V. OSTEOLOGY OF THE HERODIONES.

By Dr. R. W. Shufeldt.

(Two Plates, V–VI, and 43 Figures in the Text.)

Introduction.

Ten or twelve years ago, as stated in the body of this contribution, I published my memoir on "Osteological studies of the subfamily Ardeinæ," and it appeared in two consecutive issues of *The Journal of Comparative Medicine and Surgery* of New York City. My material was somewhat limited at that time, however, and the place in which the memoir appeared prevented its being seen except by a very limited number of comparative osteologists. This being the case, the utility of the paper was to a great extent restricted, and it failed to be of the use to those interested in the osteology of birds that it might otherwise have been, had it appeared in some medium more distinctly devoted to such subjects. The work accomplished by me in the osteology of the Herons in that paper is incorporated in large part in the present contribution, but it has been almost entirely rewritten, and greatly augmented through my researches upon far more extensive material than I commanded at the time when my first work in the group was attempted.

Moreover, the present contribution aims to present the osteology of the entire suborder of the American Herodiones, and that in a comparative way, dealing with the representatives of the several genera of this country, and also with some of those of foreign avifaunæ. It also offers the taxonomical schemes of not a few distinguished writers who are authorities on the subject of the classification of birds. Finally at the close of the contribution is added the writer's individual opinion as to the probable place of the *Herodiones* in the system. It is hoped that a work, with which so much pains has been taken, so much material examined, digested, and illustrated, will prove helpful to the avian osteologist in particular and students of comparative osteology in general. Should this prove to be the case my object will have been attained, and my labor more than repaid.

R. W. S.

Washington, D. C., 5th Oct., 1900.

OSTEOLOGY OF THE HERODIONES.

The Herodiones are fairly well represented in the avifauna of the United States. For instance, in the family *Plataleidæ*, we find *Ajaja ajaja*, or the Roseate Spoonbill, a species now nearly exterminated in this country. Of the family *Ibididæ*, or the Ibises, we have two genera, each containing two species, namely *Guara alba*, *Guara rubra*, and *Plegadis autumnalis* and *P. guarauna*. The family *Ciconiidæ* is represented only by the Wood Ibis (*Tantalus loculator*), though it has been claimed by some that the Jabiru (*Mycteria americana*) has been known to occur on this side of the Mexican border. Of the Bitterns and true Herons we have quite a number. The former are represented by two genera, *Botaurus* and *Ardetta* and three species, *B. lentiginosus*, *A. exilis* and *A. neoxena*; while the latter are contained in the two genera *Ardea* and *Nycticorax*. Of *Ardea* there are nearly a dozen species, known as Herons and Egrets. *Nycticorax* contains two Night Herons, namely *N. n. nævius*, and *N. violaceus*. With the material that has been kindly loaned me by the U. S. National Museum, added to what is to be found in my own collection, I have this group, osteologically, well-exemplified. My chief regret, however, is that, at the present writing, I have not a complete skeleton of the Spoonbill, and only a sternum and shoulder-girdle of the Jabiru. During the past few years thousands upon thousands of Spoonbills have been slaughtered in Florida for the markets, by the most unprincipled of "feather-hunters" to gratify the demands of a barbarous fashion. The bodies of those birds are allowed to rot in the heronries where they are shot, stacked up in heaps,—yet for two years I have tried to secure even one skeleton for my present purpose, without success.

Overlooking all the classifications prior to 1867, we find Huxley in his taxonomy of Birds placing the three families, *Ardeidæ*, *Ciconiidæ* and *Tantalidæ* (Ibises and Spoonbills) in his group 3 or the *Pelargomorphæ* of his third Suborder, or the DESMOGNATHÆ, while Garrod in 1874 arranged them as follows:

Order III. CICONIIFORMES.

Cohort (α) Pelargi.
(β) Cathartidæ.
(γ) Herodiones.
(δ) Steganopodes. { Family 1. Phæthontidæ. 2. Pelecanidæ. 3. Phalacrocoracidæ. 4. Fregatidæ.
Cohort (ε) Accipitres. { Family 1. Falconidæ. 2. Strigidæ.

In 1880, the eminent ornithologist, Dr. Sclater, published a classification of Birds in *The Ibis*, and in it we find the "Herodiones" (Order VII), containing the three families, *Ardeidæ*, *Ciconiidæ* and *Plataleidæ*, and standing between the orders Steganopodes and Odontoglossæ. This is the prevailing opinion, and is very probably close to the truth, though some would be inclined, as Professor Newton, to bring them nearer to the Accipitres than to the Steganopodes, on account of the Storks, as they may be, perhaps, considered the point of departure from the Herodiones for the Accipitres.[1]

Dr. Reichenow in 1882 in his "Die Vögel der Zoologischen Gärten," arranged these families in the following manner:

Order VII. GRESSORES.
Family 26. Ibidæ.
27. Ciconidæ.
28. Phœnicopteridæ.
29. Scopidæ.
30. Balænicipidæ.
31. Ardeidæ.

And they were by him placed between the CURSORES and GYRANTES, or in his serial arrangement of families, *directly* between the *Pteroclidæ* (family 25) and the *Dididæ* (family 32). This view is quite unique, and probably quite as unnatural.

Doctor Coues in his "Key" places the HERODIONES as an order, between the Orders LIMICOLÆ and ALECTORIDES—the last containing the Cranes, Rails and their Allies. The Herodiones he divides into the four families *Ibididæ*, *Plataleidæ* (of a suborder IBIDES), *Ciconiidæ* (of a suborder PELARGI), and the *Ardeidæ* (of a suborder HERODII). This essentially agrees in some respects with what we find in "The A. O. U. Code and Check List of N. A. Birds," which classifies this group as follows:

ORDERS.	SUBORDERS.	FAMILIES.
ODONTOGLOSSÆ		Phœnicopteridæ.
HERODIONES	Ibides	Plataleidæ. Ibididæ.
	Ciconiæ	Ciconiidæ.
	Herodii	Ardeidæ.
PALUDICOLÆ.	(With its divisions.)	

Stejneger places the "Herodii" (Order IX) between the Chenomorphæ (Order VIII) and the Steganopodes (Order X), and divides them thus:

[1] NEWTON. *Encyclo. Brit.*, 9th ed., Vol. XVIII, Art. "Ornithology," p. 47.

ORDER.	SUPERFAMILIES.	FAMILIES.
HERODII.	Ibidoideæ	Ciconiidæ.
		Scopidæ.
	Ardeoideæ	Balænicipitidæ.
		Ardeidæ.

Dr. Max Fürbringer in his great work which appeared in 1888 gives us the following as a part of his scheme of the classification of birds, where the Herodiones fall into the Subclass ORNITHURÆ.

ORDER.	SUBORDER.	GENS.	FAMILY.
Pelargornithes.	ANSERIFORMES.	GASTORNITHES, ANSERES or LAMELLIROSTRES.	Gastornithidæ. Anatidæ.
	PODICIPITIFORMES.	ENALIORNITHES.	Enaliornithidæ.
		HESPERORNITHES.	Hesperornithidæ.
		COLYMBO-PODICIPITES.	Colymbidæ. Podicipidæ.
	CICONIIFORMES.	PHŒNICOPTERI.	Palæolodidæ Phœnicopteridæ.
		PELARGO-HERODII.	Plataleidæ or Hemiglottides. Ciconiidæ or Pelargi. Scopidæ. Ardeidæ or Herodii. Balænicipitidæ.
		ACCIPITRES. (*Hemeroharpages Pelargoharpages.*)	Gypogeranidæ. Cathartidæ. Gypo-Falconidæ.
		STEGANOPODES.	Phaëtontidæ. Phalacrocoracidæ. Pelecanidæ. Fregatidæ.

In the part "Aves" of Bronn's Thierreich, Doctor Hans Gadow offers the following arrangement for the main divisions of the Class:

CLASS AVES.

1. UNTERCLASSE. ARCHÆORNITHES.
2. Unterclasse. NEORNITHES.

1. Division.	Neornithes	Ratitæ.	
2. Division.	Neornithes	Odontoleæ.	
3. Division.	Neornithes	Carinatæ.	

			Ordnungen.
1. Brigade.	1. Legion.	Colymbomorphæ.	Ichthyornithes. Colymbiformes. Sphenisciformes. Procellariiformes.
	2. Legion.	Pelargomorphæ.	Ciconiiformes. Anseriformes. Falconiformes.
2. Brigade.	1. Legion.	Alectoromorphæ.	Tinamiformes. Galliformes. Gruiformes. Charadriiformes.
	2. Legion.	Coraciomorphæ.	Cuculiformes. Coraciiformes. Passeriformes.

Doctor Sharpe[1] places the PELARGIFORMES (Order XX) between the GRUIFORMES (Order XIX) and the PHŒNICOPTERIFORMES (Order XXI) and classifies them in the following manner:

ORDER.	SUBORDER.	FAMILIES.
Pelargiformes.	Ardeæ.	
	Ciconii.	
	Balænicipitides.	
	Scopi.	
	Plataleæ	Plataleidæ.
		Ibididæ.

Upon comparing the views as to the position of the Herodiones in the system, as expressed in the classifications of these various distinguished authorities, it will be observed that Professor Huxley and Dr. Sclater practically agree in their propositions, while a greater or less degree of variance is seen to obtain with respect to all the others.

In July, 1889, the present writer published in *The Journal of Comparative Medicine and Surgery* (New York) a brief illustrated article entitled "Osteological Studies of the Subfamily Ardeinæ," which contained some considerable information on the skeletology of the Herons. The body of this memoir is herewith republished with its figures, as an initial groundwork for the present contribution. Later on I will supplement it with comparative descriptions of such other materials as have fallen into my hands since it was written. In the paper named the species selected for description was the Great Blue Heron (*Ardea herodias*), and after reciting the work done with the Herons by other authors, the osteology of this species was substantially given in the following words:

Of the Skull of Ardea herodias.—Upon superior view of the skull of this Heron, our attention is first directed to its long, narrow, and sharp-pointed bill. This has the outline of a lofty isosceles triangle, of which the base is the line made at the site of the cranio-facial angle, and its apex, the tip of the beak. This surface is pierced in several localities, notably near the apex, and in front of the nostrils, by minute foramina, while its sides and ridge are venated. The osseous culmen, owing to a linear depression on either side passing forward from the nostril, is in midregion semi-cylindrical, which convex surface is continued on the apex, while above the nostrils and the pre-cranio-facial region, though still convex, it is broader and flatter. The

[1] *A Review of Recent Attempts to Classify Birds.* Budapest, 1891, p. 75.

narial apertures are seen from this view, but their true form can best be described from a lateral aspect of the skull.

Across the cranio-facial articulation there is seen a transverse, depressed tract, some three or four millimeters wide, where mesially, the remains of the naso-premaxillary suture is still observable in the adult. This transverse tract is quite thin, and owing to the fact that the ethmoid stops abruptly behind it, beneath, on a line with its posterior boundary, it allows considerable movement in the vertical plane of the bill on the remainder of the skull. How free this is in life I cannot at this moment say, as I have not a Blue Heron in the flesh before me. This depression fixes the boundary very definitely between the frontal and postero-superior region of the upper mandible, and were it not for it, these two surfaces would be continuous, gradually merging into each other, which in fact they almost appear to do. The frontal region is broad between the superior margins of the orbits, faintly venated, and depressed longitudinally in the middle line.

In the skulls of *Sula bassana* and *Pelecanus fuscus*, specimens of which I have before me, this region is likewise very broad, but the median depression does not exist, it being but faintly marked in the parietal region in these birds.

Upon upper view of the skull of this Heron, we may also see the superior aspects of the long and large lacrymals. They fit closely to the sides of the frontals, and anteriorly encroach upon the external borders of each nasal.

The posterior orbital margins are pierced by a few minute foramina on either side, into which lead the larger venations coming from the parietal eminences. These latter are quite strongly marked here as they are in other Herons. Among the Pelicans and Gannets, however, this region is not thus distinguished. Still more posteriorly on this aspect we observe the very broad fossa on either side, known as the "crotaphyte fossa." The anterior margin of these fossæ passes directly across the skull, being simply interrupted in the middle line by a small triangular jog, with its apex directed backwards and continuous with the median line dividing the fossæ. Laterally, these fossæ pass out between the sphenotic and squamosal processes, occupying the entire space. Posteriorly they are bounded by the supra-occipital line, and a muscular line, on either side, leading to the squamosal process. (Fig. 1.)

This description of the crotaphyte fossæ of *Ardea herodias*, answers

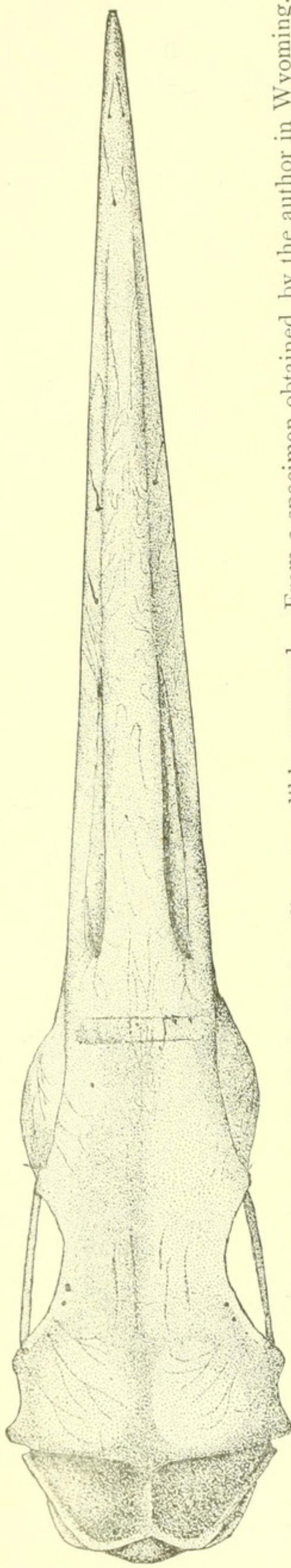


FIG. 1. Superior aspect of the skull of *Ardea herodias*, mandible removed. From a specimen obtained by the author in Wyoming. Same skull used for the figures of this Heron throughout the memoir.

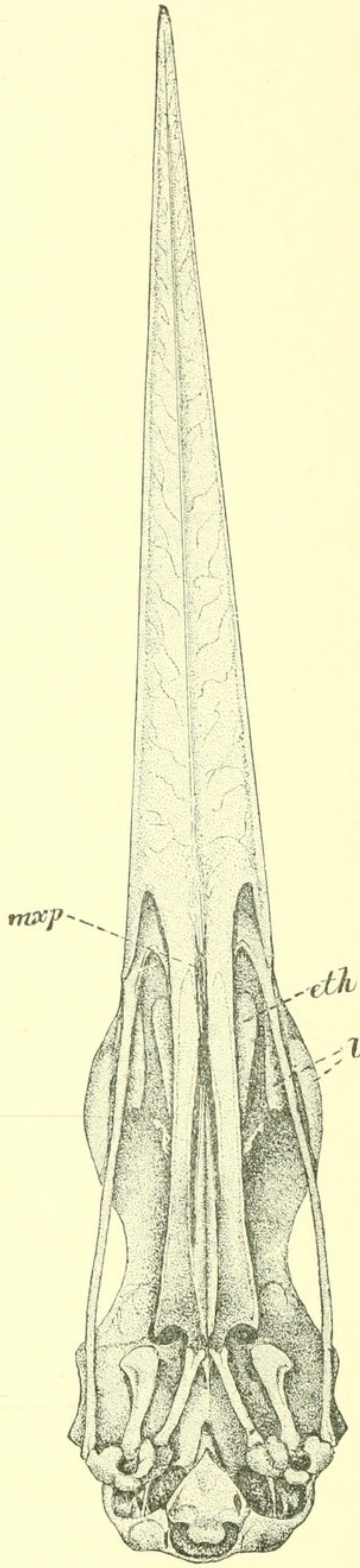


FIG. 2. Inferior view of the same, *mxp*, maxillo palatine; *eth*, ethmoid; *l*, lacrymal. Mandible removed. Both slightly reduced.

with equal exactness for the same depressions as found in *Ardea candidissima*, a specimen of which I have before me. In the Yellow-Crowned Night Heron, their forms differ materially, (Fig. 29), as well as their position. We observe in this species that these depressions are separated from each other in the median line by quite a broad isthmus, which meets the apex of the supra-occipital line. The region below this latter, presents a prominent, though rounded median crest. In the Night Heron, (*N. violaceus*), too, it can be said, that they are more on the posterior aspect of the skull, than on top. This fact is better appreciated by comparing the lateral aspects of the skulls of the two birds. (Figs. 1 and 28.)

I omitted to point out in passing the difference between the Blue Heron and *Nycticorax violaceus* in so far as the cranio-facial region is concerned, as seen upon this view. Referring to Fig. 3, we will see that the transverse depression described for the Blue Heron is not present in the Yellow-Crowned Heron, the region in the latter being occupied by a shallow concavity. The articulation is quite free, however, in the dried skull, and the relations of the mesethmoid are about the same as in the Blue Heron.

The skeleton of *Nycticorax violaceus* that I am using, is not that of an adult bird—it being "a bird of the year," which I collected at New Orleans, Louisiana, in July, 1883. But since this description was written I have come into possession of several skeletons of adults, and upon examination of them I find they fall within the account here given of the osteology of this species.

Upon a lateral view of the skull of the Blue Heron, the venated markings of the superior mandible become more evident, and the line leading forward from the anterior point of the nostril, is distinctly seen. As we would naturally be led to expect, the inferior and outer border of this mandible is a sharp cutting edge, from the point when it commences by the maxillary, all the way to the apex, and the bill as a whole tapers gradually from its base to this latter point.

The outline of the nostril is semi-elliptical, with a broad shelf of bone extending inwards from its lower margin, and becoming continuous with the general outside surface of the mandible, anteriorly. This shelf does not meet the fellow of the opposite side, as it very nearly does in the Yellow-crowned Night Heron. Behind, these shelves of bone are directly continuous with the maxillo-palatines. Above them, no nasal septum is present, and an aperture exists to the extent shown in Fig. 2. All traces between the *nasal* and contiguous bones have been absorbed, still such is the conformation of the skull, that one could predict with no little certainty, where their original sites were. Coues (Key, 2d Ed., p. 647) states that the "nasal bones are typically holorhinal" in the Herons, and so they are, according to the rule laid down by Garrod for deciding that question, that is, where "a transverse straight line drawn on the skull from the most backward point of the external narial aperture of one side to that of the other, always passes in front of the posterior terminations of the nasal processes of the premaxillæ." (P. Z. S., 1873, p. 35.) This rule, perhaps, will hold better as a guide, than the form the nasal bone assumes, for in this Heron there is an evident tendency on the part of its nasal towards schizorhinalism, its posterior narial margin, at least, being evidently distinctly angular, more so even than in *Daption capensis*, the skull of which Garrod figured, and which seems to have a similar tendency. So far as form is concerned, I observe the typical holorhinal skull in the *Gallinæ* generally—where the above noted rule also holds equally good.

Such *single* characters are of great service sometimes, to assist merely in determining a bird's position in the system, but it is hard for me to see how one could think of basing a classification upon such a trivial condition any more than we could upon the shape of the beak itself. Moreover, it would be of little use in such forms as *Sula*, where there is no nostril present, and certainly it would in some cases violently separate forms that in their general structure closely approach each other.

We find upon lateral view in *Ardea herodias*, a subelliptical aperture, that is bounded anteriorly by the nasal, posteriorly by the lacrymal, and below by the maxillary. Through it can be seen the upper parts of the maxillo-palatines. The lacrymals in this Heron are very large bones (Fig. 2); and the manner in which one articulates superiorly with the frontal and nasal has already been noted above. Anteriorly, the bone has a regularly concave margin, which bounds the aperture alluded to in the preceding paragraph. Below, a lacrymal rests rather more than its anterior half upon the maxillary, then is slightly raised above it to project backwards as a process with a transversely notched tip. Above this part of the bone there is a constriction which divides it from the larger and upper portion. The surface is smooth and the bone is highly pneumatic, air gaining access to its interior

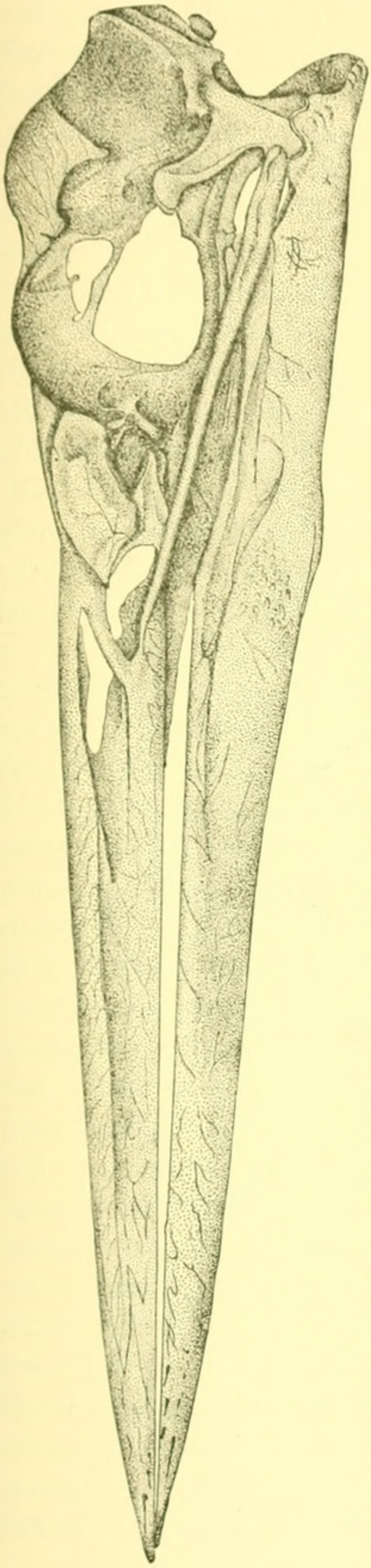


FIG. 3. Left lateral view of the skull of *Ardea herodias*. About three-fourths natural size.

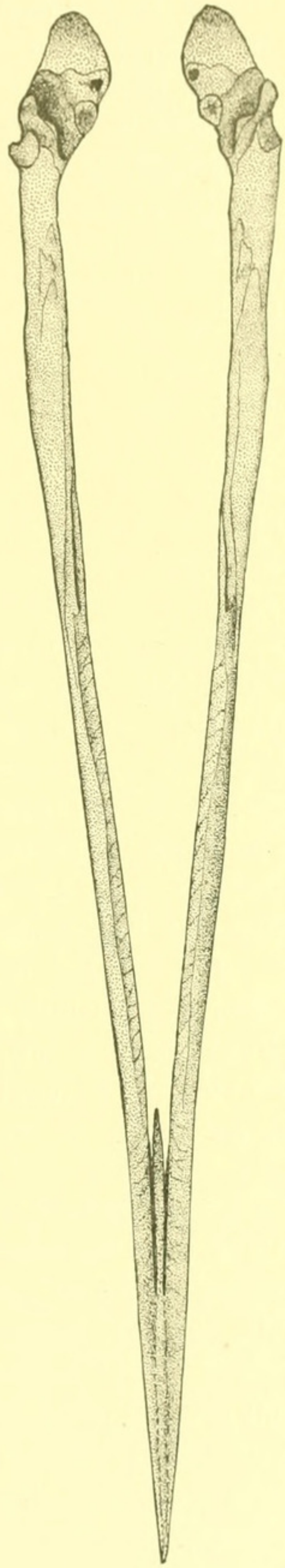


FIG. 4. Superior view of the mandible from the same skull. Reduced to about the same proportions. Drawn by the author.

through a large foramen on its mesial aspect. Owing to the broad frontals, the orbital roof is very complete, while its outer periphery is sharp and thin. This roof is quite horizontal in *Ardea*, as we see it in the Gannets, but it is inclined to be tilted up in the Night Herons, and consequently not shielding the eye so completely from above.

The ethmoid is an unusually thick and bulky bone; it spreads out a wide base for the frontals to rest upon, and its straight anterior upper margin bounds the cranio-facial hinge posteriorly; its anterior surface is broad, bearing a delicate medial crest, continued upon it from the apex of the rostrum. Its internal structure is cancellous, and air is undoubtedly admitted to permeate it throughout. At a point, on either side, half way between the rostrum and the roof, it supports a feebly developed wing, the lower spur of which meets the backward extending process of the lower and smaller portion of the lacrymal. Among such birds as the Gannets and Pelicans the ethmoid becomes lamelliform again, and it is not nearly as thick diametrically in the Night Herons as we find it in *Ardea*.

The middle third of the rostrum of the Blue Heron is a smooth cylindrical rod, which posteriorly is gradually projected from the sphenoid to merge anteriorly into the ethmoid. The inter-orbital septum is very incomplete, presenting one large vacuity, with which the foramina for the optic nerves have united, together with the smaller nervous foramina found in many birds on the outer side of the latter. Above this interorbital vacuity we note that the olfactory foramen is also very large, and the groove for the nerve leading forward from its anterior apex is faintly double. In my specimen of *Ardea candidissima* all these openings have merged into one immense aperture, permitting a full view of the interior of the brain-case. This individual is not fully matured, however, and such may not be the case in the adult Egret.

This does not hold good in the skulls of adult specimens of this Heron, for I find since writing the above paragraph, that the arrangement of these foramina in the crania of specimens of *A. candidissima* in the collection of Mr. Lucas as well as in those of this species in the U. S. National Museum, is quite as I have described it for his *A. herodias*. My thanks are due to Mr. Lucas for his courtesy in placing at my disposal the material to which I refer. From the same source I have been enabled to compare skulls of *Botaurus lentiginosus*, *B. exilis*, *Ardea occidentalis*, *A. egretta*, several of *A. candidissima*, *A. virescens*, *Nycticorax n. nævius* and *N. violaceus*, besides a few skulls and skeletons of Herons from foreign lands.

The olfactory foramen of the Yellow-Crowned Night Heron is exceedingly small, while in the specimen before me the groove for the passage of the nerve from it is single. The optic foramen, likewise, unites with the interorbital vacuity in *Nycticorax*.

The posterior orbital wall in the Blue Heron looks forwards, downwards and slightly upwards; it presents nothing of particular interest; the *foramen ovale* which pierces this wall at its lower part in many birds, has in the Herons moved round so as to appear on direct lateral view, just over the upper edge of the quadrate. Upon this aspect the dome of the parietal eminence is well seen in profile as is the crotaphyte fossa, with the muscular depression behind it.

All Herons present three processes for our examination on the side of the skull, these are, first, the squamosal process seen immediately above and rather in front of the head of the articulated quadrate; second, the sphenotic process defining the boundary of the crotaphyte valley above, and finally, another process just beyond the last, formed at the union of the outer angles of the frontal and squamosal bones.

Sutural traces among the bones composing the intraorbital bar have almost entirely disappeared; they can be made out only after careful scrutiny in my specimen of the Snowy Heron, which, as I have said, is not a fully grown bird. In the Blue Heron the line of union between the jugal and quadrato-jugal can sometimes be faintly recognized in the adult individual. This posterior third of the bar is broad and laterally compressed, and the articulation with the quadrate a substantial one, by the usual cup and process joint. The jugal division of the bone is more slender, though also laterally compressed, and the anterior end of the maxillary portion, whose relation is to be described below, is horizontally flattened, though not very broad.

Several years ago Professor Parker found a "post maxillary" in the Emu, and subsequently discovered a similar segment in several of the Herons, as *Ardea garzetta*, *Nycticorax ardeola*, and in the Bitterns, as *Botaurus viridis* and *B. stellaris*.

This post maxillary is said to be situated or found behind the angle of the maxillary. I find no such bone in the specimens of Herons before me, and can add nothing to the statements of Professor Parker given above. It may be that the post maxillary is present in *Ardea herodias* but so far absorbed in the adult as not to be recognized, or if a free bone, it has undoubtedly been lost, as my specimens have been in my collection for several years. In either case, fresh material in the flesh, both young and adult, would be required, for me to examine and decide upon such a point.

The quadrate of the Blue Heron is a large and massive bone, and indeed, such is its character in all of the *Ardinæ* so far examined by me. Its head presents for our examination two distinct and elongated articular facets, separated by an abrupt and squarish notch. These facets occupy the inner and outer borders of the head of the bone, with their long axes parallel to the long axis of the skull; the outer one, which at the same time is slightly the larger, is in advance of the inner, a circumstance which makes it rather appear that this end of the quadrate was obliquely twisted. Anteriorly, the bone develops a broad lamelliform orbital process, which is flattened behind and convex forwards in front, and gently curved throughout, to the same degree as the posterior wall of the orbit behind it, though it does not touch the latter.

The apex of this orbital process of the quadrate is nicely rounded off, and the anterior surface immediately below its border looks almost directly forwards, a difficult thing to show in a drawing. (Figs. 2 and 3.)

Posteriorly, the shaft of the quadrate is pierced by a large pneumatic foramen, sufficiently large to permit one to see the trabeculæ spanning its hollow interior, from wall to wall. The massive foot of this bone presents for examination six articular facets. They are the following: 1. A facet upon the lateral aspect the usual cup for the ball and socket joint with the quadrato-jugal. 2. On the extreme outer side of the inferior surface, a sub-elliptical facet, separated from the remaining four by a deep valley. This facet is the largest of the group; its anterior end is innermost, and it is intended to articulate with a corresponding surface on the mandible. 3. A smaller elliptical facet, with its axis parallel to the last, situated immediately across the valley referred to above. This is the lowest facet of the group, the skull being held with its superior surface, upwards. From the outer side of this facet a concave articular surface is carried down, to extend partially across the anterior margin of the intervening valley. 4. A posterior elliptical and smaller facet, higher up on the bone than either 2 or 3, being directed somewhat backwards. A concave, narrow, articular isthmus connects this facet with No. 2, occupying the posterior margin of the intervening valley. 5. A large circular facet occupying the surface of the inner aspect of the foot of the quadrate, directed downwards, backwards and inwards, the skull being held as above. This facet is separated from 3 by a distinct valley. 6. On the inner angle of the foot of the quadrate, a small circular facet, directed forwards and upwards, intended for the cup on the posterior extremity of the pterygoid. All these articular surfaces except the first and last, have corresponding elevations or depressions for their insertion on the articular end of the mandible, and I have risked the danger of being considered a "dweller upon details" in order to show what an extensive array of facets the foot of this bone supports, and how complicated a surface it offers to the articular extremity of the mandible. I believe, that a careful study of these facets, in the Class birds, will some day afford us an additional series of facts that can be used with advantage in classification.

The maxillo-palatines, the palatines, the pterygoids, and the condyle of the occiput, can all be seen on direct basal view, but these I have reserved to describe in the two remaining aspects of the skull.

Seen upon inferior view of the skull, the superior mandible presents an unbroken horizontal surface. This is bounded on either side by its sharp edges, while its middle and longitudinal line is defined by a delicate and slightly elevated crest. At irregular intervals on either side of the latter, minute foramina occur, from which spring branching concave venations, directed forwards and outwards to the lateral edges. (Fig. 2.)

The dentary processes of this premaxillary bone are directed backwards, with pointed apices to overlap the major part of the horizontal plate of each maxillary. Anteriorly, the palatines merge imperceptibly into the premaxillary, rendering it impossible in the adult Heron to define the exact line of union, their inner margin also uniting with each other, in a like manner, as far back as the middle point on the inferior border of a maxillo-palatine. Here abruptly an interval occurs between them, through which we may see the hinder half of the latter bones and the lower border of the vomer.

Still more posteriorly they become doubly carinated, the posterior angle of the outer keel being bluntly pointed. At the mergence of these keels behind, we find the articular heads for the pterygoids, the upper surfaces of both ride the under side of the rostrum.

Now the inner sides of the inner keels of the palatines are produced forwards to merge into the vomer in a sharp point beyond, thus forming in conjunction with this bone a long doubly carinated process, in the median line, opposite the middle thirds of the palatine bodies.

This process forms a part of the lower margin of the vomer, which, as I have said, it really is. The median plate of the vomer rises above this and extends beyond it, to project slightly into the interspace between the maxillo-palatines. The upper margin of this median vomerine plate is longitudinally split, as it were, and the two thin plates thus formed beautifully curl outwards and downwards, on either side, creating as they do so a median longitudinal groove on the upper aspect of the vomer, over the hinder moiety of which the apex of the rostrum hangs, and even, still more posteriorly, meets it in a free schindylesial articulation. The middle third of the inner border of the upper side of each palatine develops a broad crest that curls outwards all along its summit. On lateral view this crest hides the hinder half of the vomer.

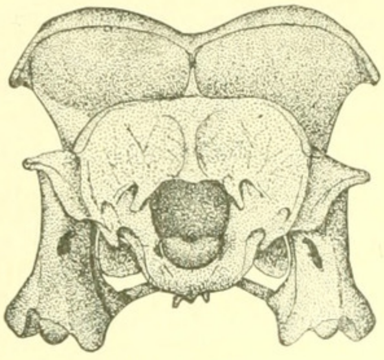


FIG. 5. Posterior view of the skull of *Ardea herodias*. Mandible removed. Natural size. By the author from the same specimen as the others.

The maxillo-palatines of *Ardea herodias* are of a highly spongy bone tissue throughout. This material imperceptibly merges into the more coarsely developed tissue of a similar character, which fills the hollow of the superior mandible beyond. Laterally, the maxillo-palatines may be said to spring from the anterior horizontal plates of the maxillaries, on either side ; such a fact is only known to us though from our knowledge of the development of these bones in other birds, for we would hardly suspect it here. The hinder halves of these bones rise parallel to each other, as lofty porous plates, which being produced forwards meet the inner sides of the nasals and the premaxillary to fuse with them. In *Nycticorax* these hinder moieties have a thin outer layer of compact bone tissue covering them which more or less masks their spongy nature.

In this Heron the relations subsisting among the palatines, the vomer, the rostrum of the sphenoid and the bones just described, are about the same as we find them in *Ardea*.

In both, too, we find that the median surfaces of the upper part of the inner carination of the posterior third of the palatines are closely applied to each other, so closely in fact that in dried skulls one has to resort to the knife to separate them before we are assured that direct union has not taken place, as we find it in the pelicans, gannets, and others, where the *entire* median surface of the inner carinal plates fuse to form one descending keel in the middle line.

My specimen of the immature Yellow-Crowned Night-Heron, shows this union to be of so firm a nature, that it would not surprise me in the least to find in an old adult of this species that perfect union had taken place between the parts of these inner keels of the palatines that come in contact behind. There is an excellent figure of the base of the posterior half of the skull of *Ardea cinerea* in Professor Huxley's memoir upon the classification of Birds in the Proceedings of the Zoölogical Society for 1867, Fig. 19, page 437.

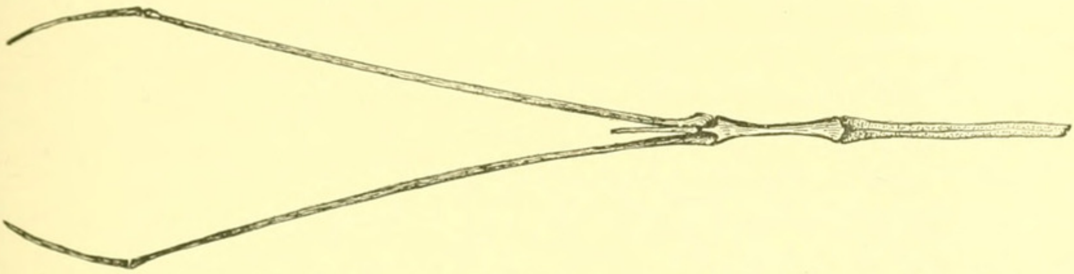


FIG. 6. The hyoid arches of *Ardea herodias*, viewed from above. Natural size, by the author from the same specimen as other figures.

It agrees in every detail with the skulls of other true Herons that I have before me, or have examined elsewhere. The pterygoid of the Blue Heron is a straight, stout bone, feebly crested upon its upper side, while its inner aspect is grooved for its entire length. Both ends are dilated, the anterior one to receive the palatine head of the corresponding side ; the other to articulate with the quadrate. Above this latter extremity a projection is developed, on the outer side of which is seen a large pneumatic foramen, which is double in some specimens. This bone is devoid of any sign of a process at the usual site where one usually develops to meet the baso-pterygoid apophysis when the latter is present. Other Herons have the pterygoids constructed in precisely the same way. I fail, however, to find the pneumatic foramina in the Night Herons in the same locality as described above for *A. herodias*, but no doubt a larger series of specimens would show it, as the same projection exists in the pterygoid.

In the Blue Heron the basisphenoidal region is elongated and develops a median keel which merges into the inferior surface of the rostrum just beneath the pterygoidal heads. The Eustachian tubes are guarded only by a thin over-arching lamella of bone. As in *Sula* and other forms the basitemporal area is much contracted, while in the dried skull the tympanic cavity is so exposed that no little care is requisite to locate its exact boundaries. The foramina for the pneumogastric, glossopharyngeal, hypoglossal nerves and internal carotid artery, relatively occupy their usual sites, as seen elsewhere in the Class.

Upon this inferior view of the skull we really see the under side of the occipital condyle, as its form and articular surface appear only in full view when the skull is looked at directly from behind.

This direct posterior view of a bird's skull is a very instructive one, a fact that was thoroughly appreciated by so talented an anatomist as Garrod, who presented us with a number of them among his valued papers, as for instance where he makes the telling comparisons among the skulls of *Chauna derbiana*, *Cloëphaga magellanica* and *Mitua tuberosa* (P. Z. S., 1876, pp. 189–200).

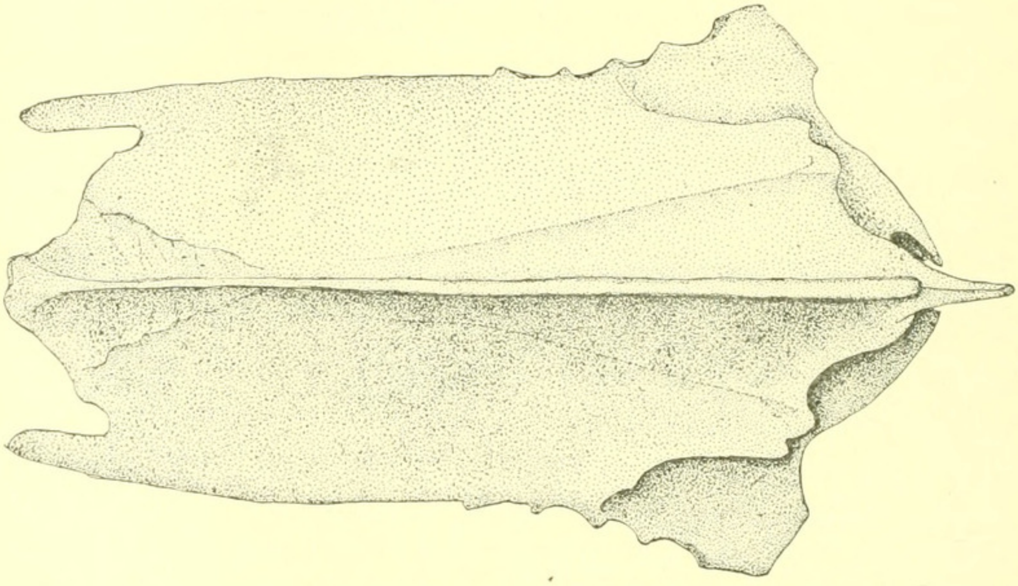


FIG. 7. The sternum of *Ardea herodias*, viewed from below. Natural size.

Such a view of the skull of this Heron is shown in Figure 5, where the broad crotaphyte fossæ are seen, separated from each other in the median line above by an exceedingly narrow space. The supra-occipital region stands out prominently, partially overhanging the subcircular foramen magnum. Regularly reniform, with the notch upwards, the large occipital condyle is here better seen, jutting directly backwards from its lower margin. Beneath, and in the middle region, the pterygoids and the four carinations of the palatines come into view. These are flanked on either side by the ponderous quadrates, which latter show the large pneumatic foramen in each, leading into their hollow interiors.

Above, on either side, the sphenotic process can be seen, pointing downwards, while below it the squamosal process juts out, and between the two, the crotaphyte fossæ pass to the lateral aspect of the skull.

In *Nycticorax* the supraoccipital region is carried to a point above, and is usually divided by a pronounced crest with rounded summit. A far broader strip separates the crotaphyte fossæ from each other in the median line.

The occipital condyle, although of the same shape, is relatively much smaller, and finally the posterior orbital peripheries can be seen peeping above the parietal domes, all these differences enumerated giving to these two skulls, even when only casually compared from this view, a very dissimilar look.

In a number of minor details, principally referable to relative position and form, the points for examination within the braincase present certain differences between the Night Herons and the genus *Ardea*.

All the essential characters in the skull of *Nycticorax n. nævius* agree with the corresponding ones in the skull of *Ardea herodias*, as they

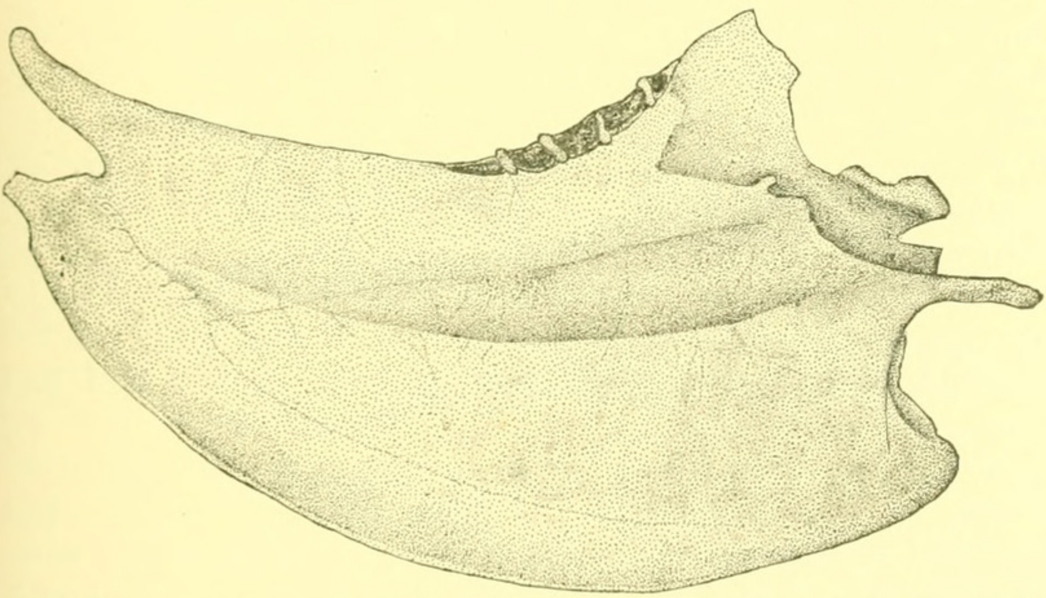


FIG. 8. Right lateral view of the sternum of *Ardea herodias*. Natural size, and same bone as shown in Figure 7.

have been described above. The skull of the former, however, is about one-fifth less in point of size than it is in the last named species. (See FIG. 29.)

The *mandible* of the Herons offers us a number of points of interest for our investigation.

In the Great Blue Heron (a bird that I have alluded to several times above as simply the Blue Heron) the outer border of either ramus of the mandible for nearly two-thirds of the distance back from the apex is very sharp, and along the middle third of the entire length of the bone, it is swelled just within this cutting edge, which enlargement has its mesial boundary developed also as a sharp border, parallel to, but on a lower plane with, the outer ramal edge.

The inferior ramal borders are rounded for their entire lengths, merging into the gently upward curved symphysial extremity anteriorly, to be extended behind to the very ends of the articular parts, while on each side they curve towards the median plane. On the external aspect of a ramus we see numerous minute foramina arranged roughly in two longitudinal rows. Some venated markings are also present. No ramal fenestra pierces this bone, where it occurs in many other birds ; but an oblique split plainly marks the site where it was sealed over during the development of the mandibular elements. This entire external surface is smooth and flat, becoming gently convex only as it sweeps beneath the articular ends behind. As I have said, the posterior third of the superior ramal border is somewhat flattened with rounded inner and outer margins. To the rear of the middle of this third, the fairly well-developed coronoid processes are seen. They consist of a series of three points in a row, on each side, one behind the other, the anterior being the largest, the other two gradually diminishing in size.

The mesial aspect of either ramus is longitudinally concave for its anterior third, while behind, it becomes flattened, to finally pass beneath the articular extremity, facing, as it does so, downwards and towards the median plane.

Viewed from above, we find the symphysis concave and more than a sixth the length of the bone. In the median line behind, between the ramal sides, it sends backwards a spike-like process, nearly 2 cm. long, which we may call the *posterior symphysial process*, this is present in *A. candidissima*, but absent in some specimens of *Nycticorax*. We also see it in very old Albatrosses.

The articular ends above, are generally concave, but two small convexities occur on the oblique line that crosses in front of the central pit. A circular pneumatic foramen is seen at about where it occurs in the majority of birds where it is present. The hinder ends of these articular extremities are obliquely truncate, (Fig. 5), the faces looking backwards, upwards, and a little outwards. In the Yellow-Crowned Night Heron these ends are cut squarely across, and are obliquely concave. In *A. candidissima* they are very much as in the Night Herons, though deeper from above downwards, less concave, and face rather more outwardly. Otherwise the mandible of this Heron resembles in every particular the bone as found in the representatives of the genus *Ardea*.

As we might expect, it is built upon the same type also, in *Nycticorax*, differing in no very essential particular. It is proportionately shorter, stouter, and more obtuse; the ramal vacuity is filled in here also.

There seems to be no exception to the rule that all Herons have the glossohyal of the *hyoid arches* in cartilage, (Fig. 6). Careful examination made with a good lens fails also to disclose to me the slightest trace of osseous tissue deposited in the cartilage of the cerato-hyals of adult specimens of *Ardea herodias*. This is equally true of *A. candidissima*, but in my immature specimen of *Nyctcorax* I find a distinct, though very small osseous cerato-hyal, on either side, embedded in the cartilage of the second visceral arch.

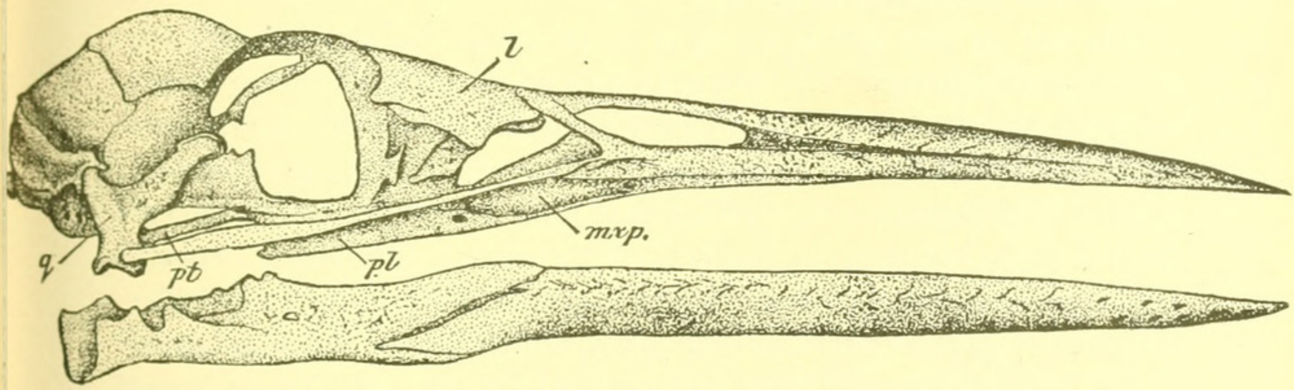


FIG. 8 *bis*. Right lateral view of the skull of *Nycticorax nycticorax nævius*. Natural size, adult; drawn by the author from a specimen collected by Dr. Streets at San Diego, California. *q*, quadrate; *l*, lacrymal; *mxp*, maxillo-palatine; *pl*, palatine; *pt*, pterygoid.

The first basibranchial is compressed from side to side in the *Ardeinæ* generally, with the posterior aspect of the hinder end fashioned to articulate with the anterior heads of the cerato-branchials, and the head of a slender styliform second basi-branchial of no great length, which rides above them in the median line. Each cerato-branchial is a long delicate rod of bone, in old individuals often attaining a length of 5.8 cm., while the epibranchials rarely exceed a centimetre and a-half in length, are very slight, and have their hinder ends prolonged by needle-like tips of cartilage, a condition which also obtains with the end of the second basibranchial or urohyal.

A specimen of the Snowy Egret before me has the bony parts of the ear so well preserved that I am enabled to see the elliptical stapedial plate, and the delicate bony rod of the mediostapedial part of the apparatus. The sclerotal plates of the eye are elongated and rather narrow, they average from thirteen to sixteen in *Ardea herodias*.

Before entering upon the remainder of the axial skeleton, I will take this opportunity to further say that the tracheal rings also ossify as in other birds. Comparatively, the tube seems to be of small calibre, and I think one would rather be lead to look for a larger windpipe in so big a bird.

Of the Vertebral Column; Ribs.—(Figs. 25, 26, and 27.) In the Great Blue Heron the *atlas* is not large, when taken in comparison with the size attained by other vertebræ in the column, as for instance the nineteenth. Its cup for the condyle is notched above, and on either side of the neural arch superiorly, the usual blunt processes are thrown backwards (Fig. 25).

The *axis* of this bird is a very irregular bone, and a difficult one to describe without resorting to tedious detail. For this reason I have added to my illustrations a figure presenting the appearance of this bone on direct lateral view. It will be seen that the "odontoid process" is quite large, being perfectly flat above and convex below. The centrum is deep; thinned in its center by the lateral concavities, beneath which, its lower margin is carried by a gentle curve from the articular surface at one end to the articular surface of the other. An elongated neural crest adds another curvature to the bone above. The facets of the post-zygapophyses face directly downwards, and the entire bone is much compressed from side to side. From the third to the sixth, the vertebræ are much elongated; their general pattern being seen on side view in Fig. 27. Along the median line of their neural arches above, these bones are thin and sharp. Their several articular facets are so arranged that they only permit the head to be bent forward and back again.

The neural canal in them is small and circular on section. The "vertebral canal" is present in all, being longest in the third vertebræ and shortest in the sixth; owing to the manner in which the parapophyses assert themselves. This is done by a foramen, which exists opposite the middle of the canal in its lateral wall; this elongates in the vertebræ from third to sixth, in a backward direction until it cuts through the hinder and outer margin of the vertebral canal of the sixth vertebra. Then a long pair of parapophyses is the result, they being very short and blunt in the third, fourth and fifth vertebræ, and only become sizable in the sixth when overtaken and developed by the advance and breaking through of the foramen in the manner indicated.

A large covered "carotid canal" is seen in the seventh to the thirteenth cervical vertebræ inclusive; a slight deficiency taking place in the wall of the last, in the median line beneath (*A. herodias*). It is the most anterior part of each of these segments, and they are further characterized by being shorter and stouter than the last four described. The pneumatic foramina of these vertebræ are chiefly within the neural canal, piercing its upper wall posteriorly. From the fourteenth to the seventeenth inclusive, these vertebræ are gradually changing in form and character to resemble finally those of the dorsal region. The fifteenth is the first to show a high neural crest, with spreading diapophyses at the fore part of the vertebra, while the vertebrarterial canal increases in calibre.

The neural crests or spines of the seventeenth and eighteenth are thick and long, and interlock with each other by an extensive joint.

In the *eighteenth vertebra* we observe for the first time a free pair of pleurapophyses, with very short bodies, but still articulating by tubercula and capitula.

Professor Owen, in speaking of the movement of these vertebra of the cervical region upon one another, says: "This mechanism is most readily seen in the long-necked waders which live on fish and seize their prey by darting the bill with sudden velocity into the water. In the common Heron, for example, (*Ardea cinerea*), the head can be bent forward on the atlas or first vertebra, the first upon the second in the same direction, and so on to the sixth, between which and the fifth the forward inflection is the greatest; while in the opposite direction these vertebræ can only be brought into a straight line. From the sixth cervical vertebra to the thirteenth the neck can only be bent backward; while in the opposite direction it is also arrested at a straight line; from the fourteenth to the eighteenth the articular surfaces again allow of the forward inflection, but also limit the opposite motion to the straight line." (Anat. of Verts., Vol. II, p. 39.)

This is precisely what I find in examining the same vertebræ in the neck of *Ardea herodias*. It can best be studied in the neck of a fresh specimen from which the skin has been removed, with the skeleton of the neck of another individual at hand for comparison.

The skeleton of the neck in *Nycticorax* differs in many particulars from that of *Ardea*; a number of these points only become evident after careful comparison, and will not be taken up in detail here. Others show a profound difference in organization, such as—the first pair of free pleurapophyses occurring on the seventeenth vertebræ instead of on the eighteenth as in *Ardea*; the third, fourth, fifth and sixth vertebræ are not elongated as in *Ardea*, but show the simple gradation in size down the cervical chain: finally, the inferior wall of the carotid canal is open in the last four vertebræ through which it passes, in *Nycticorax*, and only in the last in *Ardea herodias*.

Returning to the nineteenth vertebra in the Great Blue Heron, we find that it has a high quadrate neural crest or spine which interlocks by a free joint with the one behind; it sends down a pair of ribs that articulate with the sternum through the intervention of a pair of costal ribs. The metapophyses are short and stumpy, barely reaching beyond the transverse processes. The bone has no descending hyapophysis, though a line marks the longitudinal center of the centrum below. This fades away gradually on the remaining vertebræ. A large pneumatic foramen pierces the bone, on either side, behind the transverse process, and the cavities to which they lead seem to occupy all parts of the bone.

In the next four vertebræ we see but little change; they are all free elements; the neural spines do not decrease any in height, but they become shorter from before, backwards, shortest of all in the twenty-third or the *last free vertebra*, before we reach those united as one bone in the pelvis. Through this "dorsal region" the neural canal of a Heron is strikingly small, even small in proportion with the size of the vertebra. The transverse processes are narrower antero-posteriorly as we proceed backwards, but at the same time reach out further from the side of the vertebra As we proceed towards the pelvis we note also that the facet for the head of the rib gradually approaches the anterior part of the centrum of each vertebra, but finally does not quite reach the anterior margin of the side of the neural canal in the ultimate segment. A line joins this facet in each case, with the facet for the tubercle of the rib, which is at the outer posterior angle of the diapophysis. On either side of the beam thus formed very large pneumatic openings are seen in these ultimate vertebræ, and the trabeculæ spanning the cavities within are plainly in view.

Four pairs of hæmapophyses articulate with the borders of the sternum in all of the Herons that I have thus far examined; the fifth pair not reaching this bone, but articulating with the hinder margins of the last sternal pair. The slender pair of ribs that claim this last pair of hæmapophyses articulate with the twenty-fourth vertebra and it is the first one that anchyloses to form a part of the pelvis.

The last two pairs of vertebral ribs are without epipleural appendages, and even when these processes do occur on the ribs they are very weak and freely articulated with the border. Herons have very frail ribs at the best, a fact that strikes one the moment we examine the thoracic skeleton of one of these birds.

The seventeenth vertebra having a small pair of free ribs in the Yellow-Crowned Night Heron, we find has a still longer and better developed pair on the eighteenth in this species, and yet another free pair on the nineteenth. These latter have epipleural appendages, although they do not meet the sternum by costal ribs below. This gives three pairs of free ribs to *Nycticorax*; four pairs, as in other Herons, that meet true sternal ribs; and a pair from the pelvis, to which is attached false floating ribs, or a pair of those that articulate with the hinder borders of the preceding sternal pair proper.

In *Ardea herodias* and *A. candidissima*, the second pair of free ribs support epipleural appendages, low down on the bone.

For the moment I must now be permitted to defer our further consideration of the vertebral column, until the sternum and pectoral arch have been disposed of. After that I will return to the examination of the pelvis and coccygeal vertebræ, upon the completion of which the appendicular skeleton will finally engage our attention.

Of the Sternum.—(Figs. 7, 8, 9, 31, and 32.) Upon direct pectoral view, the sternum of *Ardea herodias* is seen to be broader in front than it is behind; this is due to the projection from the former end of the large costal processes on either side, or otherwise the bone on this aspect would have a nearly regular quadrilateral figure.

The xiphoidal extremity is doubly notched—a broad triangular indentation deeply entering upon either side. This gives rise to outer xiphoidal processes, each of which point directly backwards, and have simply rounded extremities.

Evenly convex throughout, the sternal body shows but three pairs of lines upon this view—the pair of muscular lines of the pectoral

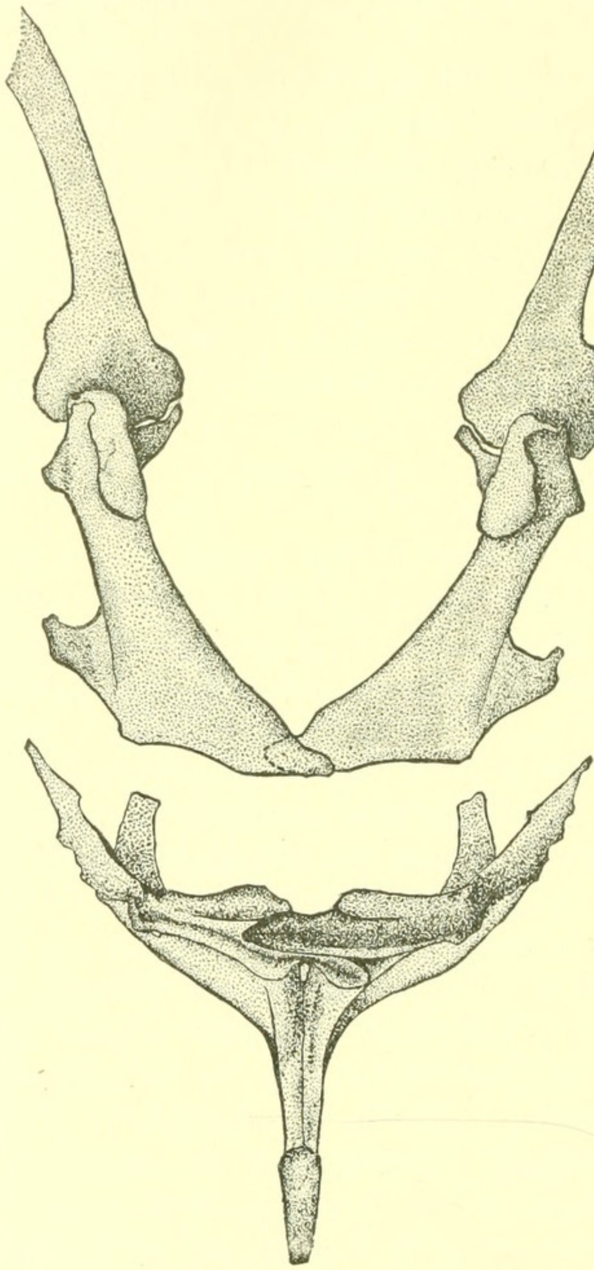


FIG. 9. Below is an anterior view of the sternum of *Ardea herodias*, showing the decussation of the coracoidal grooves. Above, lifted from their position, are the coracoids with dotted line showing the extent to which they decussate. The scapulæ are articulated above these, but the *os furcula* has been removed. Natural size, and the bones from the same specimen as Fig. 8.

muscles; the subcostal lines; and a pair, each one of which commences at the middle point of the inner border of the xiphoidal indentation, to be carried forwards and inwards to the carina, meeting the hinder ends of the pectoral lines.

Anteriorly, we are enabled to see the under side of the pointed manubrium, and the coracoidal beds, and gain some idea from the dissimilarity of the parts on the two sides of the former, of the method of decussation of the latter.

The anterior third of the lateral margins of the body of the sternum show also, upon this view, the little rounded elevations indicating the position of the articular facets for the hæmapophyses.

The keel fails to reach quite to the end of the sternal body behind, but is brought far up in front, commencing immediately beneath the manubrium.

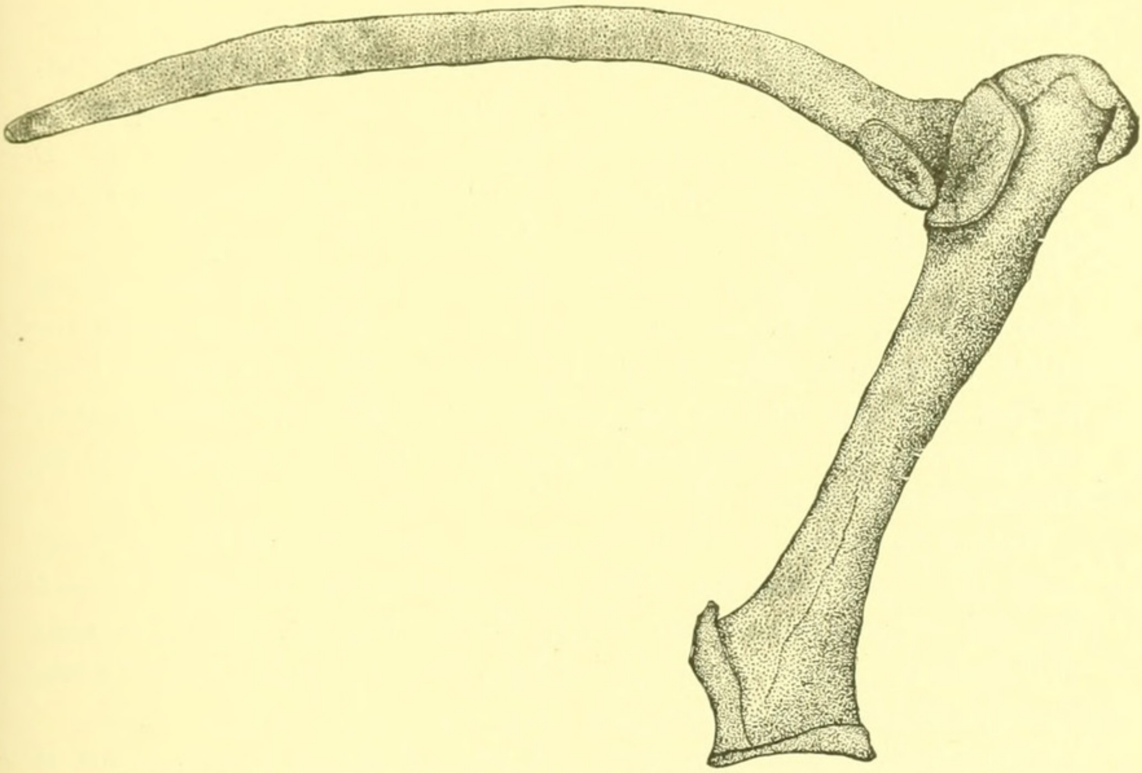


FIG. 10. Right lateral view of the coracoid and scapula of *Ardea herodias*. Natural size from the specimen.

Owing to the decussation of the coracoidal grooves, it depends upon which side of the sternum we view, as to how this part of the bone appears. In the drawing the right lateral view is presented, and in this particular specimen the coracoidal groove seems to have a deep triangular notch in it. Had we seen it the other way, the groove would appear as if it ran in one continuous belt around this anterior part of the bone.

Upon this aspect, the manubrium is seen to project directly forward as a straight process. Below it, the anterior carinal margin is sharp, being concave forwards above, and straight below. The carinal angle is rounded. Muscular lines are barely seen on the side of the keel, the surface here, as it is on the sternal body above it, smooth and polished, the bone becoming only slightly thicker anteriorly below the coracoidal beds.

The keel is bounded inferiorly by an elegantly curved margin, extending from the carinal angle to nearly the end of the sternum (Fig. 8). We are now better enabled to see the hæmapophysial facets, with the deep concavities between each and its neighbor. As in so many birds, these interarticular cavities are the favorite sites of the pneumatic foramina, and they are seen to be numerous here, occupying the bottoms of the pits. For the rest of the border behind, it is sharp and continuous with the upper border of the xiphoidal process, of which I also give a side view.

As a whole, the costal process is triangular, with its apex at the summit of the bone.

Seen directly from above the asymmetry of the two sides of the anterior border again becomes apparent, due to the method of articulation of the coracoids. A rounded notch exists in the median line, flanked by a long facet on the right of it, and one, only half the size, on the left. The manubrium is now seen to be triangular, with its surface flat and smooth.

Well within the anterior boundary of the body of the sternum, upon this superior aspect of the bone, we observe a single elliptical foramen of some size, situate in the median line, as is its major axis. This leads to cavities in the thickened part of the front of the carina, already alluded to in a paragraph above.

From anterior border to xiphoidal extremity, and from summit of costal process to summit of costal process this sternum is one general, and by no means shallow, concavity. There are no interruptions of surface, and all these parts enter into the conformation of the basin. For the most part it is smooth, and it is only in front that the surface seems to be roughened by some peculiar little granulations. Fig. 9 being a direct anterior view of the sternum of this Heron, the decussation of the coracoidal grooves is now best seen. The right one, (the left in the drawing) being the lower anteriorly, and running out over the top of the manubrium, while the left one, being the higher, crossing it in front.

So far as I have examined, this is the method of decussation in each instance, i. e., the right hand groove being the one that passes over the superior manubrial surface.

It is just possible that this crossing of the coracoids may have arisen in the habit of the ancestors of the present Herons, of passing constantly through very narrow places, as dense cane-brakes, or such other growths of analogous character, where they probably resorted

Fig 11.

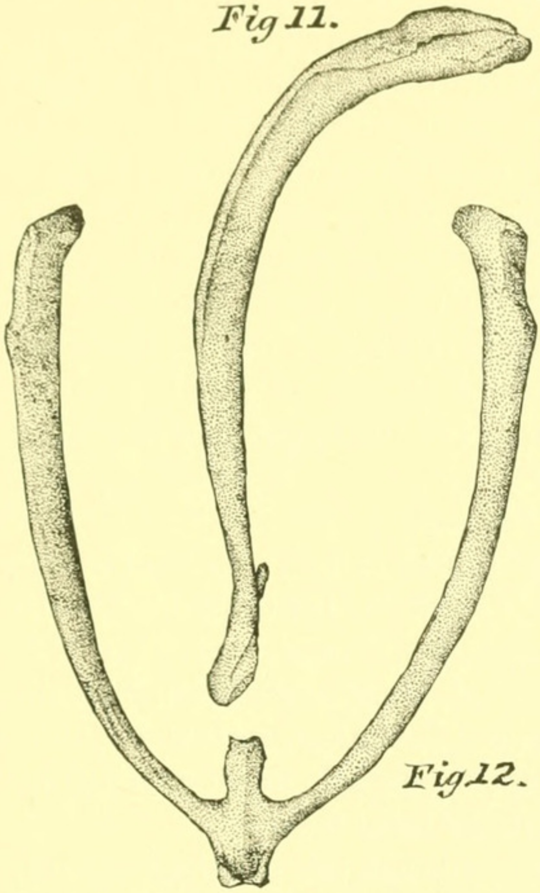


Fig 12.

FIG. 11. Left lateral view of the furcula of *Ardea herodias*.

FIG. 12. The same bone from in front. Natural size, and from the same skeleton as shown in figures 8, 9, and 10 and others.

and spent the major part of their time. There would undoubtedly be an effort made many times a day to compress the body and diminish its general bulk in a transverse direction, in such situations. Moreover, the coracoids (if arranged as in most birds) would constitute the principal obstruction to such compression ; and it certainly lessens the width of the bird's body to have them crossed as they are in the Herons. If we commence sufficiently early in the life of the individual, bones and the normal position of bones may be altered very materially by gradual pressure, differently applied ; then, why not, we ask, during the lapse of time, may not this result have been brought about in this way? It is hard to say, for even if it has been, then what are we to say about its being absent in some of the *Rallidæ*, and present again in such forms as *Polyborus cheriway* and several other Accipitres? I rarely see in any of the old-fashioned engravings, representing with the appropriate surroundings below, the noble falcon striking his prey, the doomed Heron, in mid-air, that this peculiar and unique condition of the coracoids, present in both the Hawk and his quarry, does not come into my mind. Both are desmognathous birds, yet it would hardly seem possible related through any such character as this, arisen however it may. Still we are beginning to catch glimpses of the affinities of the Herodiones, and morphology has much yet to bring to light in the premises. Fig. 9 shows these decussations of the coracoids very well, and the difference in width of the hinder and anterior parts of the bone, is well shown by the relative positions of the xiphoidal and costal processes ; the thickness of the front part of the carina now becomes evident, seen from this point of view.

The coracoids and scapulæ which I have taken the opportunity to show above will be treated of under the head of the pectoral arch. At the lower and inner angles of the coracoids, the dotted line indicates the amount of decussation of these bones when *in situ* in their grooves on the sternum. In *A. candidissima* the sternum differs from that bone in *Ardea herodias*, as I have described it above, in only the most insignificant minor details ; indeed, in all essential particulars, it is the veriest miniature of the latter bone.

With *Nycticorax*, although the principal features of a Heron's sternum are still there, yet a comparison of Figs. 8 and 32 will show that the bone has departed somewhat from the type form as seen in *Ardea*. The keel is comparatively much deeper in front and slopes up far more rapidly behind ; the manubrium bears a laterally compressed plate on its anterior extremity, which is as long as the part which corresponds to the triangular portion in *Ardea*.

Finally, the main pneumatic foramen, over the keel anteriorly, is very much larger. This may contract more, however, in specimens other than the one I have in hand, and in any event is a character of very trivial importance.

Of the Pectoral Arch.—Comparatively speaking the coracoid of the Great Blue Heron, is a large bone. Its sternal extremity is much spread out and quite thin and plate-like. Articular surfaces occur on both aspects of this end of the bone, for the fellow of the opposite side and the sternum. One would think, and naturally, that these extremities of the coracoid would be quite unlike, from the fact that they cross each other in articulation, and are fitted in differently directed grooves on the sternum. Such, however, is not the case, for with the

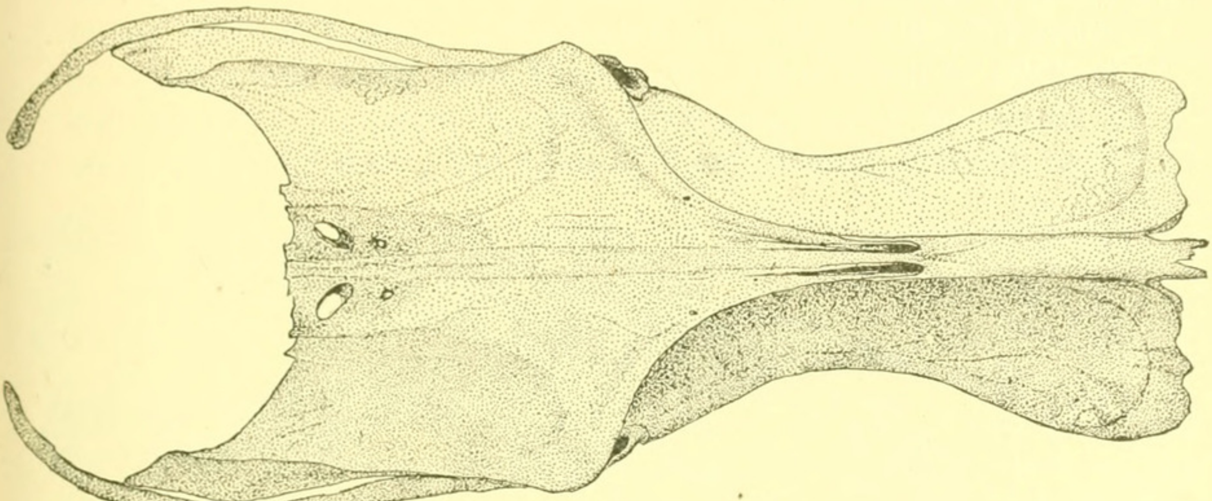


FIG. 13. Dorsal view of the pelvis of *Ardea herodias*. Natural size, and drawn by the author, as in the case of all the other figures, from the skeleton of the same specimen.

sole d fference of a slight asymmetry of the articular facets, these bones are no more unlike than we find them in the majority of birds.

The shaft of a coracoid is slender and somewhat laterally compressed, a compression that is extended to the head of the bone, where it becomes decidedly marked. The summit of the bone being capped with a tuberous crown which curls over mesiad, and extends backwards to merge into the glenoid cavity. This latter is ample and fully two-thirds of the surface is afforded by the coracoid. The scapula process with the line of its articular surface at right angles to the long axes of both bones, is no larger than is just necessary to accommodate the head of the scapula.

It never meets the furcula in any of the Herons that I have seen, and in all of these birds the bones of the pectoral arch are completely non-pneumatic.

The coracoid of *A. candidissima* differs in no particular from the bone I have just described for *Ardea herodias;* while though *Nycti-*

corax also agrees in this respect with these birds in the main, it differs in having the inner angle of the expanded sternal end of the *right* coracoid truncate, instead of being drawn out into a point as the fellow of the opposite side is. This is due to the fact that the groove on the sternum has that shape in the Yellow-Crowned Night Heron.

The *scapula* among the *Ardeinæ*, generally, is a long narrow bone, with but a slight curvature from head to distal extremity. This latter is simply rounded off in *A. herodias* and in the Snowy Heron, but inclined to be slightly truncate in *Nycticorax*. In the Great Blue Heron the head of the scapula is compressed from above, downwards, and much expanded in a transverse direction. Mesially it curls up a little to preserve the contour of the "tendinal canal," while on the opposite

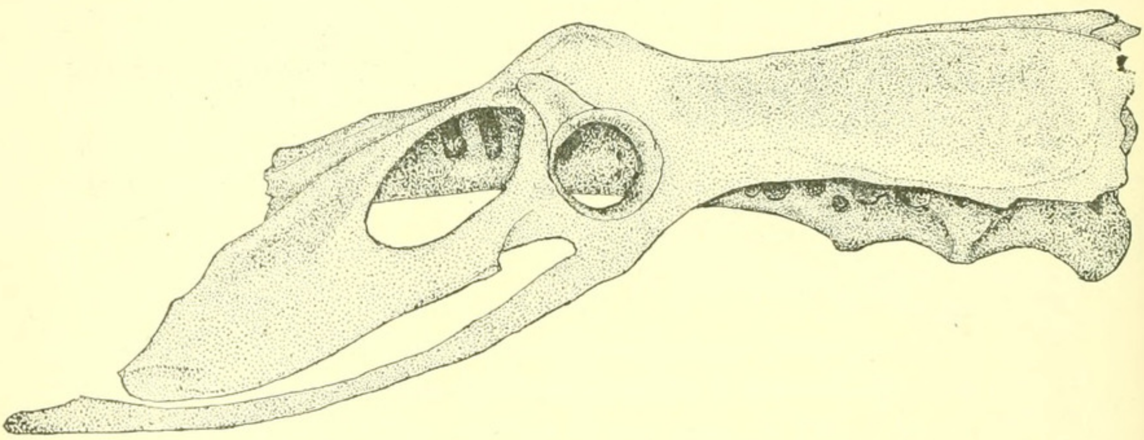


FIG. 14. Right lateral view of the pelvis of *Ardea herodias*. Natural size from the specimen.

side, it supports an oblique, elliptical articular facet, constituting one-third of the glenoid cavity.

Among the Herons the furcula, or the united clavicles, is a very interesting bone in one or two particulars.

In figures 11 and 12 I present two views of this part of the pectoral arch of *A. herodias*, taken from a specimen in my own collection, it being the same individual from which all the drawings were made which illustrate this species. I would do this, even if a hundred skeletons of the same species were at my command, as it is better in many respects. One of the chief reasons is that each skeleton, even among birds, has its own individuality, and ought to furnish all the figures if possible in any type monographed. The head of the *clavicle* in this Heron is tuberous, rather thickened, and evenly rounded off at its end. When articulated with the other bones of the arch, its superior border, quite close to this extremity, rests against the under side of the projecting summit of the mesial aspect of the coracoid. The rounded end of the furcula, from this point, reaches back a sufficient distance to barely escape touching the mesial and up-curled side of the scapular head, that to all intents closes the tendinal canal by bony walls; its complete closure is really effected by the short ligament that holds these two bones *in situ* at this, their nearest point of approach. In some birds, as for instance certain diurnal Raptores, the canal is closed by the head of the furcula reaching the tip of the clavicular process of the coracoid. From the head of the bone to the hypocleidium a gradual reduction in size takes place, while the lateral compression is sustained throughout, at any rate within a short distance from the latter part.

Now the hypocleidium of the clavicles in *Ardea herodias*, as in other Herons, consists of both an inferior and a superior process (Figs. 11 and 12), both being in the same line. In our present subject the upper one is the larger of the two, while their common surface anteriorly is smooth and flat. Behind, it is rounded and marked by a longitudinal raised line. This latter feature in *Nycticorax* is raised to the rank of a well-developed crest, and the lower process in this bird, equals the upper in length, and as a whole is comparatively slenderer (Fig. 33).

Figure 34 gives a three-quartering view of the furcula of my specimen of *A. candidissima*. It will be observed that it differs in no important particular from *Ardea*, though the anterior surface of the lower process of the hypocleidium is longitudinally grooved, a feature which, by the way, I neglected to say, is faintly indicated in the latter Heron.

A glance at any of the figures representing this bone in the *Ardeinæ*, is sufficient to satisfy one that it is a very different affair from the corresponding part of the pectoral arch in such forms as *Sula*, *Phalacrocorax*, or *Pelecanus*. In these latter types the united clavicles arch backwards to meet the carinal angle of the sternum, here to articulate with it, or even as in *Tachypetes* and very old Cormorants to anchylose with it. The lower part of the furcula in Herons, is, on the other hand, turned forwards from the sternum, assuming a curve not often seen among birds.

Anatomists have termed the clavicular head in birds, the epicleidium, and this end of the bone, according to Professor Parker, ossifies as a separate piece in some forms, notably the Passerine birds, and may be compared with the pro-coracoid of reptiles. Not having a young, or rather a sufficiently young enough Heron, at hand, I am unable to investigate the pectoral arch with the view of ascertaining how the development proceeds in the case of the forms under consideration.

Professor Owen, in calling attention to the relation between the hypocleidium of the clavicles and the carinal angle of the sternum, in other birds says: "The process itself reaches the sternum and is anchylosed therewith in the Pelicans, Cormorants, Grebes, Petrels, Frigate-bird, and Tropic-bird, also in the Gigantic Crane, and the Storks in general." I am compelled to take this statement with a little caution—as it does not always anchylose in the Cormorants, fails to do so in a number of the *Podicipididæ*, as in Clark's Grebe ; and, so far as I am aware, rarely in the *Procellariidæ* ; I have one or two exceptions before me ; the least tendency to form such a union being seen in the Grey Fork-Tailed Petrel, (*Oceanodroma furcata*).

In all of these forms, however, the hypocleidium is in more or less intimate relation with the anterior border of the keel of the sternum. I have examples where the closeness of the contact is very intimate and requires special investigation to determine whether true anchylosis really exists or not. This is so even in *Oceanodroma* and *Colymbus* sometimes. I have several skeletons of the former before me, but I have figured one where it was the least so. No doubt these facts accompanied by the lack of good material led Professor Owen to make the above statement. It holds good for our United States *Gruidæ*, as *Grus canadensis*, and *G. americanus*, but not for *Aramus*.

Of the Pelvis and Coccygeal Vertebræ.—Many years ago I made a number of anatomical drawings for Professor Coues, these now illustrate his admirable "Key to North American Birds," 2nd Edition. Among these drawings I figured the under view of the pelvis of *A. herodias*, the bone now to be described. It is figure 60, in the work cited and as the present memoir contains two other views of this pelvis (Figs. 13 and 14) I have intentionally drawn them from the same specimen, which I was so fortunate as to still have by me.

The twenty-fourth vertebra of the spinal column of this heron is the anterior one of the series that becomes incorporated by complete anchylosis with those neighboring bones which go to form the pelvis. Indeed, so far as I have been able to examine, it is this vertebra throughout the *Ardeinæ* that holds this place. (See Fig. 14 *bis.*)

This *twenty-fourth vertebra* possesses a pair of free ribs which have already been described above; its neural spine is continuous with the common median crest of the others behind; and its broad diapophyses meet the under side of the ilia, on either side, to anchyloes with them. As in the remainder of the pelvic series of vertebræ, this bone is highly pneumatic, the foramina entering the bones much in the same manner as we found them doing in the dorsal region.

The next four vertebræ behind the twenty-fourth, or the twenty-fifth, sixth, seventh and eighth, throw up apophysial abutments against the iliac walls, to completely fuse with them.

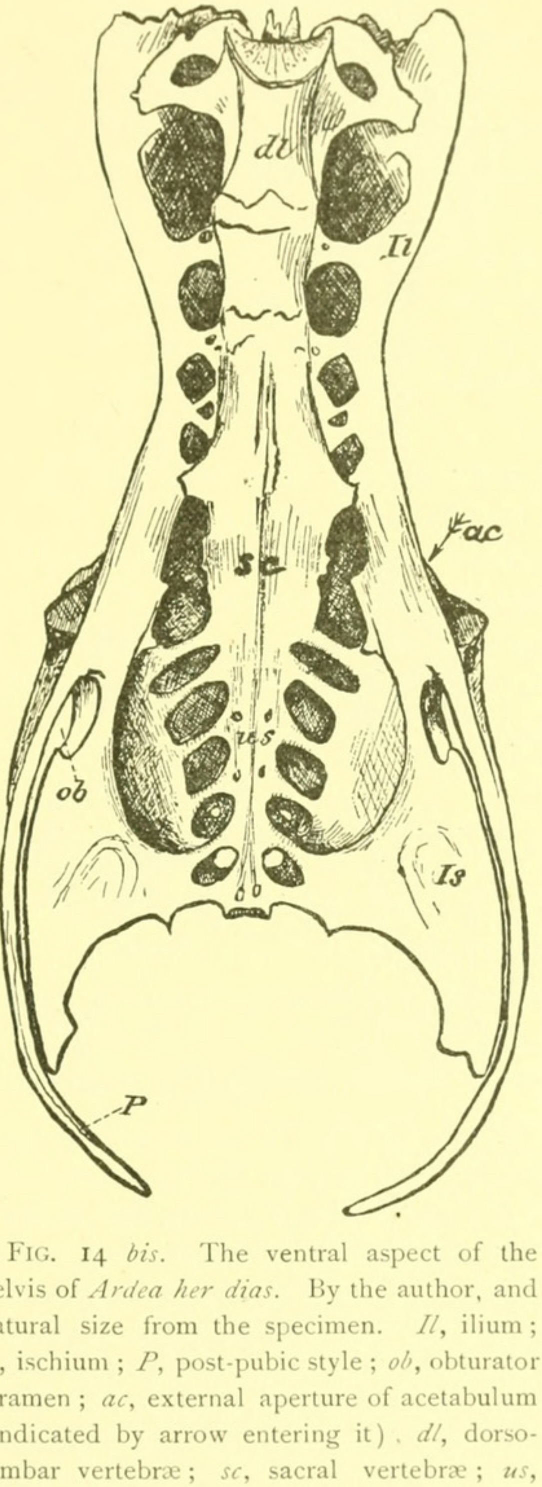
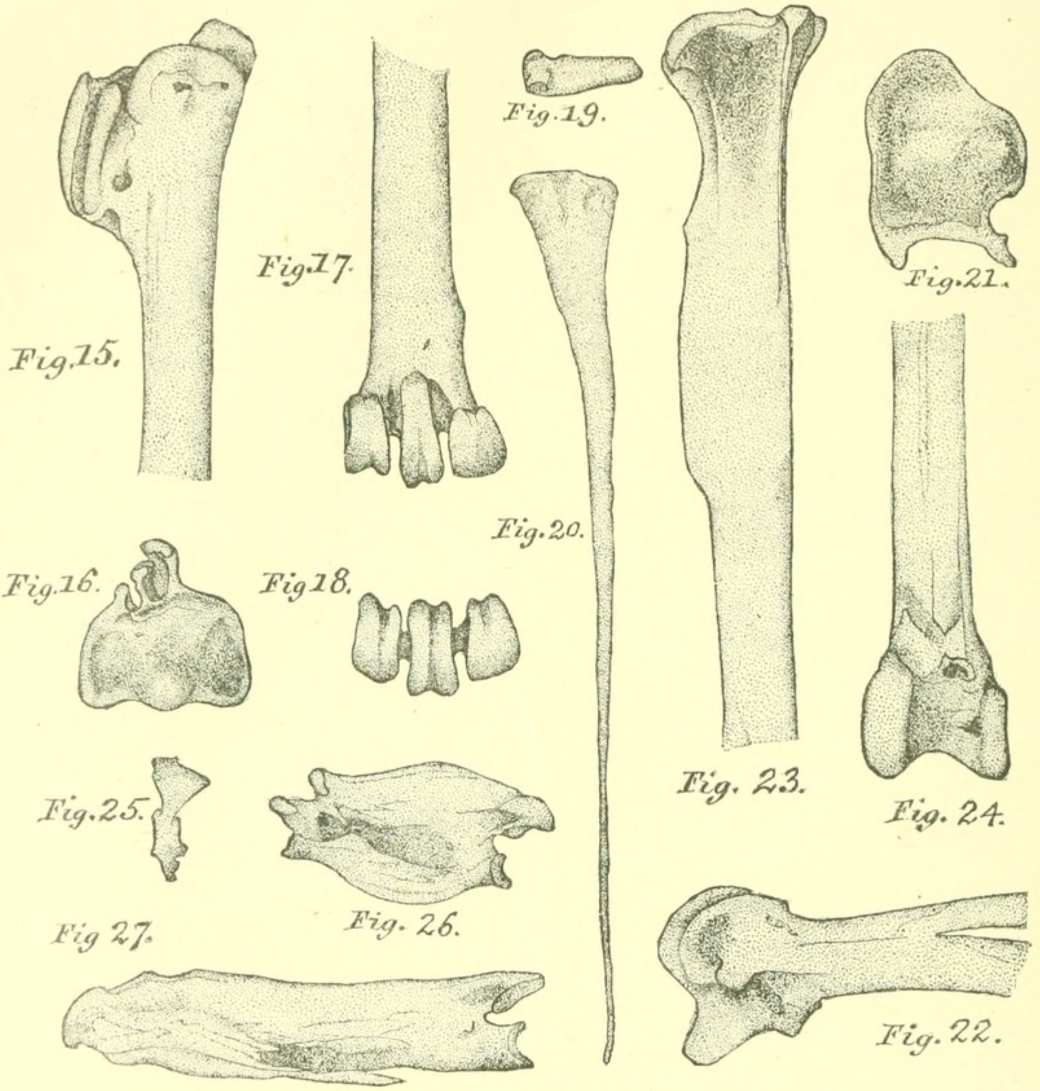


FIG. 14 *bis*. The ventral aspect of the pelvis of *Ardea her dias*. By the author, and natural size from the specimen. *Il*, ilium; *Is*, ischium; *P*, post-pubic style; *ob*, obturator foramen; *ac*, external aperture of acetabulum (indicated by arrow entering it). *dl*, dorso-lumbar vertebræ; *sc*, sacral vertebræ; *us*, uro-sacral vertebræ (probably six of them).

After we pass the twenty-eighth we suddenly meet the pelvic basin proper which is here deep and ample; the apophyses of the three next succeeding vertebræ, or the twenty-ninth, thirtieth, and thirty-first are thrown so directly upwards against the pelvic bones, that they can not be seen on direct ventral aspect. This is the region of the greatest enlargement of the neural canal, and also the bones through which



Various bones from the neck and the right upper and lower extremities of *Ardea herodias*. All from the same specimen, and natural size.

FIG. 15. Proximal extremity, right lateral view of the tarso-metatarsus.
FIG. 16. Same bone from above.
FIG. 17. Same bone, anterior aspect of distal extremity.
FIG. 18. Same extremity seen from below.
FIG. 19. Proximal end of fibula seen from above.
FIG. 20. Outer aspect of fibula.
FIG. 21. Proximal end of tibia, viewed from above.
FIG. 22. Proximal extremity of carpo-metacarpus, inner view.
FIG. 23. Anterior aspect, proximal third of tibia.
FIG. 24. The distal extremity of the same bone, anterior view.
FIG. 25. Left lateral aspect of atlas.
FIG 26. Same view of the axis.
FIG. 27. Same view of the sixth cervical vertebra.

it passes are here more massive in order to contain that part of the cord from which the sacral plexus emanates. The foramina from which they issue, on either side, are double, being placed one above another. This obtains also in at least four of the vertebræ beyond these and one other behind, making eight in all whose sides are pierced by these double foramina.

Apophysial abutments are again thrown out to anchylosé with the pelvic bones above them, by the thirty-second to the thirty-seventh vertebræ inclusive. The longest pair of these come from the thirty-second vertebra, and thereafter grow gradually shorter as we proceed backwards.

The "brim of the pelvic basin" is continuous with the processes of the thirty-sixth vertebra posteriorly, while anteriorly it merges with the posterior border of the transverse processes of the twenty-eighth. This boundary has a rounded and well-defined border in the Great Blue Heron, and is more or less determinable in the majority of birds. When viewed from above, this bone presents a strikingly smooth and unbroken superficies—it is scarcely marked by either crests or ridges, and in my specimen only two pairs of inter-apophysial foramina are seen, these being between the last two vertebræ.

Anteriorly, in the median line, the neural spine of the twenty-fourth vertebra is observed to project as a tuberous and notched process.

For some little distance back of this, the ilia meet on either side of this common neural crest sealing over the ilio-neural grooves and making one rounded summit for this part of the bone.

The anterior margins of the ilia are notched and scalloped, and bordered by a somewhat deep and slightly raised emargination. Where these bones are broadest in front, the lateral edges are quite sharp, but as the pelvis contracts in width as we near the acetabula they become rounded and smooth. The iliac surface, on either side, thus bounded, is at first directed upwards and outwards, but as it approaches either acetabulum, this surface gradually comes to look almost directly outwards. Ilio-neural grooves exist between the anterior forks of the gluteal ridges for some little distance, before these latter and well defined crests are lost anteriorly (Fig. 13).

Few traces or markings are left upon the inner margins of the postacetabular surfaces to define the boundaries which originally existed between the vertebræ and the iliac bones; they are best seen behind. For the most part though, the pelvic roof has become in the adult one unbroken surface—a very smooth and firmly-ossified tract.

The outer angles of the gluteal ridges are rounded and project immediately over the antitrochanter on either side, from which point each ridge runs almost directly backwards to the hinder margin of the bone. This latter, as a whole, is concave towards the posterior aspect, and from its outer angles the curved and inturned pubic bones may be seen pointing towards each other, their tips some two centimeters apart.

Only a limited part of the surface of either ischium can be discerned from this superior view, as these bones behind are nearly at right angles with the overhanging ilia.

Among all the *Ardeinæ* that I have had the opportunity to examine, the post-acetabular surface is about equal in extent with the pre-acetabular area. In the former the general surface is convex, while in the latter it is concave; the boundary between them I place, in common with Owen, at the line of the gluteal ridge. The post-acetabular surface slopes downwards from a line joining the outer gluteal angles; the amount of which declination can best be appreciated by a glance at my figure of the side view of this pelvic bone (Fig. 14).

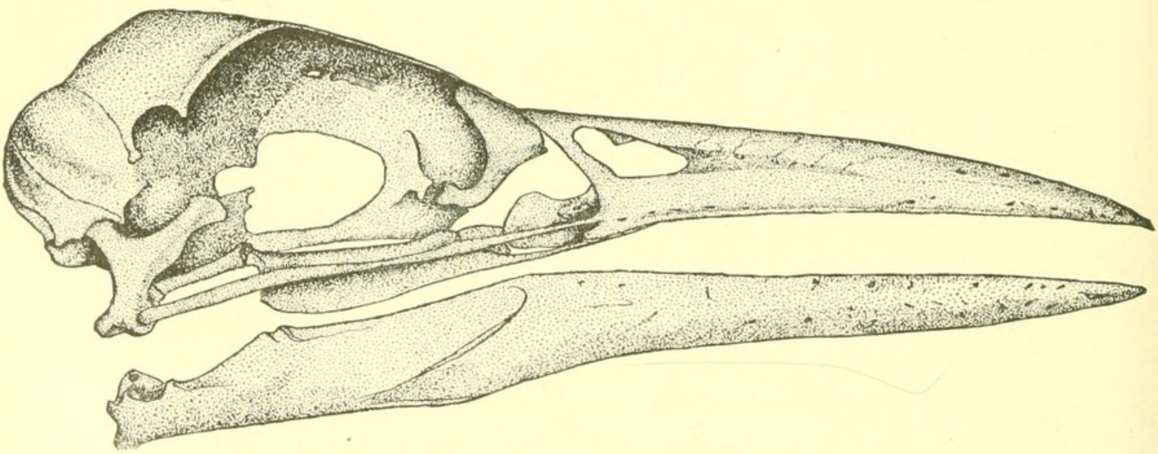


FIG. 28. Right lateral view of the skull of *Nycticorax violaceus*, "bird of the year" (July). Natural size from a Louisiana specimen collected by the author.

Upon lateral aspect the centra of the leading vertebræ may be seen below the eaves of the iliac roof, and some idea gained of the massiveness of the osseous column upon which the pelvis of this Heron is built.

The acetabulum is large and circular, with its floor more than usually deficient, the inner ring nearly equalling in size the outer, while the anti-trochanterian articular surface is carried by them both as it passes inwards. Externally this facet looks downwards and only slightly outwards.

The *ischiadic foramen* is large and subelliptical, its major axis being parallel to the line of the outer border of the post-acetabular surface, which here arches over it. Posterior to this foramen, the broad part of the ischium is roughly quadrilateral in outline, and for the most part smooth and slightly concave. It is nearly at right angles with the iliac surface above it. In this Heron the *obturator foramen* is far from complete or deserving the name of a foramen. Nearly its entire posterior arc is deficient, and the opening thus created leads into the obturator space, which latter is found beneath the entire lower margin of the ischium, being broadest in front and gradually tapering off behind (Fig. 14).

Ardea herodias has a blade-like pubis of nearly an equal width throughout, though it is rather wider behind after it passes the ischium and curves mesiad towards its fellow. Just before it does this it is slightly overlapped by the lower and posterior angle of that bone, or else meets it in a single point of tangency, or, as in the figure, does not quite come in contact with it. Quite a large pneumatic foramen is found beneath the projection of each ilium immediately behind the anti-trochanter.

The vertebral column may be seen in part through the apertures afforded by the acetabulum and ischiadic foramen upon this lateral view. Except at its sacral dilatation, the neural canal as it passes through the vertebræ of the pelvis is small; it will be remembered that we found it quite so in the dorsal region also.

My specimen of the pelvis, taken from the skeleton of *Ardea candidisima* (a bird of the year) although thoroughly herodine in all of its salient points, it still differs in some of its minor details from the same bone in *Ardea herodias*. A careful count shows that an equal number of vertebræ are anchylosed together to form the central mass for the support of the pelvic arch—fourteen in each case, *i. e.*, the twenty-fourth to the thirty-seventh inclusive. This obtains also in the Yellow-crowned Night Heron, and in both these birds the brim of the pelvic basin departs from and arrives at identically the same segments as described for *Ardea*.

In *A. candidissima*, the ilia do not overreach the twenty-fourth vertebra although otherwise these bones are comparatively longer and narrower than in *A. herodias*. A greater number of inter-apophysial foramina pierce in double rows the middle area in this Heron; these, however, may be obliterated in older birds.

Nycticorax also possesses a true heron's pelvis, and so far as this bone is concerned the differences between it and the pelvis of *Ardea herodias* are of so trivial a nature as scarcely to be noticed on first sight. The principal ones are these: in *Nycticorax* the gluteal ridges and outer angles are not nearly so prominent; a greater number of inter-apophysial foramina exists upon the dorsal aspect; the last vertebra, the thirty-eighth of the spinal column, anchyloses with the sacrum, although it projects entirely beyond the pelvis, this one corresponding to the first of the free coccygeal series in *A. herodias;* the hinder ends of the ischia are cut squarely across and do not apparently project beyond the ilia; and finally, the obturator foramen is more nearly entire.

I find seven freely articulated *coccygeal vertebræ* in *Ardea herodias* and a pygostyle. *A. candidissima* shows but six, and the pygostyle, but it may be possible that one of these vertebræ has by some accident been lost in my specimen. We saw above in *Nycticorax*, how, in that Heron the first one of the series anchylosed with the pelvis, both by its centrum and by the antero-external angles of its diapophyses.

These seven vertebræ in the Great Blue Heron are non-pneumatic, and all but the last three entirely devoid of hypopophyses, and it may be absent on the first of these.

The first five have broad flaring diapophyses, which are entirely aborted in the last segment, and only barely apparent in the one that precedes it.

In caliber, the neural canal is larger than we would be led to expect from the size of that tube as it appears in the last uro-sacral vertebra of the pelvis.

The neural spines are bifid and subcompressed, while the form of the anterior and posterior articular surfaces of the centra are transverse and flattened ellipses.

Herons being birds with short, weak tails, composed of but a few feathers, we naturally find a correspondingly feebly-developed pygostyle.

In *Ardea* this bone has projecting from its lower anterior angle a process nearly as long as half the bone itself. It represents the hypopophysis of the leading vertebra that was absorbed to form, with probably several others, this compound bone. Very faint traces of another such a process may be seen marking its side farther back, and above it the barest hint of the centrum of the corresponding vertebra. For the rest, the pygostyle is an irregular, quadrilateral plate, less than a centimeter deep, and a little more than one long, measured on its longest diameter. It has a round, thickened posterior margin, and its upper and lower edges are sharpened. A pit marks the flat anterior

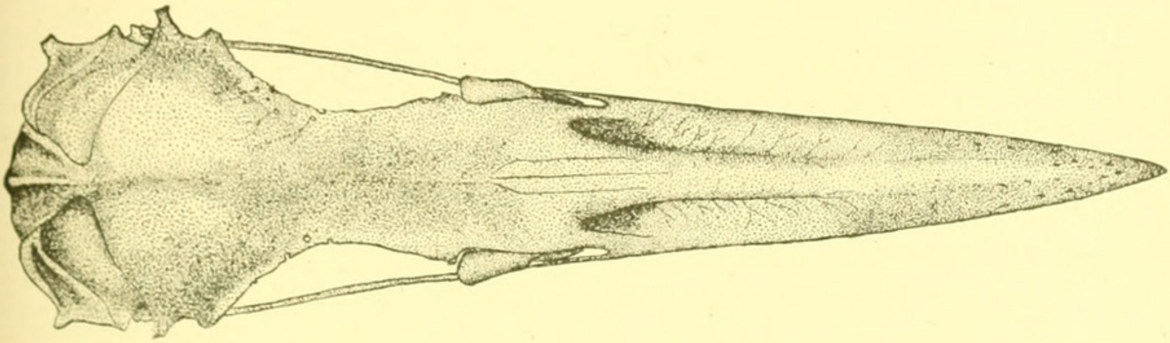


FIG. 29. Superior view of the skull of *Nycticorax violaceus*, juv. Natural size, and the same specimen as shown in Fig. 30. Drawn by the author.

surface, which continues for a short distance into the substance of the bone, the neural canal of the caudal vertebræ. Other Herons have the pygostyle rather differently fashioned from this, though in each instance the leading features are present.

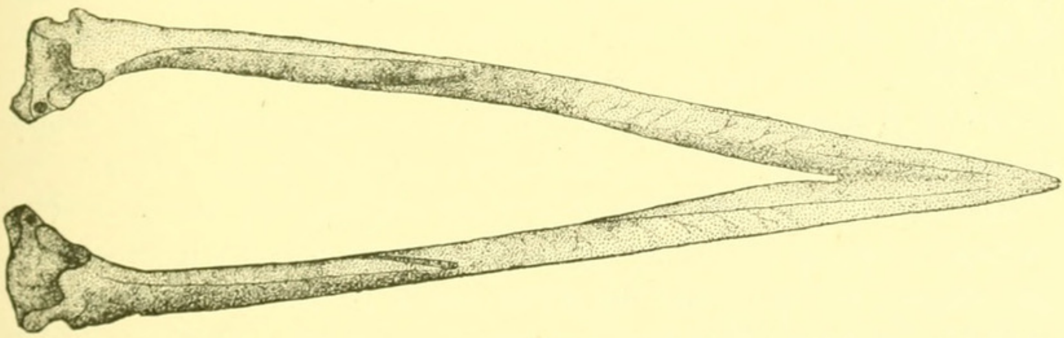


FIG. 30. Superior view of the mandible of *Nycticorax violaceus*. Drawn by the author, natural size from the specimen. From the same skeleton as Figs. 28 and 29.

Of the Appendicular Skeleton. The Pectoral Limb: Ardea herodias has a highly pneumatic *humerus*, which in the well prepared skeleton is a snowy-white, and for its size a wonderfully light bone. The pneumatic aperture is of small dimensions, it being a sub-elliptical opening at the usual site for this orifice in birds. It differs somewhat, however, in lying in the same plane with the general humeral surface, below the ulnar crest, and not being situated at the base of a pneumatic fossa, in which several openings are usually seen leading to the hollow shaft of the bone. From radial to ulnar side the proximal enlargement of the humerus is not nearly as great as we find it in many others of the Class. At its summit there is an oval, convex facet for the glenoid cavity. This is separated from the ulnar crest by a deep intervening valley, which appears all the deeper from the great prominence attained by the former.

The radial crest is, on the other hand, quite low, and not unusually developed. It extends down the shaft only to the point where the latter commences to assume the cylindrical form. On the palmar aspect of the proximal end of the humerus we have a well-defined trench extending across the bone, just behind the ulnar crest and glenoid head. Another, fainter one, though pretty well marked in the direction of the shaft, marks out the boundaries of a convex, sub-oval and flattened space, on the lowermost side of the palmar aspect of the proximal end of the bone, which is present in some form or another in this place on the humerus, in a number of the Class.

The shaft for the greater share of its length is cylindrical and smooth; the sigmoid curves it presents in the majority of birds are here well marked. The distal extremity is dilated in the same plane nearly with the proximal end, to give space for the guidance of muscular tendons on the anconal side, which there pass over grooves marking the bone, as well as affording the necessary breadth to support the ulnar and radial tubercles on the palmar side. Above the latter is seen a long, subelliptical depression, running obliquely up from this dilated portion to a point where the shaft begins to assume the cylindrical form.

The *radius* is a non-pneumatic bone, and like all bones of this character, in the ordinarily prepared skeleton becomes yellow, dark and greasy, owing to the oily constituents of the contents of the shaft gradually oozing through its walls.

This bone, in common with its companion in the anti-brachium, is considerably longer than the humerus. From proximal to distal extremity its shaft is much bowed in the palmar direction.

The proximal end is comparatively little enlarged; it presents the usual subelliptical facet for the humeral tubercle of the bone of the brachium. On its end, and shaft-wise, the ulnar facet is presented for our examination.

For its length and the general size of the bird, the shaft of the radius is quite slender. In form it is subtrihedral with the salient angles rounded off.

Usually the *ulna* is quite straight, or has only a slight degree of curvature, but in the present subject it is bowed nearly as much as the radius and very much in the same way. It is hardly necessary to say that in common with the radius and the skeleton of the pinion, that it is likewise found to be a perfectly non-pneumatic bone. Its shaft is about two and a half times the size of the radius, but instead of being subtrihedral in form, it is nearly cylindrical.

Two rows of quill-knobs are distinctly seen upon its length, one on the ulnar and one on the palmar aspect; the former being the more strongly marked.

The shaft decreases in size gradually from the proximal to the distal end, very imperceptibly from the middle of the bone on. A nutrient foramen is seen on the anconal aspect at the proximal part of the middle third.

The carpal end shows the usual trochlear surface, and the facets for the *radiale* and *ulnare* of the wrist. Proximally, the enlargement is much greater in order to afford sufficient breadth, to make room for the extensive excavations that are found at this end, to articulate with the radius and bone of the brachium. The olecranon is but feebly developed and tuberous. Measurements taken from these bones in an adult specimen of *Ardea herodias*, shows the humerus to be 19 cm. long; the radius 22 and the ulna 23.1, which goes to show that the brachium and anti-brachium are proportionately balanced as to their respective lengths. Both of the carpal elements are present, the *radiale* and the *ulnare*. They are of good size, articulate as in most birds, and are fashioned after the most usual pattern assumed by these bonelets.

The *carpo-metacarpus* makes up in length in this heron what it otherwise lacks in breadth. It measures 10.3 cm. long, while across the widest part above it is but 1.8 cm.; this latter measurement being from superior tip of pollex metacarpal directly across the bone to outer edge of trochlear surface.

The first metacarpal, anchylosed as usual at the upper and anterior aspect of the bone, is very short, slightly bent anconad, and directed rather upwards as a tuberous process. Beneath, it supports the extensive convex articular facet for pollex digit, which latter is long and somewhat laterally compressed. It bears a diminutive facet at its distal extremity, and appears as though it might have had in life a claw there, which has been lost in my specimen. Nitzsch, who examined many groups of birds to investigate this among other points, places the Herodiones in the category of birds in which he discovered it to be present. So on the authority of this eminent anatomist I believe we may safely say that our subject will be found to possess such a claw.

For its entire length the main shaft of this bone is very straight, and such part of it as is free from contact with other bones above and below, is subtrihedral in form and devoid of particular character.

Showing a considerable transverse dilatation at its proximal extremity, the third metacarpal soon quits the shaft of the second to become much smaller and rounder, being parallel to it, until within a short distance of its lower end, where both are again connected by bone.

At the proximal extremity of this carpo-metacarpus, we find a broad trochlear surface, contributed in the usual manner by the *os magnum*, one of the free carpal bones in the wrist of subadult birds. As in the majority of cases all the sutural traces of this union, have with the growth of this heron become obliterated.

Upon the palmar aspect, just below the superior convex margin of this trochlear surface, at the head of the index metacarpal, we observe projecting forwards a small stumpy process.

The distal end of the carpo-metacarpus in the adult *Ardea herodias* is almost entirely occupied by the two articular facets for index and middle digits. A notch divides them. In the case of the first, the proximal phalanx is a long bone (3.8 cm.), with a posterior blade-like expansion. This latter is not very broad, being thick and unpierced by foramina, as we sometimes see it in the Gulls and other water birds. A long, pointed subtrihedral joint succeeds this one, which in turn seems to have a facet upon its distal extremity, either for a claw or another minute joint, such as we find among the Ducks and Geese, but in my specimen it is missing. The third metacarpal supports a digit composed of a single sub-compressed, narrow phalanx, nearly two centimeters long.

Taken in connection with what Nitzsch has given us upon the subject, I believe the formula for the manus of the Herodiones will be found to be pollex metacarpal, with a digit composed of two phalanges ;

index metacarpus, with a digit of three phalanges; and middle metacarpus with a single phalanx to its digit.

So far as the material goes that I have been able to examine, the pectoral extremity among the *Ardeinæ* offers no very striking differences. As a good illustration of the slight departure that is made from a common plan among these Herons, no better example could be offered than the series of bones shown in figures 35, 36 and 37, being the right humerus from *Ardea herodias*, *Nycticorax* and *A. candidissima*.

Of the Pelvic Extremity.—After the most careful examination of the material at hand, I find it is only in the femur of *Nycticorax* that pneumatic foramina exist. These are exceedingly minute, though they may be detected without the aid of a lens just over the border of the anti-trochanterian facet on the posterior aspect of the bone. In *A. herodias* and *A. candidissima* the *femur*, as well as all the other bones, composing the skeleton of this limb, are absolutely non-pneumatic.

Our Great Blue Heron has a femur fully as long as its pelvis omitting the free, posterior end of the pubis. Its head and neck make nearly a right angle with the shaft, the former being hemi-globular and much excavated for the ligamentum teres, while the latter is short and thick. At the summit of the bone the anti-trochanterian facet is broad and extensive. From before, backwards, its surface is convex; in the other direction, that is from the head to the trochanter, it is concave, becoming gradually wider as it approaches the latter.

The trochanterian ridge does not rise above this articular surface to any perceptible degree, but becomes rather prominent as it passes down the shaft for a short distance on its outer and anterior aspect.

On the outer and proximal end of the femur, the trochanter major is broad and nodular. The shaft below this point, to where it begins to expand for the condyles, is nearly straight and quite cylindrical. Its muscular lines are distinct and raised; on the posterior aspect, above the middle, the nutrient foramen is to be seen. It opens in a direction obliquely from above downwards.

Just above the anterior ridge of the external condyle, I find in all Herons, on the antero-external aspect, a prominent and elongated tubercle. It has to do with muscular attachment, and one of the muscular lines is deflected from its course to run into its upper end.

The condyles of this bone are strong and massive. The articular surface of the inner one is broad behind, and so far produced in this locality as to render the popliteal depression appear more than usually concave and excavated. Above each condyle behind is seen a well-marked tubercle, with pits on their outer sides for the insertion of lateral ligaments and muscles. The external condyle has the usual fibular groove, deeply cleft and carried down behind well nigh to its base; it is more prominent than its fellow, though not as broad. Between them, the inter-condyloid fossa is moderately deep, rather wide, and carried up on the anterior aspect of the shaft as a "rotular channel" of like dimensions, though not mounting as high as it does in some birds. Of these two condyles, the external one is rather the lower, the bone being held in the vertical position.

I fail to find a *patella* present in any of the *Ardeinæ*; in *Nycticorax* a thickening in the ligament takes place at the usual site of this sesamoid in other long-legged birds where it is found, but this ligamentous enlargement is entirely devoid of any osseous deposit.

The *tibia of Ardea herodias* as we might expect is a very long bone, and in every particular typical as found in Herons generally. Viewed directly from above, on its proximal end (Fig. 21) we observe that it

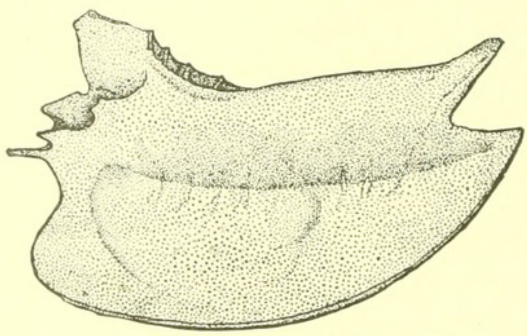


Fig. 31.

FIG. 31. Left lateral view of the sternum of *Ardea candidissima*. Adult specimen. Natural size, by the author.

has a roughly quadrilateral outline, its general surface sloping towards the fibular side.

The intercondyloid tubercle is prominent, and situated rather external to the center of this surface, while anteriorly it is bounded by a low cnemial crest.

Regarding the shaft from in front (Fig. 23), we notice that the pro- and ectocnemial ridges are but moderately developed, and very soon subside into the shaft below. A wide valley is between them, and the inner one or procnemial ridge is vertical to the shaft and exactly divides the inner surface of it from the anterior.

All about the head of the tibia the articular summit projects over with its broadly rounded margins.

The "fibular ridge" extends down the tibial shaft on its outer side but a comparatively short distance. It begins above at a point opposite where the ectocnemial ridge merges into the shaft. Behind, a longitudinal concavity fairly defines its extent from the posterior surface of the tibia; in front, the anterior surface of this fibular ridge lies in the same plane with the anterior surface of the tibial shaft.

From proximal to distal end his shaft is as straight as any long bone that I am familiar with; it is only just before we arrive at the condyles below that we notice the slightest disposition in the world to bend backwards.

For its entire length behind, the surface is cylindrical; this is entered into by both the lateral aspects, while anteriorly it is flat, and only round at all for a limited part of the shaft about at the junction of middle and upper thirds. This flat anterior surface above looks directly forwards, and this is the case also above the tendinal bridge, but as we ascend the shaft from this latter point, it gradually turns towards the outer aspect, when finally it is limited by a raised line that descends on this side from the fibular ridge, and merges at last into that part of the shaft which is subcylindrical, at junction of middle and upper thirds.

At the distal extremity, the shaft enlarges but very slightly, and just sufficient to afford a base for the condyles, which here project in consequence well out in front of it, both before and behind, more particularly in the former direction (Fig. 24).

The "tendinal bridge," though present, is not nearly so well developed as in some other birds, and in my specimen of *Nycticorax* a "bird of the year," it is not united in the middle, it being simply represented by a triangular process on either side, with their bases in the margins of the excavation, and their apices opposite and nearly touching each other. A tubercle occurs above the outer condyle at a point where this bridge arises on that side. This is its lower origin, as it spans the tendinal groove rather obliquely.

The inter condyloid depression is wide, deepest in front, to become narrower and shallower behind, where it ceases as the shaft commences.

Viewed anteriorly, the outer condyle is the broader, extends higher on the shaft, but projects no further in front than the inner one. This latter, slightly encroaching on the intercondyloid space, is excavated by a well-defined subelliptical pit, which is better marked in the Night Herons, though present in the *Ardeinæ* generally.

Viewed from behind, these condyles of the tibia in *Ardea* mount to points about opposite each other on the shaft. There, however, the inner condyle is the broader, and rather more prominent above.

Upon lateral aspect these condyles are uniform in outline with the convex surfaces below; and from above, downwards, the outer is the deeper of the two.

In my memoir on the Osteology of the Gallinæ (in MSS.) I describe the method of ossification of the cnemial crest of the tibia in the young of *Centrocercus urophasianus* and give a figure showing this development, which, in brief, consists in a large osseous segment engrafted upon the bone, at the future site of the cnemial crest and upper halves of the pro- and ecto-cnemial ridges, all of which it forms, but leaves no trace of such a development in the adult fowl.

My only regret is that I have not at this moment the proper material to investigate whether or no a like method of development goes on in the young of the Herons.

As for the distal extremity of this bone, it also has received no little attention generally, but in particular the young of our present subject has been ably investigated at the hands of Professor Morse.

It was through his studies of the tibia and tarsus of immature individuals of various spcies of *Ardea* that this distinguished zöologist was principally enabled to demonstrate the presence of the intermedium in the Class birds. Professor Morse's researches have proven, I think, beyond doubt, that the "ascending process of the astralagus" of Huxley agrees with the "pretibial" of Wyman. Further, this segment ossifies from a separate center of ossification, and as such constitutes in the avian tarsus a third bone of the proximal row, which corresponds with the *intermedium* of the Reptilia as described by Gegenbaur. No one would suspect the presence of any such bone in the adult, in any of the *Ardeinæ*, it having been completely absorbed by the tibia, and every vestige of its original limits obliterated.

The *fibula* of the Great Blue Heron is a very much aborted bone, not only when it is compared with that bone as it is found in many other birds, but when compared with the size of its own tibia (Figs. 19 and 20).

The upper surface of its distal end is devoted entirely to the facet for articulation with the condyle of the femur. Below this the bone is compressed from side to side, and produced from before, backwards. Then rapidly contracting it presents a roughened surface intended for ligamentous attachment to the fibular ridge of the tibia. Near this we see the tubercle for the insertion of the tendon of the biceps. The remaining length of the fibula becomes almost needle-like in its dimensions, and makes no osseous connection with the tibia whatever, passing but little below the upper third of its shaft, which when the bone is removed shows no evidence of its contact, more than the roughness of the fibular ridge.

Ardea candidissima has a fibula that agrees in all respects with the one I have described for the Great Blue Heron. In *Nycticorax* it differs in one important particular, and this is, that after passing its articulation with the fibular ridge of the tibia, its almost thread-like dimensions are carried well below the middle of the shaft of the leg-bone to unite with it by ossification, for at least a third part of its length.

Next in order we have to notice the *tarso-metatarsus*. The differences that this segment of the lower extremity exhibits among the various herons, seem to be scarcely worth the mention. So I expect a description of the bone as it is found in *Ardea herodias*, will answer with sufficient exactness for the group.

Different views of the tarso-metatarsus are shown in figures 15, 16, 17, and 18 all drawn from an adult specimen of the Great Blue Heron. A very prominent tubercle occupies the anterior part of the proximal extremity. It stands between the two elliptical concavities intended, when articulated, for the condyles of the tibia. The margins surrounding the extremity are raised at the sides and sharpened. Posteriorly, we can also see from this view, the three processes composing the *hypotarsus*. Of these the innermost one projects the farthest backwards, as well as extending the greatest distance down the shaft. The outermost one of the three is the smallest, being just about half the size of the innermost one. The middle one falls between these two so far as its height is concerned, but it is as long as the innermost one (Figs. 17 and 18).

In order to support this great tendon-grooved hypotarsus, and broad articular surface, the shaft of the bone at this end is proportionately enlarged. It grows gradually smaller, however, as we descend, being of the least calibre in the lower third, when it again enlarges transversely to support the trochleæ for the digits. The upper half of the bone is flat both posteriorly and at the lateral aspects. In front it is longitudinally excavated down the middle, beginning where it is the deepest, just below the inter-condyloid tubercle. As we gradually pass to its lower half the shaft becomes subelliptical on section, the major axis being transverse.

At the base of the excavation above, a few millimeters below the anterior crest of the summit, we find the shaft pierced by two foramina, placed side by side. The innermost and larger one of these passes rather obliquely through the bone to make its appearance, rather larger in size, just inside of the hypotarsus.

Considerably smaller, its companion pierces the tarso-martarsial shaft, still more obliquely downwards, to make its exit as a foramen of diminished calibre on the opposite side of the hypotarsus. The posterior opening of this latter one is seen in Fig. 15.

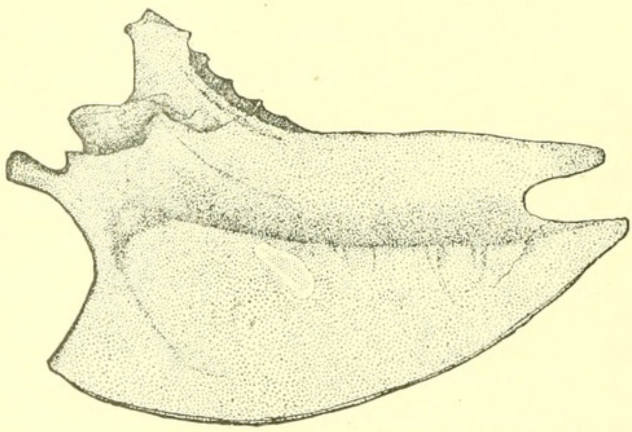


Fig. 32.

Fig. 32. Left lateral view of the sternum of *Nycticorax violaceus* (subadult). Natural size, by the author from the skeleton of the same individual that furnished Figs. 28–30.

Viewed from in front, the trochleæ present the following points for examination: the middle one extends the highest on the shaft, and projects beyond the others anteriorly. It is distinctly grooved down its middle, and descends the lowest. The inner one is the broadest and is perfectly smooth in front, being but slightly grooved behind, while the other two are decidedly so. Finally, the outer trochlea is also smooth in front, and does not descend as low as either of the others. Between this one and the next the usual foramen pierces the bone, low down 'n the groove between them.

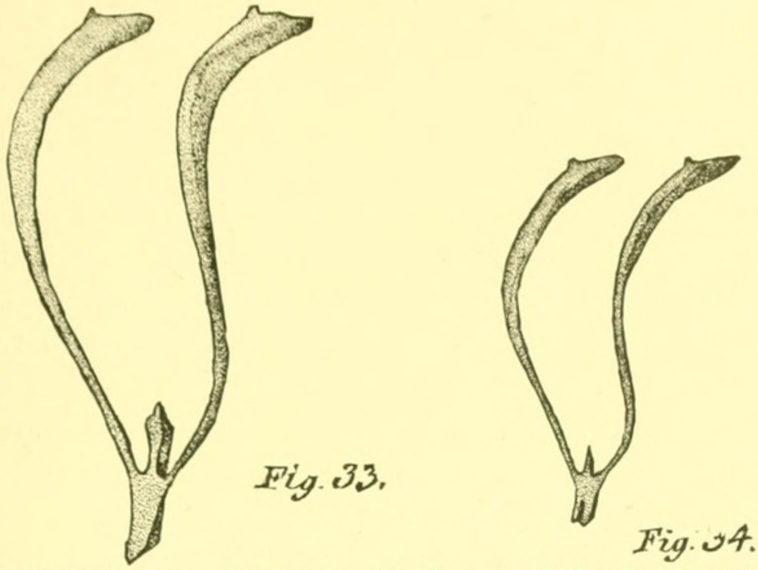


FIG. 33. Left three-quartering view of the furcula of *Nycticorax violaceus*. (Sub adult.)

FIG. 34. Same view of the *os furcula* of *Ardea candidissima*. Both natural size from the specimens.

It will be seen that these trochleæ are so placed as to be slightly convex forwards, and in a less degree concave behind, where they come up to nearly the same points on the shaft, the middle one being rather the lowest. Moreover, the mesial grooves that mark them are here carried up to their very terminations. This posterior aspect of the distal extremity also shows the foramen for the anterior tibial artery in full view. Above these trochleæ, and to the inner side, the circular facet for the first metatarsal is found.

These three long bones of the pelvic extremity of *Ardea herodias* have the following measurements in the adult: the femur, measured from the highest point on the trochanterian ridge to the lowest point on the outer condyle, is 10.5 cm. long, the tibia, 24.5 cm. and the tarso-metatarsus, 17.8 cm. long, measuring from the highest point on the intercondyloid tubercle to the lowest point on the middle trochlea. We may add here that the length of the fibula which is but 9 cm., being one and a half centimeters shorter than the femur, and fifteen and a half shorter than the tibia.

The first metatarsal is a free bone, with a peg-like shaft and exlarged lower extremity. It is enlarged at its proximal end where it supports a circular facet on its lateral aspect, to articulate in life with the surface described above on the tarso-metatarsus. Thus it is that this bone is so mobile, and can be thrown backwards to a considerable distance. Below, it bears a trochlea for the rear phalanx of hallux, which reaches high on its shaft on the digital side of the bone, being faintly grooved on the other. The entire length of this segment is 1.7 centimeters.

At the proximal end of the first phalanx of hallux, the trochlear surface is far more extensive than its opposed surface on the first metatarsal, being fully half as broad again. The shaft is rather slender, gently curved throughout, convex upwards, and subcircular on section. Its distal trochlear surface is principally on the under side of the bone. It is narrow transversely, and shows a shallow median longitudinal groove. The sides of this extremity are marked by pits for ligamentous attachment. It measures in extreme length 4.6 centimeters, being the longest phalanx of the pes.

Its osseous claw is rather more than moderately curved, and exhibits the usual trochlear surface and the tubercle for tendinal insertion. The distance from this latter point to the apex measures 1.6 centimeters. Both the convex surface above and the concave surface beneath is uniformly rounded off, while the bone is laterally compressed. A groove distinctly marks it on either side, but is not quite carried to the apex.

Second digit has three phalanges including the ungual one; the proximal phalanx has all the characters as given for first joint of hallux; it, however, is distinguished by a prominent tubercle to the inner side of the articular surface for the trochlea of tarso-metatarsus. The bone is rather stouter and somewhat shorter. The second joint is a still shorter and a slighter bone; its proximal trochlea is concave from above, downwards, very slightly convex in the opposite direction. The shafts of these bones are not curved to the degree found in the first joint of hallux, and the proximal ones are always the straightest. Agreeing even in minor details, the ungual phalanx of this second digit is smaller than the one found in the first toe, but shows about the same amount of curvature. These three joints measure from proximal to distal one, respectively 4.4, 3.1 and 1.1 centimeters; the ungual joint being measured as I measured the bony claw of the first digit.

The four joints of the middle or third digit have the general characters as given for these phalanges above. Measuring them in the same way and in the same order, I find the proximal phalanx to be 4 centimeters long; the next 3.9, the next 2.1; and the ungual one, measured as before, 1.1 centimeters long.

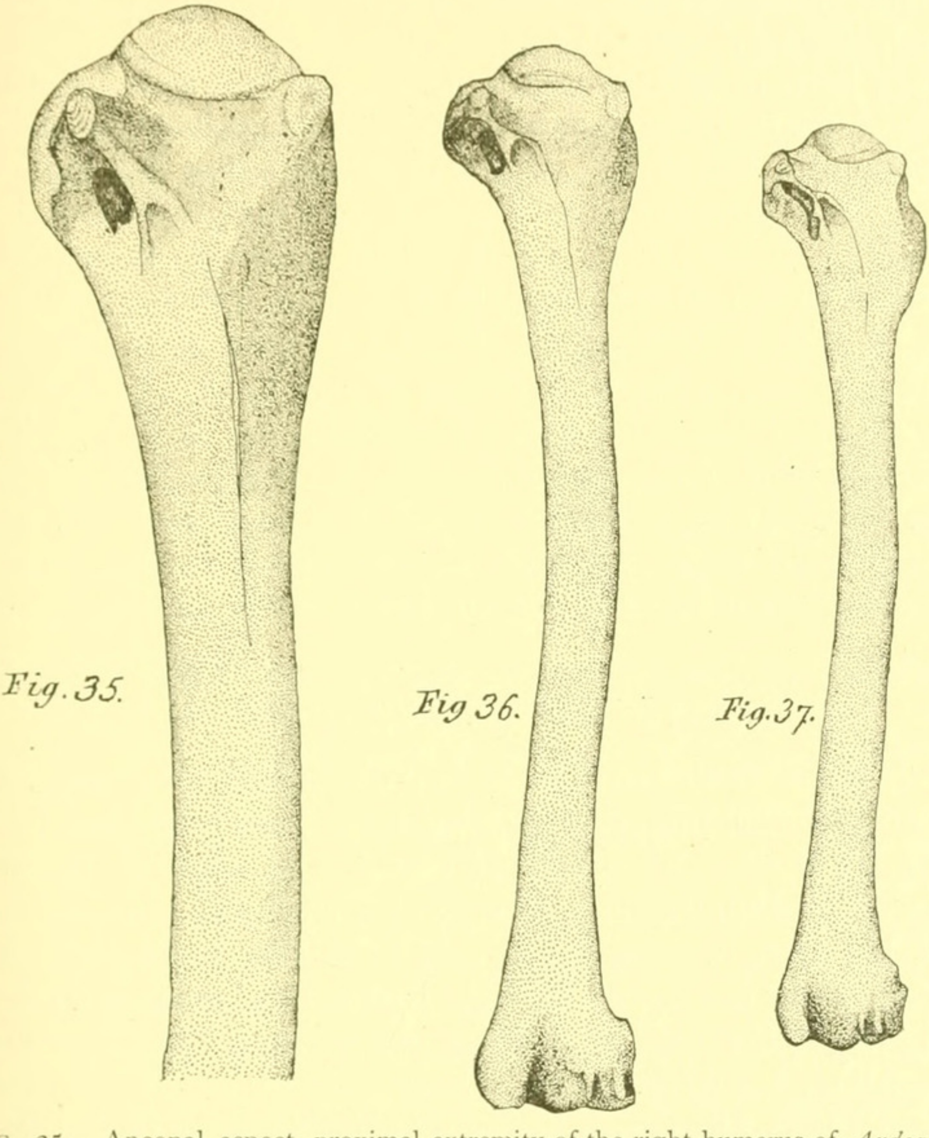


Fig. 35. Fig. 36. Fig. 37.

FIG. 35. Anconal aspect, proximal extremity of the right humerus of *Ardea herodias.*

FIG. 36. Right humerus of *Nycticorax violaceus* (subadult); anconal aspect.

FIG. 37. Right humerus of *Ardea candidissima;* anconal aspect. All three bones natural size, and drawn from the specimens by the author.

Outer digit has five joints agreeing in the main with the other phalanges of the toes of this Heron's foot. They measure, in the order as given above, from proximal to last one, 2.9, 2.8, 1.7, and 1 centimeter long. Of course the actual length of these ungual measurements will be found to be rather more than those I have given, but it must be remembered that I only present the length of the chord from the tubercle on the inner side of the proximal extremity to the apex of the joint.

Herons possess no special ossifications other than those I have mentioned, that I am aware of, in their skeletons.

They have, in addition to their general structure, three peculiar external characters in common with a no less remotely related group of birds than the *Caprimulgi*. Coues, in characterizing the Night-jars, says: "Besides the semi-palmation of the feet, there is another curious analogy to wading birds; for the young are downy at birth, as in *Præcoses*, instead of naked, as is the rule among *Altrices*." (Key, 2d Ed., p. 448.) This author does not mention there however, a third character, it no doubt having slipped his mind at the time the above-quoted paragraph was penned. It is, that both the *Caprimulgi* and the *Ardeinæ* possess in common that very rare character—the *true* pectination of the inner margin of the claw to the middle toe of pes. This character is also seen in *Fregata*, a form far removed, osteologically, from the true Herons.

Synoptical and Comparative Review of the chief Osteological Characters of certain species of North American Ardeinæ.

1. In all the North American *Ardeinæ* the superior osseous mandible is of a subpyramidal form, with its base merging into the skull and its apex at the tip of the beak. It has three sides, the angle of the culmen being rounded off, the other two angles being cultrate. In length it is a little less than twice as long as the remainder of the skull, being notably *shorter* in some of the Night Herons than in the genus *Ardea*.

2. Osseous internasal septum very incomplete or altogether absent.

3. All are acutely holorhinal birds.

4. All have (in the dried skull) a moderate movement at the cranio-facial hinge; best marked in the Night Herons.

5. Ethmoid much swelled; broad and spreading under the frontal region; and truncated transversely in front, just posterior to the line of the cranio-facial hinge.

6. Pars plana very feebly developed both in *Ardea* and the Night Herons. It fails to meet the inferior and backward extending process of the lacrymal on the same side.

7. Very large, spongy maxillo-palatines, lofty and parallel to each other in the rhinal chamber, attached to nasals and premaxillary by

bony union. In some specimens they may come in contact with each other mesially, or they may have the anterior part of the vomer resting upon their hinder ends. In *Ardea* they are nearly all of a bony spongy tissue (cancellous). In *Nycticorax* they are generally overlaid with compact osseous tissue, and cancellous internally.

8. Vomer is a single plate ; deep, sharp and produced in front ; doubly carinate above, with the two carinations curled over outwardly so as to create a longitudinal trough upon that aspect ; united with palatines behind and free anteriorly. Inferiorly it shows its original bifurcated form, with greater or less distinctness.

9. Palatines are doubly carinated longitudinally ; inner keels being in close contact on the halves towards the rostrum (a contact that may result in anchylosis in very old individuals). Anteriorly they are horizontally flattened and merge with the premaxillary and surrounding bones. The posterior angles of their outer carinations bluntly pointed and not prominently produced. Pterygoidal heads extensively in contact, and above unite to form a groove for the rostrum.

10. A post-maxillary present (?).

11. Basi-pterygoid processes absent (negative character).

12. Quadrates very large ; the foot of either having four facets for the mandibular articulation.

13. A lacrymal bone is very large and articulates with both nasal and frontal of its own side. In *Ardea* its infero-produced portion is roughly parallel to the maxillary below it. In *Nycticorax* it makes a wide angle with the same bone, the anterior end of its infero-produced portion being much elevated.

14. Interorbital septum shows one large vacuity which includes the optic and other small nerve foramina near it. In *Ardea* the foramen for first pair of nerves, generally very large. In *Nycticorax n. nævius* these are smaller. In *Nycticorax violaceus* (adult) they are *very small* indeed, and just allow the passage of the nerve.

15. Three jutting processes on lateral aspect of cranium.

16. In *Ardea* and *N. n. nævius* the crotaphyte fossæ are separated by a considerable longitudinal median line. In *N. violaceus* it is by a tract of some width.

17. Foramen ovale, lateral.

18. In *Ardea* mandibular angle *obliquely* truncated. In *Nycticorax* mandibular angle *vertically* truncated (least obliquely in *A. virescens*,

least vertically in *N. n. nævius*). As a negative character we find the mandible in all *Ardeinæ* without a ramal vacuity.

19. There are 44 vertebræ and a pygostyle in the vertebral column of the *Ardeinæ*. In all, the dorsal series are free; in all, the twenty-fourth to the thirty-seventh inclusive are anchylosed with the pelvic bones; in all there are seven caudals. In *Ardea* the eighteenth and nineteenth vertebræ bear *free* ribs, and all seven caudal vertebræ are free. In *Nycticorax violaceus* the seventeenth, eighteenth and nineteenth vertebræ bear free ribs, and the anterior caudal vertebra anchyloses with the sacrum. The *pygostyle* is comparatively small. The epipleural appendages of the ribs are small and free.

20. Sternum of good size; its manubrium prominently developed; broadly 2-notched; four articular facets on either side for costal ribs; carina rather deep, its lower border convex and nearly the arc of a circle; dorsal aspect very concave; coracoidal grooves decussate; costal processes broad; one large pneumatic foramen in the median line above, just over anterior border.

21. Coracoid and scapula non-pneumatic; coracoid very broad below, antero-posteriorly; compressed from side to side above; scapular process small; slight differences in the two bones, at their sternal ends, due to their crossing each other. Scapula broad anteriorly, much compressed from above, downwards; apex rounded; blade rather long, not truncate, but tapers gradually to the end. Furcula non-pneumatic; upper half of each limb convex anteriorly, the reverse below; when articulated with coracoid, nearly reaches the scapula at the inner anterior angle of its head; hypocleidium has a superior and an inferior process.

22. Pelvis is rather massive; pre- and postacetabular surfaces about equal; ischiac foramen large; obturator foramen opens largely into obturator space; ilio-neural grooves sealed over anteriorly; one pair of free ribs articulate with the pelvis.

23. The humerus is the only pneumatic bone of the pectoral limb, the periphery of the orifice being in the general surface; remainder of limb well proportioned. Bones of pelvic extremity long and straight-shafted, except the fibula, which is short. In *Ardea* the fibula is short and free below. In *Nycticorax violaceus* fibula long and anchylosed with tibio-tarsus below.

24. Tendinal osseous bridge at lower end of tibio-tarsus exists and is thrown nearly square across the groove.

25. The hypo-tarsus of the tarso-metatarsus 3-crested, graduated in size, the outer being the smaller; the tendinal grooves pass between them. In *Nycticorax* the two largest crests fuse across at their posterior free margins, and convert the passage between them into a closed canal for the tendon.

26. Pes composed of well-proportioned phalanges, arranged on the plan of 2, 3, 4 and 5 joints to 1–4 toes respectively.

All of the forms of our North American representatives of the genus *Ardea* have the skull very much alike, except, of course, in the point of size. In *Ardea virescens* and *Nycticorax n. nævius* the skulls are notably very much alike, no pronounced characters, in fact, distinguishing them; while on the other hand *Nycticorax violaceus* has a skull that is at once seen to be distinguished from the skull in *Ardea* by its greater average breadth; its comparatively much shorter beak; by the form of its lacrymal bone; by the difference in the amount of interspace between the crotaphyte fossæ; and by the minute foramina for the exit of the first pair of cranial nerves as compared with the large vacuities there in *Ardea*. Finally by the vertically truncate posterior ends of the mandible, they being obliquely so in the latter genus.

The form of the *lacrymal bone* in these birds is an interesting one for whatever other morphological differences may exist between the representatives of the genera *Ardea* and *Nycticorax*, we can always distinguish the skull of the former from any of the latter, so far as our North American species go, by this bone alone. This difference pertains to the lower part of the lacrymal as set forth in my description above (compare figures of skulls of *Ardea* and *Nycticorax* given above).

While engaged upon the present memoir I have had before me skulls of *Cancroma cochlearia* and other foreign heron-forms, for which my thanks are due to the U. S. National Museum at Washington, D. C. Since that time some additional material has come to hand. Part of this is my own and part belongs to the U. S. National Museum. I find I have an imperfect skeleton of the Roseate Spoonbill (*Ajaja ajaja*); skeletons of the White Ibis (*Guara alba*), White-faced Glossy Ibis (*Plegadis guarauna*); and imperfect skeletons of a few other Ibises. There are also two or three complete skeletons of *Tantalus loculator* or the "Wood Ibis," together with a sternum and shoulder-girdle of the Jabiru (*Mycteria americana*). I have also complete skeletons of the American Bittern (*Botaurus lentiginosus*) and *Ardetta exilis*.

Among the Herons I find skeletons of *Ardea cærulea* and *A. virescens*, and some additional very complete skeletons of *Nycticorax*.

There is an interesting character to be seen in the skull of the Herons, and that is the condition of the basi-temporal bone. The entire forepart of this element is a free, triangular scale, instead of the usual small antero-median lip of it, underlapping the Eustachian entrances and arterial foramina. In *Botaurus* this character is very distinctly marked, so much so that upon a direct lateral view of the skull in that genus, nearly the entire basi-temporal is seen thus to be conspicuously individualized, and projects directly forwards as a large triangular free osseous plate, having above it a deep transverse groove. Otherwise the essential characters of the skull in *Botaurus* are the same as we find in *Ardea*, especially in *A. virescens*.

Upon comparing the characters of the skeleton of *Ardea cærulea* with those set forth in my synoptical table given above, I find that it answers to them most perfectly, departing from them only in matters of minor detail and of but specific significance.

Botaurus has all the principal characters of a Heron in its skeleton and comes nearer *Nycticorax* than it does to *Ardea*, and is nearest to *Ardea virescens* in that genus. For instance, this resemblance is seen in such a character as is exhibited on the part of the *os furcula*. In both *Botaurus* and *A. virescens* the symphysial part is transversely broad, and the hypocleidium is absent, its position being occupied by a shallow notch. The supero-median process above it, seen in all true Herons, is also very small. Otherwise the shoulder-girdle and sternum of the Bittern are quite as herodine in character as they are in any other member of the genus *Ardea*. *Botaurus* has however, a few distinctive skeletal characters of its own, which, taken in connection with others in its anatomy, plainly point to its being a different genus of birds. For some distance in the pelvis, the inner margins of the ilia run closely parallel to the thin sacral crista, and it is only at one small place, anteriorly, that these bones meet the neural crest of the sacrum. But for the rest, the vertebral chain of *Botaurus* is much as it is in *Nycticorax*. This extends even to its having free ribs on the seventeenth, eighteenth and nineteenth vertebræ (see table above), instead of only at the eighteenth and nineteenth as in *Ardea*.

With respect to the long bones of the limbs, they are comparatively shorter and stouter in *Botaurus* than they are in *Ardea*, thus again agreeing with *Nycticorax;* and in both these genera the hypotarsus of the tarso-metatarsus is the same, and is different from what we find in *Ardea* (see character 25 of the Table).

From an examination of my osteological material then, I would say that if we allow *Botaurus lentiginosus* to represent the American Bitterns, its nearest affine among the true Herons is *Ardea virescens*, and next *Ardea cærulea*; and this connection is through *Ardetta exilis*. On the other hand, *Botaurus lentiginosus* is directly linked to the Night Herons, through *Nycticorax n. nævius*, and next in order *Nycticorax violaceus*.

Osteology of Tantalus loculator.

(Wood Ibis.)

(SEE PLATE V.)

To the U. S. National Museum I am indebted for the loan of a skeleton of this interesting species of Stork. It is complete all to the few terminal vertebræ of the tail and the pygostyle, and the skeletal parts of the sense organs. From the same institution I have also an extra skull of *Tantalus*. One skull is considerably larger than the other and is probably from a male specimen. The smaller skull probably belonged to a female bird. Both are from fully adult individuals.

Characters of the Skull.—The superior mandible is three and one-half times as long as the cranium, measuring from the well-marked cranio-facial hinge. Seen from above, it is to be observed that the cranial vault is but moderately rounded, and as broad between the supero-orbital peripheries as it is in the parietal region. The fronto-lacrymal sutures are not obliterated, but all sutural traces of the nasal bones have entirely disappeared. The superior mandible tapers gradually to a moderately decurved point. For its anterior moiety it is completely rounded from side to side, while posteriorly the sides become flat.

The external narial apertures are rather small and subelliptical in outline. They are not far separated from each other, nor are they very far in advance of the cranio-facial hinge. At the hinder part of the skull the crotaphyte fossæ fail to meet in the median line, to the full extent of a centimeter. But at the sides of the skull these "crotaphyte" or temporal fossæ are very deep, giving marked prominence to the squamosal process, while the insignificant sphenotic process is double. A narrow, elongated excavation passes down the anterolateral aspect of the anterior wall of the brain-case, which passes out above between these small prongs of the sphenotic apophysis. For its entire length this excavation is merely separated from the temporal fossa of the same side by a line. On this lateral aspect of the skull we are also to observe the unusual depth of the *orbital cavity* which is due to the great transverse breadth of the skull; the completeness of the roof; and the general arrangement of the surrounding bones.

The *interorbital septum* is thick and perfectly entire; the *foramen opticum* circular and small; while the foramen for the nerve of the first pair is exceedingly minute. *Pars plana* is almost completely aborted, though the *lacrymal bone* is of good size. Upon its external aspect, this latter element is flat, its lower free point being broadly rounded, and fails to reach, by quite an interval, the zygomatic bar. It makes an extensive articulation with the frontal by a broad base, and is, near its middle, perforated in the antero-posterior direction by an elliptical foramen. Sometimes this is a deep notch instead, the bone not spanning it externally. The lacrymal shows also another large foramen higher up, through which nerves and vessels pass to the rhinal chamber. The bone is highly pneumatic.

The zygoma is stout and straight, and somewhat compressed from side to side. It makes a powerful ball and socket joint with the quadrate, and at its distal extremity it becomes indistinguishably fused with the nasal and premaxillary. At this point it sends inward a horizontal maxillo-palatine plate of bone, while the mesial portion of this last-named element is of great size and composed of spongy tissue. Together with the maxillo-palatine of the opposite side it nearly fills up the rhinal space. They fuse across the median inter-palatine space with each other, and with most of the bones in the neighborhood. This open spongy mass is also carried up to the roof of the rhinal chamber on either side of the narial openings to fuse with the ventral aspects of the nasal in that locality. Posteriorly these masses rise up over and come close to the anterior free edges of the very lofty ascending plates of the palatines to a point about opposite the anterior apex of the sphenoidal rostrum.

The osseous surface of the under side of the superior mandible is extended well back; shows numerous foraminal perforations, and its lateral margins for their entire lengths, upon either side, are produced downwards as not very sharp cultrate edges.

The *palatines* are very short and broad bones; and they develop very conspicuous internal and external descending plates of bone. In front they completely fuse with other elements forming the roof of the mouth, while for the short distance between their internal descending plates they are separated from each other by a narrow, spindle-shaped space with its long axis on the middle line. Posterior to this again, and up to the point where they articulate with the pterygoid, they completely unite with each other in osseous union. Superior to this coössified portion they make a common longitudinal cavity for the rostrum, which later, by close contact, rests in the same.

The *vomer* is a long, narrow, thin and transversely compressed spine of bone. Behind, it coössifies thoroughly with the united palatines in the middle line; it then arches over to the fused mass of the spongy part of the maxillo-palatines—the concavity of the arch being below. After it reaches the maxillo-palatine mass it becomes of needle-like dimensions, and in this form, as a free spine, it is still extended forwards between them in the middle line, lying in a crease which denotes their place of fusion. This is an unusual form of the vomerine element among birds, and very different from anything we find in the Herons. Either *pterygoid* is short, stout and straight, and of a trihedral form, with sharpened edges, especially the superior one. They are in contact anteriorly when articulated *in situ*. A quadrate is comparatively large and bulky in its proportions, with powerful orbital and mastoidal processes. The latter is compressed transversely with truncated end, while the latter, somewhat twisted upon itself, has a distinct double head at its articulation. The mandibular part is massive with an arrangement of facets entirely different from what we found in the Herons. There are but *two* of these, upon either quadrate they are separated from each other by a transverse valley. The anterior facet—rather the smaller of the two—is three times as long as it is broad, and its long axis is perpendicular to the vertical median plane of the skull. With it the posterior one makes a slight angle, its outer end being the most anterior, and, at the same time, the one found below the cup for the proximal end of the zygoma. At this point the space intervening between it and the anterior mandibular facet of the quadrate is very narrow. Most of these bones at the base of the cranium are more or less pneumatic.

The Eustachian passages are open anteriorly, and the foramina for the internal carotid arteries are likewise exposed, being unshielded by the usual antero-median lip of bone furnished by the apex of the basi-temporal. This latter is small and triangular, with its postero-basal line elevated in an unusual manner. Either paroccipital is somewhat conspicuously produced as a thickened scroll-like process curling forwards as an osseous wing to protect the aural entrance.

The good-sized *occipital condyle* is thoroughly sessile—hemispherical in form—and unnotched. Subcircular in outline the *foramen magnum* looks downwards and backwards, the plane of the occiput looking rather more directly backwards. This last-named area—broadly reniform in outline—is almost completely surrounded by a well-marked occipital crest or line. On either side below this becomes continuous with the free margins of the paroccipital processes.

A true "supra-occipital prominence" can hardly be said to exist, and there are no lateral foraminal perforations, such as we find in most species of true Ibises. A narrow, median vertical ridge divides usually the occipital area, but this does not correspond to the eminence commonly described as the "supra-occipital prominence."

This Stork possesses a powerful acutely V-shaped *mandible* the symphysial portion of which is very extensive—occupying almost the entire anterior moiety. This part is narrow from side to side, moderately decurved, rounded below and deeply concaved in the longitudinal direction above. The ramal limbs are flat and deep, especially in the region where the small ramal vacuity exists in each. Either articular cup is an extensive concavity, vertically truncated behind, and upon its blunt inturned mesial process exhibiting the usual foraminal perforation for the admittance of air into this part of the bone. When articulated *in situ* the osseous mandibles do not come quite in contact for their posterior two-thirds, and this applies also to the superior ramal margin of either side of the lower jaw, opposite the proximal two-thirds of the zygoma. In either case the interval is of but small amount, being *less* in the latter than it is in the former.

Of the Trunk-Skeleton of Tantalus.—This is complete in the specimen at hand with the exception of all the vertebræ of the tail save the first one—the others having been lost. In the spinal column, the atlas appears to be non-pneumatic, but all the remainder of the trunk-skeleton enjoys that condition to a greater or less degree,—the pelvis and the distal extremity of the scapulæ perhaps being the least so, while it is quite perfect in the other bones.

Between the skull and the pelvic sacrum I count 21 vertebræ. All of these are freely movable upon each other. There are no free ribs on the first 15 cervicals, but the pleurapophyses become free upon the sixteenth vertebra, though they are hardly entitled to the name of ribs.

There is a long, free pair on the seventeenth, but they lack epipleural appendages. The pair on the eighteenth vertebra, or the first true dorsal one, connect with the sternum by short hæmapophyses. This, and the three following pairs of vertebral ribs have epipleural processes, which are of no great length and are firmly anchylosed to the borders near their middles. The vertebral ribs are inclined to be flat and broad, the ultimate pair being considerably curved both antero-posteriorly, and, above, transversely. The costal ribs become gradually longer and longer as we pass backwards, and flatter from side to side. There is a pair of pelvic ribs anchylosed with that bone above, but freely articulating with the longest and last pair of the hæmapophyses below. No epipleural spines occur upon their borders.

This arrangement gives *five* pairs of costal ribs, in addition to which we find a small pair of "floating ribs." These are attached in the usual way by ligament to the posterior margins of the last vertebro-costal pleurapophysis, lapping over the articulation.

Taking the leading vertebræ of the chain to include the 17th, we are to observe that they are inclined to be massive, and closely locked together when articulated. None of their processes or spines are prominent. A low, thickened neural spine occurs on the axis vertebra, but gradually disappears on the succeeding ones, to become quite absent on the seventh, and does not again develop until we come to the thirteenth. Here it is double, the two halves inclined to come to a point in front. This is accomplished in the fifteenth cervical, where this neural process is distinctly arrow-shaped, with its apex directed anteriorly. Such also is its shape in the sixteenth, while in the seventeenth this is changed abruptly for the flattened quadrate process seen throughout the dorsal series of vertebræ.

The infero-median arterial canal is commenced on the sixth cervical, where it is open. On the seventh to the eleventh it is nearly or quite closed, to be open again on the twelfth to the fourteenth inclusive, after which it is barely evident. The lateral vertebral canals are slightly indicated even in the *atlas*, while they are complete and closed in the second to the sixteenth inclusive. We also find parial pleurapophysial spines beginning to develop on the axis vertebra; on the third they are well-marked and thickened, but becoming long nowhere in the series, they gradually disappear after passing the ninth vertebra. The "cup" of the atlas is notched superiorly, and the postero-external angles of its neural arch are produced backwards. In the third cervical we find a short interzygapophysial bar, inclosing, upon either side, a small subcircular foramen, which is replaced by a shallow notch in the fourth vertebra. Both pre- and postzygapophyses in the second to the fifth vertebræ inclusive are exceedingly short and massive, so when these bones are articulated *in situ*, we are unable to gain a view of the interior of the spinal canal between any two of them, as we do in the case, for instance, between the seventh and eighth, on the superior aspect. The articulations among the centra are of the usual ornithic type, and the neural canal is comparatively large through the cervical chain. Elongation of the vertebræ takes place gradually from the third to the eighth inclusive, but the ninth segment suddenly assumes the general form of a dorsal vertebra. These latter are closely locked together at their articulations; are entirely devoid of hæmal processes; while their low quadrilateral neural ones are not in contact with each other in front or behind. They have metapophysial spines which project both anteriorly as well as posteriorly, but fail to meet at either point. The neural canal diminishes slowly in calibre as we near the pelvic end of the chain, but is of pretty good size throughout.

In some particulars the *pelvis* of *Tantalus* resembles that bone in the true Ibises. On the whole the bone is broad, rather shortish, and sub-compressed in the vertical direction. The postacetabular portion is but very slightly bent on the preacetabular part. Intimate anchylosis exists between the pelvic sacrum and the ilia upon either side. Viewed from above we are to note that the ilia are much expanded in front where they project considerably beyond the sacrum. Their borders are rounded here, with a pronounced emargination, while the mesial borders meet and fuse for a limited distance over the sacral crista. The fore part of this preacetabular portion of the bone for the most part faces upwards, and only outwards as it rises up on the sacrum, and forwards and outwards as it sweeps, on either side, in the direction of the acetabulæ. The "ilio-neural canals" are sealed in behind, but open, as usual, anteriorly. Passing to the postacetabular region, we find its lateral borders quite conspicuously sharpened, and where they overhang the antitrochanters — projecting. A row of interdiapophysial foramina occur in the sacrum, the holes becoming progressively larger as we pass backwards. A few scattering ones occur to the outer side, on either hand. The lateral postero-external portions of the ilio-ischiac bones extend backwards for a distance considerably to the rear of the pelvic sacrum. On side view, at the extremity of these parts, on either aspect, there is seen a well-marked ilio-ischiadic triangular notch. This character also exists in the true Ibises. The ilio-ischiac foramen is large and subelliptical in outline. A pubic style is thickish, of nearly uniform calibre, projects behind considerably beyond the rest of the pelvis, and is notably separated from the lower margin of the ischium for its entire length. This latter circumstance leaves the large obturator foramen very open at its hinder boundary. A cotyloid cavity is also large, and its inner periphery is decidedly smaller than its outer one. Nothing of special note characterizes the anti-trochanter. The latter is overarched by the iliac border, above. Viewed upon its ventral aspect, the pelvic basin is seen to be deep and capacious, and the sacrum made up of 15 vertebræ. Of these, the four anterior ones throw out their lateral processes to fuse with the under surfaces of the ilia. The fifth one just barely misses performing the same feat. In the next succeeding four the processes, or such of them as are not aborted, are extended directly upwards so as to be practically out of view. The *tenth* sacral vertebra throws out powerful lateral struts to the iliac sides, just posterior to the acetabulæ. Either one of these are expanded at the extremity. This is also done by the eleventh vertebra, but in its case they are shorter and very much weaker. Still more is this the state of these processes in the last four sacral vertebræ. As I have already said, the skeleton of the tail of this specimen has been lost, all to the first segment. It resembles the ultimate sacral one, but is smaller; it is apparently pneumatic. Its low neural spine is thick and it has no hæmal one. Most of the foramina for the exit of the nerves of the sacral plexus, on either side, are double—one occurring immediately above the other.

Passing to the consideration of the *sternum*, we find its body to be oblong in outline; roundly and deeply concaved on its thoracic aspect, where it is riddled with minute and scattered pneumatic foramina; and it is seen to be once well-notched upon either side of the keel behind. The lateral xiphoidal processes thus formed are slightly longer than the body, and directed posteriorly. The mid-xiphoidal projection is rather broad and cut squarely across. A costal border, with its five hæmapophysial facettes, occupies about half the side of the bone, the spaces among the facettes being deep little concavities with pneumatic holes at their bases.

Either costal process is tilted outwards, moderately well-developed and subquadrilateral in outline. The carina runs the entire length of the body of the bone. It is deep in front and gradually grows less so as we pass posteriorly. Its lower border is uniformly convex to the front, and near the middle of its side it is strongly marked by the pectoral muscle-line. Anteriorly, its border is concaved to the front, thickened and scooped out just below the moderately developed and pointed manubrium.

Immediately below this latter process a single pneumatic foramen is seen, occupying the bottom of the upper part of the aforesaid concavity. At the carinal angle we find a large subcircular facet for articulation with the clavicular symphysis of the os furcula. The costal grooves are rather deep and they decussate. They each extend backwards to points just in front of the corresponding base of either costal process. The anterior border of the body of the sternum is markedly convex to the front, and in the mesial portion exhibits a transverse concavity. The fore part of the keel of this sternum protrudes anteriorly beyond the manubrial process. There are a number of points in this bone which disagree with the corresponding characters as they are found in the sternum of the true Ibises, the fact that it is 2-notched instead of being 4-notched, as in the latter family, being one of the most conspicuous ones.

In the *shoulder-girdle* the bones are all stout and strong. Os furcula is of the U-shaped pattern, though somewhat inclined towards the V. Its clavicular heads are elongated, thickened, each exhibiting a peculiar twist upon itself, and is distally bluntly pointed. When articulated *in situ* either of these ends are apparently only connected with the corresponding scapula by ligament. The moderately curved clavicular limbs below the free extremities are subcylindrical in form, and at the enlarged symphysis curve forwards to terminate in a bluntly pointed hypocleidium. At the posterior aspect of this latter, at its apex we find a smooth, flat, subelliptical facet for articulation with the one described above as occurring on the carinal angle of the keel of the sternum. The pneumatic foramina of this bone are found upon the mesial aspects of the distal ends near the apices.

For the size of the bird the *scapula* is a very short bone, being at the same time thick with very little curvature to it. Its distal end is bluntly pointed, and it makes an extensive articulation with the coracoid, affording at the same time rather more than a third of the glenoidal cavity for the head of the humerus. Apparently its anterior moiety is pneumatic. A *coracoid* possesses a well-developed and curling clavicular process, while the upper end of the bone is laterally much compressed, and correspondingly deep in the antero-posterior direction. Its summit is moderately enlarged, being nearly smooth and convex on top, and rises above the clavicle when the elements are duly articulated. With respect to its shaft, we find it to be elliptical upon horizontal section, it being somewhat compressed in the direction from before backwards. As usual the sternal end is expanded, and only a rudiment of an epicoracoidal process is present. The mesial angle of this end of the bone is sharply pointed, the convex portion of the sternal facet running clear out to the end of this point on its under side. The sternal facet is continued as a concave surface over a lip-like elevation of bone, nearer the middle line, low down on the posterior aspect of this expanded end of the coracoid. No foramen is seen to pierce its shaft, as in *Plegadis guarauna*, while several sizable pneumatic foramina always occur on the inner surface of the bone below its anterior summit.

Of the Appendicular Skeleton.—*Tantalus* has an arm-skeleton of fine proportions, being at the same time well built and strong. In it the *humerus* is the only bone enjoying pneumaticity, the others lacking that character entirely. With regard to the proportionable measurements of these bones we find that the humerus has a length of 17.7 cm.; the radius 21.8 cm.; the ulna 22.8 cm.; the carpo-metacarpus 10.6 cm.; the proximal joint of index digit 4.4 cm.; the distal joint of the same finger 3.4 cm.; and the pollux phalanx 3.1 cm. No claws are found upon the fingers, and the small phalanx of medius digit has a length of 2.1 cm.

Viewed upon either direct aspect the humerus presents the usual sigmoidal curves, and its smooth shaft is elliptical on transverse mid-section. The radial crest (*crista superior*) is rather long, triangular in form, with its free border not sharp. Conspicuously developed, the ulnar crest (*crista inferior*) surrounds a capacious pneumatic fossa, but the air hole is not especially large, is single, and situated on the extreme mesial side of the fossa, near the middle line of the long axis of the shaft. The fossa seen between the smooth demi-ellipsoidal humeral head and the prominent projection of the ulnar tuberosity, is deep, as is also the incisura capitis. At the distal end of the bone both the trochlea radialis and ulnaris are large, the large fossa above them being well scooped out. A low ectepicondylar process is developed. On the anconal side of this end of the humerus we find the usual grooves for the guidance of passing tendons, the *sulcus anconei lateralis* being the best marked.

Passing to the *ulna* we are to note that its stout, subcylindrical shaft is but slightly curved, while down its palmar edge there can be counted fourteen papillæ indicating so many points of insertion of the secondary quill-butts of the feathers of the wing. At the proximal end a good-sized olecranon process is seen, being situated directly over the fossa of articulation of the trochlea ulnaris of the humerus.

As to the *radius*, when the bones of the forearm are articulated *in situ*, it projects, distally, somewhat beyond the end of the ulna, which it there accurately overlaps. The reverse of this is the case at the proximal ends. Again, the distal moiety of the radial shaft is nearly straight, and runs parallel with the shaft of ulna, while the proximal half of the radius is somewhat curved, its concavity facing the other bone of the antibrachium, or the ulna. The shafts of these two elements of the forearm come in contact then only at their extremities, thus creating an elongated interosseous space, which is of greatest width proximad. Two free *carpal bones* are present, having the usual ornithic characters. This latter remark might also be applied to the *carpo-metacarpus*. Regarding it, however, we would say that its main shaft (index metacarpal) is very straight, and has a calibre about one-third greater than that of the middle third of the shaft of the radius. Its curved medial metacarpal is far slenderer, and stands well away along its continuity from the main shaft. Proximad, where it fuses with it, it is considerably expanded from side to side, while distally, where it joins the index metacarpal again, it is seen to be not quite as long as the latter. Pollex metacarpal is very short and projecting. The articular surfaces of all the bones entering into the composition of the carpus are as we find them in birds generally, that is, of the ordinary species.

The proximal phalanx of index digit is rather elongate with its expanded part not markedly developed. This latter part has a small, distinct process distally which projects beyond the true shaft-part of the bone. It also has, on its palmar surface, an oblique ridge, dividing the shallow concavity there formed into two nearly equal fossæ. Transversely, the head of this bone is wider than the distal end of the index shaft of the carpo-metacarpus which articulates with it. *Medius digit* presents nothing peculiar; it has the usual small process-like elevation upon its hinder border, and when articulated *in situ* is closely pressed for nearly its entire length against the first joint of the index finger. The trihedral terminal phalanges of pollex and index digits are much alike in their morphology, and depart in no striking character from what we see in those bones in all large ordinary birds. Small free sesamoidal bones seem to be absent from about any of the articulations of this arm-skeleton of *Tantalus*.

In the matter of development the *pelvic limb* is equal to the pectoral extremity, but the relative proportions of the corresponding bones of the three first segments is quite different. For instance, the femur has a length of 10.3 cm., while the tibio-tarsus is 26.5 cm. long, and the tarso-metatarsus measures 21.1 centimeters. Of course, in this, the fingers and toes do not enter into a comparison, and we would simply add that the mid-anterior toe has a length of about 10.7 cm. The basal phalanx of the outside toe is the longest of all the joints of pes, measuring 5 cm.; that of the middle toe being 4.2 cm. and of the inside one 4.4 cm. The free first metatarsal bone is 2 cm. long, and the basal joint of hallux has a length of 4.0 centimeters.

As in the case of the humerus of the arm, the *femur* is highly pneumatic, none of the other bones of this limb enjoying that property. A large, single pneumatic foramen, subelliptical in outline, is found on its anterior aspect near the summit, and just in front of the trochanter. Other minute ones occur in the rotular channel between the condylar crests. This bone is quite straight with smooth cylindrical shaft upon which the usual muscular lines are but faintly marked. Antero-posteriorly, the great trochanter is of considerable width, and its crest rises conspicuously above the smooth articular summit of the shaft. The large, globular and sessile caput femoris exhibits on its upper surface a well-circumscribed pit for the insertion of the round ligament. At its distal extremity we are to note the unusual depth of the rotular channel in front, giving, as it does, great prominence to the condyles in that region. These last are of themselves large, with their lowermost points being very nearly in the same horizontal plane. Posteriorly, the external condyle is powerfully developed and very prominent. It is also deeply cleft for articulation with the head of the fibula. The internal condyle is here markedly flattened. Above them, the popliteal fossa, though circumscribed, is quite deep. It is made so more particularly by the form of the internal condyle, which has a sharp, elevated internal border carried up for a short distance upon the shaft, and a ledge-like connection with the external condyle, the flat upper surface of which forms the distal side of the popliteal fossa. The *patellæ* are not present in my specimen, and *Tantalus* may either not possess those sesamoids, or they may have been lost. I am inclined to believe the species does not have them, and they are not present in *Plegadis guarauna*.

The wonderfully long shaft of *tibio-tarsus* is perfectly straight for its entire continuity until we reach a point immediately above the condyles of the distal extremity ; at this point it makes barely a perceptible turn forwards. The posterior and lateral aspects of this shaft form one continuous rounded surface, while the anterior aspect is nearly flat, with a gradual and very slight inclination to become longitudinally grooved at the junction of the lower and middle thirds for a distance extending over about 3 centimeters. On the summit of the bone the articular surface is nearly level and the entire width of the cnemial crest is developed but a short distance above it. Pro- and ectocnemial processes are produced hardly at all down upon the front of the shaft, but otherwise they are in no wise reduced, and exhibit the usual ornithic characters. Almost immediately below the external one we find the fibular ridge commencing, and this, after extending down the shaft for a distance of about 3 cm., terminates somewhat abruptly. At the distal extremity the condyles are of a size in proportion with the other parts ; they have the ordinary reniform outline ; and one of them is no lower on the shaft than the other. They project beyond the latter about as much posteriorly as they do in front. But the intercondyloid groove is decidedly shallow both below and in the former situation. Anteriorly, however, it is very deep, and at its upper part here forms a distinct rounded concavity. This is intended for the reception of the conspicuous and rounded process situated on the antero-median aspect of the summit of the tarso-metatarsus, when that bone is powerfully flexed upon the leg. Above the just-mentioned concavity, the bone also juts out a little ways, thus forming an abutment to add additional security to the articulation. Just internal to this is the very small lower aperture of the tendinal canal. The proximal aperture is hardly any larger, while the overspanning osseous bridge is thick and strong. Proximad to these characters again, the anterior aspect of the tibio-tarsal shaft is inclined to be slightly grooved for a very limited distance. Nearly opposite each other on the borders of this are two osseous tubercles. They are intended for the attachment of the ligament which holds in place some of the tendons during life.

Fibula is strongly developed above the point where it articulates with the fibular ridge of the tibio-tarsus. Then it begins gradually to dwindle in size, and near the middle of the latter bone, fuses indistinguishably with its shaft. We would note also, that its ligamentous attachment with the fibular ridge of the tibio-tarsus is extremely close for the entire length of that projection.

On the summit of the *tarso-metatarsus* the concavities for the tibio-tarsal condyles are deep, and standing between them in front is the very pronounced articular process mentioned above. The short and massive hypotarsus exhibits a wide and deep median longitudinal groove for the tendons. The free edges of its sides are thickened and each turned outwards away from the central excavation.

To the outer side of the external aspect of this hypotarsus, and to the inner of the inner side of the internal one, there is a foraminal aperture, which passing through the shaft of the bone, in either case, makes an appearance anteriorly immediately above the very distinct and double tubercle for the insertion of the tendon of the tibialis anticus muscle. This hypotarsal enlargement makes but a feeble attempt to an extension down the shaft behind. As to the shaft itself, it is quite straight throughout. Its sides are flat, it being somewhat grooved longitudinally for its entire length posteriorly, and very much more profoundly so, anteriorly. In the latter case the groove is carried from the summit down to within a short distance above the large subelliptical perforating foramen of the anterior tibial artery, and even this last has a deep and narrower groove running into it from above. All the distal trochlear processes are well-developed. The central one is the lowest on the shaft, the two lateral ones descend about equal distances, and then each turns in behind towards the median axis of the bone. Between these trochleæ the spaces dividing them are rather wide, thus lending to the processes themselves a notable distinctness. The median one is clearly marked by its articular groove for its entire extent ; in the case of the other two, the groove is not at all evident in front ; only faintly so distally, but becomes very manifest posteriorly.

The free *first metatarsal* is articulated in the usual manner. Its facet on the metatarsæ is elongated, being on the lateral edge of the shaft about a centimeter above the internal trochlea. As to the accessory metatarsal itself, it is somewhat twisted; expanded proximally; and bears distally the usual trochlea for articulation with basal joint of hallux. The joints of *pes* are upon the normal arrangement, that is, 2, 3, 4, 5 for first, second, third and fourth toes respectively. They are proportioned, present nothing peculiar, and their principal measurements have been given above.

The terminal or ungual joints are rather short, inclined to be weak, are pointed distally, and show scarcely any curvature,—really none at all,—in the antero-posterior direction. This also applies to the intermediate phalanges between them and the trochleæ of the tarso-metatarsus.

On the Sternum and Shoulder-girdle of Mycteria: Taken in their main characters, these parts of the skeleton in the Amazonian Adjutant (Spec. 11511, S. I. coll.) agree more or less with the corresponding ones as we have described them above for *Tantalus*. There are a number of important differences however, as, for example, the coracoids in *Mycteria* do not discussate in their sternal beds, but are separated by an interval of several millimeters of bone. *Mycteria* again, has but *four* hæmopophysial facets upon either costal border of the sternum, and the latter bone is relatively shorter and more massive. In front, the manubrium is entirely aborted, while posteriorly it is 2-notched in a manner quite similar to what was found in *Tantalus*. It is highly pneumatic, its thoracic surface very deeply concaved, being actually riddled with various air-holes. Peculiar transverse and irregular corrugations occur upon the same aspect, the pneumatic foramina occurring in the intervals between them. The carina is of great depth, and somewhat swollen in its anterior moiety by a pneumatic cavity. The upper half of the anterior carinal border presents a deep longitudinal excavation, at either basal end of which exist pneumatic foramina leading into the carinal swelling mentioned in the last paragraph. Strong muscular lines mark the sides of the keel, and the ventral aspect of the body of the sternum. The several bones of the pectoral arch resemble those of *Tantalus* in general form. They are also pneumatic. *Os furcula* however, is more of a decided U-pattern, though its symphysis below makes the same articulation with the carinal angle of the sternum, as occurs in *Tantalus*. The apices of the free clavicular ends of the arch are connected in life with the scapulæ by an interval, on either side of ligament, which likewise agrees with what we found in the Wood Ibis. A rudimentary epicoracoid process is found upon either coracoid, and the anterior extremities of these latter bones are laterally compressed, and when the elements of the girdle are articulated *in situ*, they stand but very little above the clavicle upon either side.

Each *scapula* is short and thick, being bluntly pointed at the distal end. Scapula also shows a general curvature along its continuity, being somewhat more marked than it is in *Tantalus*, and, what I should have said above, the lower border of the keel of the sternum is decidedly more convex than it is in that bird. When the several bones are articulated as in life, the long axis of a coracoid is almost parallel with the imaginary line representing the long axis of the body of the sternum. The scapulæ articulate, each with its corresponding coracoid at an angle of about 86°, and the long axes of the clavicular heads of the os furcula are about in line with them, on either side; while the plane in which the remaining part of the furcula may be supposed to exist, is parallel to the long axes of the coracoids. Either clavicular head of the furcula is extensively and rather closely applied to the mesial side of the coracoid where it articulates, and about a centimeter beyond this, the limbs at once curve down in the direction of their symphysis. The very thickish hypocleidium bends abruptly forwards—its posterior aspect being entirely applied to the facet occupying the carinal angle.

ON THE SKELETON IN THE IBISES.

(*Guara alba, G. ordii, and Plegadis guarauna.*)

(SEE PLATE IV.)

Of the axial Skeleton:—Osteologically, these birds are very different from *Tantalus*. Viewed from above, the *cranium* is seen to be rounded and smooth, with the superior margins of the orbits wide apart. These latter borders are not sharp, but rounded off. In the frontal mid-region, just posterior to the premaxillaries, it is inclined to be concaved in *Plegadis*, and markedly so in *Guara alba*. In the former genus, too, there is a median longitudinal furrow, which is absent in the White Ibis. Both are schizorhinal birds, especially in the case of *Guara*, where the narial apertures are very narrow, elongated slits, and the premaxillary processes of the nasal bones are defined. The long, curlew-like superior mandible is very much decurved, and the culmen is rounded off. It is roughened towards the tip as in certain snipes, and, as in them, somewhat transversely dilated distally. The extreme apex is bluntly rounded. On the posterior aspect in *Plegadis* we find the supraoccipital prominence very conspicuous, and upon either side of it, a large, subelliptical foramen. These two characters are not so strong in *Guara*, where the foramina are relatively, as well as actually, smaller and more elongate. In this genus, however, an "occipital ridge" is pretty well marked, and it is not so evident in *Plegadis*. The crotophyte fossæ are, mesially, well separated.

Upon lateral view, we notice that the anterior end of the narial slit in the beak is extended forwards as a narrow split aperture more than half way towards the extremity, as it is in the Curlew (*Numenius*). Ibises, however, have the separated premaxillary limbs thus formed, far more rigid than they are in the Curlews. This is due to the fact that the maxillary fork of the premaxillary is deeper and stouter in the Ibises, and it is more firmly held in place by the enlarged and united maxillo-palatines within. *Plegadis* has a very slender and straight zygoma, with its maxillary end completely fused with, and much hidden by the bones surrounding it. The free bar of the nasal bone, or that portion passing between the frontal region and the maxillary process of the premaxillary, is straight and flattened.

A *lacrymal* makes a very extensive and close union with the edge of the frontal bone and nasal. Actual anchylosis, however, does not take place along the line of the suture. Its superior portion is subhorizontal in position and from this part it sends inwards a distinct process towards the rhinal chamber; and downwards a broader and antero-posteriorly flattened process towards the maxillary. This latter bone it reaches by the intervention of a well-developed osseous rodlet representing an *os uncinatum*. This descending process of the lacrymal also sends directly inwards a small process that touches the tip of a similar one sent outwards on the part of the small quadrate *pars plana*. The anterior wall of the brain-case is entire, as is also for the most part the interorbital septum. The foramen for the exit of the first pair of nerves is nevertheless much cut away; while on the other hand the foramen rotundum, and the smaller nervous foramen to its outer side, are not so very much larger than is required to pass the nerves they are severally intended for. Each orbital cavity is then moderately deep, its general shape being subhemispherical. Comparatively, however, the orbit of this Ibis is not so deep, nor so thoroughly surrounded by bony walls, as it is in *Tantalus*. A temporal fossa, as seen on this lateral aspect of the skull in *Plegadis* is narrow, fairly well deepened, and elongate in the antero-posterior direction. The squamosal and postfrontal processes are small. The entrance to the aural cavity is considerably shielded by the bony rim that surrounds it, while we are to note that the *foramen ovale* makes encroachment upon its anterior precincts. But little importance distinguishes a *quadrate bone*. Broad and quadrate in outline, its orbital process is squarely truncated at its free inner extremity. There is a double facet upon the mastoidal head, while the mandibular facets are but feebly carved out. As compared with *Tantalus*, these latter are somewhat differently disposed, especially the innermost one, it being markedly angulated in the Ibis and strictly transversely placed in *Tantalus*. *Os quadratum* in both genera possess a small hemispherical facet for articulation with the proximal end of a pterygoid ; while the broad outer projection presents upon its supero-external aspect the usual little pitlet for articulation with the peg-like process on the inturned end of the proximal extremity of the zygoma. It will be as well to say nere in passing that the facets on the mastoidal head of the quadrate bone in *Tantalus* are much more distinctly separated than they are in *Plegadis*.

Turning to the base of the skull we find the foramen magnum to be of large size and subcordate in outline. In some specimens its superior margin is closely approached by the supraoccipital foramen upon either side, lending to the postero-basic aspect of the cranium in this region a very open appearance. The occipital condyle is very small for a bird the size of *Plegadis*, and it is seen to be sessile, with a faint notch on its supero-mesial side. Immediately posterior to the aural cavity, upon either side, there is developed a strong and distinct descending paroccipital process—a character practically aborted in *Tantalus*. Within these, and still further forwards, we observe small circumscribed pits, one on each hand, that give passage to vessels and nerves through foramina at their bases. The basitemporal area, triangular in outline, is of fair size, while its anterior angle as a free scale-like tip underlapping the openings to the Eustachian tubes. These are open channels for the best part of their extent in front, being covered over only just before arriving at either aural cavity.

The rostrum is rounded beneath and carried to a distinct pointed process anteriorly. Above this, as the anterior ethmoidal margin, it is carried obliquely forwards and upwards to finally spread out and give support to the fore part of the cranium in the facial region, at its inferior surface.

Ibises lack basipterygoidal processes, and the pterygoids stand far away from the lower part of the brain-case.

A *pterygoid* is of good size, and may be said to be truly twisted upon itself, with its hinder half very much compressed from side to side, as is its anterior moiety similiarly compressed in the opposite direction. Its anterior outer border is exceedingly sharp and thin. When the pterygoids are articulated as in life, they make an extensive articulation with pterygoidal heads of the palatines as they do with each other beneath the spheroidal rostrum. This is also the case in *Tantalus*, and the bones are not altogether in the two genera. From side to side, the *palatines* are very narrow bones. Posteriorly for a notably small part of their extent they are tightly pressed together, and form on their upper aspects in this locality a short longitudinal groove for the reception of the rostrum. In passing forwards they are quite parallel to each other, and thus beneath the maxillo-palatines to become, in the adult, completely and indistinguishably fused with the other bones. Upon their under sides posteriorly, each one sends down both an internal and an external lamina of bone. These plates are about of equal proportions, and the postero-external angle of the outer one is completely rounded off. Anteriorly, and upon their upper aspects, the palatines develop extensive ascending processes or plates, which have their planes nearly parallel to each other. These, when we regard the skull upon its lateral aspect, shut the free part of the sphenoidal rostrum out from view, and the entire anterior border of either one of them has resting upon it, the large maxillo-palatine of the same side. *Plegadis*, as in the case with other American Ibises, has a long, very slender, and anteriorly pointed *vomer*. This bone is completely anchylosed with the palatines behind, exhibits barely any curvature as it passes forwards, while its extreme tip just reaches the maxillo-palatines at the point where those bones fuse across the interpalatine valley. This vomer has only two points of contact then, and these are at its extremities, it being nowhere else anywhere near the surrounding bones. There is no doubt but that in very old Ibises the palatines anchylose with each other in a very thorough manner. One specimen in my collection exhibits this condition, and it agrees with what we find in *Tantalus* and its palatine bones. In fact, as different at first sight the bones at the base of the skull appear to be in *Tantalus* and these Ibises, they are fundamentally the same in character. The *maxillo-palatines* are large, spongy bones, completely overlaid with a thin coating of compact tissue. Posteriorly, they extend far backwards and are here well-separated from each other, the entire interpalatine space and the vomer standing between them. In this region too, they mount well up into the rhinal chamber occupying much of its room. Between the maxillaries and immediately in front of the apex of the vomer their behavior is very different. They here cross the median space to completely fuse with each other, and that for a distance for at least a centimeter in front of the vomerine spine. This desmognathous condition is not quite as complete, or rather quite as extensive, as it is in *Tantalus* for example, because in front of those fused maxillo-palatines in the Ibis we again meet with another open vacuity in the middle line, which may be a centimeter or more in length. It usually extends as far forwards to a point nearly opposite the anterior terminations of the external narial apertures, which, of course, are above it. We may add here, what perhaps should have been said in another place above, that we find a small foramen above either *pars plana*, for the passage of the nasal nerve, and the supero-anterior part of one of those mesethmoidal wings is turned forwards in a peculiar manner, so as to form between it and the mesial ethmoidal plate proper a deep fossa, open in front and below. *Plegadis* has the osseous circlet of sclerotal plates in the eyes complete as in other birds, but the individual pieces are each very small and overlap their fellows all round for at least a third of their surface, the arrangement gives a large pupiliary aperture, and the posterior plates are but slightly larger than the anterior ones. Ear bones have been lost in all my present specimens, as have those of the hyoidian apparatus.

Coming to the *mandible* we find it decurved in a manner to correspond to the upper bill. This curvature is general from one end to the other. The anterior ramal symphysis is very extensive, extending back for nearly or quite half the length of the bone. Below, it is deeply grooved in the middle line from the apex to where the symphysial part terminates posteriorly. This grooving is also seen upon the superior aspect, but much more fully marked. A similiar longitudinal groove also occurs down the entire middle line of the superior mandible upon its under side, and as in the case of that part of the bill, the lower jaw has also a slight dilatation at its distal end. The posterior half of the mandible is acutely V-shaped, its upper and lower ramal borders being rounded and not sharp. The sides increase in vertical depth as we proceed towards the articular ends, and the ramal vacuities do not exist. There is a sizable ramal perforation or foramen however, further back on either side, near the point where the temporal muscle makes its insertion. Each articular cup is rather small, though its internal process is well-developed and the posterior one even still better. These posterior articular processes are absent in *Tantalus* but present in *Ajaja*. Here in *Plegadis* they each spring from the extreme external and back part of the articular extremity, and each has to its inner side a concavity which occupies the true posterior aspect of either articular end of the mandible. This part of the bone is pneumatic, but the air-holes are very small, and found further from the apices of the internal articular processes than is usually the case in most birds.

Seventeen vertebræ are to be found in the cervical region of the spinal column of *Plegadis*, before we arrive at that one the ribs of which are joined to the sternum through the articulation of hæmapophyses or costal ribs. This is the eighteenth vertebra, and it together with the nineteenth, twentieth and twenty-first are solidly anchylosed together so as to form one bone, such as we find among the typical gallinaceous fowls. The twenty-second vertebra is free and stands between this compound dorsal piece and the sacrum of the pelvis. This latter has fourteen more vertebræ in it, they being fused together as in the sacra of all ordinary birds. In the skeleton of the tail we find five vertebræ, and to these is to be added the pygostyle. Thus it will be seen that this Ibis has forty-one vertebræ in the skeleton of its spinal column, plus a pygostyle, which is probably composed of several others.

There is a tiny pair of free ribs, of the most elementary character, on the sixteenth vertebra; the free pair of the seventeenth are rather long and slender, and are possessed of uncinate processes. Then follow six pairs of *true ribs*, all of which unite below with the sternum by means of connecting costal ribs. The last pair is a pelvic pair and they lack unciform processes. All the rest have these, though they become progressively smaller as we pass from the ribs of the eighteenth vertebra to those of the twenty-second. These unciform processes anchylose with the several ribs to which each one belongs. These ribs are narrow, very thin and slender, and from first to last gradually increase in length and curvature. The costal ribs are also much compressed from side to side, and are graduated in a similar manner.

Considering the *vertebræ* of the *cervical region* from the first to the seventeenth inclusive, we are to observe that the characters they individually present are for the major part quite different from those found in the corresponding vertebræ in the neck of either *Tantalus* or the Herons. The *atlas* has a broad and deep neural arch, with its postero-external angles produced. Its articular cup is notched superiorly by the odontoid process of the axis. Below, it has a bifid hæmal spine, and its other characters are quite of the common ornithic type. In the axis vertebra there is a low, thickened neural spine, with a rather longer, better developed and more pointed hæmal one. This vertebra also has a completed lateral vertebral canal, with parapophysial spines projecting from them behind. These spines are longest on the third vertebra, and the fourth. On the fifth they show signs of shortening, which is decidedly the case in the sixth cervical, after which they rapidly shorten throughout the series as we pass backwards, to become quite absent in the twelfth. There is also a progressive lengthening of these vertebræ from the third to the eighth inclusive, they becoming at the same time more slender in appearance. From the ninth backwards they gradually shorten and thicken again until they finally assume the form of those of the pre-dorsal ones. Semi-aborted neural spines are found upon the third, fourth, fifth and sixth cervicals, being entirely absent on the seventh, and do not again appear till we come to the thirteenth where this process is bifid. On the fourteenth it is represented by a single median tubercle, while on the fifteenth to the seventeenth inclusive it is elongated and plate-like. Lateral vertebral canals extend throughout the series from the second to that vertebra which first bears free riblets. In the middle of the chain, the pleur- and parapophyses closing them in are rather broad and deep. The infero-median hypopophysial carotid canal commences with the fifth vertebra, where it is open and rudimentary. It is nearly closed on the sixth, to become completely so on the next following one. After this its walls are unusually complete, and antero-posteriorly deep. This condition obtains until we come to the twelfth cervical where we find it small and open again. In the thirteenth its place is occupied by a single, plate-like hæmapophysial spine, but this latter character rapidly aborts in the succeeding vertebræ, to include the seventeenth. The articulations among the second, third, fourth and forepart of the fifth are very close, the zygapophyses being short and thick, and no intervals among the bones occur here. As we pass backwards however, the postzygapophyses gradually lengthen, and meeting the short, elevated prezygapophyses with their facets facing the median plane, large lozenge-shaped vacuities occur down the chain as far as the thirteenth vertebra. In the third and fourth vertebræ small interzygapophysial foramina are present, one on either side. Among these vertebræ the articulations of the centra are of the usual ornithic type, and the elongated bodies of the fourth to the eleventh inclusive are flat both ventrally and laterally. The twelfth cervical is very flat and broad on its dorsal aspect, it there having the form of an arrow-head with the point to the front, and the lateral projections being represented by the postzygapophyses, with their facets under the ventro-posterior sides. This condition is to some extent foreshadowed in the eleventh vertebra, but quite disappears in the thirteenth.

For the fore part of the skeleton of the neck, the neural canal is of rather small calibre, particularly in the anterior end of the vertebræ, but it gradually becomes larger as we approach the dorsal region.

In the tenth to the eleventh inclusive, upon either side, we observe a very delicate osseous loop passing backwards from the pleurapophysial part of the bone to the side of the centra of the same vertebra, where it again coössifies. These loops are immediately above the lateral vertebral canal, and are absent in all the other vertebræ. We find no such arrangement, however, in the skeleton of the neck among these Ibises as we described for the Herons and Bitterns, any more than is there in *Tantalus*.

Omitting the twenty-second vertebra, the low neural spines of all the dorsal vertebræ are completely fused together, as are the outer extremities of their diapophyses, the latter by strong and broad metapophysial coössified connecting bands. Hæmal spines are present upon the eighteenth and nineteenth dorsals, while the centra of the eighteenth to the twenty-first inclusive are fused together in such a complete manner that the points of union are scarcely distinguishable. The twenty-second vertebra possesses characters intermediate between hose of the twenty-first and the anterior vertebra of the pelvic sacrum.

If we omit perhaps the atlas, all the vertebræ of the cervico-dorsal region of the spine with their ribs and hæmapophyses, as well as the major portion of the pelvis, are more or less pneumatic. The caudal elements do not seem to enjoy this condition.

There is considerable difference in size in the skeletons of the male and female *Plegadis*, and this difference is very well seen in the pelvis of the two sexes. In the male the *pelvis* has a length of 6 cm. and an extreme width of 3.7 cm., the first measurement being a medium one, taken between the anterior points of the ilia to the line of articulation between the posterior extremity of the sacrum and the first vertebra of the tail. Measuring the pelvis of a female in the same manner, we find these lines to be respectively 5.2 cm. and 3.1 cm. in length and width. Upon the dorsal aspect we find the anterior margins of the ilia to be transverse, with their antero-median angles slightly produced forwards. These bones here extend somewhat beyond the first vertebra of the sacrum. Their preacetabular portion is concaved and smooth, having the surface upon either side looking forwards and outwards posteriorly, the direction gradually changing as we pass to their anterior ends so as at last it comes to face almost directly upwards. Mesiad, they completely fuse with the superior border of the sacral crista, and in such a manner as to entirely close the neural canals behind.

Passing to the postacetabular region, it is seen that the mesial margins of the ilia do not fuse with the external borders of the sacrum, while the latter, being of the elongate-lozenge form, has a very regular double row of interapophysial foramina down its length. These foramina begin small anteriorly and gradually increase in size as we proceed towards the tail. The superficial surface of the postacetabular part of an ilium is about half as wide as it is long, being moderately convex anteriorly and concaved behind.

Posteriorly, both ilium and ischium project considerably beyond the hinder end of the sacrum. On a side view of this pelvis we find the inner ring of the cotyloid cavity to be rather smaller than the outer one; the antitrochanter is small; while the ischiac foramen is of good size, and broadly elliptical in outline. Posterior to this latter the side of the bone is much concaved, and distally there is a sharp angular notch existing between the ilium and the ischium, similar in character to the one found in *Tantalus*. The lower ischial margin is sharp, and it is only the extreme postero-inferior angle of this bone that comes in contact with the upper border of the corresponding pubic style. This leaves between them an open obturator foramen, and an elongated obturator space. Each pubic bone is a long slender style of nearly uniform width, extending backwards far beyond the rest of the pelvis or even slightly beyond the pygostyle of the tail. These pubic elements are pointed at their distal ends, and are throughout gently curved, much after the manner of an *f*.

As the sides of this pelvis behind are nearly at right angles with the roof, we have as a consequence quite a roomy pelvic basin, more or less protected by bony walls. In front, on this ventral aspect, we find the first four leading sacral vertrebræ, having their lateral processes thrown out against the under sides of the ilia. That vertebra which is opposite the acetabulæ behaves in the same manner, and in its case the extremities of the apophysial braces are much dilated in order to be more efficient. Between this vertebra and the fore end of the sacrum, the latter takes on the usual enlargement for the accommodation of the sacral enlargement of the spinal cord in that locality. Foraminal perforations for the exit of the nerves of the sacral plexus are double in apparently every case, and, as in other birds, one is placed above the other.

Skeletons of the tail show a number of points indicative of feebleness of development in these Ibises. In the first three the diapophyses are not large, and although they have low neural spines, they are lacking entirely in hæmal ones. The remaining vertebræ are even still more rudimentary, and although they may have minute evidences of a hæmal spine or hypopophysis, they are much aborted in all other directions. Lastly, the pygostyle is much elongated, transversely compressed, small and narrow, and almost as weak as that bone as we find it in certain Grebes. These Ibis-birds have a very light and pneumatic *sternum*, that is very much concaved upon its dorsal aspect, where the anterior wall is especially developed and nearly vertical to the body of the bone. Its inner side in the middle line is fortified by a thickening, at the base of which occur a few minute pneumatic foramina, as there do also a few to the right and left of it. These openings are not seen elsewhere on the sternum, except in the pitlets beween the small hæmapophysial facettes upon the costal borders.

The sides in front are well-elevated above the thickened anterior border, though the costal processes are much truncated off, and thus made triangular in form. Posteriorly, this sternum is markedly four-notched, and the pair of lateral xiphoidal processes on either side are rather long and slender,—the median one very considerably stouter and longer. The mesial notches are a little deeper than the outer ones. A costal border occupies about one half of the lateral margin of the bone. The carina extends the entire length of the sternal body, and is wonderfully deep in front, where it is thickened just within its sharpened border.

The lower border is very thin, and the carinal angle is one of about 90°. On the lower or ventral aspect of the sternal body we find the main pectoral muscle-line well marked.

Either one extends from the outer end of a costal groove back to the distal point of the base of the carina, or nearly there. As in *Tantalus* and the Herons the costal grooves decussate and are remarkable for containing transverse, narrow, elongated, low, articulate eminences, which convexities are intended to accommodate similar concavities seen at the sternal ends of the coracoids. Now although the costal grooves of the sternum decussate in all the birds we have just mentioned, it will be as well to add here, in passing, that the characters of the facets of those grooves and other points about them are quite different in the several groups. There is a small peg-like manubrium present on the sternum of *Plegadis*, as is the case in the sterna of its immediate ibine allies, and, as a whole, this bone differs but little among the American genera of these birds. When the elements of the *shoulder-girdle* are articulated *in situ* the long axes of the coracoids are nearly in the same line with the long axis of the body of the sternum, and the os furcula not only curves well away from the former, but its symphysial portion is far removed from the anterior border of the carina of the latter. The scapulæ have their distal apices immediately opposite and above the anterior margins of the ilia of the pelvis, and they, as a whole, are well elevated above the osseous parietes of the thorax.

Os furcula is of the broad U-shaped variety. It is of nearly uniform thickness and width throughout, with its clavicular limbs much compressed laterally, and their free ends very bluntly rounded off. As we near the symphysis below, the surfaces gradually become reversed, so that what was the mesial aspect of either clavicle above, comes to face below as the anterior surface of the symphysis of its own side, as does the outer aspect of the clavicle come to be the posterior symphysial surface. The merest rudiment of a hypocleidium exists, scarcely worthy of the name. During life the distal end of either clavicle overlaps and is in contact with the top of the head of the scapula of its own side, resting also a very little on the scapular process of the coracoid.

A *coracoid* is comparatively rather a short bone, being somewhat compressed in the antero-posterior direction. Its scapular, wing-like process is well produced, and is perforated by a small foramen near its center. As usual, its sternal end is expanded, and an elongated concavity occupies its inferior border, it being intended for the long convex facette in the coracoidal groove of the sternum, which was described above. There is a rudimentary epicoracoid process present. Superiorly, the summit of the coracoid exhibits the ordinary tuberous head, and below this for a limited distance the shaft position, irrespective of the scapular process, is laterally compressed. With the aid of a scapula it forms, in the usual manner on either side, the glenoid cavity, which is of good size in these Ibises. A *scapula* has a cimiter-like blade, which gently along its continuity is curved outwards. It is smaller at its neck than it is distally, where it is obliquely truncated from within outwards, a circumstance which gives a sharpened distal apex. Its posterior portion is thin and flat, and somewhat broad; its neck is thicker. With the scapular process of the coracoid it makes an extensive articulation, and mesially is overlapped with the end of the clavicle. All these bones of the pectoral arch are undoubtedly pneumatic, but owing to the extreme smallness of the foramina those openings are found only after careful search.

A male *Plegadis guarauna* has a scapula 5.6 cm. long, and a coracoid 4.0 cm. high; the same bones measuring in the female 4.9 cm. and 3.6 cm., respectively. In taking the lengths of the coracoids we measure them from the highest point on the summit to the minute process seen at the outer termination of the facette of the sternal extremity.

The Pectoral Limb: As in *Tantalus*, so in *Guara* and *Plegadis*, the *humerus* is the only pneumatic bone of this part of the skeleton. In *G. alba* it has an average length of 10 cm., while in *P. guarauna* it rarely exceeds 9 cm. Of course, it is relatively as well as actually shorter in the females. Apart from this matter of size, the bone has the same general characters as we have given them above for *Tantalus*. In these true Ibises, however, the radial crest is better developed, and its free convex border presents an unusually regular curve, resembling the arc of a circle. Moreover, the expanded portion of the proximal end of the bone is shorter than in *Tantalus*, but the single pneumatic foramen holds the same position in the three genera. In a male

Plegadis guarauna the *ulna* measures in length 10.9 cm. and the hand in the same specimen is 9.5 cm. long.

The essential characters of the bones of both the antibrachium and pinion agree in both *Guara* and *Plegadis*, but the row of osseous papillæ down the shaft of ulna are almost obsolete in the latter genus, while in the White Ibis they are very strongly marked—relatively stronger, even, than in *Tantalus*. At the same time, the ulna and the radius ; the carpal segments ; the various bones of manus, have in general the same essential characters in these true Ibises as we found in the corresponding bones of *Tantalus*. This does not pretend to take into consideration either the matter of size or of relative lengths. These of course differ, although not so very much in the latter respect.

The Pelvic Limb : The characters exhibited on the part of the bones of this lower extremity are almost identically the same in *Plegadis* and *Guara ;* and in neither genus is the femur pneumatic as we found it to be in *Tantalus ;* and the shaft of this bone is relatively longer in those genera also, than it is in the last named genus. Otherwise the characters are much the same all round, and at the distal end of the femur in either *Plegadis* or *Guara* we find the same big condyles, with the deep " rotular channel " between them in front, and, indeed, all the other principal characters described above for *Tantalus*. With equal truth this applies to the bones of the leg, the tarso-metatarsus and pes. In the tarso-metatarsus, however, the longitudinal groove down the back of the shaft of that bone, is by no means so well marked in *Plegadis* as it is in *Tantalus*. It is particularly deep in front in *Guara*, but does not there extend more than half way down the shaft.

In *Plegadis guarauna*, in the same male specimen as I used above, I find the tibio-tarsus to have a length of 13.7 cm. and the tarso-metatarsus a length of 10.5 cm. These measurements are relatively very different in *Guara alba*, for in the same bones, respectively, we find the lengths to be 12.6 cm. and 8.7 cm.—showing about a centimeter's difference in the tibio-tarsi, but nearly two in the case of the tarso-metatarsi. *Guara* is the shorter legged bird, without having lost any skeletal alar extent with respect to the pectoral extremity.

Notes on the Osteology of the Roseate Spoonbill.
(*Ajaja ajaja.*)

(See Figures 38, 39, 40 and 41.)

As I have before said, my material, illustrating the osteology of this interesting form, is incomplete. We have a skull, however, and I also find the bones of the extremities.

Of the Skull : Regarded from above, it is seen that the vault of the cranium, including an area bounded by the occipital ridge, the orbital peripheries, and the anterior terminations of the frontal bones, is smooth, completely convex and rounded, being unmarked by either elevation or depression of any kind. In the frontal region the transverse line measuring the shortest distance between the very rounded orbital margins, usually averages about a centimeter and a half. The cranio-facial region is but very slightly depressed, while the fusing of the nasal, maxillary, frontal, to a great extent the lacrymal, and finally, the premaxillary bones as seen upon this view is wonderfully complete. So much is this the case, that the only sutural traces at all evident are those of the premaxillary and of the lacrymals, and even these are very faint.

The superior mandible is very broad from side to side, and greatly compressed in the vertical direction. It gradually contracts in width as we pass forwards, up to a point about midway between the cranium and its anterior termination ; and at the same rate, it begins to widen again, to finally spread out distally into a broad spatulate extremity, which shows a slight decurvature at its tip. The anterior half of this almost unique structure is perfectly flat and in the horizontal plane, having about the uniform thickness of the blade of a table-knife. The bony external nasal apertures are well forward ; are of medium size and spindleform in outline. They stand about half a centimeter apart, with their major axes parallel to each other, and pierce directly backwards. As the floors of these openings are laid down in solid bone, and their calibres not large, we can gain through them no view of the rhinal chamber into which they lead. Starting from the anterior apex of either one, we find an indented line passing directly forwards. It sweeps round the margin of the bill within a few millimeters of its free border, to end by abruptly running out at that border at a point slightly to one side of the median one of the apex. These lines are very sharply defined.

On the lateral aspect of the skull the post-frontal process is quite rudimentary, and the squamosal one, hardly much larger, is represented by a small, sharp, inturned spinelet.

The valley of the temporal fossa between them is short but well-marked. An orbit is deep and subcircular in its general form, while the septum separating these two cavities, is entire.

The small foramen for the exit of the first pair of nerves is a short and rather broadish slit, and the nerve passes forwards in a very well defined, open groove, which leads directly into a circular foramen in the supero-mesial angle of the thickened *pars plana* of the ethmoid. The "foramen rotundum" is just of a sufficient size to pass its nerve, as is also the case with the lesser opening to its outer side. Still further externally we note in plain view, the foramen ovale. It is likewise circular in outline, and nearly equal in size to the foramen rotundum. A zygoma is short, very straight, and slender. Proximally, it makes the usual articulation with the quadrate, while distally, the maxillary portion completely fuses with the very broad nasal and the premaxillary. This latter end of the zygomatic arch is found in a much higher plane than the quadrato-jugal extremity when the skull is in the horizontal position. At its externo-inferior angle the pars plana develops an outstanding thin plate-like process that fails to quite come in contact with the *lacrymal*. This latter bone is not large, and is twisted upon itself, so that its descending plate faces forwards and backwards; while from its lower external angle a little tip is produced, which through the medium of a short rod-like and free *os uncinatum*, is extended so as to reach the maxillary bone below.

In front of these three last-named, and bounded anteriorly by the free, sharp, convex margin of the nasal, we are to observe a large, subcircular vacuity that looks into the rhinal chamber. This last is much filled in by the very extensive and fused osseous mass, made up chiefly of the swollen and spongy *maxillo-palatines*. The anterior wall of the brain-case is more than usually thick and dense, and is unperforated in any part of its extent by foramina. Posteriorly, the cranium of *Ajaja* is more than commonly rounded and smooth; the occipital ridge being but feebly pronounced, and the supraoccipital prominence not very decidedly marked. On either side of this the bone is very thin, but foramina are not seen there in thoroughly matured birds, as they are in *Plegadis* and *Guara*. *Foramen magnum* is inclined to be large, and is nearly circular in outline. Its plane makes an angle of about 45° with the base of the cranium or more. The *condyle*, of no great size, is at the same time somewhat jutting. At the base of the cranium the outstanding paroccipital processes are conspicuous, and the small basitemporal area is tilted upwards, so that its anterior apex occupies a much higher plane than its base posteriorly. The thickened sphenoidal rostrum is inclined to be triangular for its hinder portion, so that, although the palatine ends of the pterygoids extensively articulate with each other, they are at the same time applied against the *sides* of the rostrum. In front it runs out as a spine, and the ethmoidal mass has nearly a straight anterior margin (or at the best but little concaved), which at the same time is nearly vertical. The *pterygoid* is short and curved, with its convex sharp edge presented outwardly, when articulated. These bones make the usual articulation with the *quadrates*. One of these last is a comparatively large bone for the size of the bird. Its broad orbital process has its free end truncate; its mastoidal end presents the double articulatory facet, with a feeble division drawn between them; and, as for its mandibular articulation, it is peculiar from the fact that it appears to have but one general elongated transverse facet, with an extremely shallow and faint antero-posterior line at all dividing it into two. Otherwise, the bone has the usual ornithic form, with the body somewhat compressed from before, backwards. The short *palatines* are extremely broad and are separated mesially, but by a very narrow slit. Through this latter the long, spine-like *vomer* is seen, that anchyloses with them posteriorly. Upon their under sides the palatines are flat and smooth. Behind, they meet the pterygoids, and in this part of their extent they are considerably swollen, with their outer angles completely rounded off. In front they are indistinguishably fused with the usual bones of the face and palate that they meet.

All the ordinary palatal laminæ and processes are much subordinated and inconspicuous; the main object of these bones here seeming to be to furnish a broad, osseous roof to the fore part of the mouth, and this they most emphatically accomplish. Either ear entrance is pretty well surrounded by bony walls, while the apertures to the Eustachian tubes, in front, are more or less exposed. The usual nervous and arterial foramina are found occupying their more common sites, at the skull's base, in this Roseate Spoonbill. Beyond the abrupt anterior termination of the palatines, the under side of the superior mandible is flat and rather smooth, being unpierced in any part of its extent by vacuities of any kind. There is a line-like median, longitudinal furrow, best marked posteriorly. There is a peculiar emargination to the spatulate end of this bone on its aspect now being considered. It is narrow where the mandible is narrow, and broad where it is broad. Anteriorly, it runs out before coming to the middle point upon either side, and is marked for its entire extent by a system of very delicate linings, that are close together and take the same course as the margins of the bone itself. Somewhat fainter lines of a similar nature mark the central portion of the under surface of the spatulate end of the upper bill.

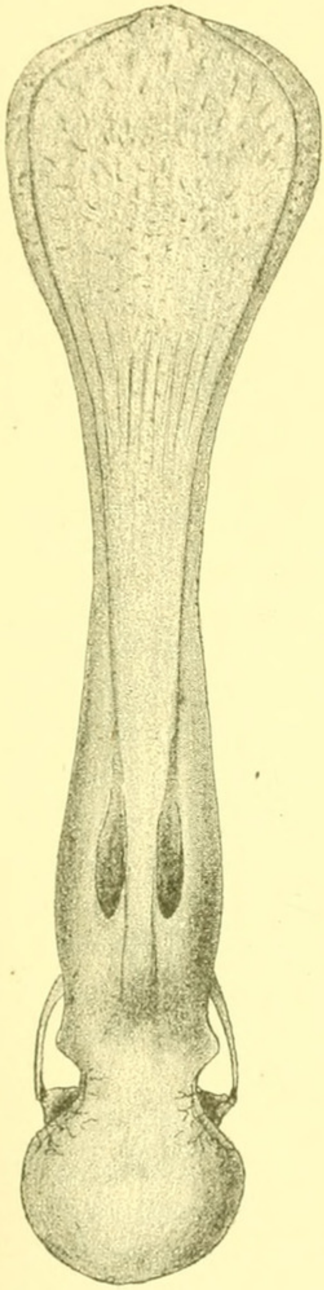


FIG. 38.

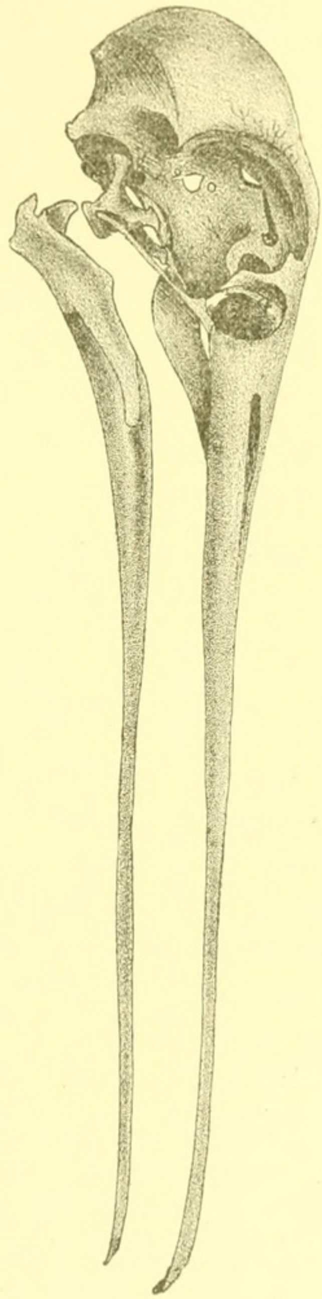


FIG. 39.

FIG. 38. Superior view of skull of *Ajaja ajaja*. Two-thirds natural size (probably a female). Drawn by the author from specimen 1505 of the Smithsonian Collection.

FIG. 39. Right lateral view of skull and detached mandible of *Ajaja ajaja*; ⅔ nat. size. Drawn by the author from same specimen shown in Fig. 38.

The upper surface of the *lower jaw* is similiarly sculptured, and we will not refer to the fact again. The distal portion of this bone in the Spoonbill is dilated, horizontally flattened, lacking in either concavities or convexities, and having a form quite similar to the expanded portion of the distal third of the superior mandible. For their middle third, the mandibular rami are slender, and very much compressed in the vertical direction. On the other hand, their proximal extremities are low and transversely compressed, and no ramal vacuity is present in them. The general form of the bone may be said to be U-shaped, but this is to a great extent masked by the distal expansion. The articular ends are decidedly though gradually decurved, and their distal extremities present the usual ornithic characters. Their "cups" are deep; the inturned processes blunt; and posteriorly they are somewhat produced and hooked. In this latter particular, however, the character it not quite so pronounced as it is in the true Ibises.

Since writing the above, and upon further investigation, another skull of *A. ajaja* was discovered in the collections of the Smithsonian Institution, which upon examination was found to be a very old and incomplete one. Such characters as it exhibited agreed in all essential particulars with what has just been given above. The sternum, os furcula, and right scapula, of an adult specimen of a female *Ajaja regia* from New South Wales, Australia, was also met with in the same collection, and these bones were sufficient to show, that in this part of the skeleton at least, *Ajaja* agreed very closely indeed with the true Ibises, as *Plegadis* and its near allies. The *sternum* in this species is 4-notched and lacks a manubrium, and the *furcula* is a broad U-pattern, of a typical Ibis character, as is also the *scapula*. From this it is fair to presume, that in the matter of its *trunk skeleton*, the Spoonbill probably agrees with those birds.

Of the Limb-bones: A lot of these, numbered 1504 of the Smithsonian collection, belonged to a specimen of *Ajaja ajaja*. They consist in a skeleton of the right pectoral limb, perfect all to the pollex digit; in a skeleton of the left leg below the femur, perfect all to the last joint or two of the outer and middle toes; and finally, of an imperfect fibula and tibio-tarsus of the right pelvic limb, the proximal end having been cut away and lost.

This *humerus* has an extreme length of 13.5 cm. thus being about one-third larger than that bone as we find it in a male *Plegadis guar-*

auna. Apart from this difference in size the essential characters as found in it, the Spoonbill practically agrees with the corresponding ones as they occur in the humerus of the Ibis. This statement applies with equal truth to the bones of the *forearm*, *carpus* and *hand*. I find

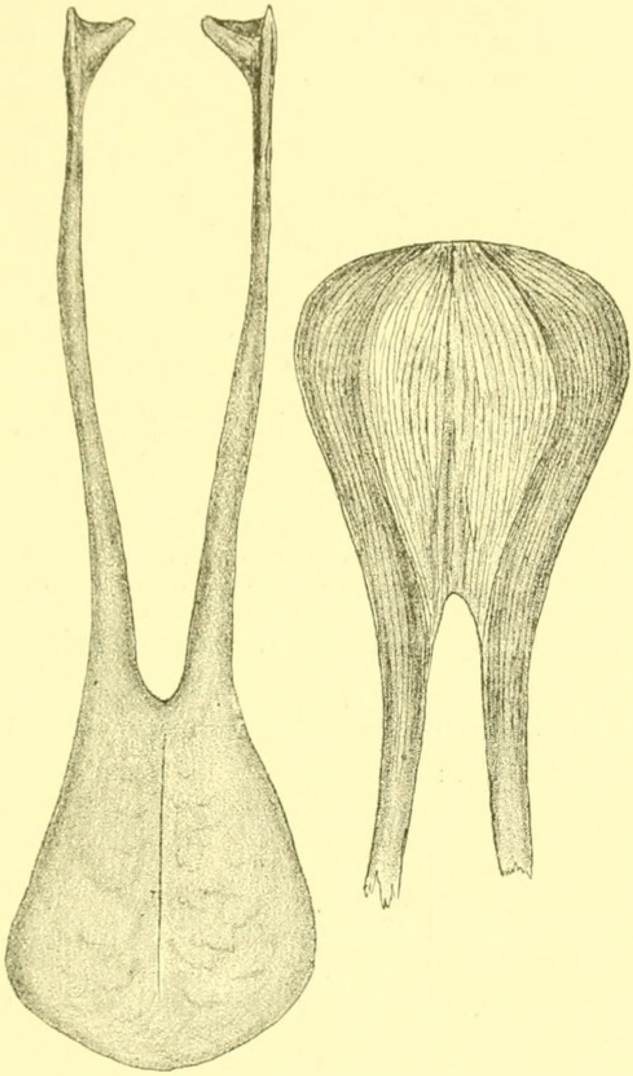


FIG. 41. FIG. 40.

FIG. 40. Distal end of the mandible of *Ajaja ajaja*: superior surface; ½ nat. size. Probably a male.

FIG. 41. Mandible of *Ajaja ajaja*. Inferior surface; ½ nat. size. Belongs to the same skeleton from which the skull shown in Fig. 39 was taken. Both figures drawn by the author.

in *Ajaja*, however, the *ulna* to have a length of 15.7 cm., and *manus* an extreme length of 9.4 centimeters.

Passing to the bones of the *pelvic extremity*, we are at once struck by a very notable difference in these two genera, for although the salient characters of the skeleton of these parts are truly those of the ibis in *Ajaja*, yet in the latter the *tibio-tarsus*, the *tarso-metatarsus*, and the joints of *pes* are each and all proportionately very much shorter and stouter than they are in *Plegadis*. In the case of the tibio-tarsus it has a length in the Spoonbill exceeding that bone in the ibis by but a trifle more than two centimeters; while in the case of the tarso-metatarsus there is a difference in length of but about half a centimeter in favor of *Ajaja*.

The several toe-joints in the foot of the latter are also proportionately stouter than the corresponding ones in the skeleton of pes in *Plegadis*, but they vary considerably in the matter of their several relative lengths. For example, the basal phalanx of the middle toe in *Ajaja* has an extreme length of 3.5 cm.; in *Plegadis* it measures 3.2 cm. while in the case of the second joint of the inside toe, we find they are precisely of the same length in the two species.

On the Taxonomy of this Group

From my studies of the osteology of the American and other forms representing the HERODIONES, and taking into consideration all else that has ever come to my notice upon the rest of their morphology and habits, I conceive the several groups of birds composing this suborder to have a relation to each other something after what is proposed in the subjoined scheme, viz.:

SUBORDER.	SUPERFAMILIES.	FAMILIES.
HERODIONES	Ibidoidea	Plataleidæ. Ibididæ.
	Ciconoidea	Ciconiidæ. Scopiidæ.
	Balænicipitoidea	Balænicipidæ. Cancromidæ.
		Ardeidæ.

Taken as a whole there is hardly any question now I think, but that the Herodiones are linked with the Anseres, through the *Plataleidæ* of the present group, and the Flamingoes, of the group next to be considered. Perhaps *Ajaja ajaja* is the species among the American *Ibidoidea* most nearly related to *Phœnicopterus ruber*. Many other avian taxonomers of the first rank likewise claim that the Herodiones are in some way linked with the *Accipitres* or even with the *Steganopodes*, with the first by the Storks leading through the Secretary Bird, and with the latter in some strange way with the Tropic Birds or even the Frigate Birds. To me, the first-named affinity may be probable, but I am somewhat sceptical in regard to it; in any event far more extensive anatomical comparisons are necessary between the representatives of those two groups, than have as yet been made in their case.

That the *Plataleidæ* and the *Ibididæ* are two distinct families, I have no manner of doubt. For although it is likely that *Ajaja* possesses a skeleton, apart from the skull, that is in all essential particulars that of ibis, it differs, nevertheless, osteologically very materially in the characters of the excepted part, from the corresponding characters in the skull of any true ibis. And, to say the least of it, *Ajaja* is essentially a holorhinal bird, while all the true Ibises are strongly schizorhinal.[1]

Of the three American superfamilies composing the Herodiones, perhaps the most thoroughly distinct group is seen in the *Ardeidæ;* in other words the gap existing between the Herons and Storks, or, between the Herons and the Ibises, is decidedly more evident than is the gap existing between the Storks and the Ibises; indeed the typical Ciconoidea are probably linked with the *Ibididæ* through the genus *Tantalus*.

As for the relations of the Herons and Bitterns to each other, nothing more need be said here beyond what I have already pointed out in my remarks closing the osteology of the family *Ardeidæ*, given above.

EXPLANATION OF PLATES.

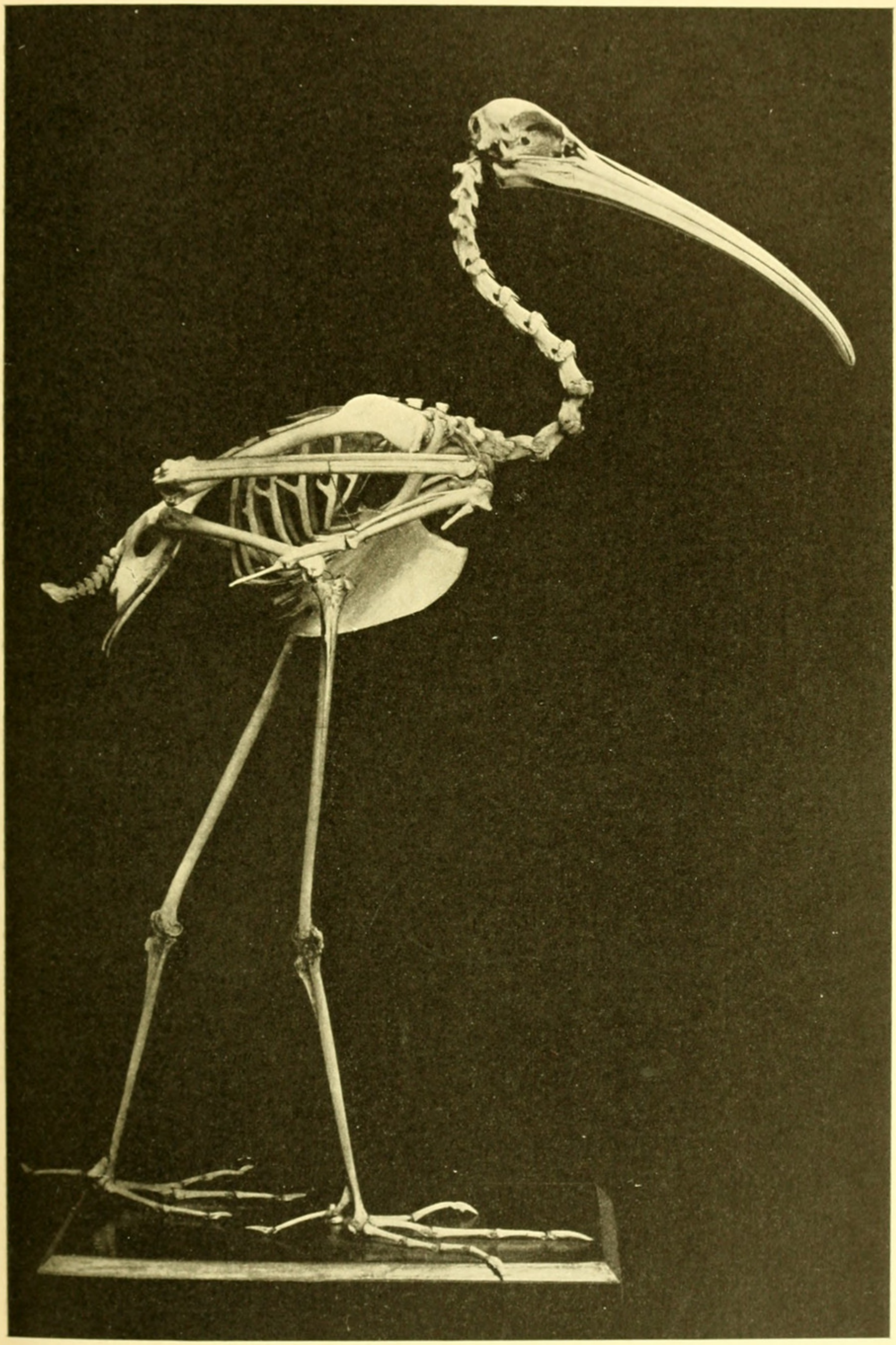
PLATE V.

Skeleton of an Ibis (*Plegadis falcinellus*): Coll. U. S. National Museum, No. 14,406. (Reduced.)

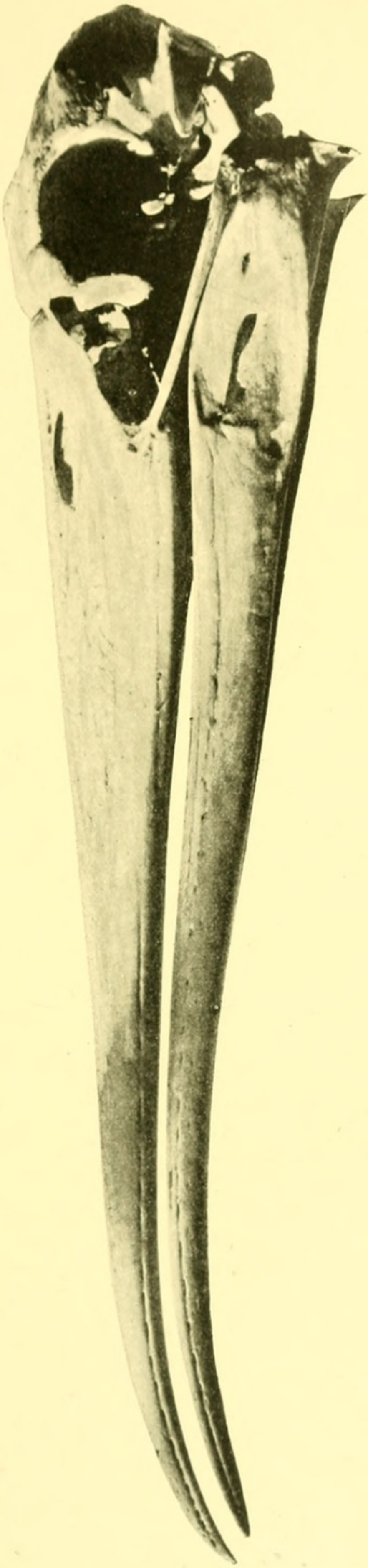
PLATE VI.

Left lateral view of the skull of the "Wood Ibis" (*Tantalus loculator*). Reuced. From a photograph by the author. (Specimen No. 1,508: Coll. U. S. National Museum.)

[1] I am aware when I make this statement, that Garrod placed both *Ibis* and *Platalea* among his schizorhinal birds, but the latter is a long ways from being typically so, and besides *Ajaja* has a good many other characters in its skull quite unlike the comparable ones in the skull of a true Ibis. These characters have been set forth in detail above.



Skeleton of an Ibis (Plegadis falcinellus).



Left Lateral View of Skull of Wood Ibis (Tantalus loculator).