, thus entirely masking the nature of the pterygo-palatine articulation from the ventral aspect of the palate.

In *Podargus humeralis* the pterygo-palatine articulation is so oblique, that at first the pterygoid appears to be an unsegmented bone as in the Palæognathæ.

The peculiar form of the pterygoid in *Podargus* at first much disconcerted me, seeming, as it did, to show that the unsegmented, pointed, pterygoid was not alone peculiar to the Palæognathæ. A more careful study, however, has placed its real nature beyond all possibility of doubt—it has modified a cup-shaped articular surface into an elongated facet. The palatines in *Podargus*, as in *Steatornis*, are peculiar in that they send inwards a ventral keel to meet in the middle line, thus forming a tubular passage. In *Steatornis* the floor of this tube lies further forward than its roof, underlying the vomer. In *Podargus* the floor of the tube lies directly under its roof.

Summary.

Briefly, the result of this paper has been to show that the differences between the Palæo- and Neognathine palate are those of degree and not of kind.

The Palæognathine is undoubtedly the older form. In it the vomer and pterygoid are uninterruptedly connected, one with another, throughout life; whilst the palatines remain permanently separated one from another caudad, and are connected only with the maxillo-palatine processes distad.

In the Neognathæ the vomero-pterygoid relations are interrupted by the segmentation of the pterygoid distally; whilst the palatines, caudad, have moved inwards to meet in the mid-ventral line beneath the distal ends of the pterygoids, with which they eventually fuse, and, distad, have lost their primitive connection with the maxillo-palatine processes, and have established a new connection with the palatine processes of the premaxilla. The fusion of the distal ends of the pterygoid with the underlying palatine is accompanied by segmentation of the former and the formation of a pterygo-palatine joint.

In my recent memoir on the Palæognathæ I inadvertently described the inward movement of the palatines as having resulted in "thrusting the vomer forwards" (p. 206). This is inexplicable, since it is obvious, from the very next sentence, that I had not lost sight of the fact that this bone still retains its primitive connection with the pterygoid. That both pterygoid

and vomer, however, have been affected by this movement there can be no doubt, since, as I have pointed out, in many cases it has brought about the suppression or atrophy of the hemipterygoid element, and has assumed the functions thereof by taking up the support of the vomer, as in the Anseres and Falconidæ.

The most primitive form of Avian palate is most certainly the Dromæognathous, *not*, as has been stated, the Schizognathous. The Schizognathous and Ægithognathous palates are both specialized forms derived by modification of the Dromæognathous type. The Desmognathous palate is a highly specialized condition which appears to have arisen independently amongst both Schizo- and Ægithognathous forms.

The Neognathine palate is undoubtedly undergoing a further change, a change resulting in the transference of the support of the vomer from the pterygoid to the palatine. This has followed upon the movement of the palatines from the original position outside the pterygo-vomerine bar to a position beneath this. But the disturbance does not end here, for it is in the most highly specialized forms accompanied by the degeneration of the distal end of the pterygoid and the suppression of the vomer.

EXPLANATION OF THE PLATES.

Plate 31.

Fig. 1. Ventral view of the skull of *Dromæus novæ-hollandiæ*, showing the most primitive arrangement of the palatal bones among living birds. The vomer is of great size, and extends backwards in the form of a pair of broad limbs beneath the laminate, pointed pterygoid. The palatines are connected by suture, posteriorly with the external lateral vomero-pterygoid border, anteriorly with the maxillo-palatine process.

Fig. 2. The palate of *Rhea americana*. The vomer has relatively decreased in size. Its relations with the pterygoid are much the same as in *Dromæus*; but this fact is masked by the palatines, which have moved inwards beneath the pterygo-vomerine articulation so as to approach one another in the middle line. The palatine, as in *Dromæus*, is connected by suture with the maxillo-palatine process anteriorly. It is interesting to note that the posterior narial aperture of *Rhea* has been largely filled up by the inward and backward extension of the maxillo-palatine precess. In *Dromæus* this aperture is very large. The premaxillary processes of *Rhea* are also very large.

Fig. 3. The palate of *Nothoprocta perdicarius*. Compared with *Rhea*, it will be seen that the vomer is, relatively, still further reduced, and that the palatines have moved still further inwards beneath the

pterygo-vomerine articulation. Distally, the palatines are seen to have come into relation with the maxillo-palatine processes, inasmuch as they just touch their hindmost extremity. The quadrato-jugal (inferior temporal) fossa has greatly increased in length.

Fig. 4. The palate of *Rissa tridactyla* showing the typical Neognathine palate. The inward movement of the palatines has reached its maximum, meeting one another in the middle line, beneath the pterygoid and vomer. Following upon this, the distal end of the pterygoid has become divorced from the main body, to form the hemipterygoid (fig. 1, Pl. 32). Later, the latter fuses with the palatine; and at the point of fracture, immediately caudad of the palatine, a joint is formed. Thus, in the adult Neognathæ by the disappearance of the hemipterygoid element the pterygoid appears to be a free bone, articulating with the palatine, instead of being connected therewith by squamous suture. The vomer in the adult skulls of this type appears now to be completely divorced from all association with the pterygoid.

Fig. 5. The palate of the Common Fowl (*Gallus bankiva* var. *domestica*). The bones in this palate have undergone still further specialization. The hemipterygoid appears to be totally suppressed, so that the vomer is actually supported only by the palatine (see also *Tetrapteryx*, fig. 4 *a*, Pl. 32). The slight groove indicated in the figure immediately caudad of the vomer was, in the freshly prepared skull, filled by two threads of cartilage running backwards from the vomer, and indicating its sometime further backward extension, wedged in between the palatines and articulating with the now suppressed hemipterygoid.

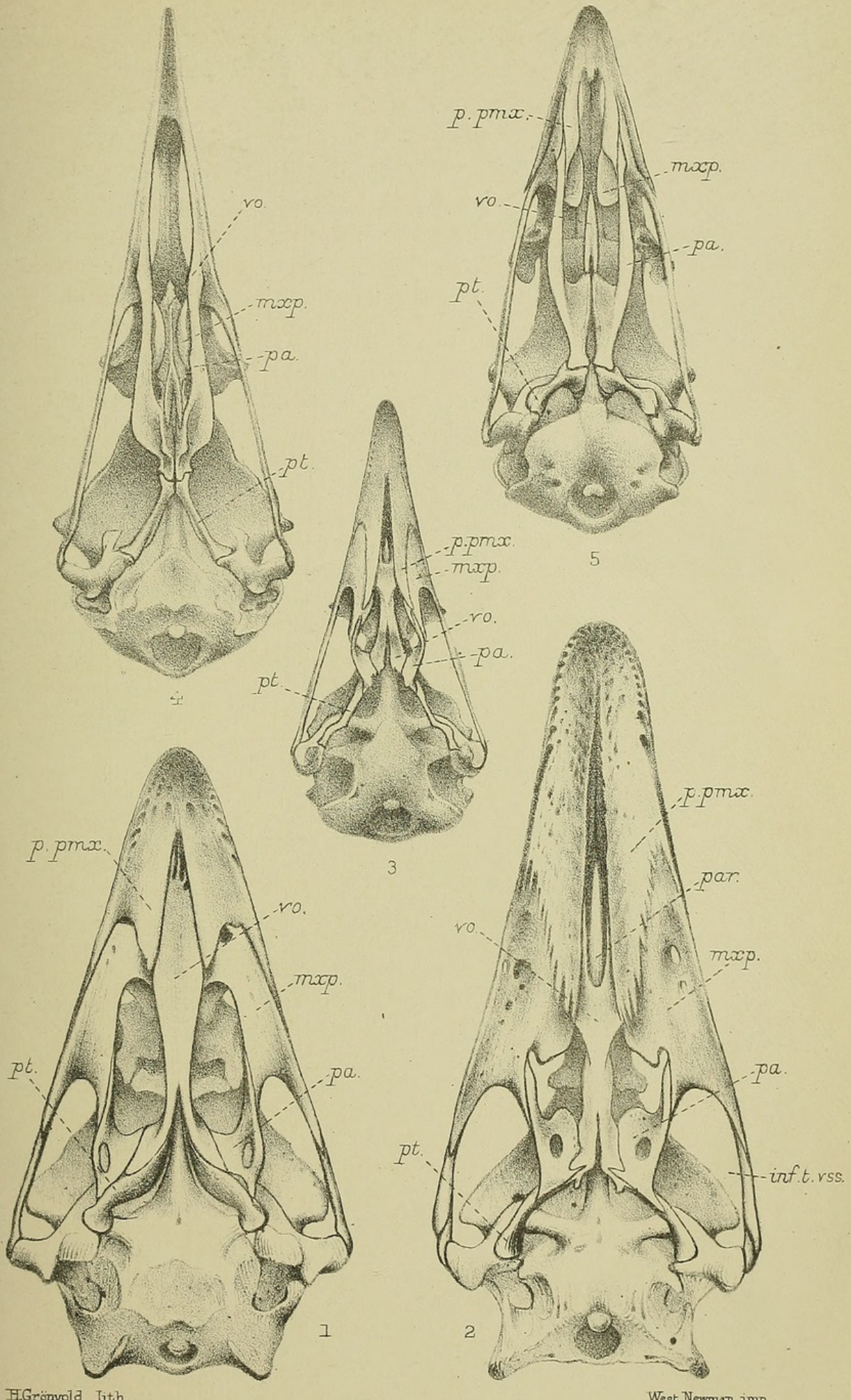
Plate 32.

Fig. 1. The pterygoid of a nestling *Podiceps cristatus*, lateral view; showing the still distinct hemipterygoid element which extends forwards to the vomer. Later the hemipterygoid, losing itself by fusion with the palatine, gives the appearance, in the adult, of a true palato-pterygoid articulation, thereby making it appear that the vomer in the Neognathæ is unconnected with the pterygoid, and thus, on this account, sharply distinguishing the Neo- from the Palæognathæ.

Fig. 2. The pterygoid of a nestling *Oceanodroma leucorrhoa*, lateral view. The palatine has extended backwards beneath the hemipterygoid to share in the articulation with the main shaft of the pterygoid.

Fig. 3. The pterygoid of a nestling *Pygoscelis tæniata*, lateral view. At this stage the hemipterygoid appears as if wedged into the distal end of the main shaft, as by fracture; later a perfect glenoid cavity is developed between the distal end of main shaft and the hemipterygoid element.

Fig. 3 *a*. The dorsal aspect of fig. 3, showing an early stage in the decline of the hemipterygoid, which just fails to reach the vomer.



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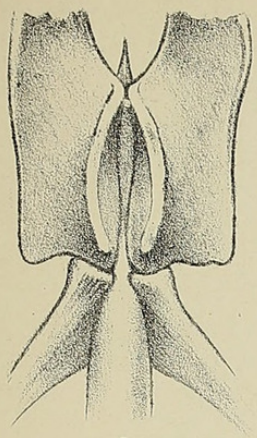

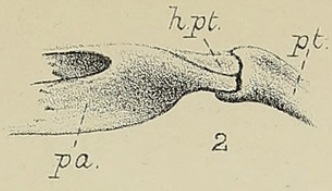

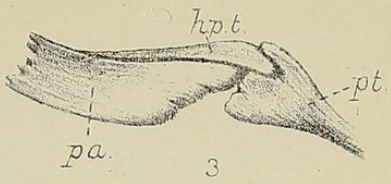

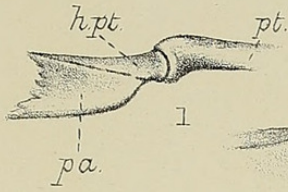

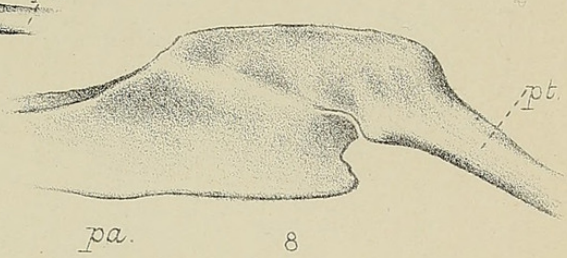

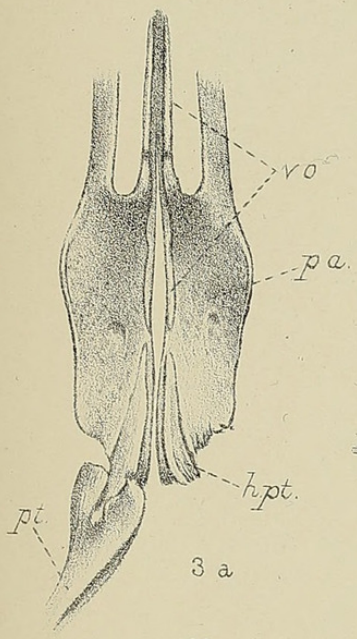

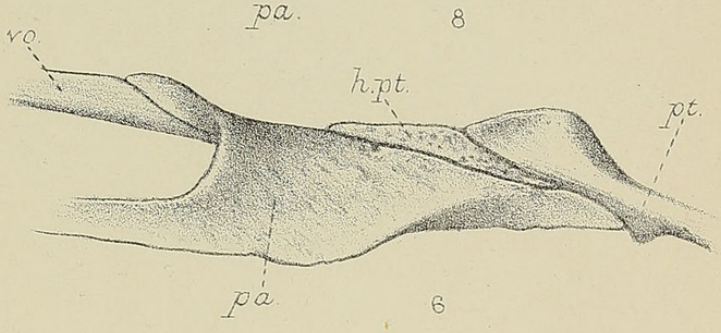

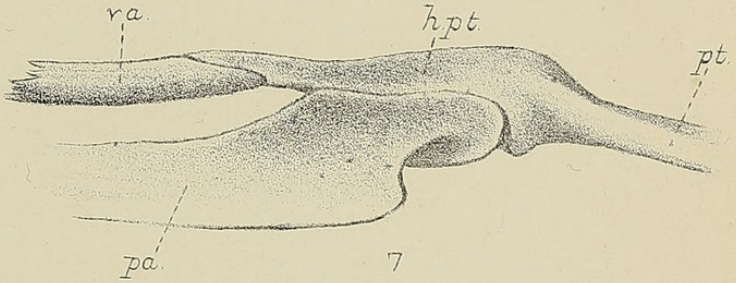

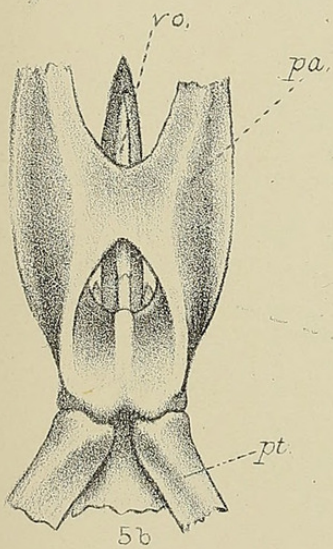

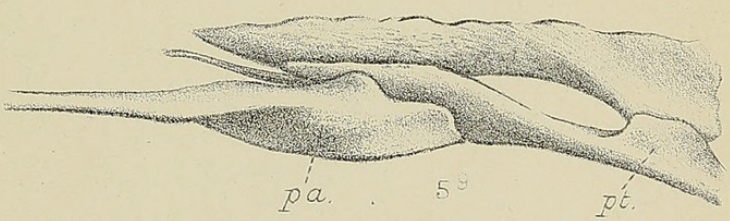

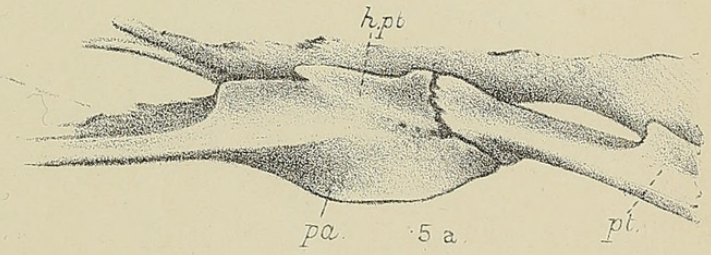

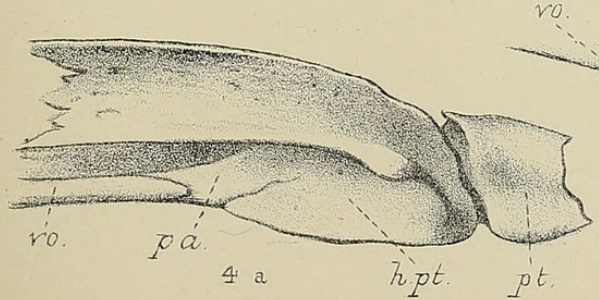

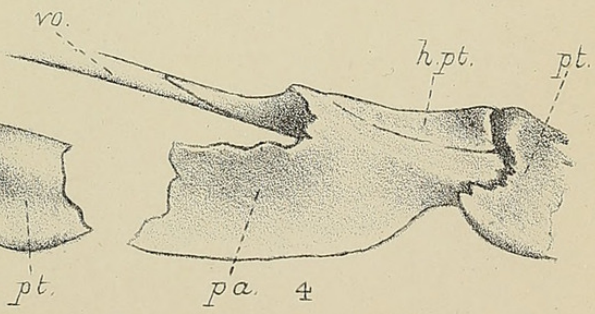

H.Grönvold lith. West, Newman imp.

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