IX. OSTEOLOGY OF THE FLAMINGOES.

(Odontoglossæ.)

Family: Phœnicopteridæ, Sp. *P. ruber*.

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What I have to say here upon the osteology of this small but very interesting group of birds is based upon a complete disarticulated skeleton of *Phœnicopterus ruber* (No. 18494) belonging to the U. S. National Museum, and also a fine mounted skeleton of a Flamingo in the collections of the same institution of which I present a plate. *P. ruber* has been known to occur at rare intervals in Florida, and from the Florida Keys it ranges southward to an undetermined latitude. Other species occur in various parts of the world, and the distinguished French savants Professors Gervais and A. Milne Edwards have described a number of fossil Flamingoes. *P. copei* has also been described by the present writer, it having been discovered in the Equus Beds of Oregon (Tertiary U. S.).

The great weight of opinion among the best avian taxonomers is in favor of creating a distinct group to contain these birds, and that its place in the system is to be found between the true *Anseres* on the one hand, and *Herodiones* on the other. This was even the opinion of Linnæus who claimed they stood "medium inter *Anseres* et *Grallas*, si quis ad præcedentem ordinem referat, forte non errat" (*Syst. Nat.*, ed. 12, I, p. 230), though he retained the Flamingo known to him (*P. antiquorum*) in the latter assemblage. A century later Huxley arrived at practically the same opinion, and in the Proceedings of the Zoölogical Society of London, for 1867, made a group, the *Amphimorphæ*, to contain these birds alone, placing it immediately between the *Anatidæ* (Chenomorphæ, with *Palamedea*) and the herons, storks and *Tantalidæ* (Pelargomorphæ). Professor W. K. Parker, however, has dissented from this view, saying "Professor Huxley has overstated the Anserine characters of this bird [Phœnicopterus]; its 'basipterygoids' are aborted, as in the Ibises."[1]

[1] On the "Manus" of Phœnicopterus, see The Ibis for April, 1889, p. 185.

Garrod's view of the position of the Flamingoes seems to me to be one of the most unnatural that has been published up to the present time. They are placed in his "Cohort B" of his Order GALLIFORMES of his Subclass HOMALOGONATÆ, thus:

Cohort (B) GALLINACEÆ.
Family 1. Palamedeidæ.
2. Gallinæ.
3. Rallidæ.
4. Otididæ.
Subfamily 1. *Otidinæ.*
2. *Phœnicopterinæ.*
Family 5. Musophagidæ.
6. Cuculidæ.
Subfamily 1. *Centropodinæ.*
2. *Cuculinæ.*

Dr. Sclater arrayed them as an Order (VIII) Odontoglossæ, standing between the Herodiones and Palamedeæ; the latter being followed by the Anseres (Order X).

Professor Alfred Newton believed that "the *Phœnicopteri* so much resemble the *Anseres* in certain points that they should form a Suborder of that group, equal in value to the true *Anseres* and the *Palamedeæ.*

Reichenow places them in his Order (VII) GRESSORES as a family (28) between the *Ciconiidæ* (27) and the *Scopidæ* (29), while Stejneger creates a superfamily for them, the *Phœnicopteroideæ*, of his Order (VIII) Chenomorphæ, which last is followed by the Order (IX) Herodii.

Dr. Fürbringer places the two families *Palæolodidæ* and *Phœnicopteridæ*, as one of the "Gens" (Phœnicopteri) of his Suborder Ciconiiformes of the Order PELARGORNITHES; and Mr. Seebohm gives us the following, extracted from his classification:

SUBCLASS.	ORDER.	SUBORDER.
4. Galliformes.	Lamellirostres.	23. Palamedæ.
		24. Anseres.
		25. Phœnicopteri.
	Gallo-Grallæ.	26–32.

Doctor Bowdler Sharpe places them as an Order PHŒNICOPTERIFORMES (XXI) between the Orders PELARGIFORMES (XX) and ANSERIFORMES (XXII), which is quite in keeping with the prevalent opinion of the present time. On the other hand Gadow places the

Flamingoes among his *Ardeiformes* as a family, and far removed from the *Anseres*,[1] which latter are found in his *Anseriformes*, and these are separated from the *Ardeiformes* by the *Falconiformes*.

Many other authorities could be cited here, but from what has been given it is clear that a great variance of opinion still obtains among us as to the position in the system the Flamingoes really occupy.

It is my intention here to compare the skeleton of *Phœnicopterus ruber*, bone for bone, and character for character with the corresponding ones as they occur in the skeletons of all our N. American Mergansers, Ducks, Geese and Swans on the one hand, and the Ibises, Herons, Storks and their immediate allies on the other. Not that I hope that such a comparison will settle the matter for good and all, as to the affinities of the Flamingoes, because the only true way to arrive at such a desirable end as that, is to compare and intercompare the characters presented in the *entire* structure of all these groups. It will show, however, what the skeleton has to say on the subject, and so far as it goes, the results arrived at will be set forth in the present memoir.

COMPARATIVE OSTEOLOGY OF PHŒNICOPTERUS RUBER.

Of the Skull.—Omitting the consideration of the lower jaw or mandible, for the present, as well as the ossifications of the organs of special sense, and directing our attention to the remaining part of the skull, the remarkable form of the upper jaw of the Flamingo first commands the attention. This has a length more than twice that of the cranium proper, while in the matter of its special shape it stands quite unique among birds. Its distal moiety is bent downwards upon the proximal half at an angle of rather more than a right angle. This gives to its mid-longitudinal line upon its under side a sudden curve at the point of flexure, while the corresponding line upon the upper side is more abrupt and angulated. Upon both sides, as well as at the apex of this mandible the free edges are very sharp and are directed directly outwards. The anterior or downward-bent portion of this osseous superior mandible is very much compressed and flattened in the antero-posterior direction; its extreme point being slightly bent backwards. On the upper surface it exhibits a central leaf-like area, lanceolate in outline, that has upon either side, near the lateral boundary a single row of very pronounced foramina. The remaining sur-

[1] P. Z. S., 1892, p. 229.

face between this leaf-like area and the free-edge of the beak upon this aspect is ornamented with a series of shallow pitlets, placed close together upon either side, which have at their mesial terminations sub-concealed foramina leading into the interior of the bone. Passing to what may be called the horizontal portion of this upper mandible, we find that its average width is somewhat less than the part we have just been considering; its narrowest portion being anterior to the narial apertures. The culmen is flattened and very slightly rounded from side to side, the nasal bones being large, broad and smooth. All the sutures between these, the frontals, and the premaxillary are quite obliterated in the skull of the adult, and the bill shows a tendency to a slight rounded elevation, in front of the transverse, fairly-well marked cranio-facial line. Either narial aperture is very large, sub-elliptical in outline, and in no way separated from the opening of the opposite side by an osseous nasal septum. In front of these apertures, the sides of the superior mandible are lacking in a covering of compact bony tissue, and as a consequence the cancellous nature of the interior is considerably exposed at these places. This state is continued backwards along the otherwise solid supero-median floor of the nose, to a point where the large maxillo-palatines meet each other across the middle line. The under surface of the upper beak is upon the whole smooth, while its central longitudinal portion is raised above the rest of the surface as a rounded crest or elevation. This is best marked anteriorly, as it bifurcates and becomes flatter as we pass to the rear posterior to the flexure, where it usually shows in the median line a few foraminal elongated vacuities. These lead into the cancellous interior of the bone.

Regarding the superior aspect of the cranium proper we have to notice that the frontal region is depressed, and triangular in outline; the base of this triangle being formed by the cranio-facial line, and its apex by the approximation of the supra-orbital glandular depressions. These last are very large and well marked in the Flamingo, and closely approach each other in the median line. The trans-orbital interval is narrow, and the supero-orbital peripheries are subcultrate, or moderately rounded off. We are permitted to see also upon this view of the cranium, the extensive suture, upon either side, formed by the articulation of the lacrymal with the corresponding fronto-nasal border. More posteriorly, the parietal region is rounded and smooth, and is entirely lacking in anything like a median furrow extending

between the frontal region and the supra-occipital prominence, as in many of the Ibises and *Anseres*. At the back of the cranium, the elevation to which reference has just been made, is a very conspicuous feature, and upon either side of it is a large subelliptical foramen, the pair being similar to those vacuities which we find located in this place in such an Ibis as *Plegadis;* in many typical Ducks, as *Aythya vallisneria;* but which are small in certain Geese, as *Bernicla canadensis;* and may be entirely absent in Swans, as they are in *Olor buccinator*. *Phœnicopterus* has a large *foramen magnum*, the plane of which faces almost directly backwards, and but slightly downwards; its major axis is in the vertical line. The occipital condyle is comparatively small, and exhibits no supero-median notch as in the *Anseres* (as a rule), and in the Ibis *Plegadis*, where it is at least evident. No sharp osseous ridge defines the occipital area at the back of the skull in our Flamingo, as it does in almost all Ducks, Geese, and Swans. Such a ridge is also wanting in many Ibises, still the *general facies* of the hinder view of the skull of the Flamingo is more, considerably more, like that of *Bernicla* than it is like that of *Plegadis*. A good deal of this is due to the fact that the temporal fossæ of the Flamingo are small and entirely lateral, thus agreeing in this particular with the Goose and not with the Ibis, where they are elongated and produced backwards to the supra-occipital prominence.

Turning next to the lateral view of the skull, we are at first struck with the great size of the *lacrymal bone*. This never co-ossifies with the frontal and nasal at any time in the life of a Flamingo, as it does in all true adult anserine birds, and in many Ibises. It is in form broad, being somewhat transversely compressed; with a sharp ragged anterior border, and a thickened posterior one. On its outer aspect, at the junction of its upper and middle thirds, it is marked by a distinct horizontal groove, while below this, the descending body of the bone is composed of a narrow, vertical, thickened posterior part, with smooth external surface, and a thin anterior part, which latter is abundantly riddled with numerous minute perforating foramina. Both upper and lower borders are roundly convex, the superior one being the more extensive, and articulating for its entire length with a concave facet offered to it by the united frontal and nasal bones. The lacrymal does not come in contact with the zygomatic arch below, nor does it meet any of the other elements of the skull not mentioned. Indeed, these great lacrymals in a Flamingo are quite independent,

and hang down as very conspicuous features of the lateral aspect of the skull. In most particulars they are like the lacrymals as found among many Geese and Swans, and entirely different from those bones in such an Ibis as *Plegadis*, or its near allies. In all true *Anseres*, however, the lacrymals always anchylose with the cranium in front of the orbit.

Either *zygoma* in *Phœnicopterus* is a straight, stout bar of bone, that is more or less transversely compressed. At its proximal end it develops the usual little inturned process for articulation with the quadrate, while along its shaft all traces of the sutures indicating the original bones that enter into its composition are absent in the adult. Beyond the lacrymal it gradually becomes very much broader, and twists upon itself so that the anterior part of the *maxillary* portion lies quite in the horizontal plane. This extremity, fusing completely with the surrounding bones, passes in *between* the maxillo-palatine and the palatine, being *above* the latter. In the Swans, Geese and Ducks the zygoma is much slenderer; shows very little enlargement and no twisting anteriorly, and in them passes in between the pre-maxillary and palatine, being *below* the latter. This is a radical as well as a very interesting difference.

In *Plegadis* the maxillary end of the zygoma lies *above* the anterior end of the palatine of the same side. A large vacuity exists in the interorbital septum of the Flamingo, and in either orbit another extensive foraminal opening occurs above this in the anterior wall at the brain-case. Both in Ibises and anserine birds the interorbital septum is more or less entire, though the foraminal openings into the cephalic-casket may be of the same size, especially in the former group. In *Plegadis* the *pars plana* meets the lacrymal of the same side, but in neither the Flamingoes nor in the true anseres do these ethmoidal wings of the mesethmoid develop in bone.

In *Phœnicopterus ruber* both the post-frontal and the squamosal processes are very much aborted, and the temporal valley between, though deep, is of limited extent. These processes are likewise singularly small in *Plegadis*. A very different state of affairs exists in the *Anseres* in this particular. In them the squamosal process may be quite absent or, if present, so small as not to attract attention. On the other hand, these birds usually possess a post-frontal process of uncommon length. Its tendency is to extend forward and meet the backward extending lacrymal bone. This is actually accomplished in the duck known as

Dendrocygna autumnalis, the ends of the two bones completely fusing and thus forming an orbital osseous ring co-equal with anything we find of the kind among the Parrots.

Flamingoes have the osseous ear-cavity very much exposed, for after the quadrate is removed there is hardly any bony protection, and it is only at the back that a solid wing of good proportions semi-surrounds it in that quarter. Both the Ibises and the Anseres are better off in this particular; especially the first-named group. Without entering upon details, I may say that upon the whole the characters of the osseous ear-cavity and its most immediate surroundings in our Flamingo agree better with those same parts as we find them in *Bernicla* than they do with those in such an Ibis as *Plegadis*. Turning next to the base of the cranium, we find the triangular area formed by the *basitemporal* to be comparatively limited in extent. Its mid-anterior apex is thin and scale-like, and the Eustachian passages are for the most part open canals. This is what occurs in *Plegadis*, whereas in the anserine types these tubes are not thus exposed, while the median point in front where they in common open is, in these birds, large and conspicuous. The *basisphenoidal rostrum* is slender in the Flamingo, and more or less flat upon its under side. In front it terminates abruptly at the antero-inferior angle of the mesethmoid. The paroccipital processes are but moderately developed, and the pteryapophysial ones are not found. These latter are notoriously large among the *Anseres*, as may be appreciated by referring to my work upon the osteology of that group (in MSS.).

It is an interesting fact to note that upon the left side in the skull of the Flamingo at my hand, at the site where the pteryapophysial facet would be found in a Goose, for example, we observe a minute "prickle" of bone protruding, that would lead one to suspect the presence of these processes in birds allied to our subject, even did we not know of its relations to the Anseres. This sometimes happens in other groups, and may be the case within the group. Ibises are entirely wanting in pteryapophysial processes. In the Flamingo, a *pterygoid* is a short bone, being very markedly compressed in the vertical direction, while its anterior end is considerably dilated. I am not sure that these bones are in contact anteriorly (where articulated *in situ*); as is so distinctly the case in *Plegadis*. Otherwise the pterygoid of the Flamingo more or less resembles that bone as it occurs in the skull of the Ibis just mentioned, and very different from the pterygoid as it exists in any of the *Anseres*.

As compared with the other elements of the skull, *Phœnicopterus* has a big *quadrate*. Its orbital process is broad, thin and quadrilateral in outline, with the internal free extremity abruptly pointed ; its mastoidal portion is compressed in the oblique antero-posterior direction, and distinctly exhibits the double head for articulation with the skull. At its mandibular base the arrangement of the facets, as well as their forms, differ very materially from what we find in either the anserine birds or among any of the ordinary Ibises, though they agree better with the latter than they do with the former. This is somewhat remarkable from the fact that the orbital process of the quadrate in our Flamingo is more like that part of the bone as seen among Swans, Geese, and Ducks than in such an Ibis as *Plegadis*. Both the quadrates and the pterygoids of *Ajaja* (*Platalea*) are manifestly different in their important characters when compared with those bones in either the *Anseres* or the Ibises, or even the Flamingo. For their posterior moieties, in the middle line, the *palatines* are pressed together with the greatest intimacy, and we find here, coössified with them, the vomer which will be described further along. Viewing these bones from beneath we observe that the meeting between them is for the entire length of the "ascending process" of each, to include posteriorly the pterygoidal processes. Their "bodies" are flat, lie in the horizontal plane, are each rather broader in front than behind, and are likewise nearly parallel to each other. A very considerable median interval, or open space, separates the body of one palatine bone from that of the other, while anteriorly they pass beneath the maxillaries to become completely fused with the premaxillaries and maxillo-palatines. The "postero-external angle" of either palatine is rounded off, and both the internal and external laminæ are but feebly developed.

This by no means applies to the ascending process upon the superior aspect of the bone, for this is a most elegant scroll-like affair, that springs from almost the entire outer margin of the supero-external border of the body of the bone, to sweep upwards and inwards, to meet and fuse with the postero-superior edge of the vomer. The anterior border of this ascending process of either palatine, is seen to be a deep, loop-like curve, with its concavity directed to the rear. The inner line of the curve is continuous with the superior border of the vomer, while the outer sweep of the curve passes across the body of the palatine to finally become continuous with the mesial edge of the same.

As I have said, the *vomer* is fused with the palatines, and it is nowhere closely in contact with any of the other bones of the skull. Its free anterior end is pointed, and its inferior margin extremely sharp. Indeed, this thin plate of bone is greatly compressed in the lateral direction, while its body shows a large elliptical vacuity in it, just beneath the mesethmoid. This last-named element of the skull is much thickened superiorly where it is greatly spread out beneath the frontal bones with which it is indistinguishably coössified in the adult. Its supero-anterior edge is transverse, being devoid of any projection, and is found almost exactly beneath the line of the very firm and almost immovable cranio-facial hinge.

A *maxillo-palatine* is a large, somewhat concavo-convex bone, that exhibits an open spongy structure upon its external and convex surface, but a smooth compact one upon its concave mesial aspect. Externally, it fuses with the nasal, maxillary, premaxillary, and the extreme anterior end of the palatine, while internally it most completely coalesces across the middle line with the fellow of the opposite side. The maxillo-palatines of a Flamingo are decidedly anserine in character and do not reach back posteriorly to come in contact with the entire anterior margin of the ascending process of the palatine, of either side as they do in *Plegadis* but never do in such a goose as *Bernicla*, for example.

The *mandible* of *Phœnicopterus* is a truly elegant structure in bone, and it further possesses a form that is quite unique among birds. Its anterior half is bent downwards at an angle that coincides with the decurvature of the upper jaw, but instead of this part being flat and thin as in the case of the latter, it is vertically very deep at the point of flexure, though it tapers off gradually towards the apex, and posteriorly towards the rami. This part is moreover profoundly scooped out internally where the surface is smooth and composed of a very thin layer of compact tissue. From the rami to the apex, the two superior borders of this dentary part of the mandible are very considerably rolled inwards towards the median plane. These inturned edges, however, again gradually die out as we proceed towards the anterior tip of the bill, or upon the ramus upon either side. In a similar manner too, the general concavity of this dentary portion of the beak dies out gradually as we near the anterior apical extremity. Of course this is not the case posteriorly where considerable depth is maintained throughout. All over the enlarged dentary portion the

external surface shows its cancellous structure, and it is only meagrely covered in certain places by irregular areas of very thin compact osseous tissue. These are generally off-shoots from the external surface of the rami. The superior surfaces of the inturned borders of the dentary portion do not show this cancellous structure, but are smooth and unmarked, with their inner free edges rather sharp. Viewed upon its inferior aspect, the hinder boundary of this part of the mandible is seen to be concave, with the convexity directed forwards and it is marked by a deep, median, quadrilateral notch. Beyond this notch the bone is profoundly and broadly furrowed mesially, for the distance of about three centimeters. A median crest of bone divides this furrow into two equal longitudinal halves. The excavation dies out within about two centimeters of the surface, marked distinctly by a dozen or more peculiar striæ that converge towards the tip of the bill, but fail quite to reach it. Either ramus of this mandible is smooth, and for the most part shows no cancellous structure. Its upper and lower borders are rounded off, especially the superior one. Anteriorly, just before passing into the dentary portion, described above, it is somewhat swelled from side to side. On the mesial aspect of the ramus, between this locality and the articular cup, there is found an elongated elliptical concavity, showing some cancellous structure in its anterior portion. The outer surface of either ramus is very smooth and the ramal vacuity is *completely* obliterated. On this surface, below the coronoid process, a small subcircular foramen is constantly found. From the fairly-well marked coronoid process to the mandibular articulation, the superior ramal border drops abruptly. The "articular cups" present nothing very peculiar; they have the usual inturned hooked mesial processes, with the pneumatic foramen on the upper side, near the apex. The articular concavities and convexities are conformed to meet the opposing articular surfaces offered on the part of the mandibular articulatory process of the quadrate.

The apophysis at the angle of the jaw is conspicuously developed, and uniformly recurved upwards and backwards. Its lower and hinder margin is dull, and directly continuous with the inferior margin or border of the ramus. The anterior margin is jagged and sharp, while the apex is rather squarely rounded off. As in the anserine fowl, these angular apophysial projections are lamelliform in character, being thin and greatly compressed in the transverse direction.

In my specimen of *Phœnicopterus ruber* the *sclerotal plates* of either

eyeball have been lost, so I am at present unable to record anything about them. This also applies to the intrinsic bonelets of the middle ear, and still more unfortunately to the ossifications of the hyoidean apparatus.

For the most part, the skull of the Flamingo, including the mandible, is highly pneumatic; even more so than it is in many geese, as for example, in *Bernicla*. From quadrates to apices, the osseous mandibles of *Phœnicopterus* are more or less closely in contact when thus articulated *in situ;* this is especially the case for the anterior moieties of the dentary portion, and as it is known, these are the parts of the beak, principally used by the bird in the seizure of its food, taking it in a manner as it does, different from that of any other member of the class *Aves*—for with neck bent down, and head completely upside down—the flat anterior surface of the superior mandible is brought opposite to the bottom of the water where the individual may be feeding, while the mandible or lower jaw is *above*, occupying the position of the *upper jaw* in representatives of other groups while thus occupied.

In its external narial apertures; in the possession of supraorbital glandular depressions; to a small degree in its lacrymal bones; in the posterior aspect of its skull (generally); in its quadrates; in the possession of large recurved processes at the mandibular angles—the skull of the Flamingo is more or less anserine in character. But on the other hand, in its pterygoids; in some respects in its palatines; to some degree in its vomer; and in some other minor points, the skull of this bird is more or less ibidine in character. Finally, the skull of *Phœnicopterus* has a number of characters strictly peculiar to itself—but these have already been sufficiently dwelt upon above. I have also carefully compared the skull of *Phœnicopterus* with the skulls of an *Ardea;* with *Tantalus;* a stork; and with *Ajaja*, but in this part of its skeleton, I am convinced that it comes nearer the typical Ibises than it does any of these other groups or genera. To be sure it has a character here and there in its skull that more or less closely resembles a corresponding one, say in the skull of the heron, or another in a stork, but to me the ibis-characters seem to predominate.

On the Remainder of the Axial Skeleton.—There are 43 vertebræ and a pygostyle in the vertebral chain of the trunk skeleton of *Phœnicopterus ruber*. Of these, the first 18, counting from the atlas backwards,

are free ; while in the dorsal region the 19th, 20th, 21st and 22d are solidly fused together so as to form a single bone. The 23d vertebra is again free, after which the succeeding 14 are coössified together to form the pelvic sacrum. Finally we find 6 free caudals in the skeleton of the tail, plus a terminal *pygostyle*, which last is comparatively very small for the size of the bird, being somewhat elongated, pointed and shaped like a blunt lance-head. It is a process projecting forwards from its antero-inferior angle.

The *atlas* has the usual ornithic-type form, with its cup for the occipital condyle profoundly and roundly notched above, while its inferior spine is conspicuous, rather elongated, and is extended directly backwards. Passing this vertebra, the first thing that commands our attention in the cervical system of bones is their unusual slenderness, and their progressive elongation from the axis vertebra to include the 12th of the chain—the 9th to the 12th inclusive having almost exactly the same length, or about 5.3 cm. After the 12th they gradually shorten and widen again, until they come to assume the form of vertebra seen in the dorsal region. Through these elongated vertebræ the neural canal is also small, and even does not exhibit much increase of calibre where the neural cord gives off the brachial plexus. With the exception of the caudal vertebræ the entire chain of bones seems to be more or less pneumatic, the atlas, perhaps, being the least so of all, and the consolidated piece of the back the most so.

The *axis vertebra* has a long, low, thickened neural spine with broadly rounded superior edge ; its hæmal spine is likewise reduced to an elongated low crest with its inferior border somewhat sharpened. The odontoid process is prominent, pointed and somewhat tipped up in the direction of the neural canal. A long, extremely low, sharp and thin neural crest, longitudinally disposed, is also found upon the third vertebra, and upon all its successors to include the twelfth. It suddenly shortens up and becomes slightly more manifest in the 13th—distinctly so in the 14th and 15th—while in the 16th it is the most conspicuous feature of the bone, short, lofty and markedly bifurcated behind. This is pretty much the case, too, in the 17th and 18th segments, while in the coössified dorsal piece the neural crest is for the most part low and inclined to be spreading, especially anteriorly. In the free 23d it is much shortened, high, and considerably thickened. On the extreme forepart of the third vertebra there is a short median hæmal spine, that in the case of the 4th vertebra becomes distinctly bifid,

forming the parapophysial canal for the carotid arteries. This canal remains open throughout the series, where it is always seen to be short and situated at the extreme anterior part of the centrum beneath. It is well marked in the last five or six vertebræ of the neck, and even appears to be present on the 19th vertebra, or the first one of the solid dorsal bone. Its place is taken by a single, forward-directed spine on the 20th, and after that every trace of it disappears. The lateral vertebral canals are also at the extreme anterior part of the several cervical vertebræ that possess them, and they, too, are very short, being found first in the third cervical, and continue to be present to embrace the seventeenth. After that free pleurapophyses are in order. These vertebral canals are of very small calibre in the leading cervicals, but gradually become larger, until they are of some size in the 16th, 17th and 18th vertebræ. The parapophysial spines form a very remarkable feature, they being of very considerable length, and of absolutely hair-like dimensions. In the 15th vertebra the pair suddenly shortens up, to become quite unnoticeable, and in the 16th vertebra they are supplanted, upon either side, by a low inconspicuous tubercle. The 15th vertebra is also peculiar in possessing interzygapophysial bars, which are so often present in the third cervical of other birds, but which in the present bird are almost aborted in that segment of the spine.

The zygapophysial processes are very short and thick in the first six cervicals, leaving, when the vertebræ are articulated, no lozenge-shaped interspace upon vertical view between the bones, but in the seventh vertebra the posterior pair begin to elongate, and this is continuous to include the 14th, whereupon they again shorten and thicken throughout the lower part of the neck and the back. When the vertebræ are normally articulated in the cervical region, the spine there forms a long sigmoid curve down to the dorsum. As a rule the articular facet on the anterior part of the centrum is extremely shallow in the vertical direction and correspondingly wide transversely; the posterior interarticular facet, on the other hand, has more or less of a quadrilateral outline. All this holds true, especially in the leading cervicals, whereas in the last free dorsal vertebra, both anterior and posterior facets are strictly of a quadrilateral outline. They are "heterocœlous" throughout the spine, with the exception of the atlas, which is, of course, procœlous anteriorly, with its posterior face, slightly convex.

The coössified vertebral piece of the dorsum, composed, as I have said, of four vertebræ, presents some few additional characters worthy of our notice. Ragged metapophyses are developed in the usual way at the extremities of the transverse processes, but they do not reach either far enough forwards or backwards to bring the several vertebræ in contact at these points. Vacuities exist at either side of the low neural crest, where the fused articulations of the pre- and postzygapophyses are found. They are larger posteriorly than anteriorly, and admit of a view of the neural canal through them. Viewing this piece upon lateral aspect, the several facets for the ribs are seen to be very distinct, especially those for the capitula, where the edges are raised and prominent, thus forming a decided concavity for the head of the rib. On the other side, and immediately anterior to any one of these facets on the centrum of the vertebra is seen a large subcircular vacuity. It opens directly, in every instance, into the spinal canal, and is directly opposite the corresponding opening of the other side of the bone. A similar pair is formed when the last free dorsal vertebra is articulated *in situ*, and it is seen to be formed by the meeting of the zygapophysial processes laterally and above, and by the centra below. These centra of this fused piece are deep, and markedly compressed in the transverse direction, with an infero-median longitudinal sharpened border, which terminates in front on the apex of the second or last hyapophysis.

As to the *ribs* of this Flamingo, there may be a thoroughly rudimentary pair on the 18th vertebra, or the riblet may be free upon only one side of the same. There are four pairs of well-developed ribs, however, that come from the coössified dorsal vertebral piece; a pair from the vertebra that follows it; and finally there is a pelvic pair. All of these are connected with the sternum by means of costal ribs, and behind the pelvic pair, articulating neither above nor below, is a very delicate pair of so-called "floating ribs." Both costal and thoracic ribs are completely pneumatic, and exhibit some notable peculiarities. If we take the anterior pair that come from the first vertebra of the dorsal piece, we find that either one of them is greatly compressed in the antero-posterior direction between the head and the tubercle, while the "body" of the bone is similarly much flattened in the reverse direction. The unciform processes are simply elongated swellings on the side of the shaft, and the part of the bone above them is much expanded, the expansion being directed entirely

forwards and on its mesial aspect are seen the pneumatic foramina. This peculiar expansion becomes much less as we pass through the series in the direction of the pelvis, but is never entirely lost; while on the other hand the unciform processes become enormously elongated and widened, being anchylosed to the ribs. But these again in turn are a little less conspicuous as we approach the pelvis, and the pelvic pair of ribs are without them entirely. The *costal ribs* are slender and flattened, and not much curved, with the exception of the ultimate pair, and even they do not show it as much for their lengths, as in some other birds. Measuring the chord of one of these last, it is seen to be 6.3 cm. long, while the length of one of the first pair is not more than 1.7 cm.

The *pelvis* of *Phœnicopterus* is inclined to be rather narrow, or at least moderately so, and deep in the vertical direction. Viewed upon its dorsal aspect, the superficial area of the preacetabular region is about equal to the postacetabular, but the latter is nearly flat in character, while the sides of the former are somewhat concave, and face far more outwardly than upwardly. The long, median axis of the sacrum is almost a straight line. Anteriorly, the borders of the ilia are much rounded, jagged in character, emarginated, and these bones here overarch the first sacral vertebra, to a considerable degree. A double row of intervertebral vacuities are present, the first half dozen pairs being all more or less of a size, but posterior to them, the last two sacral vertebræ become far more individualized—the ultimate one being very distinctly so, projecting as it does beyond the iliac bones posteriorly.

In the preacetabular region the mesial margins of the ilia meet over the top of the sacral crista only at their middle points, and these bones in this locality are completely fused with the sacrum—the ilio-neural canals being thus thoroughly covered over, and sealed up both in front and behind. As these iliac borders sweep round in the direction of the acetabulum upon either side, they are seen to be roughly sharpened and rather prominent. Over either ilio-ischiac foramen the ilium is seen to jut out in the horizontal plane, thus forming an overhanging ledge above that vacuity, of a fairly well-marked character. Below, as well as in front of this projection, and especially above and in front of the cotyloid ring, the bone is wrinkled, and puckered, and pitted, the various little concavities thus formed harboring at their bases the pneumatic foramina that lead into the internal tissue of the pelvis. On

lateral aspect, the acetabular ring is seen to be large, nearly circular in outline, with raised antero-external margin. The antitrochanter is also conspicuously developed. Behind it is the very extensive opening of the ilio-ischiac foramen, which in this species is so broadly elliptical in outline, as to appear more than usually circular—its minor axis being about three-fourths the length of the major one. Posterior to this foramen the side of the pelvis is both deep and smooth, with but the barest suspicion of an ilio-ischiac notch in its hinder margin. The "obturator foramen" and the "obturator space" have practically merged into one, there being barely an osseous isthmus dividing them. The latter is very large owing to the deep downward sweep of the pubic bone, and the concavity of the inferior margin of the ischium. The *pubis* is long, narrow and slender, being nearly of uniform width throughout. It projects nearly two centimeters beyond the ischium behind, and its extreme tip is slightly spatulate and decurved.

Ventrally, we are to notice that the first sacral vertebra, though considerably larger than any of the others, is still smaller than the last free dorsal one, and has many of its characters, notwithstanding its complete fusion with the remaining vertebræ of the sacrum and with the ilia. The four that succeed it throw out their lateral processes to the under surface of the ilium on either side, to completely coössify there with those bones, or, as in the case of the last two of these four, to press closely against them. After these there next abruptly follows the deep concavity of the pelvic basin, showing, in either one of its lateral walls, the very circular and smooth internal ring of the acetabulum, and the large ischiac foramen. These are separated by a strong, though narrow osseous isthmus, the upper part of which, upon either side, serves as an abutment against which rest the outer expanded extremities of the produced parapophyses of what are really the two true sacral vertebræ. The next four sacral vertebræ have their lateral processes elevated, with their dilated outer ends abutting against the mesial margins of the ilia, but in the case of the last two of these no anchylosis takes place where they meet. As already explained, the ultimate sacral vertebra projects beyond the iliac bones behind. (See Plate XIII., Fig. 7.)

Within the pelvic basin small groups of pneumatic foramina occur in various places, and a strongly-marked rounded ridge passes longitudinally over about the site of the original line of meeting of the ilium and ischium of either side. The pubic bones are nowhere in con-

tact with the latter except at their commencements in the acetabular rings.

With respect to the *six* free *caudal vertebræ* and *pygostyle* we are to notice that from first to last they gradually decrease in size, and that the lateral processes also become progressively shorter and shorter to be entirely absent in the two last vertebræ and the pygostyle. The neural canal very small at the commencement likewise becomes rapidly reduced in calibre, though it persists as far as the pygostyle, into which it penetrates for a short distance. All the neurapophyses are very low, thick and stumpy, and exhibit a feeble tendency to bifurcate in front. It is only the last two caudals and the terminal piece that develop hæmal spines, and these are short and pointed, being on the antero-inferior margin of the centrums, and are directed forwards to underlap the vertebra next in front of them. The zygapophyses are aborted, unless it be that the minute bifurcations spoken of above as appearing on the anterior part of the neural spines, represent the rudiments of prezygapophyses, which indeed they may. Each centrum is procœlian in character, and a hæmal canal is absent. In the mounted skeleton of *P. antiquorum* (see Plate IX.), in the collections of the U. S. National Museum, the ultimate "uro-sacral" is not fused with the others, so in this specimen it may be considered as more properly belonging to the tail vertebræ, thus making *seven* instead of *six* of those bones, as I have stated above for *P. rubra*. A similar variation is sometimes formed among the *Anseres*, where, too, the usual number of caudal vertebræ appears to be six or seven. In the same specimen there is also a striking difference in the ribs from those of *P. rubra*, for the pelvic pleurapophyses have semi-aborted epipleural processes upon them, and there is a pair of elongated, free "cervical ribs," which lack them altogether.

Of the Sternum and Shoulder-girdle.—Unlike the *sternum* of the Ibises of the genus *Plegadis*, this bone in the Flamingo is, behind, but once deeply notched upon either side of the carina—and in this respect it agrees with the sternum as found in all typical Geese and Swans, and also in many Ducks. The style of the notching, however, is more as we find it among the Geese of the genus *Bernicla*, only in the latter the lateral xiphoidal processes are longer than the body of the sternum, are more curved, and have their extremities somewhat dilated; the mid-xiphoidal process is likewise broader in the sternum of the Goose, and its postero-lateral angles are produced. In *Tantalus* the "notching" of the sternum agrees with the Flamingo.

In its general form the sternum of *Phœnicopterus* is oblong, being somewhat wider in front than it is behind. The six hæmapophysial facettes upon either costal border occupy less than half the length of the same. Dorsally, the sternal body is profoundly concave, and a scattered row of small circular pneumatic foramina occur down the median line upon this aspect. In front, the border of the bone is greatly arched, the convexity being directed anteriorly. There, too, we find in the middle line a broad concave notch, while laterally, the "costal processes" are subtriangular in form, and by no means conspicuously developed.

The carina is deep and occupies the entire length of the bone, sloping gradually away posteriorly, while its thickened anterior border is concave, and its inferior one moderately convex. The carinal angle is more rounded off than we usually see it in the *Anseres*. On the ventral aspect of the sternal body we observe that the pectoral muscular line runs to the *middle* of the base of the keel, while in most *Anseres* this line runs the entire length of the sternal body to the termination of the carina behind. This in each case also applies, of course, to the muscular line on the lateral aspect of the keel, which always joins at a rounded angle posteriorly the pectoral muscular line of the ventral surface of the sternal body. The deep *coracoidal grooves* of the sternum of *Phœnicopterus* decussate mesially as they do in *Plegadis* and *Tantalus*, which is not the case in the *Anseres* in so far as I have examined them. There is also present in the Flamingo a large *manubrial process* of the typical trihedral form. This apophysis is also seen at the fore part of the sternum of *Bernicla canadensis*, where it is comparatively smaller and varies somewhat in shape in different individuals of this species. It is entirely absent in the Canvas-back Duck (*Aythya vallisneria*), and more or less aborted in some Ibises, as, for example, *Plegadis*.

Regarded as a whole, the sternum of *Phœnicopterus ruber* presents us with as many genuine ibidine characters as it does with anserine ones, thus sustaining a fact so evident in other parts of the skeleton of this remarkable bird. In some respects it may be said, however, that the bone offers us characters which call to mind the ciconine sternum (*Tantalus*), as for example, it being two-notched instead of four-notched as in *Plegadis*, though this may mean anserine affinity apart from any kinship the Flamingo has with the Storks.

Judging from the bones of the shoulder-girdle we are strongly

inclined to believe this to be the case. These latter will now be considered.

Upon comparing the *os furcula* of *Phœnicopterus* with that bone as we find it in the *Anseres* and in various species of Ibises, I find it to be decidedly more anserine in character that ibidine. Indeed, the fourchette of our Flamingo may very well answer for that bone in any average Duck of medium size, and in its general characters it departs but little from the os furcula of *Bernicla*. It is of the typical broad U-shaped pattern, with a semi-aborted, stumpy hypocleidium at the posterior aspect of the symphysis. The latter feature is usually absent among the *Anseres*, and rarely if ever present on the bone as found among ordinary Ibises. Viewed upon lateral aspect it will be seen that it is markedly curved in the antero-posterior direction, the convexity being to the front; and that the clavicular limbs as well as the symphysial arc of the arch are nearly of uniform calibre. The former is somewhat compressed in the transverse direction and the latter antero-posterior-wise. Each free clavicular extremity is considerably drawn out and very gradually terminates in a blunt point behind. On the upper side of either clavicle, at about 1.5 cm. anterior to the blunt posterior apex, we are to observe the barest evidence of a minute tubercular elevation; it is no more conspicuous than we see it in such a genus of Geese as *Bernicla*, but in some ducks this process is a very well pronounced character, as it is also in some Mergansers. The os furcula of *Phœnicopterus ruber* is non-pneumatic, and, although its coracoids and scapulæ present all the usual appearances of bones that enjoy that condition, I have failed to find any foramina in the latter, and they are very small in the former. They occur in an unusual place in the coracoids as we shall presently see.

Upon comparing the *coracoid* of the Flamingo with that bone as it is found in various Ducks, Geese, Swans and Ibises, I find it to be most like the coracoid of such a Goose as *Bernicla canadensis;* it, however, offers some characters which readily distinguish it from that bone. In the first place it is somewhat shorter and rather stouter; then also its scapular process is longer and more curved, and is perforated at its base by the elliptical foramen seen in many birds. This foramen is present in *Plegadis*, where it is very small. On the inner aspect of this foramen in the Flamingo (on the shaft side) the bone has been absorbed so as to create a pneumatic aperture of some considerable size—the opening being as large as the perforating foramen itself.

From its hidden position, however, this pneumatic foramen is not likely to be observed upon casual observation.

The sternal expansion of the coracoid is very broad, being compressed in the antero posterior direction with a very large facet upon its hinder aspect just as we find it in *Bernicla*. The "lateral process," however, is rather more conspicuous in the Flamingo than it is in the Goose, and the internal process is at the same time more pointed. The summit of the bone is tuberous and enlarged, and the shallow glenoid cavity extensive. A deep, circumscribed fossa is seen for the accommodation of the head of the scapula—a character which is also present in the coracoid of *Bernicla*. Minute spinous processes are found upon the lower interno-mesial border of the shaft, which are but very faintly developed in *Bernicla*, though in the latter, on the posterior aspect of the bone, the muscular lines of which these processes are the mesial extension, are very much better marked than they are in the Flamingo. *Phœnicopterus* possesses a comparatively long *scapula* of the usual ornithic pattern. Its clavicular apophysis is produced well forwards, and the blade of the bone is curved in both vertical and lateral directions. Posteriorly it is *gradually* drawn out to a point, thus differing from the scapula of *Bernicla* wherein the hinder end of the bone is squarely truncated, or from *Plegadis*, wherein it is seen to be obliquely truncated. Measuring the chord extending from the apex of its clavicular process to the posterior tip of the bone we find it to be 9.4 cm. Unfortunately, in the sole specimen I have in hand for description, the ossifications of the air-passages, as the trachea, etc , are all missing, not having been preserved by the person who prepared it, therefore I can give no account of them at this writing. The bones of the hyoidean apparatus have also been lost, as have likewise the ossifications of the organs of special sense.

Of the Appendicular Skeleton.—Here too, apparently, a few of the small bones are missing, having been lost at the same time with the others mentioned in the last paragraph—for I have no first metatarsals, which the Flamingo undoubtedly possesses, and the ends of the finger-joints of the pollices appear to terminate in minute articular surfaces, leading one to suppose that those joints supported terminal claws. As far as my material goes the skeleton of the limbs offers the following bones for examination. In the *pectoral extremity*—a humerus, the radius and ulna; two free segments in the carpus; the carpo-metatarsus; the phalanx of pollex; the two joints of index; and the very

small joint of the medius digit. In the *pelvic extremity*, there is found the femur; a patella; the tibio-tarsus and fibula; the tarso-metatarsus; and a foot composed of joints arranged on the plan of 2, 3, 4 and 5 joints to the first, second, third and fourth toes respectively.

In the pectoral limb the humerus is the only bone that enjoys a condition of pneumaticity, as is the femur the only one in the pelvic limb. With respect to the humerus the pneumatic foramina are very small indeed and scattered, being found in the shallow pneumatic fossa, and a few in the incisura capitis near the humeral head. In the femur they are very much larger and are found, as usual, on the anterior aspect of the bone just below the crest of the trochanter major. Apart from being somewhat longer and larger, the *humerus* of *P. ruber* is very like the humerus of *Bernicla canadensis*. It presents, though not to a very marked degree, the usual sigmoidal curvings of the shaft and extremities; the former being smooth and subcylindrical in shape. The "radial crest" is long and not very lofty, it being relatively higher in *Plegadis*, shorter, and more rounded. "Incisura capitis" is deep, and well separates the ellipsoidal humeral head from the tuberculum internum. The apex of this latter is flat in the Flamingo, whereas the tuberculum externum is rounded. The very reverse of these conditions obtain in *Bernicla; Plegadis* has both of these tuberosities, not flat, but slightly concaved. Again, as I have already pointed out, the pneumatic fossa in *Phœnicopterus* is shallow, and the foramina small and scattered. In the goose the fossa is also shallow. but the single air-hole is unusually large, deep, open, and more or less elliptical in outline. Both in the Ibis and in *Bernicla* we find a small nutrient foramen near the middle of the humeral shaft; this character is absent in the humerus of the specimen of *Phœnicopterus* at hand. At the distal extremity of the bone, the usual fossa found above the trochlear tubercles on the palmar aspect of the shaft is well marked and individualized in both Flamingo and *Bernicla*, but not so in *Plegadis*, where only a shallow, general concavity occupies the same site. Indeed, the characters found at this end of the humerus are quite the same in both the Flamingo and the Goose, with but one exception, for in the latter we meet with a well-marked circumscribed fossa of no great size, just above the trochlea ulnaris on the anconal aspect of the bone, which is not evident in the former nor in *Plegadis*. In *P. ruber* the humerus has a length of about 18.8 centimeters in the adult.

Neither the *ulna* nor the *radius* offer us with any unusual characters beyond what we find in the bones among the larger-sized waders. Each is slightly bowed from end to end along the continuity of the shaft; particularly is this true of the radius, where the character is pretty strongly marked. This latter bone is somewhat peculiar in having its entire shaft very much flattened upon its entire anconal surface, a feature not especially noticeable in either *Bernicla* or *Plegadis*. On the shaft of the ulna the row of tubercles for the quill butts of the secondary feathers, so conspicuous in many birds, are here apparently quite absent.

The *chord* of the radius has a length of about 19.8 centimeters, and the ulna measures a few millimeters more than 20. In the wrist the two usual carpal elements of the Flamingo present the common ornithic characters, and these depart hardly at all from the corresponding ones as we find them in the *ulnare* and *radiale* in the *carpus* of *Bernicla*. I have compared these two birds, articular facet for articular facet, border for border, fossa for fossa, and in general form I find them to be almost identically alike. In speaking of the skeleton of the pectoral limb of *Phœnicopterus ignipalliatus*, Parker has said "On the whole, this is a very perfectly formed wing, and is more like that of an Ibis than that of a Goose, as, indeed, is much of the structure of *Phœnicopterus*."[1] At one time I was inclined to concur in this opinion, but upon carefully comparing the skeleton of manus in *P. ruber*, *Bernicla canadensis* and in *Plegadis guaranna*, my former view of the subject has somewhat changed, modified as it has been by the examination of better material.

P. ruber has a *carpo-metacarpus* that measures about 9.5 cm. in extreme length, whereas that bone in *B. canadensis* usually measures a little less than 9 cm. In the Flamingo the long axis of the first metacarpal makes but a very slight angle with the long axis of the second or index metacarpal; in the Goose the same angle is more obtuse. In this little point the Flamingo and the Ibis agree, but in the Ibis the shaft of the third metacarpal is obviously bowed, while in both Goose and Flamingo it is nearly parallel with the shaft of the second metacarpal. At the distal extremity of the bone the fusion between the shafts of the second and third metacarpal extends further proximad in *Phœnicopterus* than it does in either *Bernicla* or *Plegadis*, and I observe this is also true of *P. ignipalliatus*, judging from Parker's figure in the article

[1] Ibis, April, 1889, p. 185. Science, Vol. XIV, No. 347, pp. 224, 225.

quoted above. That eminent authority in the same place invites attention to the rudiment of a fourth metacarpal in this bird, it being a mere tubercle situated at the proximal extremity of the third metacarpal on the palmar side of the bone. I find it also in *P. ruber*, but it appears to be absent in Geese and Ibises. Before I am quite satisfied, however, that this is the correct determination of this not very conspicuous tuberosity, I must have examined embryo Flamingoes at various stages of their growth.

The process called by Parker the "first distal carpal" is strongly developed, not only in *P. ruber*, but likewise in both Geese and Ibises. In all these birds the shaft of the second metacarpal is very straight and rather stout, being at the same time flat upon the anterior surface; it has about the same length as the third metacarpal. In *P. ruber* the proximal joint of pollex is long, much compressed from side to side, with a sharp anterior border. Professor Parker found that in *P. ignipalliatus* it supported distally a large claw, and I think very likely this also obtains in *P. ruber*, but it has been lost in my specimen.

In the case of the proximal joint of the index digit, aside from the fact that the bone is longer and more narrow in the Flamingo than it is in *B. canadensis*, they have precisely the same characters. Both have the dilated part of this joint very nearly flat, somewhat thickened and quite smooth upon either side. In *Plegadis*, however, it is very thin indeed, and distinctly divided into two fossæ by a thicker ridge of bone.

The second joint of index has much the same form as the digit of pollex but it is longer and somewhat twisted. It is probable that it supports distally a small claw, but it is, during life, enveloped in the skin, instead of being encased in a true horny theca, as in the case of the claw of pollex. This phalanx in *Bernicla*, that is the second one of index, develops proximally upon its antero-lateral border a very deep little tendinal groove, that comes very near being a closed canal; this character is not seen either in Flamingoes or in *Plegadis*. Finally, the phalanx of the third finger is short and small, being slightly curved, and when articulated *in situ* is closely pressed against the ulnar border of the expanded part of the proximal joint of index.

On the whole, there is a preponderance of the anserine characters in the skeleton of the wing of a Flamingo over the ibidine ones, but the excess is by no means very great..

Of the Pelvic Limb.—This species of Flamingo has, comparatively speaking, a short and very bulky *femur*. Owing to its high pneumatic condition, the dried bone is extremely light. It measures in total length 9.1 cm., while a femur of *Bernicla canadensis* I find to be 7.8 cm. long, and that of *Plegadis guarauna* 5.2 centimeters. The trochanter major is conspicuously developed, being broad externally, where it is powerfully marked by muscular lines and depressions, while antero-internally it curls upwards and forwards so as to be reared above the extensive articular surface on the summit of the bone. The globular femoral head is large, markedly sessile, with the diffuse excavation for the round ligament quite shallow. Turning to *Bernicla* we at once see that the proximal end of the femur is very different from this, for the caput femoris is relatively smaller, and the fossa for the ligamentum teres even less deep ; indeed, so shallow as hardly to attract attention at all. But a still greater difference is seen in the trochanter major, for in this Goose that process is a quite inconspicuous feature, not rising above the summit of the bone, and being but very slightly produced anteriorly. In *Plegadis* the trochanter major is sharp and thin-edged, and by no means well-developed—in fact the femur of this Ibis differs very considerably from that of the Flamingo in most of its characters. Passing to the shaft of the bone in *Phœnicopterus* we find it to be nearly *cylindrical* and straight, with the surface exhibiting a peculiar roughness, and the chief muscular lines powerfully marked. Especially is this latter the case on the posterior aspect where they run down to the internal condyle. At the distal end, the condylar protuberances are particularly massive and bulky, with their anterior crests conspicuously developed, wide apart, and nearly parallel to each other. All this gives a spacious "rotular channel," which below merges into the intercondyloid fossa. The long axes of the anterior condylar crests each make an angle with the long axis of the shaft. These angles are very nearly of the same aperture, owing as we have said, to the crests being nearly parallel, and they open, widely obtuse, internally. In other words, when the femur is articulated *in situ*, the condylar end of the bone exhibits a *bending towards* the mesial plane of the trunk. The external condyle has double the bulk of the internal one, is lower on the shaft, and presents an immense fibular cleft posteriorly with its inner part greatly produced backwards. Comparatively speaking, the popliteal depression is not so well marked as it is in *Bernicla*, there being scarcely

any excavation at all. Posteriorly, in the case of the Flamingo, the external condyle comes up higher on the shaft than the smaller internal ones, while in the Goose their extension in this respect is about equal. At the usual sites we observe that the pits into which the ends of various tendons and ligaments are inserted during the life of the individual, are circumscribed, and very distinctly marked.

A good sized *patella* is present in the pelvic limb of *Phœnicopterus*, it being nearly a centimeter and a half long, and about half as wide. It is roughened on its antero-convex surface, but quite smooth upon its postero-concave aspect. These sesamoids are thoroughly independent of any connection with the tibio-tarsus of either side, being simply encased in the tendon of the great extensor muscle of the leg, in the usual manner.

The nearly straight *tibio-tarsus* is of great length, measuring fully 33.5 cm. The summit of the bone is but slightly excavated for the internal condyle of the femur, while the facet for the external condyle is convex, oval in outline, and situated at the external angle of the head of the bone. When the shaft is held in the vertical position, this facet looks upwards, outwards, and slightly backwards. The cnemial crest rises somewhat above the tibio-tarsal summit, being composed chiefly of the procnemial process, which is large, oval, with its upper part bent abruptly over to the outer side, while below it is not at all extended down upon the shaft, from which it is produced directly forwards. On the other hand, the ectocnemial process is produced directly outwards ; is smaller than the procnemial, triangular in outline, and terminates in a blunted angle externally. It also fails to be at all produced down upon the shaft of the bone. The fibular ridge is comparatively short, and but slightly produced. For its proximal third, the shaft of the tibio-tarsus is somewhat antero-posteriorly compressed, the surfaces being smooth. As we pass to the middle and lower thirds of the bone, however, it becomes more or less oblong upon horizontal section—the sides being flat, and the anterior and posterior surfaces more or less longitudinally grooved, especially the former. At the distal end we find the tibio-tarsal condyles, which are here reniform in outline, each being antero-posteriorly elongated, and slightly farther apart in front than they are behind. They project a little in the latter situation, and considerably so in the former, where they are thicker from side to side than they are elsewhere. The intercondyloid excavation is profound anteriorly, shallow below, and

deepens a little again behind. Above this intercondyloid concavity in front we meet with a distinct projecting abutment, supporting a small subcircular facette upon its lower aspect. This projection prevents the bending of the tarso-metatarsus upon the tibio-tarsus beyond a certain angle. This angle is about equal to a right angle, and when the two bones mentioned are brought to that position, being at the same time normally articulated, the mid-anterior process on the summit of the tarso-metatarsus comes in contact with the aforesaid facetted projection, and a further bending in that direction is prevented. To the inner side of this projection, we find the usual osseous bridge spanning the tendinal canal. The span is broad and thick, and the tendinal passage created by it of no very great calibre.

The *fibula* is perfectly free from the tibio-tarsus, measuring in length but a little more than one-third of that bone. As is so commonly the case among birds, it simply makes articulation with it along the fibular ridge, being held in its position during life by means of a ligamentous attachment. Its proximal moiety is stout and rather bulky, especially its head, from which latter part it tapers gradually to its free distal end; its lower third being markedly slender and of small calibre. The summit of the fibula is moderately compressed from side to side, and rather elongate in the opposite direction, thus giving to its articular surface on top an oblong outline. At the outer side of its shaft a well-marked pit with raised margins indicates the point of insertion of the biceps muscle. It is nearly opposite the middle of the long, narrow articular line found on the inner border of the bone, intended for articulation with the fibular crest of the tibio-tarsus.

Both in *Bernicla* and *Plegadis* the lower end of the fibula fuses with the shaft of the tibia; more particularly is this the case in the latter genus, than in the Goose, where the fusion is less firm. And this leads me to say that I see more points of resemblance, in other ways, however, between the bones of the leg of the Flamingo and *Plegadis guarauna*, than I do between the former and *Bernicla canadensis*. The projecting apophysis with its facet, which occurs anteriorly above the intercondyloid fossa of the tibio-tarsus, described above for *Phœnicopterus* is present in the Ibis but entirely absent in the Goose.

The *tarso-metatarsus* of *P. ruber* lacks but a little (2.2 cm.) of being as long as the tibio-tarsus. For the most part its shaft is nearly

straight, and it is only at the proximal third that a very slight curving backwards is to be noticed. The anterior surface of the shaft is strongly grooved in the longitudinal direction for its entire length; this is also the case on the hinder aspect, but here it does not commence for at least two centimeters below the hypotarsus, and gradually dies out, for a little more than that distance above the trochlea. Laterally, either side of the shaft is flat and quite smooth.

Passing to the proximal end of the bone, we find on the summit two deep, subelliptical excavations, well separated mesially, for the reception of the condyles of the tibio-tarsus. In front, and standing directly between these on the anterior margin is the usual intercondyloid process—here more than commonly conspicuous. Below this, anteriorly, the proximal beginning of the shaft is somewhat excavated, and this concavity harbors a double tubercle for the insertion of the tibialis anticus. Above these are two foraminal perforations, which pass to emerge one upon either side of the hypotarsus behind—the outer one being considerably larger than the inner one. Their course is oblique from above downwards. The hypotarsal process is very pronounced, but does not extend down upon the shaft behind. It consists of two oblong plates, placed vertically as usual, with a wide, deep passage between them for the accommodation of the tendons at the back of the bone. Three trochlear processes are found at the distal end of the shaft, and they are all well developed. The middle one, which is very large, is the lowest one on the shaft—the outer one next, and the inner one is highest of all. The outer and inner ones are produced well backwards, especially the inner one, which holds in the main a decidedly posterior position. A deep notch separates the middle and outer one, and above this notch, in the longitudinal groove there found, is the single, and large antero-posterior perforating foramen for the anterior tibial artery. Very feebly marked indeed is the articular facet, for the articulation of the free, first metatarsal. Indeed, in the Flamingo, as in the Ibises, the latter is simply hung to the bone by means of ligamentous attachments, without making any true articulation, as it does in so many other groups of birds.

Swans, Ducks, and Geese have, in so far as I have examined them, a very different tarso-metatarsal bone from the one I have just described for *P. ruber*. Upon comparing the latter, however, with the tarso-metatarsus of *Bernicla canadensis*, we find that the trochlear processes at the distal extremities resemble each other in some particulars, but

not in all. On the other hand, when we come to compare the tarso-metatarsus of *Plegadis* with the corresponding bone of the skeleton in the Flamingo, we find the agreement of characters to be greater in number than in the case of the Goose. In each the form of the hypotarsus is essentially upon the same plan, as is the summit of the bone and the articular depressions found there. At the distal ends, the trochlear processes are more or less alike also, but in the Ibis there are two perforations, one above the other, for the passage of vessels (and nerves?) to the sole of the foot. The lower opening of the more distal one of these is to be found at the base of the notch that separates the middle and outer trochlear projections.

The foot of the Flamingo has the usual four fully developed toes, and they possess from hallux to the outer one 2, 3, 4, 5 joints respectively. The basal phalanx of the hallux is inclined to be slender as we find it in many Ducks and Geese; while the basal phalanges of the three anterior toes, are very much stouter and stronger, the middle one having a length in the foot of the individual I am examining of 4.9 centimeters. In the outer toe the three joints following the basal one are small, for the most part short and weak, the ungual phalanx of this toe being more compressed than they are seen to be in the middle and minor toes where they are short and decidedly stumpy. The ungual claw of the hallux is considerably longer, being at the same time distally pointed, and very nearly straight. The second and third joints of the middle toe are stout and have the appearance of being somewhat compressed from above downwards, especially at their distal ends. The second measures but 2 centimeters in height, and the third one is just half as long. Coming to the *inner toe* we find its basal and second joints to be well proportioned, being neither specially short, nor long, nor stout, nor slender; the second one measures more than half the length of the basal one, while their extremities are enlarged and present us with the usual form of articular surfaces there found in those phalanges in the ordinary ornithic type of foot.

Now, for one to say whether this skeleton of the pes in *Phœnicopterus* is on the plan of structure of the Goose, or Ibis, is very difficult. The truth of the matter is it is neither one, nor the other, but probably has an extraction of both in it, and this has given it a particular facies quite its own. For my part, I am inclined to think there is considerably more Ibis in it than there is Goose, inasmuch as the tibio-tarsus and tarso-metatarsus of the Flamingo agree in characters far better with those

bones as we find them to occur in any ordinary Ibis, than they do with the corresponding parts of the skeleton of any anserine fowl at present known to me. Likewise it is a significant fact that the tarso-metatarsus of the Flamingo is so very like that bone in such a bird as *Tantalus loculator*, and this applies only in a very slightly less degree to the tibio-tarsi of those birds.

ON THE SYSTEMATIC POSITION OF THE FLAMINGOES.

From what has been said above in the course of my observations upon the Osteology of *Phœnicopterus*, the reader no doubt is prepared to hear what I have to say on the taxonomy of these birds. I take the Flamingoes primarily to form an independent group, or suborder, for which the name ODONTOGLOSSÆ may be retained. This group corresponds exactly with Huxley's *Amphimorphæ*, and I believe Huxley was perfectly right when he decided that this was an intermediate group standing between the anserine fowls upon the one hand and the pelargo-ibine assemblage of forms on the other. Among the *Anseres* the Flamingo comes nearest to certain Geese than it does to the Swans, or some of the Ducks and Mergansers. To what existing genus of Ibis or Stork, however, it is more nearly allied I am not at present quite prepared to say, not having examined all the material necessary to come to a decision in the matter. The phœnicopterine stock may be pretty old; the present writer has described a Flamingo from the Equus beds of Oregon, and that tertiary fossil departed but very slightly from our existing *P. ruber*. Judging from its skeleton the Flamingo seems to borrow characters from a number of grallatorial forms, as the Spoonbills (Ajaja), the *Ibididæ*, and from *Tantalus*. If we take the genus *Ardea* as an example, however, I fail to find very much heron in the osteology of *P. ruber*, indeed, hardly any, and I am inclined to believe that it is pretty well removed from that stock among the *Herodiones*.

EXPLANATION OF PLATES.

PLATE IX.

Fig. 1. Skeleton of a Flamingo. (*Phœnicopterus antiquorum.*) Coll. U. S. National Museum, Washington, D. C., U. S. A. No. 14,407. (Much reduced.)

PLATE X.

Fig. 2. Right lateral view of the skull of the Flamingo. (*P. ruber.*) Natural size from a photograph by the author. No. 18,494. Coll. U. S. National Museum, Washington, D. C., U. S. A.

PLATE XI.

Fig. 3. Basal view of the skull of an American Flamingo. (*P. ruber.*) Natural size, from a photograph by the author. Spec. No. 18,494. Coll. U. S. National Museum. Mandible removed.

Fig. 4. Superior view of the mandible of American Flamingo. Photograph by the author. Natural size. From the same specimen shown in Pl. IX, Fig. 1, and in Fig. 3 of this Plate.

PLATE XII.

Fig. 5. Right lateral view of the four coössified dorsal vertebræ of the skeleton of the American Flamingo, as well as the same view of the last free dorsal vertebra. (*P. ruber.*) Natural size.

Fig. 6. Same view of the three (3) coössified dorsal vertebræ of *Grus Americana* (?) (Marked incorrectly *Grus canadensis.* No. 820 Coll. U. S. National Museum, Washington, D. C.) Both figures from photograph by the author. Natural size.

PLATE XIII.

Fig. 7. Dorsal view of the pelvis of the American Flamingo. (*P. ruber.*) Natural size, adult. (Photograph by the author). Spec. No. 18,494. Coll. U. S. National Museum.

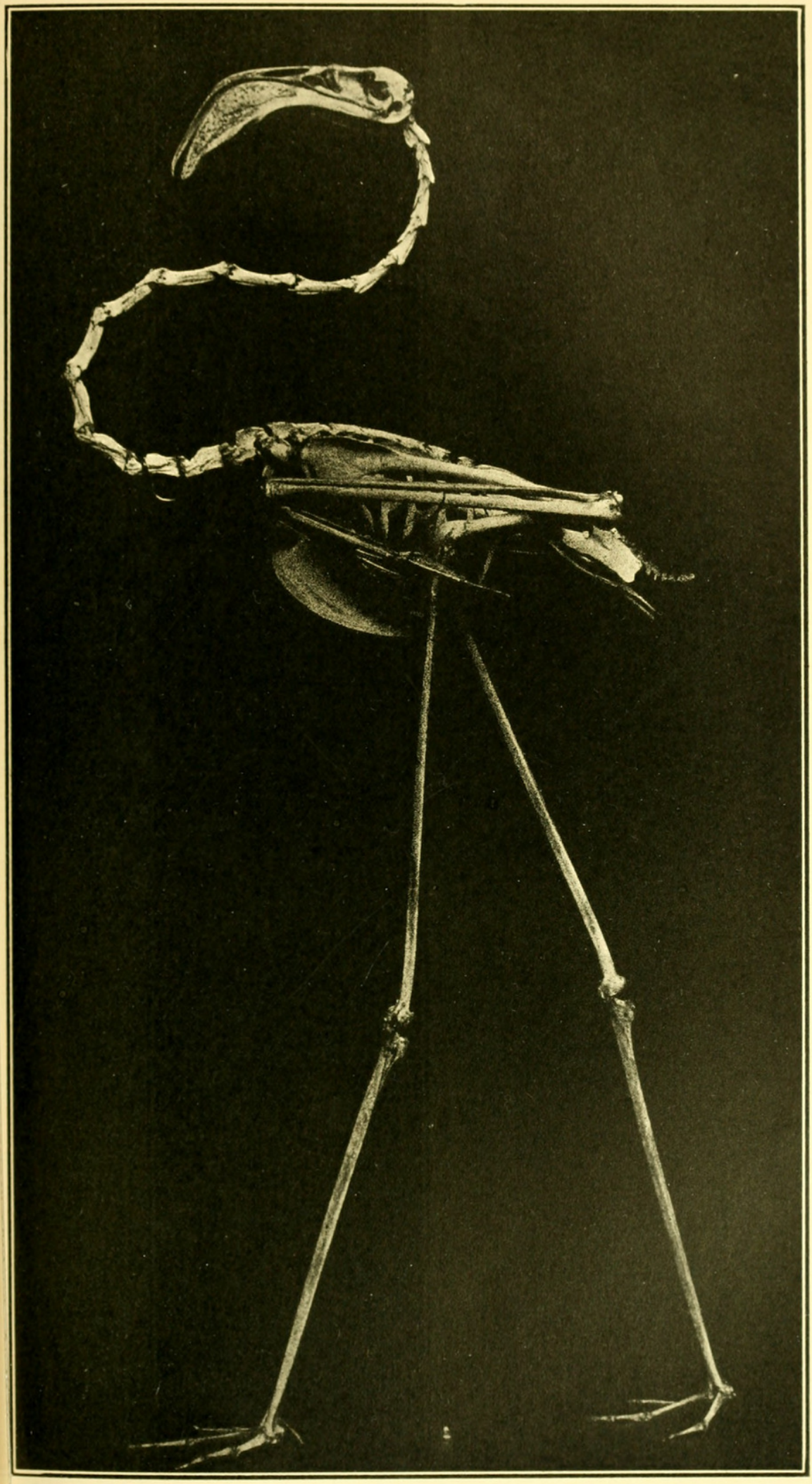
PLATE XIV.

Fig. 8. Anterior view of the right coracoid of a Flamingo. (*P. ruber.*) No. 18,494. U. S. National Museum. Natural size.

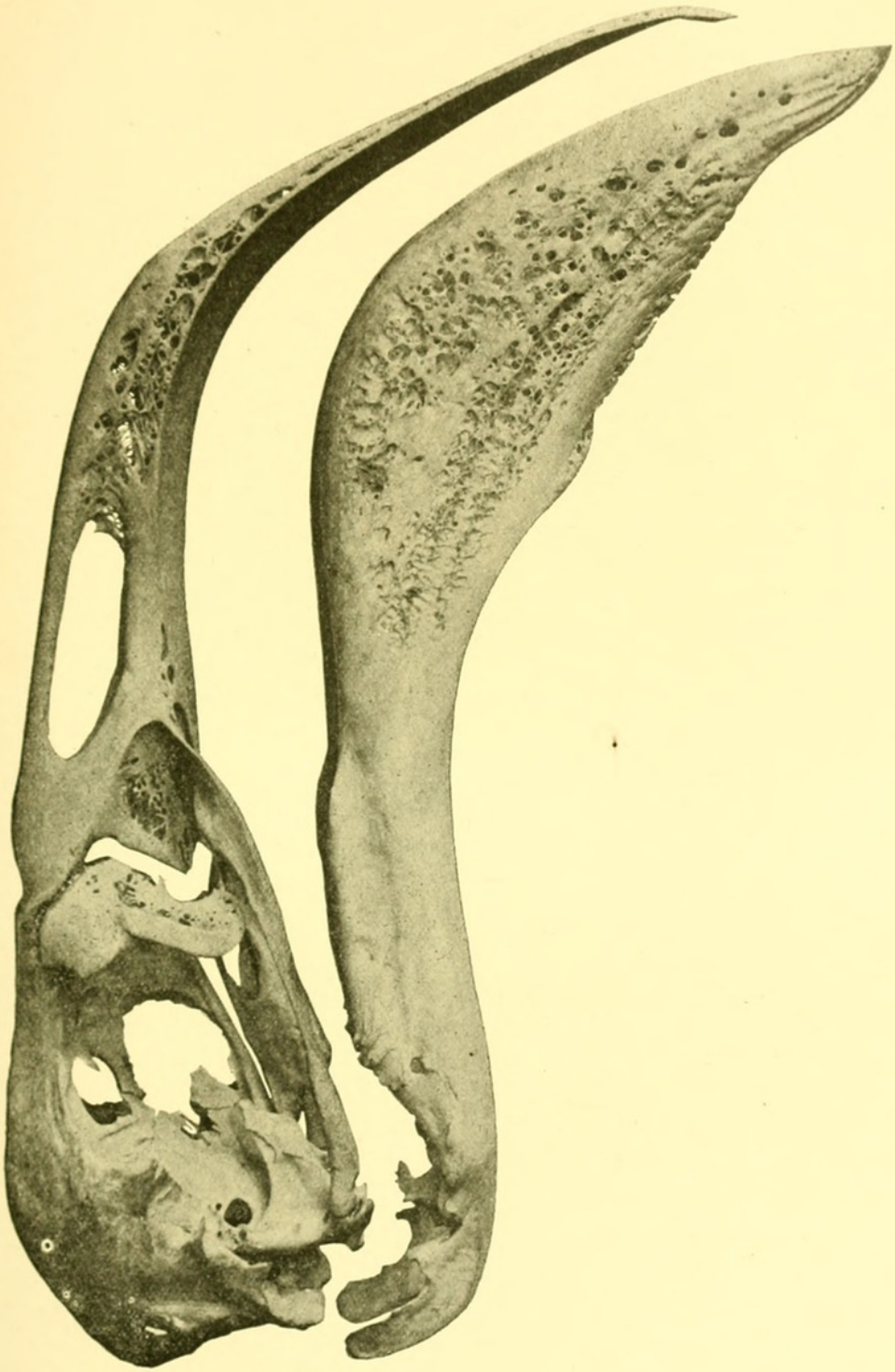
Fig. 9. Antero-oblique view of the furculum of the same specimen.

Fig. 10. Anterior view of the left femur of the same specimen.

Fig. 11. Subdirect ventral view of the sternum of the same specimen. All figures are of natural size, and from photographs made by the author direct from the specimens.



Osteology of the Flamingoes.



Osteology of the Flamingoes

Fig. 3

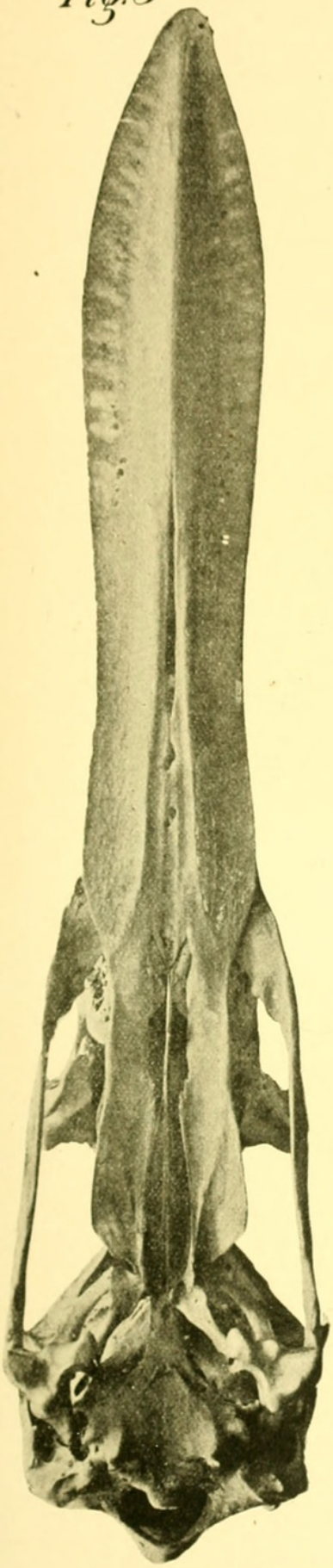
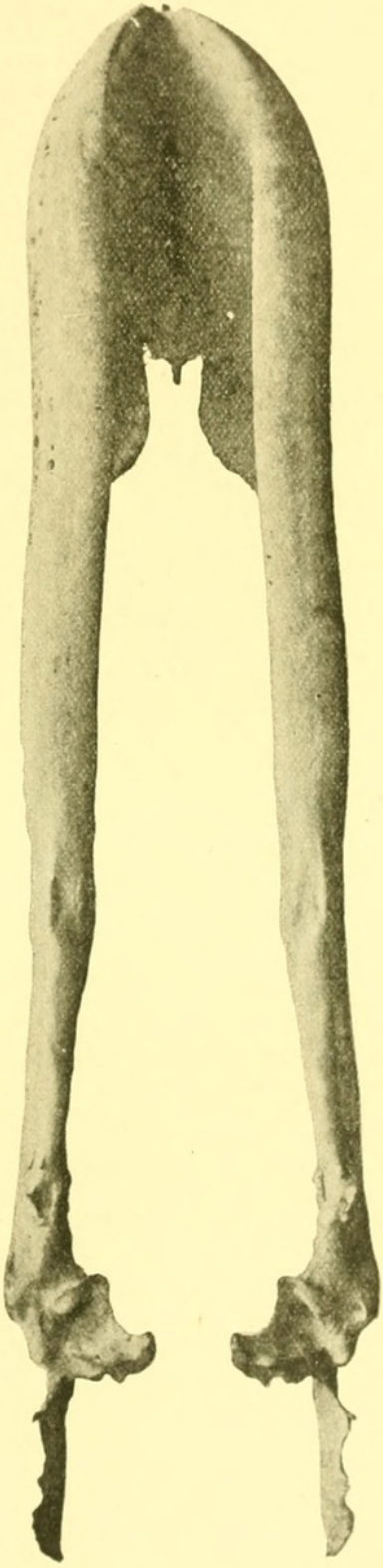


Fig. 4



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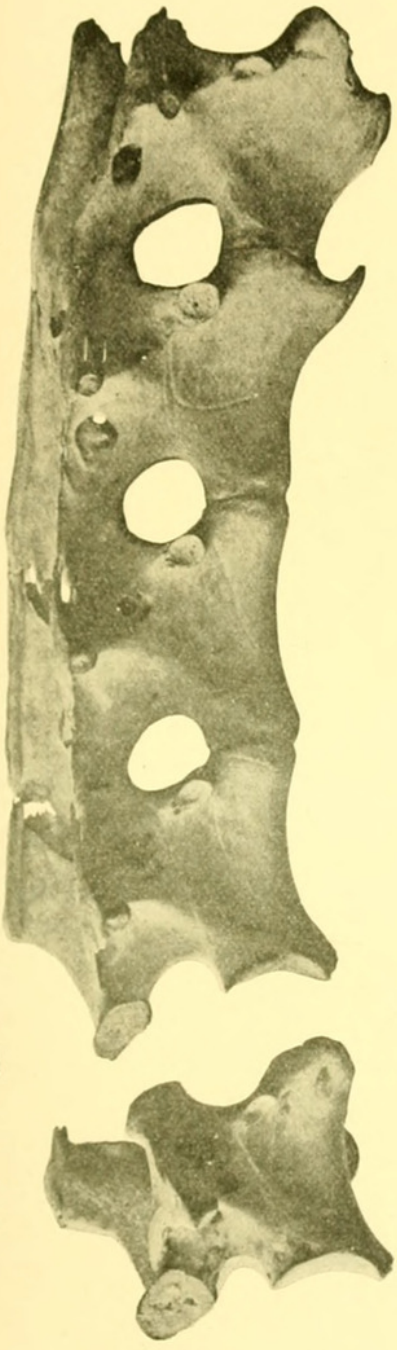

Fig. 5

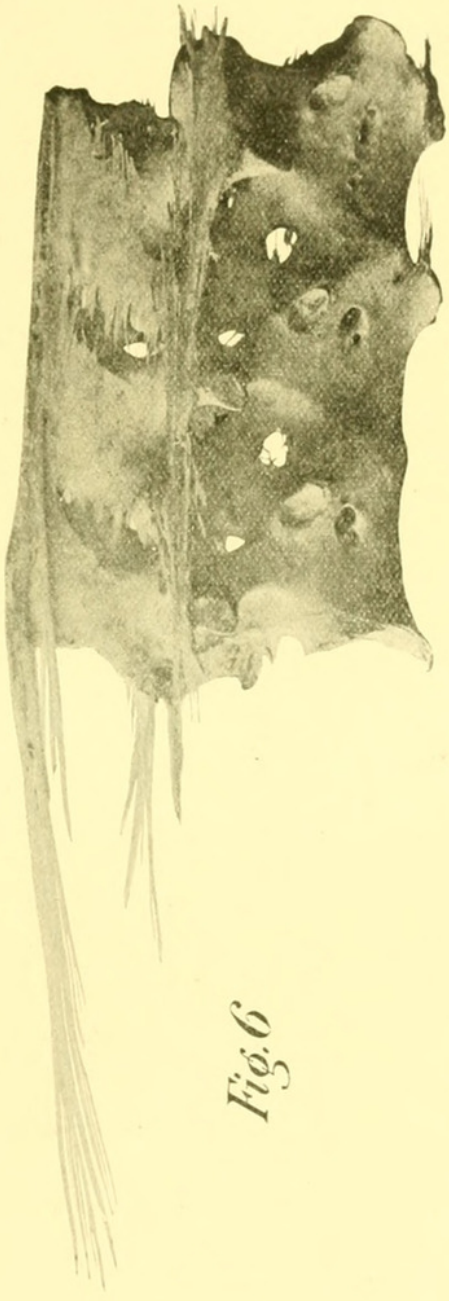

Fig. 6

Osteology of the Flamingoes.

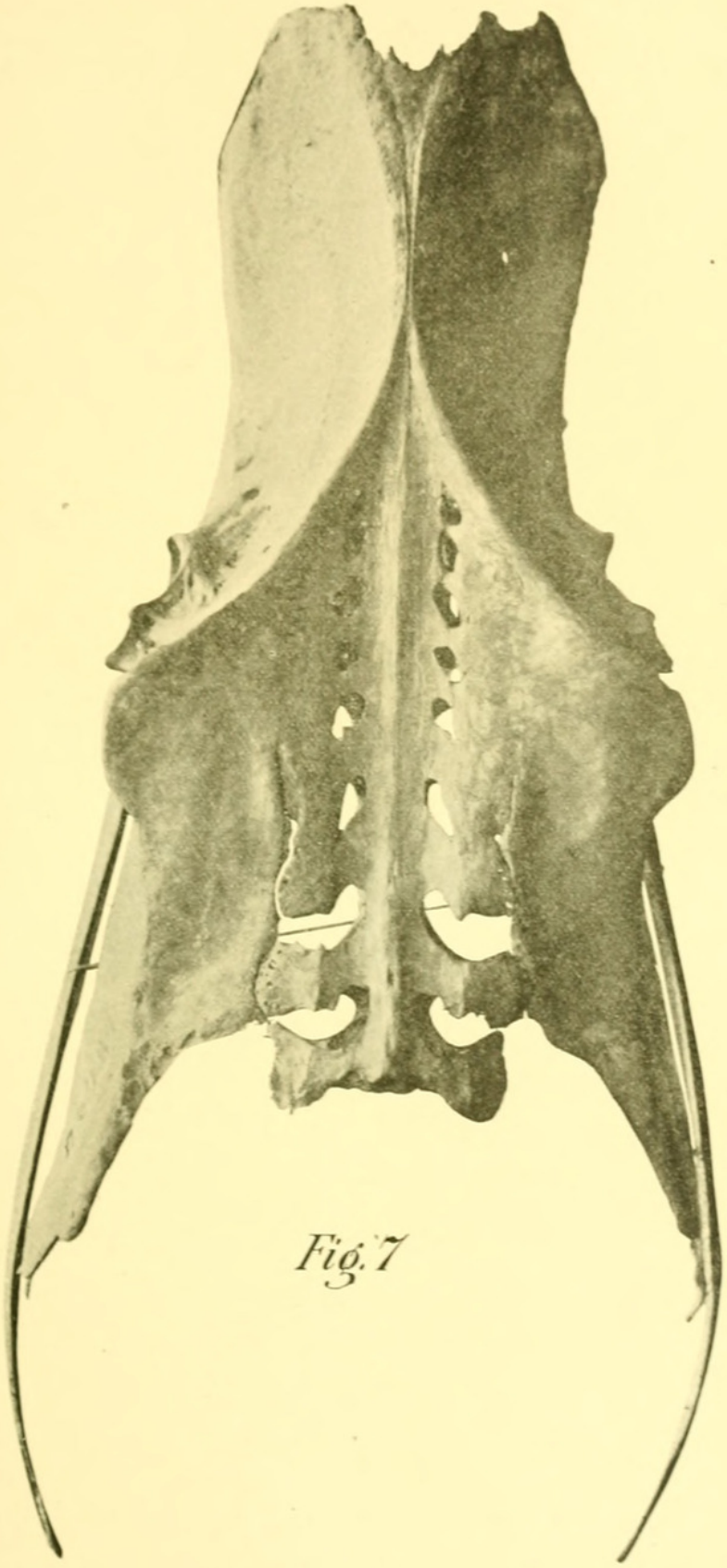

Fig. 7

Osteology of the Flamingoes.

Fig. 8

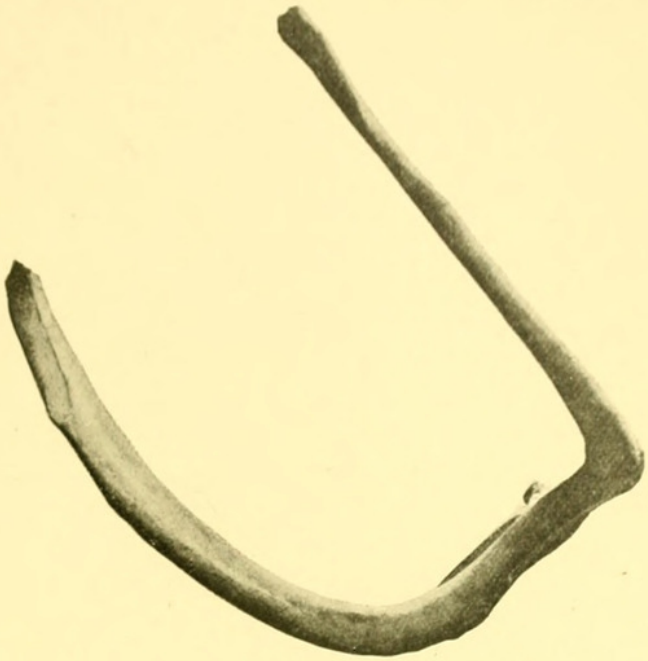

Fig. 9

Fig. 10

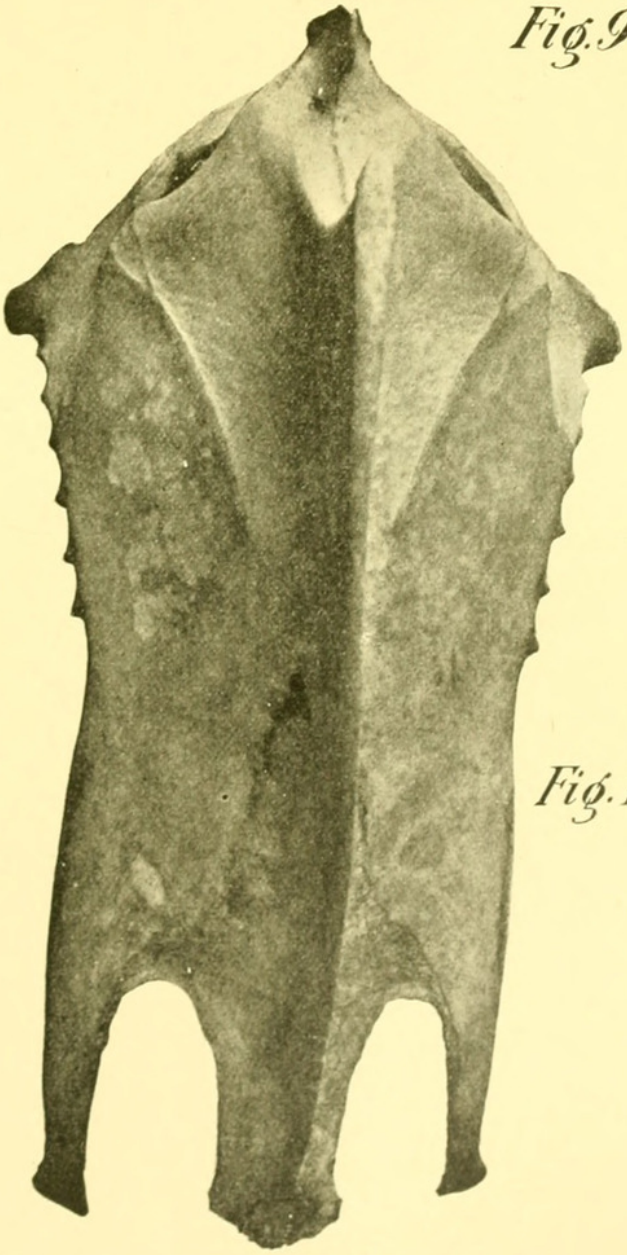

Fig. 11

Osteology of the Flamingoes.