III. OSTEOLOGY OF THE LIMICOLÆ.

By Dr. R. W. Shufeldt.

Introduction.

Two or three years ago I gathered together into one memoir a number of papers I had published on the limicoline birds since 1883, digesting, as well as augmenting, the material thus collected. Subsequently I went over this entire MS. again, improving it in many ways and adding many new facts, which I had obtained as a result of my studies of more extended series of skeletons of this group. Finally, at the present writing, that is the last part of September, 1902, the entire monograph has been carefully gone over again, and largely remodeled, and this entailed a copying of many pages of the work — a task cheerfully performed for me by my wife Alfhild, to whom my thanks are due. As the paper now stands, it is probably the most extensive contribution to the osteology and taxonomy of the *Limicolæ* that has appeared from the pen of any writer on the subject up to the present time. With this brief prefatory history I pass at once to the consideration of the results of my researches in the osteology of the forms contained in this suborder.

On the Osteology of the Limicoline Birds, with Views Upon Their Classification.

It was Professor Alfred Newton who said under the article "Plover" in the ninth edition of the Encyclopædia Britannica (Vol. XIX., p. 228) that "Though the various forms here spoken of as Plovers are almost certainly closely allied, they must be regarded as constituting a very indefinite group, for hardly any strong line of demarcation can be drawn between them and the Sandpipers and Snipes. United, however, with both of the latter, under the name *Limicolæ*, after the method approved by the most recent systematists, the whole form an assemblage, the compactness of which no observant ornithologist can hesitate to admit, even if he be not inclined to treat as its nearest relations the Bustards on the one hand and the *Gaviæ* on the other, as before suggested." This is quite in harmony with my own views in the premises, and I believe with Professor Newton that it meets the ideas of the majority of systematists, and I may add, what is more important, the ideas of most avian morphologists.

Of the *Limicolæ*, this great suborder of birds, widely known as the "plover-snipe" group, and in the main constituting the Charadriomorphæ of Professor Huxley (P. Z. S. 1867, p. 457), Coues has said, that "Most of the families of this order are well represented in this country, and will be found fully characterized beyond. The position of *Parridæ* is in question, and it probably belongs here rather than among the families where it is ranged [*Alectorides*]. There are several outlying or inosculating families in the vicinity of *Limicolæ* and *Alectorides*, of uncertain position. The largest of these is the Bustard family, *Otididæ*, which connects *Limicolæ* and *Alectorides* so perfectly, that its position has long wavered between these two orders; the balance of evidence favors its reference to the latter. The typical families are *Charadriidæ* and *Scolopacidæ*." ("Key" 2d ed., pp. 596, 597.)

In these remarks Coues says nothing about his having placed the Herodiones between the Limicolæ and the Alectorides in the work cited, which he has done, and his remarkable classification of the latter group is too well known to call for any comment here.

Professor Max Fürbringer in his great work upon the Morphology of Birds arranges the *Limicolæ* in the following manner.

O. Charadriornithes (Ægialornithes).	S. O. CHARADRIIFORMES.	G. S. LAT. LARO-LIMICOLÆ.	G. S. STR. CHARADRII.	F. Charadriidæ.
				F. s. str. Glareolidæ.
				F. s. str. Dromadidæ.
				F. Chionididæ.
				F. Laridæ.
				F. Alcidæ.
				F. Thinocoridæ.
		G. PARRÆ.		F. Parridæ.
		G. OTIDES.		F. Œdicnemidæ.
				F. Otididæ.

Dr. R. Bowdler Sharpe in his "Hand List of Birds" (1899) considers them as an Order, (XV.), CHARADRIIFORMES, and places them between the LARIFORMES, (Order XIV.) and the GRUIFORMES, (Order XVI.). He divides the Charadriiformes into no less than seven Suborders, namely the Chionides, the Attagides, the Charadrii, the Parræ, the Cursorii, the Œdicnemi, and the Otides, and these names will sufficiently indicate the families of birds this author considers to belong to the limicoline assemblage — everything in fact from a Sheath-bill to a Bustard.

The author's views on the position of the Limicolæ are presented with a discussion of their affinites at the close of the present Memoir.

More or less typical limicoline birds are found in nearly all parts of world, and they are particularly well represented in the avifauna of the United States. So that the full description of their osteology given beyond will thoroughly characterize the group as a whole.

Much has been written on the subject of their skeletology, and of this I have availed myself. My own writings, published for a number of years in the *Journal of Anatomy of London*, the *Journal of Morphology* and elsewhere, illustrated by many plates and figures, have already set forth the osteological characters of the American *Limicolæ* quite exhaustively. This work will be used to the fullest extent here, and thoroughly revised. In dealing with the *Aphrizidæ*, as I remark further on, I have only employed my monograph in the *Journal of Morphology* to the extent of using the facts set forth in it, and not incorporated it here as a whole.

My private cabinets afford the skeletons of many American limicoline forms, and these have been handsomely supplemented by the loan of many others from the collections of the U. S. National Museum, and from still others from the collection of Mr. F. A. Lucas. Professor Alfred Newton has also sent me for my inspection several specimens from the Museum at Cambridge, England, and others from his own collection. These very well illustrate points in the osteology of *Scolopax rusticola*, *Pavoncella pugnax*, *Vanellus vanellus* and others, for all which my thanks are here tendered. Others have also sent me useful material and it is referred to later.

Osteology of the Phalaropes.

(Complete skeletons of *Crymophilus fulicarius* and *Phalaropus lobatus* examined.)

Phalaropes have a skull of much the same general form as we find it among the Sandpipers, the narrow and extended superior mandible being considerably larger than the cranium, while the very open structure of the latter gives it a peculiarly delicate appearance. Upon severe maceration the premaxillary does not appear to come away, and detach itself, as it does in most *Tringæ*, and it is rather more spread out laterally than it is in those birds. The narial vacuities are long, open slits, and there is no osseous septum narium. Phalaropes are typically schizorhinal birds, and their skulls are characterized by having a deep longitudinal median depression over the region of the cranio-facial axis, upon either side of which the upper portion of the small lacrymal is prominently tipped up. Below, this bone sends down a thread-like osseous limb, which bending smartly backwards, fuses by its posterior extremity with the upper and outer angle of the rather large and quadrilateral pars plana. Nasal bones and the zygomæ are straight and very slender. On the superior aspect of the cranium, the frontal region is seen to be extremely narrow between the superior margins of the orbits; the fronto-parietal region is rounded and smooth. Further back there is a fairly well marked superoccipital prominence, which in the Red Phalarope is pierced upon either side by a foramen, which is not the case in *P. lobatus*. Both the anterior wall of the brain-case and the interorbital septum are very deficient in bone. Into the last open space there is thrown backwards from the posterior margin of the mesethmoid a free, horizontal, and very slender spur of bone. On the lateral aspect of the skull we find the post-frontal and squamosal processes, especially the latter, to be inconspicuous spinelets of bone. At the base of the cranium the foramen magnum is large and of a cordate outline; the basitemporal region beyond it being somewhat contracted.

The pterygoids are short, small, and vertically compressed, and they articulate, as in all true limicoline birds, with the basi-pterygoid processes of the sphenoid. Their palatine heads are separated in the middle line as are the palatines for much of their length behind. These latter bones have extremely narrow prepalatine portions, widely apart anteriorly, and *below* the naso-maxillary junction fusing with the maxillo-palatine plate, upon either side. Posteriorly, their postero-external angles are rounded off, while their descending internal and external margins are prominent and keel-like. In the middle line in front they merge to form a spiculiform point, which coössifies with the broadish, thin, lamellar vomer, which latter terminates in a free blunt apex anteriorly.

Either maxillo-palatine is of an oval outline, scroll-like and lamelliform in structure, with a great perforation existing in it, which absorbs its entire central portion, leaving barely more than the rim of the bone. These maxillo-palatine processes are well separated from each other in the middle space, and they neither of them come in contact with any of the adjacent bones, as the vomer, or palatines.

This plan of structure is, as we know, what Huxley has termed the schizognathous type, and it is characteristic, as we have seen, of the first three suborders of birds treated in former memoirs, as it is of several others.

A quadrate bone in one of these Phalaropes is very pneumatic, as is indeed most of the rest of the skull, and it has a *double* mastoidal head, with a conspicuous orbital process, and a small internal mandibular facette, separated by a valley from a larger oblique external one upon its same aspect. The bony meatus of the ear is very open, and in *P. lobatus* permits a view along the entire length of the eustachian tube to its anterior exit.

In the eyeballs the sclerotal plates are small, and the bones of the hyoidean arches are slender.

Long and of an acutely V-shaped pattern, the mandible has comparatively rather an extensive symphysis, and from it behind, in the median line, may project directly backwards a delicate spine. Either ramus is rather shallow in the vertical direction, and is pierced by a slit-like "ramal vacuity," exposing the presence of the splenial element of the jaw. The angular processes are lamellar in structure, and inclined somewhat to hook upwards. They are by no means inconspicuous in *P. lobatus*.

With respect to the characters of the remainder of the skeleton, they may well be seen in a specimen of the species I have just named. I find twenty-one free vertebræ in its spinal column before arriving at the pelvis. Counting from the skull, the fourteenth vertebra supports a pair of tiny free ribs, while those on the fifteenth are considerably longer, though they do not reach the sternum, there being no costal ribs for them. There are six pairs of true vertebral ribs, all being very delicately constructed, as are their long slender unciform processes. The hæmapophyses of the one pair of pelvic ribs do not reach the sternum, and there is a tiny "floating" pair of the former kind behind them.

The dorsal vertebræ fit very closely together in their articulations, and their metapophyses are notably long.

The *pelvis* is a very thin, light, and open structure. Anteriorly, the iliac margins are rounded off in front, and these bones do not meet over the crista of the sacrum. The parial foramina, two rows upon either side of the middle line of the bone, are large and open among the lateral processes of the fused vertebræ of the sacrum, lending to the pelvis a peculiarly frail appearance, already noted above. At the lateral aspect we find the rather extensive obturator space separated by bone from the foramen of the same name. Behind, the post-pubic style is long drawn out and drooping upon either side, and the posterior *foot* of the ischium, which is applied to the superior margin of the same, is notably long and slender. Upon the nether side we find but one pair of the lateral processes of the sacral vertebræ, thrown out, modified, and lengthened to act as braces opposite the acetabulæ. There appear to be *seven* free vertebræ in the skeleton of the tail, and to these is to be added a squarish and rather large pygostyle.

The *sternum* of *P. lobatus* (as well as other species of the genus) has essentially the same pattern as the sternum of any typical Plover, as for instance *C. squatarola*. Its carina is ample, with the carinal angle in front rather prominent and jutting, which in some degree is caused by the concavity of the anterior border of the keel. Posteriorly the sternal body is twice notched upon either side, while the manubrium is small, and the costal processes triangular, broadish, but not particularly high.

Os furcula of the shoulder-girdle is of the U-pattern, being much bowed to the front, and with a small hypocleidium below. Either free clavicular extremity develops near its pointed end upon its outer aspect a shoulder, supporting a small facet for articulation with the head of the corresponding coracoid. When articulated *in situ*, this pointed extremity rides well over the clavicular process of the scapula, being at the same time in contact with it.

The *coracoids* are short, but not especially stout, the shaft being straight with its sternal extremity much expanded. Here we find three processes, so often to be observed among the water birds at large. Of these, one is at either extremity of the sternal facet of articulation, and the other is a conspicuous lateral one, triangular, and lamelliform, being almost exactly as we find it in *Aphriza* and other types.

The blade of the *scapula* is somewhat expanded for its posterior moiety, and its apex is truncated obliquely from within outwards and backwards. Its way of articulation with the *os furcula* has already been described above.

Phalaropes have non-pneumatic limb-bones throughout. The *humerus* is long, and its shaft is nearly straight. At the proximal end the ulnar crest is prominent and overshadows an extensive concavity; the radial crest is not nearly so well developed. Distally above the oblique tubercle an epicondylar process juts out, and indeed the whole bone has much the form of the humerus as seen in *Charadrius dominicus*. The *radius* and *ulna* present nothing very peculiar, and the latter is but little bowed along the continuity of its shaft. The row of nibs for the secondary quill-butts are present.

The distal phalanx of the index digit is long and slender, and the expanded portion of the proximal generally exhibits two small perforations, as in the *Laridæ*. The index and medius metacarpal are nearly straight, the latter being very slender.

Passing to the *pelvic limb* we find the short, straight *femur* to possess a length just equal to half the length of the *tibio-tarsus*. Its head is sessile on the shaft, and the trochanter is moderately raised above the articular summit of the bone. In the tibio-tarsus the cnemial crests are conspicuous, especially the inner one, and in fact they almost exactly resemble in form those parts in miniature, as we observe them in a Fulmar. The lower part of the *fibula* is of hair-like dimensions. The hypotarsial process of the *tarso-metatarsus* is small and subcubical in form, being both pierced and grooved for tendons. The accessory metatarsal is suspended above the distal trochleæ, and the hallux digit is small and feeble. As to the other toes, their basal joints are the longest in any case, and they gradually diminish in length as we proceed in the direction of the terminal ungules.

Comparative Osteology of the Plovers.

(Skeletons of representative species of the genera *Vanellus*, *Charadrius* and *Ægialitis* examined.)

A number of years ago in my article on the osteology of *Æ. montana*, a bird at that time designated by American ornithologists as *Podasocys montanus*, I remarked that "there has always been something strikingly columbine to me in the outward appearance of a plover's head — a similitude that is by no means shaken when we come to examine the prepared skull, in which so many of the bones are arranged as they are in the cranium and face of a pigeon." The skull of *Æ. montana* is extremely light and fragile, due to the access of air to numerous cells in certain parts of its interior, and likewise to a generous supply of diploë in other localities. I find in the chick of the plover only a few days old, that the premaxillæ have thoroughly coalesced along the culmen of the beak for its outer or anterior third, but the suture dividing them posteriorly along the nasal process of these bones is, at this tender age, distinctly visible, whereas all the sutures in the face become obliterated in the adult.[1]

Posteriorly along its dentary border the premaxillary throws backwards two processes, each of which articulates by squamous sutures; the first and longer, the maxillary, with the maxillary bone; the second, or shorter, the palatine process of the premaxilla, with the palatine. This arrangement is found in all of our plovers. Several formina are seen on the sides of the culmen beyond the anterior border of the nostril.

The *nasals* have each a broad expansion in front of the frontals, where they articulate with each other along the median line as far forwards as the nasal process of the premaxilla; here they contract and dip under that bone on either side, conforming themselves to its width and form, still so as to articulate with each other beneath it, as far forwards as the prolongation of the premaxillary, where they slightly diverge from each other, to terminate in pointed extremities. Posteriorly, the nasals throw down, obliquely forwards, straight bars of bone, which bound the osseous nostrils behind, to be carried forwards over the maxillæ on either side, to the maxillary process of the premaxilla, where they articulate by squamous sutures beneath the bone.

This arrangement of the nasals is very much as we find it in the pigeon (*C. livia*); and, as in the pigeon, the aperture forming the bony nostril is long and very open. Both are schizorhinal birds. The mesethmoid extends well forwards in the plovers, thus affording above a spreading table for the frontals, nasals, and premaxilla to rest upon.

The *lacrymals* in *Vanellus* and *Ægialitis* are not very large bones, and in the adult they anchylose with the anterior margins of the frontals, where they form the rounded anterior terminating margins of the orbital peripheries. In *C. squatarola* this part of a lacrymal is more jutting and conspicuous, owing to the fact that the anterior foramen of the supraorbital gland is in that species converted into a deep, rounded notch. In *Æ. montana*, a lacrymal sends down an attenuated process that fuses with the outer margin of the antorbital plate, or lateral mass of the mesethmoid. From this margin the lacrymal develops two spine-like processes, which project forwards, the upper one being the longer, the lower one almost touching the maxillo-jugal bar. These spine-like processes are absent in *Vanellus*, and very much

[1] As I transcribe these remarks from my memoir in the *Journal of Anatomy* I amplify them by the use of the more extensive material now at hand.

aborted in the Killdeer Plover, where the descending process of the the lacrymal is much broader and fuses more completely with the pars plana.

Varying in size in the different species, the pars plana long remains cartilaginous in the plovers, but eventually becomes a quadrate osseous partition, quite effectually separating the orbit from the rhinal chamber. An irregular foramen for the passage of the nerves always occurs above it, being very large in *Charadrius*, owing to the comparatively smaller size of its antorbital plate.

The *vomer* of the Mountain Plover is an extremely delicate and elongated bone ; in front it runs out into a free and needle-like point, while posteriorly it is bifurcated so as to articulate with the palatine upon either side. It glides freely beneath the anterior pointed end of the rostrum.

Turning our attention to the *palatine* bone, we find that on either aspect it forms the osseous roof of the mouth by sending forwards a tapering prepalatine to anchylose with the maxillary and premaxillary at their junction. The postpalatine portion of the palatine is expanded, and it is separated from the fellow of the opposite side in front, where the inner margin dips down to form the "internal lamina" of the palatine bone. Outwardly the bone is produced still further down to form the "external lamina." The pterygoidal processes of the palatines are in contact with each other, while the "ascending processes" articulate with the forks of the vomer as already pointed out above. The maxillo-palatines are elegant scroll-like laminæ of bone, often perforated by a few foramina. Posteriorly, they do not normally come in contact with the palatines on either hand, or with the vomer above them. Anteriorly each bone has two processes ; one, the stouter, connecting it with the palatine ; the other, much more slender, with the maxillary, while between the two a circular foramen is thus produced.

In all our Plovers the zygoma is a very straight bar of bone, and somewhat slender in its proportions.

The superior periphery of an orbit, formed by the frontal and nasal of the corresponding side, is uniformly tilted upwards all along its continuity. Within this raised orbital rim, upon either side, we find the well-marked depressions for the supra-orbital glands, pierced along their bases by minute foramina, the largest perforation being at the anterior end. In *C. squatarola* these glandular depressions pass beyond the osseous orbital border in front, the gland, during life, resting there upon the tissues that overlie the eyeball superiorly.

This tilting up of the superior orbital borders is best marked in the curious skull of *Æ. semipalmata*, where it offers a very striking feature. In it, too, the supra-orbital glandular depressions are very distinct, and

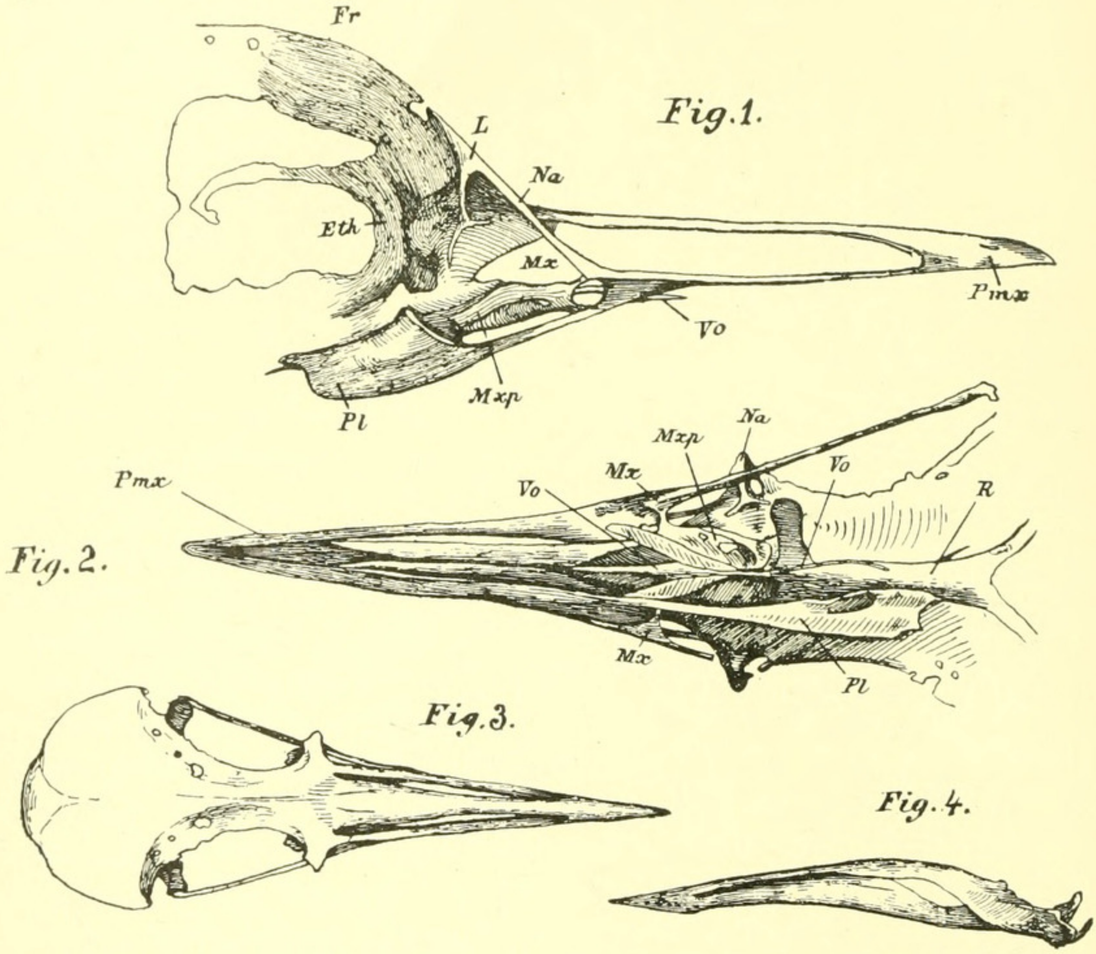


FIG. 1. A side view of the forepart of the skull of *Charadrius pluvialis* enlarged, *Mx*, maxillary; *Mxp*, maxillo-palatine; *Pl*, palatine; *Na*, nasal; *Fr*, frontal; *Eth*, ethmoid; *L*, lacrymal; *Pmx*, premaxillary. (After Huxley.)

FIG. 2. Under view of the same (*C. pluvialis*) partially dissected and enlarged. (After Huxley.)

FIG. 3. Skull of *Charadrius squatarola*; superior view. (Spec. 7963, Coll. U. S. Nat. Mus.)

FIG. 4. Left lateral view of the mandible of *Charadrius squatarola*. Natural size. Figs. 3 and 4 drawn by the author.

they each terminate anteriorly in a single, large subcircular foramen, situated well within the external edge of the orbit.

The fronto-parietal vault of the cranium is very smooth and rounded externally, and is very thin in *Æ. montana* — thicker in the Golden Plover. A large vacuity absorbs almost entirely the interorbital septum below, merging with the foramen rotundum behind. Separated by an osseous horizontal lamina, there exists above this another large vacuity, the forward extension of the foramina for the first pair of cranial nerves, which are greatly increased in size.

At the back of the cranium there is a fairly well pronounced supra-occipital prominence pierced upon either side by an oval foramen.

In examining the base of the cranium in a young chick of the Killdeer Plover (*Æ. vocifera*) I observe that the bony bridge that lies between the supra-occipital foramina is formed by the supra-occipital itself; it is cleft above at this stage, and stouter lateral masses are seen on either side of it. The basi-temporal is still distinct as an element, as are the ex- and basi-occipitals. At the side we find that the squamosal sends upwards an ascending process, long and slender, which overlaps the posterior third of the rounded margin of the frontal, and itself makes the periphery of the orbit. This bone below develops a "zygomatic process," marked by a semicircular nick at its extremity, which arches over the articulation for the quadrate. In adults a sphe notic process is fully developed. The occipital condyle is small and circular, with the notochordal notch nearly obliterated.

With respect to the *quadrate*, it is peculiar only in having its processes and shaft much compressed and plate-like. The orbital spur, making up nearly half the bone, is a quadrilateral lamina, with its base applied to the entire length of the body of the shaft of the quadrate proper. A long narrow condyle surmounts the otic process, placed at right angles to this orbital offshoot, and the pit for the quadrato-jugal occupies the summit of the outstanding lateral mandibular process. Rather undue shortening takes place in the shaft of a pterygoid, owing to the far backward reach of the palatine and the great size, on the other hand, of the quadrate. Basi-pterygoidal processes are present and articulate with facettes at the base of the sphenoidal rostrum.

The hyoidean arches are very delicately constructed, but present nothing peculiar; they are described for other limicoline birds beyond.

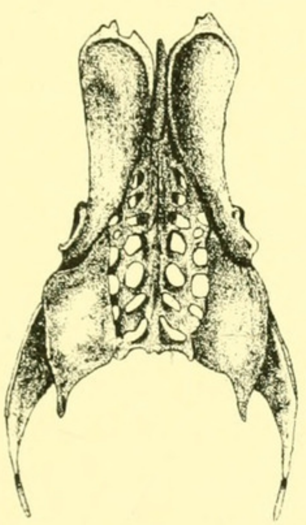
The mandibular elements fuse together early in all true plovers, and in the chick the ramal fenestra is not obvious, whereas, as the bird matures, a small slit-like opening makes its appearance.

The posterior angular processes of the lower jaw are recurved spines of bone slender in comparison with the rather massive inturned angular processes, each of which is pierced near its apex with the pneumatic foramen, seen in so many of the class. The rami of the mandible of this mountain plover make a very acute angle with each other, and the upper margins are quite sharp, while they are rounded inferiorly. Ossifications of the organs of special sense, as the eye and ear, present nothing but their usual ornithic characters.

Of the Axial Skeleton. — Twelve vertebræ, including the atlas and axis, are found in the spinal column of the neck of all of our plovers. The cup of the atlas is roundly notched behind to its center, and the axis possesses a knob-like neural spine. In the third vertebra this process becomes a small compressed square lamina, and in this segment, too, we find an extensive quadrate hypapophysis below, and a minute foramen on either side, in the bony plate joining the zygapophyses. These features reappear in the fourth vertebra, but the foramen mentioned has so increased in size here that it is reduced to a mere interzygapophysial bar. In the fifth, sixth, seventh and eighth, the neural spine has disappeared; the hypapophysial plates are longer and shallower; the parapophyses persist as parial and at the same time lateral spines, directed posteriorly. The last four vertebræ of the twelve under consideration are modified for the carotid canal. Upon them the neural plates are suppressed. These four vertebræ are the longest in the neck, and their post-zygapophyses, diverging from each other, reach well backwards. In several respects the thirteenth and fourteenth vertebræ are peculiar, and differ from the leading twelve cervicals. They are broader, wider, and each supports a pair of free ribs with well-developed tubercula and capitula; the second pair, or those on the fourteenth vertebra, may bear uncinate processes, situated low down on the rib. The neural spines are still suppressed, but the hypopophyses again make their appearance mesiad and beneath the centra; in the thirteenth it consists of a single plate, while in the fourteenth a lateral offshoot springs from each side of this, so that three lamelliform prongs are present in that segment. A deep pit, with overhanging brim on each side of the centrum, is for the first time observed in these two vertebræ as we descend the series. It becomes wider and shallower as we pass through the vertebræ beyond, but does not disappear until we pass to those united to form the sacrum.

The succeeding six vertebræ, or the fifteenth to the twentieth inclusive, are all free, and all support true vertebral ribs that articulate with the sternum by the means of costal ribs or hæmapophyses. The neural spine is well pronounced in the first (fifteenth) of this series, but in the remaining five it is a lofty median crest, each interlocking, before and behind, at the angles at the summit, in a schindylesial articulation. Transverse processes stand out horizontally from these vertebræ, and needle-like metapophyses connect them in several instances, though they do not quite meet in every case. The fifteenth and sixteenth vertebræ retain the hypapophysial processes, being triple in the former, while in the latter it becomes single again, long and triangular. In the remaining four it is entirely absent. The vertebral ribs are quite slender, and all support long unciform processes, which in the adult articulate with their posterior borders; the costal ribs become longer as we proceed backward in the direction of the pelvis.

There are twelve vertebræ in the pelvic sacrum, and from this compound bone, during ordinary maceration, the true bones of the pelvic



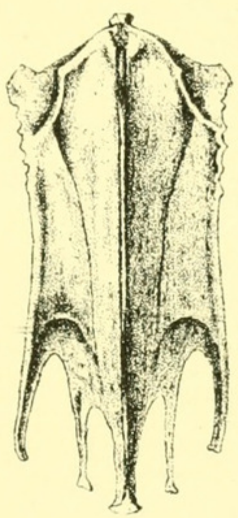


FIG. 5. Pelvis of *Charadrius dominicus*, viewed from above; natural size (Specimen No. 16,715; Collection of the Smithsonian Institution. Collected by the Point Barrow Expedition of 1882 in Alaska). By the author.

FIG. 6. Sternum of *Charadrius dominicus*, pectoral aspect; natural size. By the author, from the same specimen which furnished the pelvis for Fig. 5.

girdle are easily detached. The first four sacral vertebræ throw out their lateral processes as abutments against the nether sides of the spreading ilia; and above, these last-named bones meet the sacral crista but not each other across it. There is a pair of slender pelvic ribs, but their hæmapophyses fail to reach the costal borders of the sternum. They articulate with the hinder borders of the last pair that do. The next five following sacral vertebræ are compressed from above downwards, allowing for a swell in the neural canal within, which is to accommodate that enlargement which here takes place in the myelon. The ninth sacral vertebra has its transverse processes strengthened and lengthened to act as sustaining abutments opposite the acetabulæ. To still further insure strength, the outer ends of these processes are vertically expanded.

Four rows of interapophysial foramina, two upon either side of the sacrum, constitute one of the main features of the pelvis of a plover, when we come to regard it upon its dorsal aspect.

Either post-pubic style is of nearly uniform caliber, and is produced considerably beyond the ischia behind. The posterior extremity of either ischium is produced, long and pointed, and rests during the life of the bird, against the upper surface of the post-pubic style. Mergence of the obturator space and the small obturator foramen may or may not take place. It even may vary for the same species or be different on the two sides of the same pelvis. I must note here that in a pelvis of a Killdeer Plover before me the ilia do not meet the sacral crista; that character does not go for much, however. Including the pygostyle, from seven to eight vertebræ make up the skeleton of the tail in Plovers. I find eight in *Æ. vocifera*, and seven in *Æ. montana*. *Vanellus* also has eight. Probably specimens of the Mountain Plover will eventually come to hand having eight of them, also.

Coming next to the *sternum* and *shoulder-girdle*, I find the entire apparatus to be non-pneumatic in nature. No foramina are to be observed.

The *os furcula* is the perfect miniature of that bone as it occurs in much larger birds of the present suborder, *Numenius longirostris*, for instance. The clavicular limbs are of uniform thickness throughout, and only very slightly increased in bulk where they unite, mesiad and below, to support a small quadrilateral hypocleidium. Substantially, the method of articulation of the shoulder-girdle bones with each other is the same as we found it among the Phalaropes. The form of the coracoid is almost identically the same in *Æ. vocifera* and *Phalaropus lobatus* and there is very little difference in the shape of the scapulæ — either species having the bone fully twice as long as the *shaft* of a coracoid; and in *Æ. montana* its blade is curved, broad, and rounded at its posterior extremity. It reaches well back towards the ilium, overlapping the ribs.

The manubrium of the *sternum* is a stumpy process, shaped like a wedge, being notched above and sharp below. Above this process the coracoidal grooves nearly meet at a point in the mesial plane at its base, while the lateral processes of the same name, of a triangular form, rise only to a moderate degree above the superior margin of the bone, to bear along the posterior border of either one, the facettes for the costal ribs, six on each side.

The xiphoidal extremity of the body of the sternum of *Æ. montana* is four-notched, the notches being deep, and giving rise to five processes, a median one, the under surface of which supports the hinder part of the carina, and a pair on each side of it. In *Vanellus* the inner pair of perforations are subelliptical foramina and not notches.

Fig 7

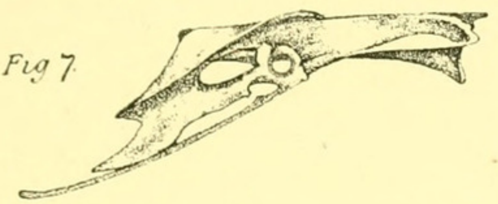


Fig 8.

FIG. 7. Pelvis of *Charadrius dominicus*, right lateral view. Natural size (Spec. 16715 Coll. U. S. Nat. Mus.).

FIG. 8. Pygostyle and last caudal vertebra of *Charadrius dominicus*; right lateral view. Natural size. Same specimen.

In the sternum of a Killdeer Plover at my hand (*Æ. vocifera*) the inner notch on the right-hand side is also converted into a foramen. *C. squatarola* has them as in *Æ. montana*. Viewed laterally the sternum of a Plover very closely resembles that bone as we see it in *Aphriza virgata*; indeed, in so far as shape is concerned, irrespective of mere size, this bone is of a very uniform pattern throughout the majority of our typical *Limicolæ* — the Woodcock, (*Philohela*,) and Wilson's Snipe, (*Gallinago*,) being conspicuous departures therefrom.

Ossification in Plovers is normally extended, as in so many other birds, to the plate of the superior larynx, the rings of the trachea, and a few tendons and sesamoids.

Of the Appendicular Skeleton. — The chief point of interest that attaches to the limbs of our Plovers is that they are, in every case, absolutely non-pneumatic, both the pectoral and pelvic extremities presenting, in all the bones that compose them, those characters, after maceration, so well described by Hunter.[1] The long bones are also non-pneumatic in *Gallinago* and *Philohela*, which are other birds of

[1] Observations on the Animal Œconomy, Palmer's ed., 8vo, 1837, p. 178.

not very dissimilar volatorial habits. All the bones of the limbs in Plovers are impressed with the more usual ornithic characters.

In the *humerus* we find the proximal extremity well expanded, and a strongly marked, curling crest overshadowing the usual site of the pneumatic foramen in birds where it is present. The "preaxial ridge" is shorter than we usually find it, that is, it does not extend so far down the shaft; this shortening, however, is not accompanied by any diminution in the height of this ridge.

The humeral shaft is straight and subcylindrical on section; its distal extremity supports the usual points for examination, and the epicondyloid spur is well developed. (See Fig. 9.)

Both *radius* and *ulna* are moderately bowed along the continuity of their shafts, and the row of *quill-butts* are ranged along that of the

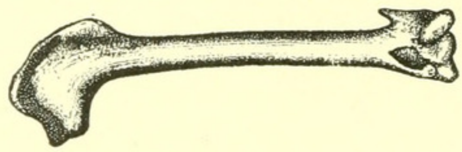


FIG. 9. Left humerus of *Charadrius dominicus*, palmar aspect; natural size; by the author, from specimen 16,715 of the Smithsonian Collection (taken at Point Barrow, Alaskan Expedition of 1882).

latter. There are a dozen of these in *Vanellus*. The skeleton of the hand in any true Plover is a long one, and in *C. squatarola* that segment is fully as long as the skeleton of the antibrachium. The pollex has one joint, the next digit two, and the last, one; there are no claws or spurs in the manus of these birds, as seen in some of the Asiatic forms. There is a very remarkable resemblance of the skeleton of the pectoral extremity of a Plover to the corresponding structures in a Gull. (Compare for instance *L. delawarensis* and *C. squatarola.*)

The entire length of the skeletal arm of *Æ. montana* measures 14 centimeters — of which the humerus takes 4.4; the ulna 4.6; the carpus 0.2; the metacarpus 2.3; and the two phalanges of index digit 2.5.

In the *femur* we notice that the head is sessile on the shaft, and placed nearly at right angles to it; on its upper surface the pit for the ligamentum teres is seen.

The crest of the great trochanter is sharp and elevated above the general surface of the summit of the shaft. At the distal end, the outer or larger condyle falls but a little below the inner one, the groove for the head of the fibula being well cut into it.

Of the two processes on the anterior aspect of the head of the *tibio-*

tarsus, the inner one is of a broad quadrilateral form inclined outwardly, while the external one is a rounded, claw-like, and sharp process, curving downwards. The usual osseous bridgelet for the confinement of tendons is seen in front just above the condyles.

The *fibula* is a very delicate spicula of bone, reaching down, in the articulated skeleton, only half way to the external condyle.

The *hypotarsal protuberance* of the *tarso-metatarsus* is in reality converted into two processes, so deep is the tendinal grooving down its posterior aspect. In *Æ. montana* the inner process is the larger, and sends from its lower portion a sharp ridge of bone that is carried down on the shaft and gradually merges with it. The pits to receive the condyles of the tibio-tarsus on the superior aspect of the head of the tarso-metatarsus are deep, and a knob-like apophysis arises between them on the anterior boundary. Just below this a fossa exists, at the base of which a foramen is seen, which pierces the shaft from before backwards, coming out behind to the inner side of the larger process of the hypotarsus. In all our plovers the shaft of this bone of the leg is long and straight, and the mid-trochlea projects well beyond its fellow on either side. The usual foramen is seen just above its base and on the outer side.

Among our plovers it is only in *C. squatarola* and in *Vanellus* that we find a small hallucial joint present, hung rather high on the shaft of the tarso-metatarsus. It is altogether absent in the Killdeer and others. Otherwise the podal joints are normal, both in arrangement and character, so far as the three anterior digits are concerned.

Measuring from the summit of the trochanteric crest of the femur, on a straight line to the apex of the claw of the mid-digit in the skeleton of the leg in *Æ. montana*, we find it to be in the adult male, 15.5 centimeters in length. Of this the femur takes 3.0, the tibio-tarsus 5.6, the metatarsus 4.2, and the mid-digit 2.7 centimeters.

With respect to its skeleton, no true Plover will depart in any marked degree from the pluvialine skeletal characters as they have been set forth in the above account.

On the Comparative Osteology of Numenius longirostris.

Curlews agree with all other true limicoline types in being typically schizorhinal birds. (See Fig. 10.)

In the skull the *nasal* bones are arranged and formed much as they are in the Phalaropes, but without an immature specimen, which I am

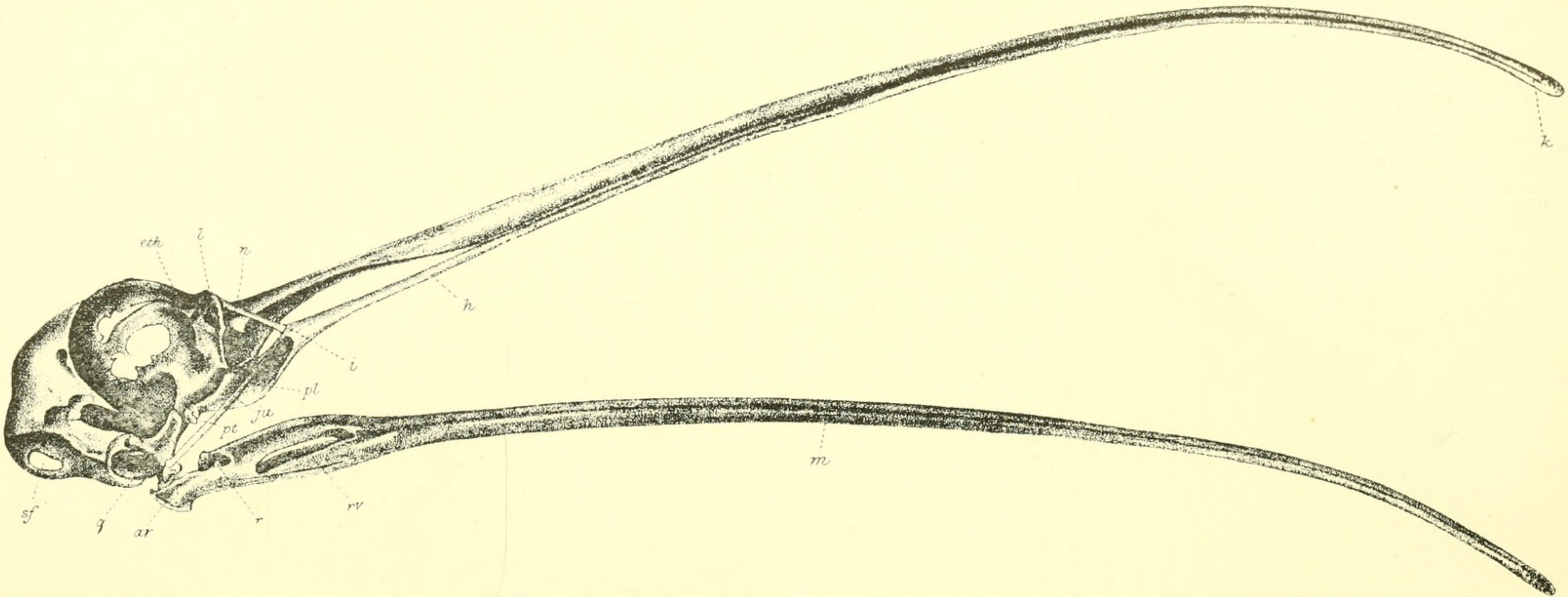


FIG. 10. Right lateral view of the skull of *Numenius longirostris*, with mandible attached : natural size, *sf*, supraoccipital foramen ; *q*, quadrate ; *pt*, pterygoid ; *i*, jugal ; *pl*, palatine ; *i*, point of meeting of nasal (*n*) and maxillary ; *h*, subnarinal bar (formed by premaxillary); *k*, premaxillary ; *n*, nasal ; *l*, lacrymal ; *eth*, ethmoidal wing (*pars plana*).

sorry to say I lack, it is impossible to tell how far forwards beneath the culmen, and on the inner sides of the premaxillary the nasals are extended. We have just seen above that they reach almost to the tip of the beak in Plovers.

The *premaxillary* is quite broad and subcompressed as it slopes somewhat gently away from the frontal region of the skull between the nasal bones. It becomes gradually narrower as it proceeds towards the distal tip, but alters but little in form. In an old individual of *N. longirostris*, it is nearly six times as long as the remainder of the skull, twice as long as the corresponding parts in *N. borealis*. Other forms graduate between these two; in *N. arquata* it is fully four times as long, and is more generally curved throughout.

At the point marked *i* in Fig. 10, and in *B* of Fig. 11, the nasal meets the maxillary. Beneath, and a little beyond this point, the palatine also merges with these bones. These elements thus unite to form a common rod that contracts immediately after the union to a delicately fashioned stem to which I have given the name of the subnarinal bar. They are seen on either side of the nasal process of the premaxillary, at first beneath the osseous narinal slit, then to pass under this bone, becoming at the same time flatter, more closely applied for the entire length, until they merge into it near the tip at *k*, Fig. 10. In *N. longirostris* these bones may be pulled away from the other part of the premaxillary, as shown by the dotted lines in Fig. 11, *A*, and they spring back to their original position when the hold is released.

This is only possible in those curlews that have very long bills. It is not a particularly noticeable feature in the Eskimo Curlew, nor the whimbrel. The sutures among these bones are completely obliterated in the adult skull, so it is not possible to tell the precise limits of the several ones entering into the composition of this bar; no doubt the dentary or maxillary process of the premaxillary takes a large share. The delicate curling crest of bone found just within the nasal bar above, and united with the rounded outer margin of the premaxillary, belongs to the nasal of that side.

In *N. hudsonicus* this character is absent, while, on the other hand, it is exaggerated in *N. borealis*, in which bird the entire rhinal chamber seems to be filled with this enlarged bone, here forming a hollow sub-cylinder, which meets a similar cylindrical formation of the maxillo-palatine coming from below. (Compare C and D, Fig. 12.)

We find the vomer to be a very well developed bone in *N. lon-*

girostris. It is a thin spearhead-shaped lamina of bone, pointed in front, bifurcated behind, where either fork fuses with the ascending process of the corresponding palatine. On the under side of this horizontally disposed vomer there is a thin, vertical, median crest, which in front merges into the free pointed extremity, while posteriorly it is produced backwards by two vertical plates which grasp and ride upon the rostrum. These latter are the bifurcations to which I have just alluded. In *N. hudsonicus* and *N. phæopus* the anterior tip of the

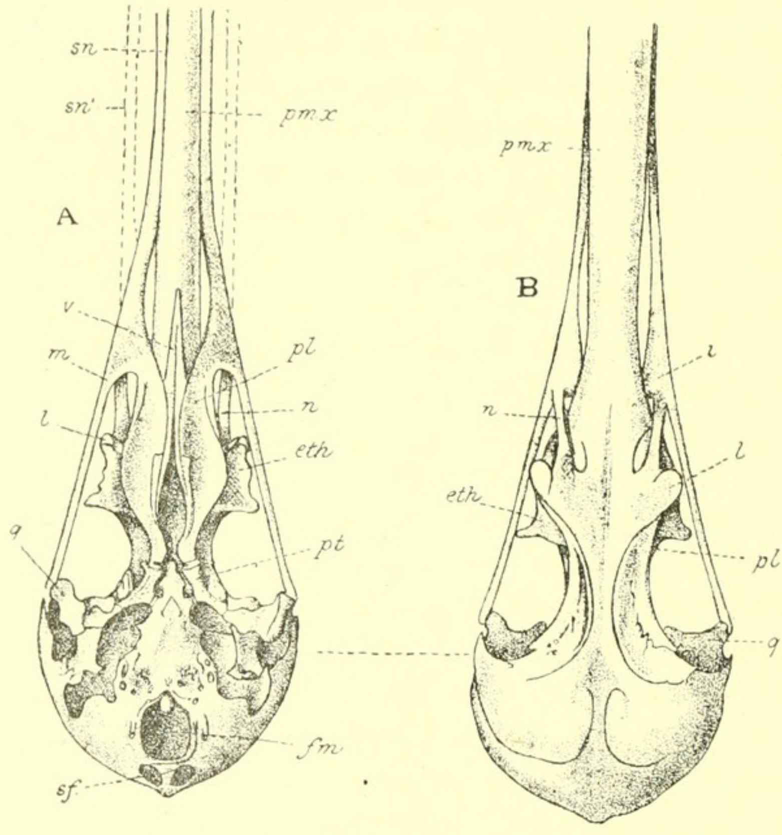


FIG. 11. Basal and superior views of the skull of *Numenius longirostris*, natural size; A, the basal view, lower mandible removed; B, the superior view, like lettering designating like parts. *pmx*, premaxillary; *v*, vomer; *pl*, palatine; *m*, maxillary; *n*, nasal; *eth*, lateral wing of ethmoid; *l*, lacrymal; *q*, quadrate; *pt*, pterygoid; *fm*, foramen magnum; *sf*, supra-occipital foramen; also in A, *sn*, the subnarinal bar, and *sn'* its position in dotted lines as drawn away from the premaxillary on either side. In B, *i*, the point of meeting of nasal and maxillary.

vomer is bifurcated. As a rule the maxillo-palatines are not as much curled as we find them in the Plovers, and the union with the palatine is more extensive. As in the Plovers, however, they are riddled with perforating foramina; more frequently the foramina in either maxillo-palatine plate merge into two regularly suboval ones.

The postpalatine portion of the *palatine* is broadish with its lamina and process strongly developed. These bones are well separated from each other beneath the rostrum, and the pterygoid process is turned outwards. Taken in proportion to the size of the bird, the prepalatine portion of the palatine is relatively shorter in *N. longirostris* than in any other species, while *N. hudsonicus* and *N. phæopus*, with their comparatively longer crania, have that portion of the palatine correspondingly lengthened out.

The *lacrymal*, though small, stands out quite prominently at the antero-superior orbital border. It articulates largely with the nasal, and in all curlews sends down a slender bony style which unites with the upper and outer angle of the *pars plana*, by which means a large foramen in this locality is encircled. These ethmoidal wings have the same general appearance in all the members of the genus. Each one is a quadrilateral plate, projecting nearly at right angles from the mesethmoid, to form an ample partition between the rhinal and orbital cavities.

The interorbital septum is never entire in any of the true curlews, but is pierced in almost identically the same manner in every species. The forms of these interorbital vacuities can best be seen by referring to the several lateral views of the skulls illustrating this memoir. But one specimen of the skull of *N. hudsonicus* lies before me, and in that the dividing bar between the two openings is evidently broken out. I have restored it by dotted lines (Fig. 12, *C*). The *pterygoids* are comparatively short bones in all the curlews, more particularly so in our present subject. They are twisted and angular in appearance, with sharp longitudinal edges. An elliptical facet occupies the middle of the inner aspect of each, which articulates with the basisphenoid process on either side.

Each *quadrate bone* presents the usual undulatory surface upon its mandibular head for articulation with the lower jaw. Just above this, on the inner aspect, is a small, semiglobular facet for the cup on the outer end of the pterygoid. The orbital process is a quadrate, lamelliform plate with truncate extremity, while *two* articulating facets are seen to occupy the dilated end of the mastoid process of the bone. On the outer side we find the usual cotyle for the projection on the quadrato-jugal. The form of the quadrate varies but very little among the other representatives of this genus.

Several foramina are seen at the base of the deep sunken cavity from which the fifth pair of nerves issue. This is the case in all the species, and this elliptical pit on the posterior wall of the orbit, just above the quadrate, is quite a striking feature of the skull. Ossification is so far deficient in the interorbital septum opposite the exit for the optic nerves that this aperture is here one large circular opening. To its outer side, however, separate and minute circular foramina exist for the third pair. This latter condition seems to be common to all the species. The olfactory nerve in the anterior part of each orbit has for its reception a well-marked canal that leads to a foramen (*N. longirostris*), or a notch (*N. phæopus*), into the rhinal chamber. A side view of the skull presents for examination, in addition to other points already noticed, the osseous entrance to the ear, which is here shielded behind by a rather prominent tympanic wing. The sphenotic process in all curlews, except *N. borealis*, is a long, sharp-pointed spine, and even in the excepted species it may become quite long in old birds.

An upper and lower spine project forward from the squamosal, over the articulation for the quadrate. This feature is more prominent in the continental species, *N. arquata*, than in any of our American forms of curlews, though it is by no means entirely absent on the lateral aspect of the skull of *N. longirostris*.

In the eye the usual sclerotal plates are found; they are comparatively small and about twenty in number. The superior aspects of curlew skulls offer some very diverse characters. In all the cranio-facial region is concave and traversed by a faint longitudinal median groove that becomes lost beyond on the premaxilla. This groove is deepest in *N. arquata*. In *N. longirostris* the superior orbital peripheries are but slightly serrated, and the orbital roof just within them is pierced by but very few minute foramina.

The "glandular depressions" are shallow. The surface between them is depressed, though the inner margins or boundaries of these depressions are somewhat raised and prominent. These margins, in *N. phæopus*, merge into a single median ridge or crest; the orbital rims are decidedly serrated with small incomplete foraminal perforations, and the glandular depressions would hardly attract attention.

The raised median line is single and still more prominent in *N. arquata*, causing the depressions to appear more concave. In my specimen one large foramen is seen close to the orbital rim on one side, situated rather posteriorly, with a corresponding notch on the opposite side. In *N. hudsonicus* the orbital rims are comparatively smooth; no evidences exist of the glandular depression, and the region is barely concave; a minute foramen exists on each side posteriorly. *Numenius borealis* has strongly marked glandular depressions of a semilunar form, situated just within the smooth orbital peripheries. A decided median groove divides them longitudinally, which in that species is continued on the culminar portion of the premaxilla for a short distance. The glandular depressions terminate anteriorly in this curlew, in a notch, on either side, just behind the lacrymal bones. The parietal region is smooth and globular, being impressed in most of the species by a longitudinal median groove, most noticeable in *N. arguata*, less so in *N. borealis*, least of all in *N. phæopus*. Among the chief points of interest in the basal view is the form of the foramen magnum. This is nearly circular in *N. longirostis* and *N. arquata*; cordate in *N. phæopus*.

The condyle is small and hemispherical in all the species, and has situated beyond and on either side of it, the usual vascular and nervous foramina seen in this locality in ordinary birds' skulls.

Two large supraoccipital foramina, of elliptical outline, exist in our present subject and in *N. arcuata*; these openings are very small in the Whimbril, and exist only on one side in *N. borealis*, as a minute perforation.

The surrounding muscular line of the occiput is quite strongly marked in all the species; least of all in the Eskimo Curlew.

Within the brain-case we find the tentorial ridges quite prominent, well dividing the various encephalic compartments. The longitudinal one appears to be ungrooved by the sinus.

Foraminal openings occur in the usual localities for the entrance or exit of nerves and vessels. But little diplöic tissue seems to be deposited between the tubular walls of the cranial vault, these latter being quite thin, and composed of firm, compact bone.

The curvature of the *mandible* is almost identical with that of the upper bill or premaxillary. When articulated with the skull it is found to be in all the species a few millimeters shorter than the latter bone. In *N. longirostris* the rami separate and diverge from each other at a point about midway between tip and articular extremity. Beyond this point the mandible is in one piece, rounded beneath and with rounded lateral angles above. A groove deeply marks the bone along its entire course in this portion, in the median line. The rami still remain rounded for some distance backwards after they separate from each other, but, just before they arrive at the long slit-like ramal vacuity, they dilate to become lamelliform plates compressed from side to side. The upper borders of these plates curve inwards towards each other. A second small circular foramen, situated at the base of a larger concavity, on the outer aspect of the ramus, between the vacuity and the hinder end, exists in all the specimens before me, except *N. hudsonicus*.

The articular ends are of a form most common to all ordinary birds of the present suborder; they are produced posteriorly into small vertical plates that turn outwards, but do not curve upwards to any great extent, thus differing from what we found in the Plovers. The usual pneumatic foramina are found at the inturned apices of the articu-

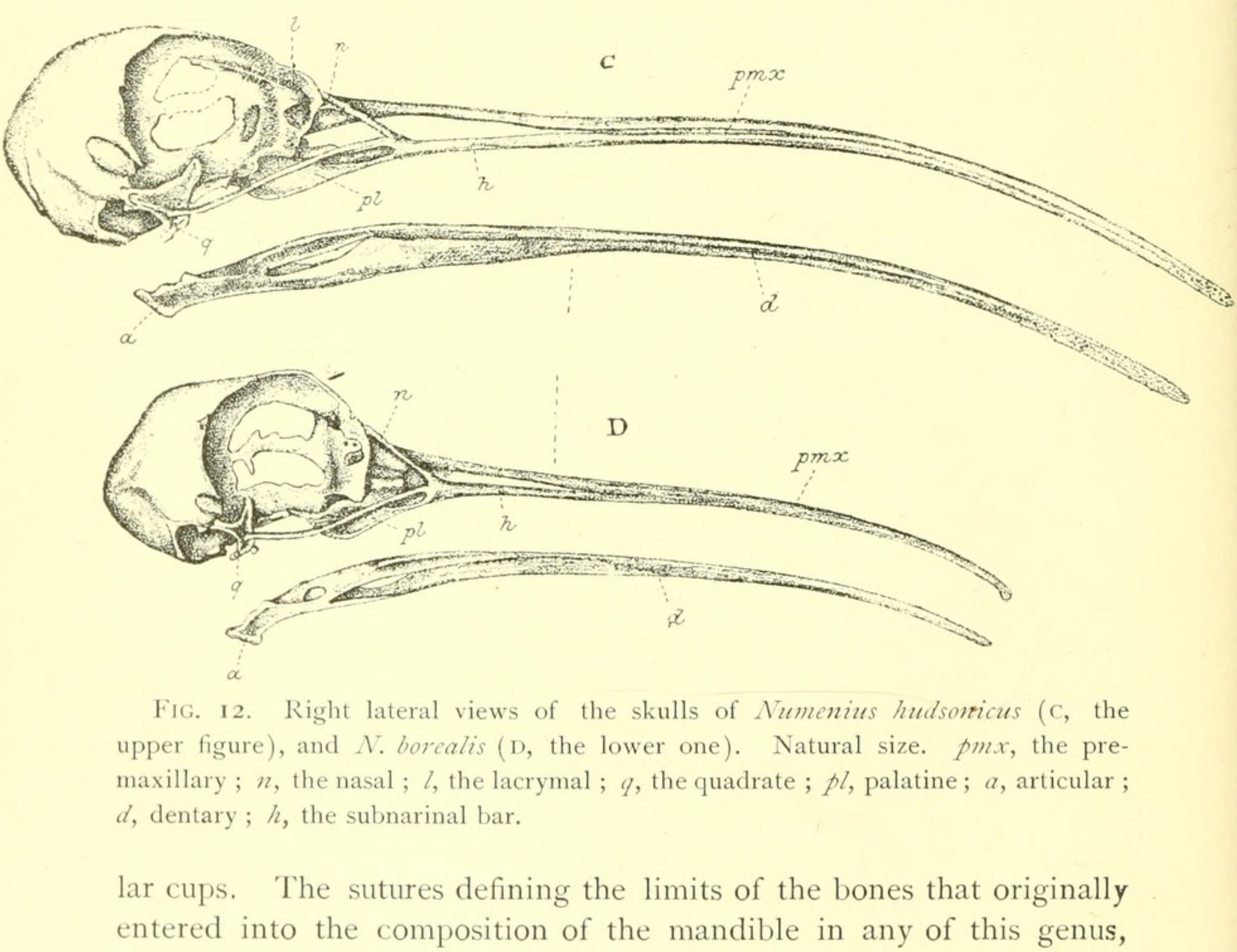


Fig. 12. Right lateral views of the skulls of *Numenius hudsonicus* (C, the upper figure), and *N. borealis* (D, the lower one). Natural size. *pmx*, the premaxillary; *n*, the nasal; *l*, the lacrymal; *q*, the quadrate; *pl*, palatine; *a*, articular; *d*, dentary; *h*, the subnarinal bar.

lar cups. The sutures defining the limits of the bones that originally entered into the composition of the mandible in any of this genus, have become almost entirely obliterated, the edge of the dentary alone sometimes being persistent.

With the exception that the *ceratohyals* have fused with the *glossohyal*, or the posterior part of it, as is usual among birds, all the remaining elements of the *hyobranchial apparatus* of the curlew remain free during life. The first piece of the arch, just named, has the form of a long arrow-head, with quite a sizable fenestra towards its hinder end. This is the inter-cerato-hyal fenestra. The first basi-branchial has a median longitudinal ridge above, connecting the two enlarged articulating extremities; the posterior one has two facets for a cerato-branchial element on each side. These are long and slender, curving upwards. They support the equally delicate epibranchials, which terminate in filaments of cartilage. The second basibranchial is quite short, comparatively speaking, it being in turn produced backwards by a slender, cartilaginous tip.

It will be seen from this description, as far as I have carried it, how really very much alike is the skull of a Plover and the skull of a Curlew.

Comparative Notes from the Skulls of other Limicoline Birds. — Although the skull of *Himantopus mexicanus*, the Black-necked Stilt, has most of the usual limicoline characters, its general form is quite different from that of the skull of either a Plover or a Curlew. Viewed superiorly, we find the median crease very deep between the orbits, and the glandular depressions on either side of it are semilunar in form, strongly stamped and definite in outline. The convexities are directed towards each other.[1] Each terminates anteriorly in a single foramen, that pierces the roof of the orbit beside the lacrymal bone. The inter-orbital septum of this Black-necked Stilt is markedly deficient in bone, and the anterior wall of the cranium does not fare much better in this respect (see Fig. 13). Supra-occipital foramina of the most usual form are found in this bird also, the muscular lines of the occiput being well defined above them. The *pars plana* of either side is but feebly developed, and the descending spine of the lacrymal falls far short of reaching this bony projection of the mesethmoid. Upon basal view we find the palatines long and narrow, with the vomer slender, and terminating in a sharp point anteriorly. The hinder end of each articular part of the mandible in *Himantopus* has the appearance of being scooped out, so as to form a semiluniform cavity.

Recurvirostra americana.—Several of the characters presented on the part of the skull of *Himantopus* are substantially reproduced in the case of the Avocet. Chief among these is the form assumed by the proximal ends of the mandible, the extreme narrowness of either *pars plana*, and the free-hanging descending limb of either lacrymal,

[1] The present specimen may be defective. It was prepared at U. S. Army Med. Museum before I had charge.

though the superior part of each of these bones projects much further from the skull than it does in the Stilt. The Avocet also differs from *Himantopus* in having a more perfect interorbital septum; in the supra-occipital foramina being circular; in the vomer being broad and widely forked at its expanded anterior extremity; in the shallower supra-orbital depressions, which in the Avocet merge together in the middle line, and are carried out on the projecting lacrymals. It is scarcely necessary to call attention to the difference in the form of the skeleton of the bills in these two birds. The Avocet stands alone with his upturned mandibles, and even the beak of the Stilt is quite unique.

The Skull in the Woodcocks, and in Gallinago. — Although essentially limicoline in their general character, the skulls of *Scolopax rusticola*, *Philohela minor* and *Gallinago delicata*, and no doubt others of those genera, depart in some very striking particulars from the limicoline skulls we have thus far considered in this paper. Except in point of size there is scarcely any difference between the skulls of the European[1] and American Woodcocks, the former being about one fourth larger.

In the former the great, capacious and circular orbits, with their raised superior borders, have crowded the greater part of the brain-case downwards and forwards, thus bringing the foramen magnum into the horizontal plane, and the other parts of the skull have the appearance of being moved to the front. All this is also seen in *Gallinago*, but not quite to such a marked degree. In the Snipe, also, the orbits are more elliptical in outline (Fig. 13, F), and the median, longitudinal crease between them on the superior aspect of the skull, more pronounced. Both Snipes and Woodcocks have the occipital condyle very small and hemispherical in form; it being sessile in the former, but rather inclined to be pedunculated in the latter. The supra-occipital prominence is well seen in *S. rusticola*, in which species the foramina, one upon either side, are absent, though they are generally found in the American Woodcock, and always in *Gallinago*. Of a cordate outline, the foramen magnum is of large size in these birds, being as wide in *S. rusticola* as the basitemporal area in front of it. An osseous septum narium exists in all the birds, being most complete in the Snipe. It

[1] I use the specimen kindly loaned me by Prof. A. Newton, F.R.S. (No. 308) from the cabinets of the zoölogical collection (osteological department) of the University of Cambridge, England.

is very peculiar in the woodcock, for from a median lamelliform plate between the nostrils it gradually swells beneath the culmen as it passes to the front of those apertures, then again soon contracts to merge with the narrow and flattened median process of the premaxillary, near the juncture of the anterior and middle thirds of this part of the bill. Below this point the dentary processes of the premaxillary are thin and horizontally flattened. In front of this again the mandible becomes solid, being only grooved in the middle line upon

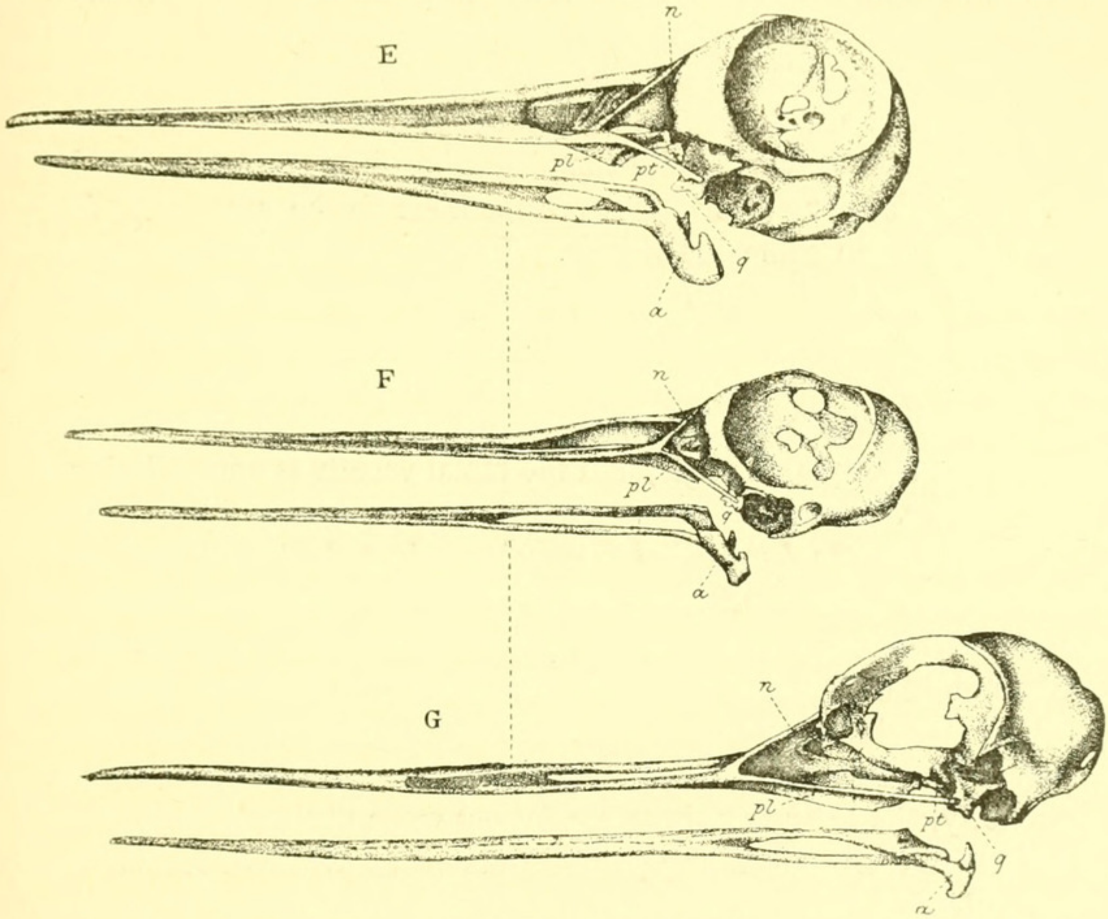


FIG. 13. Left lateral views, natural size, of skulls of *Philohela minor* (E), *Gallinago wilsoni* (F), and *Himantopus mexicanus*, (G). *n*, nasal; *pl*, palatine; *pt*, pterygoid; *q*, quadrate, and *a*, articular.

its nether aspect. Now from this plan of structure we have in this straight superior mandible of the woodcock a section about a centimeter long, which from the thinness of the bones is quite flexible in the vertical direction, the continuity of the osseous beak both in front and behind this section being much firmer and stronger. This feature, if anything, is still better marked in the snipe. It is well known that the woodcock and snipe have the ability to curve up the anterior extremity of the upper bill, and so far as the skull in these birds is concerned the power to perform such a feat is quite apparent.

Passing to the cranio-frontal region, we are to note the large *lacrymal* which sweeps backwards to join with the post-frontal, thus completing the orbital periphery in bone, a very rare condition, as we know, in birds.

In the Woodcock the plate-like *vomer* is vertically disposed, but at the same time it is exceedingly small, being drawn out in front to a point of absolute hair-like dimensions. It is horizontal in *Gallinago*, and both larger and longer. In *Gallinago* and in the Woodcock, too, the interorbital septum is quite complete, though in the former species many small deficiencies may occur in the bone on the anterior wall of the brain-case in some individuals. The *pterygoids* are exceedingly short and thick, the facet for the basisphenoid process occupying nearly the entire length of the shaft. This is especially the case in *Philohela*.

In the *mandible* of Snipes and Woodcocks the hinder end is bent down almost at a right angle, and the ramal vacuity is unusually large in *Gallinago*.

The Skull in the Long-billed Dowitcher.—In a skull of this species, *Macrorhamphus scolapaceus*, which I collected in New Mexico, I see a number of characters to remind me of the skull in *Gallinago*, but notwithstanding this, the conformation of the skull, especially its cranial portion, partakes more of the character of the larger Sandpipers.

The morphology of the superior osseous mandible is as in *Gallinago*. Superiorly, the *lacrymals*, however, jut out more distinctly and prominently, and their descending portions, *not at all produced backwards*, fuse with the large square pars plana. The post-frontal process is very long and extremely slender, while the interorbital septum is not so thoroughly completed in bone. *Maxillo-palatines* are practically absorted, as indeed they are completely so in Woodcocks and *Gallinago*. An osseous septum narium is also to be found in *Macrorhamphus*, which, as in Wilson's Snipe, is an extension forwards of the mesethmoid, and probably the nasals grasp it in the middle line beneath the premaxillary, but I would have to have the skeleton of a young snipe to prove that point. In all these true scolopacine types the zygoma is very short, straight, and slender, and inclined to be transversely compressed (especially in Wilson's Snipe).

The *mandible* of *Macrorhamphus* agrees with that bone in *Gallinago*, and the hyoidean apparatus in the two species is practically alike. Its osseous parts are extremely delicate in point of structure.

The skull of *Micropalama himantopus* offers us a most perfect go-between, standing as it does exactly between the Dowitchers (*Macrorhamphus*) and the *Tringas*. It is undoubtedly a Snipe-sandpiper in every sense of the word. The structure of the upper bony bill, as described above for *Gallinago*, has, in it, *almost* mellowed down to what we find in the typical Sandpipers, while the mandible shows the posterior flexure to some degree, and its cranium is truly scolopatringine.

Notes upon the Morphology of the Skull in the Sandpipers. — There is at my hand a complete skeleton of *Tringa maritima*, and its skull, except in point of size, appears to be almost exactly like the skull as we find it in *Phalaropus lobatus*. So far as the essential characters are concerned they are absolutely identical in the skulls of these two birds, and it is only slight variation in *pattern* that causes any differences to exist at all. The bill of the Phalarope is *straight;* the bill of the Sandpiper is somewhat *decurved*, but withal, the characters of this part of the skull are the same. *T. maritima* has the supra-occipital foramina present, but they are likewise so in *Crymophilus*, and I count very little on that fact.

Tringa ptilocnemis has a skull that very closely resembles the skull as found in *Aphriza virgata*. The differences between the two are hardly worthy of notice.

Tringa minutilla has a skull of the most delicate construction, but it is typically limicoline and scolopacine as well.

Most noticeable in *Tringa* is the absence of the supra-orbital glandular depressions and the extreme narrowness of the region of skull where they occur in the other forms. *Tringa fuscicollis* has the supra-occipital foramen and the fenestra in the interorbital septum, as in the curlews. There seems to be in the mandible an inclination for the hinder ends to bend downwards.

This character is also observable in *Tringa minutilla*, and in this sandpiper the space between the orbital margins, on the superior aspect of the skull, is reduced to a very narrow isthmus. It is much wider, comparitively, in *Tringa bairdi ;* and this form also faintly shows the glandular depressions. They are quite well marked behind. The mandible shows the posterior bend, and the articular extremities throw off behind lamelliform, upturned processes that are a prominent feature in this bone. The vomer is pointed in front, and the supra-occipital foramina are present.

Tringa maculata and *Tringa alpina* possess skulls very much alike in many of their characters — in the arrangement of the maxillo-palatines, the presence in each of the glandular depressions with a similar form. Both have the supraoccipital foramina and great deficiency of bone in the anterior wall of the brain-case and interorbital septum. They differ in the form of the ethmoidal wings. *T. maculata* shows a little bony loop, projecting forwards from the outer borders of this plate, which is absent in the Dunlin. In the Pectoral Sandpiper this ethmoidal plate is not carried up so far as it is in *T. alpina*, in which bird it absorbs the lacrymal on either side.

The little osseous loop on the ala-ethmoid, referred to as a character in *T. maculata*, is seen also in *Rhyacophilus solitarius*. Here, however, its upper limb comes down from the lacrymal to throw in its lower limb at a right angle to the ethmoid. This explains the manner in which it is developed and accounts for its presence. The vomer is pointed anteriorly in the Solitary Tattler. A deep median pit characterizes the cranio-frontal region in *T. pusillus*.

In *Actitis macularia* the glandular depressions on the roofs of the orbits are long and narrow and bound the entire supra-orbital periphery. This constitutes a real difference as compared with all true sandpipers, and also denotes in some degree a relationship to the curlews.

A. macularia has also the supraoccipital foramina present, and of some considerable size. Very large vacuities occur in the interorbital septum, and the foramina for the optic, olfactory, and other nerves have all run together to form one large irregular foramen.

Bartramia longicauda does not possess the supraoccipital foramina, and the glandular depressions above the orbits are still narrower than they are in *Actitis*. In this latter Sandpiper we find a minute spur on the anterior margin of the *pars plana*, directed forwards; and its maxillo-palatines have each such a large vacuity in their bodies that either one is reduced to a mere hair-like rim of bone. Its *vomer* is long and pointed.

The skeleton of the remarkable Spoon-bill Sandpiper (*Eurynorhynchus pygmæus*) has been examined by Mr. J. Anderson, and he completes his paper on the subject by saying that "The foregoing examination of the osteology and other characters of *Eurynorhynchus* reveals only one important feature wherein this bird structurally differs from the genus *Tringa*, namely, the singular expansion of the bill, the structural equivalent of a similar modification in *Platalea leucorodia*. Indeed, this species, as pointed out by Mr. Harting, was originally placed in the genus *Platalea* by Linnæus." [1]

A careful study of the skull of *Heteractitis incanus* convinces me that in that part of its anatomy it indicates rather close affinity with such forms as *Totanus flavipes* and *T. melanoleucus*.

We will now pass to the consideration of the skull in some of these birds, as well as of the Godwits and others.

Skull of the Godwits, Willets, Tattlers, and Others.—In *Totanus melanoleucus* the glandular depressions above the orbits are wider again, and the supraoccipital foramina are present. A median notch is found in the upper border of the foramen magnum. In *Totanus flavipes* nearly half the anterior wall of the brain-case is deficient, and the interorbital septum is not formed in bone at all. This latter character does not occur in the Willet (*Symphemia semipalmata*). In this interesting bird we find the supraoccipital foramina to be of some size, and of an elliptical outline. The glandular depressions are barely perceptible. Just beyond the cranio-facial region, on the culmen, we note the persistence of the premaxillary sutures. This shows to some extent how far the nasals must extend forwards. The vomer is pointed anteriorly, and the interorbital vacuity is divided by an osseous bar. Upon a basal view we find that the lower borders of the maxillo-palatine plates appear. They are attached to the palatines anteriorly, being directed backwards as free lamina. Their connection anteriorly with the maxillaries is by their outer angles. In the mandible of *Symphemia* the true ramal vacuity has become a mere slit, filled in with a plate of bone ; while the small foramen I described in the Curlews is here very large, and has more the appearance of the true ramal vacuity as seen in other birds.

This condition likewise exists in *Limosa fedoa* and *L. hæmastica*. The rims of the orbits in the former bird are rounded, differing in this respect from the Curlews. In this Godwit, too, we note a pointed

[1] Anderson, J. "On the Osteology and Pterylosis of the Spoon-billed Sandpiper (*E. pygmæus*)." Trans. Linn. Soc. (2 ser.). I. Zoölogy. London, 1879, pp. 213–217. The quotation is from p. 217. A handsome plate (osteology) illustrates this memoir.

vomer in front, and the presence of the supraoccipital foramina in the occiput. The glandular depressions above the orbits have disappeared, and the openings in the interorbital septum are three in number, and smaller. A deep, circumscribed, and obliquely inclined groove is found on the lateral aspect of the skull, back of the entrance of the ear. In *Limosa rufa* a deep gutter is seen between the orbits on viewing the skull from above. Anteriorly it is bounded by an eminence on the premaxillary. The lacrymal is small in all the Godwits, and connects with the ethmoidal wing, as in the Curlews. In this genus *Limosa* the structure of the superior osseous mandible is much as we find it in *Gallinago*, as given above.

I have not examined the skull of the Ruff (*P. pugnax*) ; it, however, probably only exhibits the usual limicoline characters, with some slight modifications for that particular species. In writing to Professor A. Newton for a skeleton he replied to me in a letter of the 27th of November, 1889, and said: "Herewith I send you a sternum of *Machetes*; I regret to say that we have no skull. It is a most useful thing to have correspondents who make demands like yours upon us, as thereby we learn our deficiencies. Of course we ought to have at least one skeleton of this form, and I shall made it my business to try to get one next year — but it will not be a very easy matter; the bird is practically extinct in England (*i. e.*, there is only one place known where it still exists, and nothing would tempt me to procure one thence) and is become so rare in Holland that I doubt whether any are now sent to our markets, and I think it must be ten or a dozen years since I have seen one in a poulterer's shop."

Comparative Notes upon the Remainder of the Skeleton in the Curlews and other Forms.

There are fifteen vertebræ in the cervical portion of the spinal column of *N. longirostris*. The only other complete skeleton I have of a Curlew (*N. borealis*) shows the same number, so probably this holds for the genus. Free ribs occur on the fourteenth and fifteenth, and in my specimen of the Long-billed Curlew, the thirteenth vertebra of this chain shows persistent sutures upon the lines of anchylosis of the pleurapophyses on either side. So individuals of this species may be found wherein three pairs of cervical ribs exist, they being free upon the last-named vertebra. In the *atlas*, the neural arch is very broad from before backwards, with its posterior angles tipped with small nodules of bone. The cup for the occipital condyle is perforated by a minute foramen at its base. We find the neural spine of the axis to be represented by a large and tuberous knot of bone, and the transverse processes in this vertebra, directed upwards, backwards, and outwards, are unusually stout and heavy. The "odontoid process" is small, and shows an articular facet on its inferior aspect. Beneath, the hypapophysis is a strong plate of bone, pointing backwards, with thickened border below.

The third vertebra has well-developed parapophysial spines; a closed vertebral canal; elliptical foramina, one on each side, in the

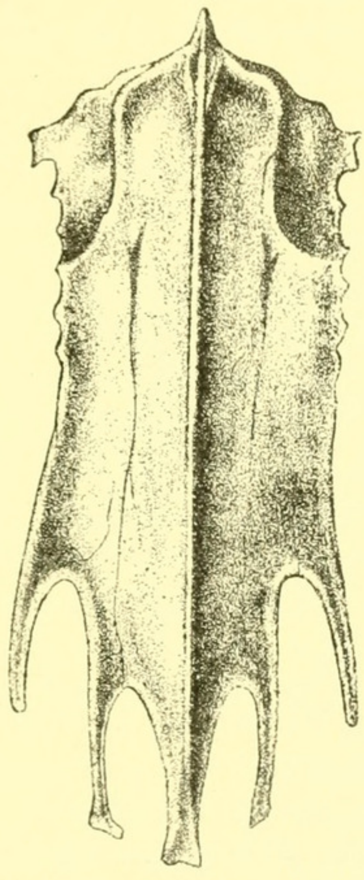


FIG. 14. The sternum of *Numenius longirostris*; pectoral aspect, natural size.

lamina of bone extending between the zygapophysial processes; a neural and hypapophysial spine, the former being a small plate situated posteriorly. In the fourth vertebra these characters are all still to be found, though the foramina above are closed in only by an extremely slender interzygapophysial bar. The fifth vertebra is very much elongated; the mid-portion of the centrum is represented by a median longitudinal lamina of bone, extending between the more solid and terminal pieces that support on their outer aspects the articular facets for the vertebræ before and behind it. The neural spine is reduced to a sharp line; the posterior zygapophyses are outstanding processes. The sixth, seventh, eighth, and ninth vertebræ are substantially the same in character as the fifth, though they are growing shorter as we proceed backwards. They show also the open carotid canal. In the tenth vertebra this is replaced again by a hypapophysis, a single plate placed anteriorly on the centrum beneath. The vertebral canal is still a closed passage, and the neural spine is absent. Extensive pneumatic foramina exist in all the ultimate segments of the cervical division of the spinal column. The eleventh and

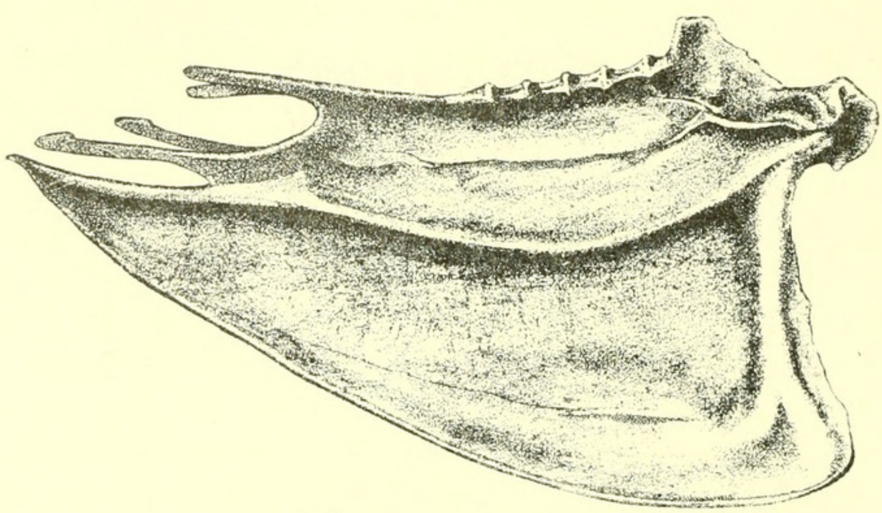


FIG. 15. The sternum of *Numenius longirostris*; right lateral view, natural size.

twelfth vertebræ are slowly changing, to bring about what we find strongly developed in the thirteenth. In this latter we observe a well-pronounced *double* neural spine, occupying a mid-position on the neural arch. The postzygapophyses are elevated, but still project outwards. Anteriorly, the vertebra is very broad from side to side, owing to the far-spreading transverse processes that here overarch the vertebral canal, it being closed in beneath by the anchylosed ribs, already alluded to above as being a character of this vertebra. The lateral aspects of the centrum show a deep elliptical pit on each side, with numerous circular pneumatic perforations at their bases. The hypapophysis is a single plate, occupying the mid-portion of the centrum. In the fourteenth vertebra the ribs, or rather the delicate pleurapophyses, have been liberated; the hæmal spine exhibits evidences of becoming tricornute; the neural spine stands well above the vertebra as a tuberous and solid mass, bearing sharp spines directed backwards upon its outer and posterior angles. These are the continuations of the lateral raised rims of the neural spine proper, and they project also somewhat anteriorly. This is one of the most prominent features of the fifteenth or last cervical vertebra; it is explained, however, in the dorsal series by its evolution into the ordinary quadrate dorsal neural spine, with the forked extremities of the limiting rim at their crests. The hæmal spine of the fifteenth vertebra is triplicated, having three plates, though they are not particularly prominent. In it, too, the free ribs are quite long, and are without uncinate processes.

Numenius borealis shows but few structural departures in its cervical vertebræ from those I have just described for *N. longirostris*.

The cup of the atlas does not seem to be perforated at its base; the pleurapophyses of the thirteenth vertebra bear no striking resemblance as yet to free ribs, as they do in the Long-billed Curlew. The carotid canal is found traversing identically the same vertebræ in mid-neck. In both these Curlews there are five vertebræ in the dorsal series, all articulating freely with each other. Above, they have long osseous metapophysial filaments that stretch for the length of one or nearly two vertebræ before and behind, in the middle of this region. The tendons have also become ossified and attached, and reach far backwards from each segment, those of the last running into the ilio-neural canals of the pelvis. The first dorsal vertebra shows two little lateral processes at the lower extremity of its hæmal spine; this plate is single and prominent in the next vertebra, but does not appear in any of the others. Each dorsal vertebra has a pair of ribs, of the most common pattern, as seen among birds. They connect with the sternum by costal ribs, and have freely articulated uncinate processes. These latter are very long and narrow, reaching nearly in mid-series to the second rib to their rear.

In Curlews the pelvis also supports two pair of free ribs. The first pair has all the character of the dorsals, being simply slenderer and longer. The ultimate pair is devoid of uncinate processes, and their hæmapophyses only articulate along the posterior borders of the pair in front of them, so do not reach the sternum. I find again in my specimen of *N. borealis* an additional piece, or free costal rib, attached to the posterior border of this last pair of costal ribs, on either side.

The number and arrangement of the vertebræ and ribs of the spinal column, as far as examined, agree very nearly with *Limosa fedoa* and *Recurvirostra*.

In *Himantopus* the number of cervicals and dorsals is the same as in *Numenius*, but there appear to be one pair less of sacral ribs.

The arrangement in the Phalaropes agrees with what we find in *Himantopus*.

In *Gallinago* and the Woodcocks the arrangement is different. In them there are twenty-one free vertebræ between the skull and pelvis; but two pairs of cervical ribs (the first very minute); six pairs of dorsal ribs that meet the sternum through costal ones below; two pairs of pelvic ribs, the hæmapophyses of the first not reaching the sternum, and the last pair fused with the ilia and almost aborted.

In *Tringa maritima* these latter are not present, otherwise the arrangement and number of the ribs and vertebræ in the cervico-dorsal part of the trunk skeleton is the same as in *Gallinago*. On the other hand *Bartramia longicauda* agrees with the Curlews in this matter, while all the Sandpipers that I have examined have these parts as they occur in *T. maritima*. The arrangement for other important forms will be fully presented when we come to examine the osteology of *Aphriza virgata* beyond.

Of the Pelvis and Coccygeal Vertebræ.—Viewing the pelvis of *Numenius longirostris* from above, we observe that the total pre-acetabular area is about equal in extent to the post-acetabular area. The ilia are long and narrow, with serrations in their anterior borders. These bones are concaved in front, and present a dimple immediately in advance of either acetabulum on this aspect. About their anterior thirds they grasp the common neural spine of the sacrum between them, thus creating closed ilio-neural canals.

Posterior to the acetabulæ, these bones present convex surfaces, being drawn out behind into prominent processes that curve inwards towards each other and the median plane (see Figs. 16 and 17). They develop outstanding ledges that overhang, on either side, the anterior half of the ischiadic foramen. The sacrum does not unite with the post-acetabular part of the ilia, a very marked interspace existing between them. A double row of elliptical foramina standing among the fused lateral processes further characterize this compound bone.

Upon a lateral view, the long and pointed ischium is presented to us. Posteriorly it reaches nearly as far backwards as the post-pubic style (see Fig. 17), the latter being in contact with it near its termination. The pubic style does not quite close in the obturator foramen in any of the Curlews. Above the latter we find the ischiadic foramen, which in *Numenius* is very large and elliptical in outline.

The lower part of the posterior border of this pelvis exhibits a triangular notch which marks the original division between the ilium and the ischium, and this latter bone from being so long and narrow, is deserving of especial notice.

There appear to be fourteen vertebræ fused together in the pelvic

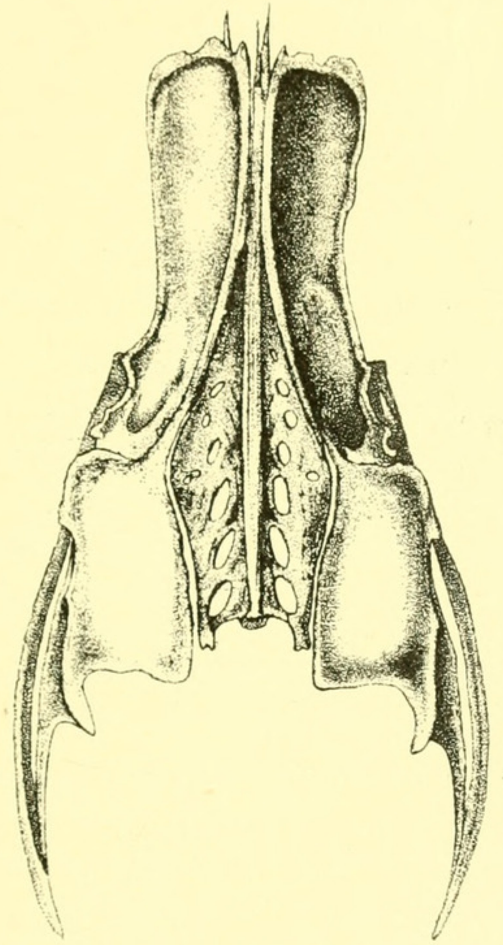


FIG. 16. The pelvis of *Numenius longirostris*, seen from above; natural size.

sacrum of a Curlew, and the two anterior ones throw out diapophyses to the ilia, and bear the facets for the pelvic ribs. In the third vertebra of this series, these processes are extended almost directly upwards, while in the fourth and fifth, again, they are horizontal, as in the first and second. From the points where the diapophyses of the fifth meet the ilia, these latter bones sweep outwards, and are fashioned to form the anterior part of the "basin of the pelvis." The tenth sacral vertebra throws out a strong pair of transverse processes that have widely dilated extremities which articulate with facets especially designed for them on either ilium just posterior to the acetabulum, one on either side.

Foramina for the exit of the sacral nerves are double, one being placed above the other, the increase of caliber in the neural canal of the corresponding dilatation of the cord taking place in the sacral vertebræ from the fourth to the ninth inclusive.

Although more delicately constructed, the pelvis in *N. borealis* agrees substantially in all particulars with the bone I have just been describing for its more powerful congener, the Sickle-bill.

There are ten coccygeal vertebræ in *N. longirostris*, which count includes the triangular and rather large pygostyle.

In *Gallinago delicata* the pelvis is inclined to be long and narrow, and its ischia behind deep and drooping. In front, the ilia meet the sacral crista for a limited distance, on the ridge anteriorly. At the

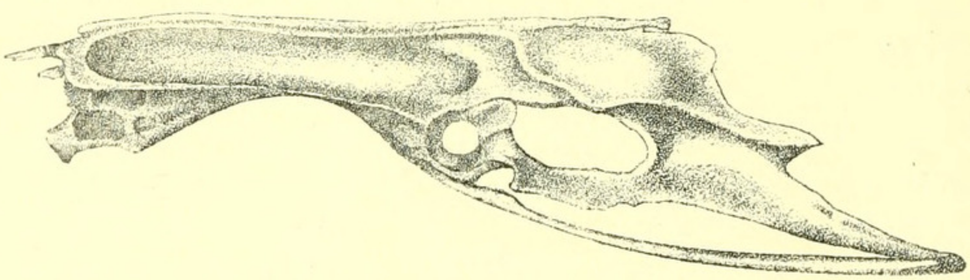


FIG. 17. The pelvis of *Numenius longirostris*, left lateral view; natural size.

side, the obturator space is quite obliterated, and the obturator foramen of very small size, indeed. Broad and triangular processes, one on either hand, project backwards over the ilio-ischiac notches posteriorly. There are two vertebræ that throw out apophysial braces opposite the acetabulæ within the pelvic basin.

Including the rather small pygostyle there are *eleven* vertebræ in the skeleton of the tail in this Snipe. There appear to be but ten in a specimen of the American Woodcock (*P. minor*), and the pelvis of this bird much resembles that bone in *Gallinago*, though we note that the ilia by no means meet the sacral crista anteriorly on the dorsal aspect, and the posterior ends of the ischia are not so long or pointed.

Sandpipers (*Tringa*) and the Phalaropes have their pelves and coccygeal vertebræ much alike. The pelvic bones in *Tringa maritima* are somewhat thin, and the interapophysial foramina of the sacrum numerous, and very open or rather large. On the whole the bone is broadish and compressed from above downwards; the ilio-ischiac notch distinct; and the ischia very much produced behind, being carried along on top of the post-pubis, on either side, as a delicate pointed spine, reaching almost to its end behind. This species has, including the pygostyle, *ten* coccygeal vertebræ. Other Sandpipers possess pelves much upon the same plan.

In *Limosa*, *Totanus*, *Heteractitis* and in the Willets (*Symphemia*) the pelvis comes considerably nearer the pattern as we found it above among the Curlews. I am confident that in the *Limicolæ* the number of coccygeal vertebræ is liable to vary even within the genus. They range from seven to eleven, and may or may not be constant, although I think that the number which may fuse with the pelvic sacrum, in any

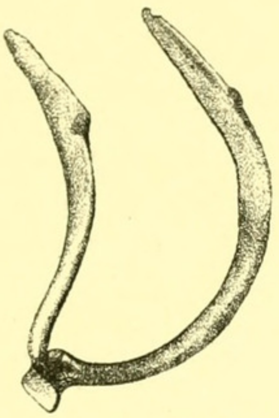


FIG. 18. The *os furcula* of *Numenius longirostris*; a three-quarter oblique view from the right side; natural size.

species, has not a little to do with it. The count in immature birds would be the most accurate.

Of the Shoulder-Girdle (Fig. 18). — We find in *Numenius longirostris* the usual bones allotted to this arch free and articulated in the manner as commonly seen in many of the class. The shape of the *os furcula* is upon the broad U-variety, and is broader in this Curlew than it is in others of the same genus, and still more so than in the Plovers. Viewing it laterally, we observe also that it is very decidedly curved upon itself, with the convexity directed forwards when *in situ*. When articulated, the long and pointed clavicular heads rest on either side against the inner aspects of the summits of the coracoids, while the tips extend backwards to meet the usual process furnished by each scapula. This brings the hypocleidium opposite the middle of the anterior border of the sternum, from which it is separated by quite an interspace.

The clavicles are broader and larger at their superior or coracoidal extremities, being compressed from side to side. Above, the broad surface looks outwards; but it is gradually changed in direction as we descend to the hypocleidium, so that below it looks forwards (Fig. 18). The hypocleidium is of a quadrate form, rather small, and has an extension of its posterior border carried up behind on the line of the median clavicular union.

In *N. borealis* (No. 12,595, Smithsonian Collection) the *os furcula* possesses all the characters I have described for the Long-billed Curlew. As already intimated, however, the arch of the U is not as open, the clavicular heads are not so pointed, and the hypocleidium is nearly round in form, not being so perceptibly carried up on the clavicles at their point of meeting below. Among the Plovers we found that it had the same general characteristics, and it holds the same relative position when articulated to the other bones of the shoulder-girdle.

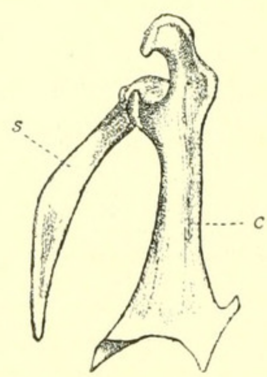


FIG. 19. Direct anterior aspect of the left coracoid and scapula of *Numenius longirostris*; natural size. *s*, scapula; *c*, coracoid.

For the size of the bird, the furcula is large in *Gallinago*, as it is in the Woodcock, but the general pattern remains the same as for the Curlews. Indeed it varies but little in form for the *Limicolæ* generally. In the Sandpipers, as a rule, the hypocleidium is more posteriorly situated, and in *Actitis* this process almost comes in contact with the anterior edge of the keel of the sternum, when the bones are *in situ*.

In some genera the hypocleidium is very small, as in *Limosa*; in others, as in the European Woodcock (*S. rusticola*), the bone is large but its limbs are slender. The hypocleidium is also small and a distinct jutting facet is thrown out on the external aspects of the free clavicular ends above, for articulation with the fore part of the head of either coracoid. This is a Plover-character, and more remotely indicates larine affinities, and relationships with birds belonging to more lowly groups, wherein this character is far more pronounced and at the same time a very common one. In the Ruff, and some other forms, the U is not so spreading, and the clavicular limbs in front of the coracoidal articulations are considerably compressed in the transverse direction. And these latter, in this situation, are upon their outer aspects longitudinally concaved in *Gallinago delicata* and in *Totanus flavipes*. Some Sandpipers also exhibit this latter character. Taken as a whole, however, the *os furcula* varies but very little in its general form among the typical limicoline birds.

The *coracoid* of *Numenius longirostris* is comparatively a short, thick-set bone, as scarcely any true shaft exists between its humeral

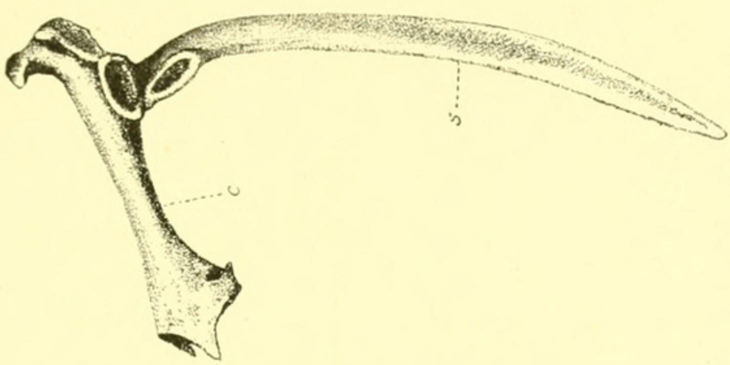


FIG. 20. Left scapula and coracoid of *Numenius longirostris*; natural size.

and sternal extremities. Such as it is, however, is transversely elliptical on section, the section being made just below the inner process at the head of the bone. The sternal extremity is broad from side to side, in which direction it is also convex anteriorly and concave behind. Below, the sternal margin is divided into two deep concavities; the inner and broader one is completely occupied by the articular facet for the sternum. The outer is sharp and free, having attached to its upper horn a pointed and up-tilted little spine, that I will call the *costal spine* of the coracoid, it being opposite the costal border of the sternum. On the outer aspect of the bone we find the usual elliptical facet that here forms about the two thirds of the glenoid cavity (Figs. 19 and 20). The summit of the bone consists of a massive hooked process, directed forwards and inwards. Above and behind, it is impressed by a shallow concavity, while its inner surface is devoted to an elongated facet for head of clavicle. Below this on the inner side, we find another lamelliform process, curving inwards, upwards, and forwards, that at its tip also comes in contact with the clavicle when the bones are *in situ*. The posterior margin of this latter process is given up wholly to the scapula, which in life abuts against its entire length, as well as the shaft behind as far as the glenoid cavity.

In *Numenius borealis* the coracoid is a mere miniature of the bone I have just described for the Sickle-bill. Its costal process is, however, much less strongly marked, and would hardly attract special notice. The coracoids, as well as the other bones of the shoulder-girdle, are non-pneumatic in the genus *Numenius*, and I believe generally so among the *Limicolæ*.

When articulated, the coracoids lean well forward as they spring from their sternal beds in the Curlews, while the scapulæ make angles with them of about 90°. They do not quite meet in the median line in any of the species, but are seperated at this point by a thin compressed surface on top of the manubrium.

The anterior extremity of the *scapula* in *N. longirostris* is decurved, broad, and compressed from above downwards. The blade of the bone, which is comparatively long, becomes thinner and slightly wider posteriorly, to be very obliquely truncate at the inner side of its posterior third. The angles thus formed are well rounded off, resulting in the production of a very ordinary form of this bone (Fig. 20). *N. borealis* has the hinder moiety of the scapula broader, more blade-like, the truncation more decided, and its posterior apex in the articulated skeleton overhanging the anterior margin of the ilium.

In other limicoline birds the coracoids and scapulæ have always much the same general appearance that those bones have in the Curlews.

In the European Woodcock the coracoids are relatively longer than in *Numenius*, and they are inclined to be compressed in the antero-posterior direction. The costal process of one of them is conspicuous, and the summit of the head of the bone is marked by an oval pit. This last character is also seen in *Aphriza*, *Tringa*, and in the coracoids of many other shore birds. Everything else being equal, the coracoids in *Gallinago* are shorter and more slender than they are in the Woodcocks. Comparatively speaking they become still shorter among the Sandpipers. The scapulæ agree pretty well all round, varying only with the size of the species, and occasionally in the pattern of its posterior third, where the style of acumination is apt to vary.

In the Avocet and in the Oyster-catchers when the shoulder-girdle is *in situ*, the coracoids touch each other in the median plane over the manubrial process of the sternum.

The Willets (*Symphemia*), *Totanus flavipes* and *Bartramia longicauda* all have the costal process of the coracoid quite prominently developed; in *Limosa uropygialis* (Smithsonian Collection, No. 12,590) it is broad and quadrilateral in outline and but slightly curved upwards.

Of the Sternum (see various figures).—This bone is greatly developed in all the limicoline birds, and in *L. longirostris* it is unusally so, when we come to take into consideration the size of the species to which it belongs. The manubrium is for the most part a thin compressed median plate, with sharp edge below and thickened border above. At its base superiorly, it is contracted again to an edge, that just keeps the coracoids apart in the articulated skeleton. The coracoidal grooves lie in the horizontal plane; they are broad from above downwards, convex at their middles, and concave at their inner and outer limits. Anteriorly, the margin of the keel is very sharp, being carried clear up to the base of the manubrial process. It appears above, however, merely as a line on the front of that column of bone that descends in this situation, to be gradually lost as its expands on either side of the keel below within this anterior margin. The carinal angle in *N. longirostris* is rounded in front, being partly covered by the raised rim that bounds the entire length of the keel below. This latter part of the sternum is exceedingly deep, being carried backwards to the very end of the sternal body by a graceful curve (Fig. 15).

Upon the costal border we observe six transverse facets for articulation with the hæmapophyses. They are limited beyond by a low quadrate costal process—a feebly-pronounced feature in the sternum of our Curlew. So high do the sides of the sternal body itself arise that it reminds one very much of a very deep spoon with slender processes projecting from its free border in front, corresponding to the hinder border of the sternum. These processes are four in number, two on either side, making this sternum a four-notched one. Their shape and arrangement can best be seen by referring to my drawing in Fig. 14. On the superior aspect of the sternum, in the median line, and just within the anterior boundary, we find a deep pit with rounded margins. At its base, there seems to be a few minute, pneumatic perforations. The usual muscular lines are found to be strongly marked on the sternal body and keel in this Curlew, being carried back, in each case, nearly to its xiphoidal extremity.

The chief differences presented to us in the sternum of *N. borealis* are a greater width of the mid-process posteriorly, and a very decided protrusion forwards of the carinal angle anteriorly. In all other respects the sternum of the Eskimo Curlew seems to be the very miniature of the bone I have just described for the Sickle-bill Curlew.

Passing next to the sternum as we find it in *Scolopax*, *Philohela*, and *Gallinago*, it is to be observed that the bone has, in its general form, precisely the same pattern as it has in *Numenius*. The carinal angle, however, is more prominent and pointed, and the sterna of these birds lack the internal pair of xiphoidal notches. I have one sternum of a specimen of Wilson's Snipe (*Gallinago*) though, that on the right hand side has a foramen at the locality where the inner notch occurs in other *Limicolæ*. Most Sandpipers have a sternum like what we found in the Curlews, but the posterior xiphodal border, as indicated by the ends of the xiphoidal processes, lays more in a transverse line, not being nearly as much rounded as it is in *Numenius*. *Limosa* has the inner pair of notches very small, and they are absent again in such genera as *Pavoncella* and *Rhyacophilus*. Avocets have all four of the notches, and in them they are about of equal depth, while in *Totanus* they agree with *Limosa*. *Bartramia longicauda* shows a small pair of inner notches in its sternum, with very deep outer ones.

Gallinago has the manubrium very small, and in the sternum of that species the pectoral muscular lines on the sides of the carina are raised and rounded welts. This last character is wanting in Woodcocks, and in them the manubrium is larger. I believe in all the unmentioned species the sternum is four-notched, and in other respects substantially has the pattern of that bone as it is seen in *Numenius*.

Of the Appendicular Skeleton.— All the bones of both limbs in the *Limicolæ* are non-pneumatic in character. As a rule, the long bones are straight, and comparatively very long. They are also strong and otherwise perfectly developed — shore-birds being, as we know, good fliers.

The *os humero-scapulare* seems to be absent, its place being taken by ligaments, as in other birds where this ossicle does not appear.

The *humerus* (Fig. 21) of *Numenius longirostris* has a shaft that is much straighter than is commonly seen among birds, where it is usually formed like a long ʃ. Its proximal extremity is comparatively widely expanded, which expansion includes the graceful canopy that arches over the unpierced pneumatic fossa. A deep notch divides this from the articular facet or head for the glenoid cavity.

The radial crest is well developed and bent outwards almost at a right angle with the vertical plane of the bone, when viewed in a position of rest. Should a section of mid-shaft be made, the figure would be very nearly circular; it becomes triedral proximally and roughly elliptical towards the distal end. In this latter region, above the external condyle, an "epicondylar" process is developed; and this process is developed in a greater or less degree in all shore-

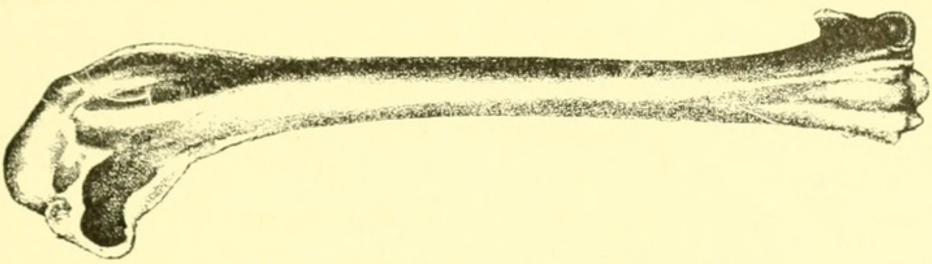


FIG. 21. Right humerus of *Numenius longirostris*, anconal aspect; natural size.

birds. Its apex is intended for muscular attachment. There is a well-marked fossa just proximad to the distal articular tubercles of the humerus.

Viewed from above, the shaft of the *ulna* is seen to have a long, gentle curve, extending from one end of the bone to the other, being the greatest near its proximal extremity.

The papillæ for the quill-butts along the shaft are quite distinct in this bird, and still more so in the Oyster-catcher, where they present the unusual condition of being narrow and oblong in shape, and placed, as it were, obliquely on the shaft. To the inside of these a secondary row is seen, running down the shaft longitudinally. These little protuberances are scarcely perceptible in the Phalaropes or in *Tringa*.

The radius of *N. longirostris* does not exhibit so much of a curve in its shaft as its companion in the antibrachium, though it is gently bent throughout its length. A concavity is scooped out of its shaft near the head, over which tendons pass in life.

The *carpus* contains the two free bones ordinarily found there in adult birds, articulating after the usual manner.

All of the *Limicolæ*, so far as I have examined them, are endowed with a remarkably long hand. If we allow the bones of the carpus to be added to it, its length in the Sickle-bill is fully equal to that of the ulna. Each bone lends its proportional share to produce this result. The shaft of the second metacarpal is, for the most part, cylindrical in form, while its anchylosed companion is of very slender proportions. I find in *Numenius* and *Hæmatopus* a delicate, curved and free claw-joint, suspended from the distal end (Fig. 22, *x*).

There is an ample expanded portion springing from the posterior

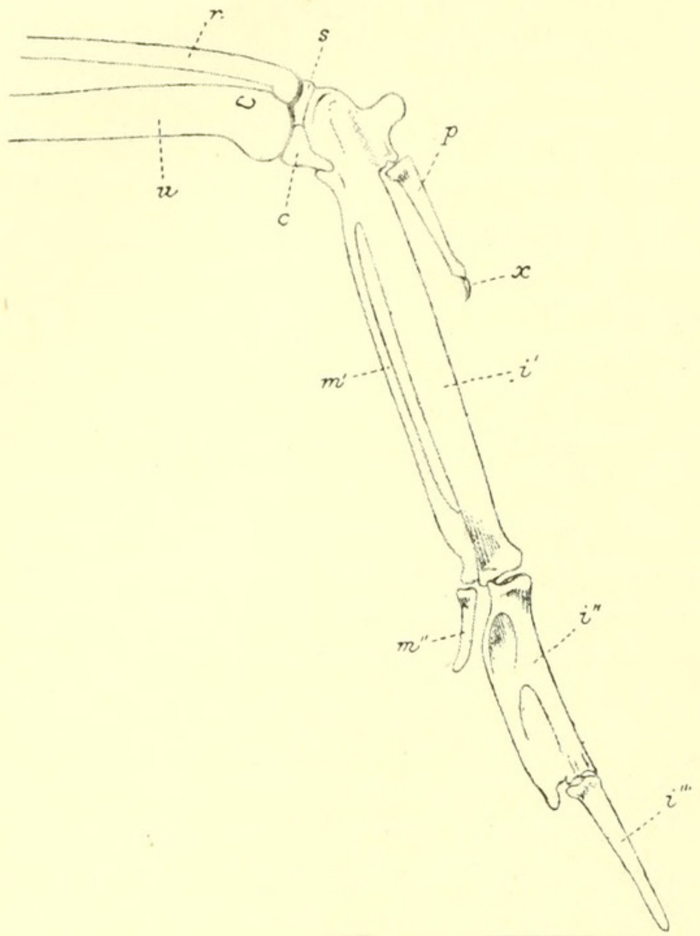


FIG. 22. Palmar aspect of right manus of *Numenius longirostris*, showing also distal extremities of radius and ulna, natural size. *r*, radius; *u*, ulna; *s*, radiale; *c*, ulnare; *p*, pollex; *x*, claw on pollex; *i'*, index metacarpal of carpo-metacarpus; *i''*, its first or proximal phalanx; *i'''*, its distal phalanx; *m'*, medius metacarpal of carpo-metacarpus; *m''*, its digit.

aspect of the first digit of second metacarpal. It is produced downwards as a flattened and peg-like process, not commonly seen. This phalanx supports below one more long and slender joint. The smaller digit of the third metacarpal has a shape not unlike a compressed claw, as it hooks over the expanded portion of the finger at its side.

The Pelvic Limb. — After the process of maceration and drying, the femur of this Curlew has all the appearance of a pneumatic bone, but careful search fails to discover the orifices at their accustomed sites, though a few very minute openings are to be seen on the opposite side of the bone, below the facet. This, I must believe, would be an unusual locality for such foramina. The femoral shaft in *Numenius* is straight, smooth and cylindrical, with all muscular lines nearly obsolete. A rough surface is found on the back of the trochanterian prominence, and this portion rears well above the facet at the summit. The pit for ligamentum teres is very shallow, and rather irregular in outline. Several of the characteristic features of the distal extremity of the bone are more keenly defined than those just described for the proximal end. The intercondyloid notch is deeply excavated; the anterior border of the external condyle is a sharp crest, while the corresponding surface on the internal one is evenly rounded. Upon the reverse aspect we find the popliteal depression well sunken, and the notch for the head of fibula cleanly cut out. A tubercle and pit exist on its outer and condyloid side for ligamentous attachment.

The length of the tibio-tarsus in this Curlew is double that of the femur, and the shaft of the bone has a general convexity inclined outwards. Sections taken through its middle third are subellipses, and the expanded extremities are rather abruptly attached, more particularly the proximal one. There the pro- and ectocnemial processes rise squarely from the shaft, showing but little of that tendency to merge gradually into it below. The ectocnemial process is shaped like a claw, with its joint inclined downwards. Its fellow is much larger, lamelliform, slightly turned outwards, quadrilateral in figure, with the angles rounded off. They are produced upwards as a rotular process to a very slight extent. The fibular ridge stands out from the shaft on its outer aspect as a prominent and rather extended crest of bone.

At the distal extremity we find the inner condyle to be smaller than the opposite or outer one, as well as proportionately narrower from above downwards. In the groove between them anteriorly, the tendinal ridge is ossified, the span being thrown directly across, and not obliquely, as it is in some birds. Prominent tubercles exist on either side, immediately above it, for ligamentous attachment, and an additional bridge is formed of this material above this point. The *fibula* is compressed from side to side above, and club-shaped. After articulating with the ridge designed for it on the tibio-tarsus, it merges into the shaft of that bone a little over half-way down, measuring from the proximal extremity.

Himantopus, with its pelvic limb of twenty-nine centimeters in length, has a fibula that descends but one fourth the distance down the tibial shaft.

The *patella* in *Numenius* is, comparatively, very small, and of an odd, irregular shape. Oyster-catchers have this sesamoid only repre-

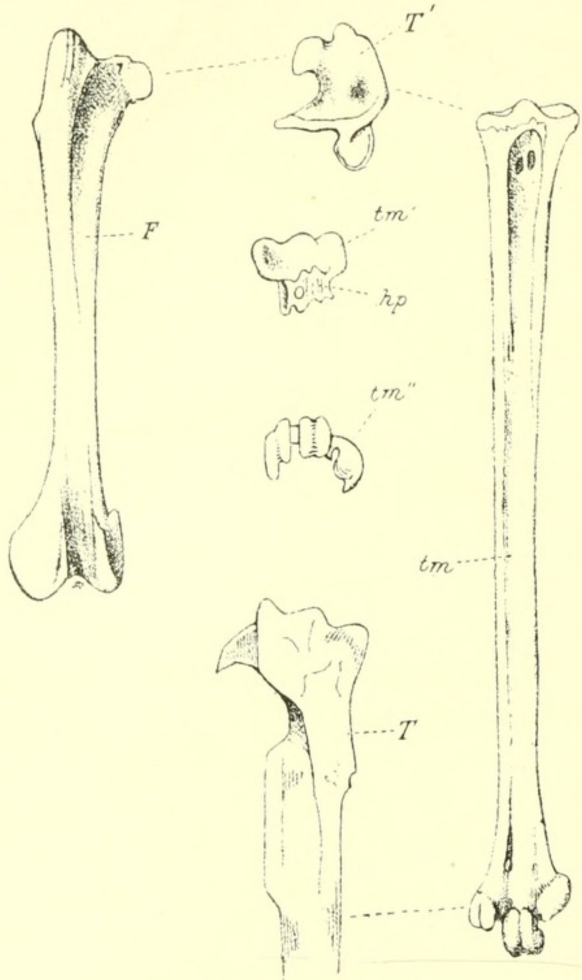


FIG. 23. PARTS OF RIGHT PELVIC LIMB OF NUMENIUS LONGIROSTRIS, Natural size. *tm*, anterior view of the tarso-metatarsus; *tm'*, a view of the surface of its proximal extremity at right angles to the shaft; *hp*, the hypotarsus; *tm''*, a view of the surfaces of the distal extremity of tarso-metatarsus at right angles to the shaft, showing the trochleæ for the podal digits; *T*, upper extremity of the tibia; *T'*, view of its proximal surface at right angles to the shaft; *F*, anterior aspect of the femur.

sented in a diminutive cartilaginous nodule, and it is absent in other shore-birds. It is small in Avocets and Willets.

The *tarso-metatarsus* of *Numenius* is but a little over a centimeter shorter than its tibio-tarsus. Upon the superior surface of its proximal extremity the articular facets for the tibial condyles are deeply impressed, and a prominent tubercle arises between them on the anterior rim (Fig. 23, *tm*). Behind, the hypotarsus is bulky, being both grooved and pierced for the passage of the tendons. The shaft of this

Fig 24

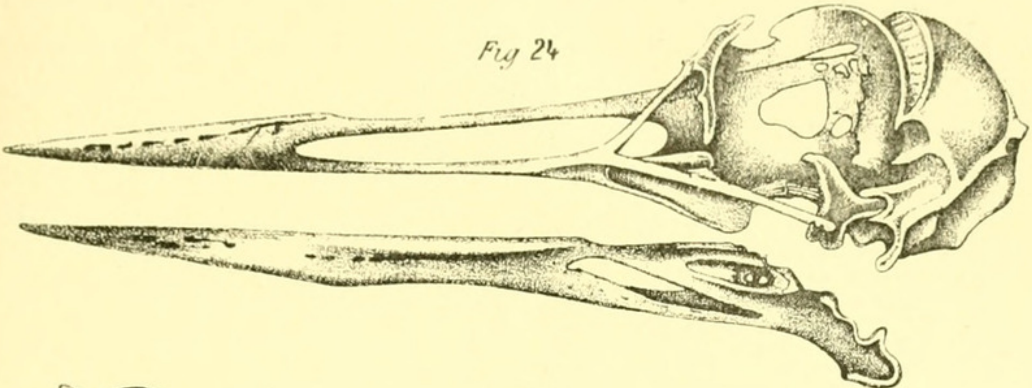


Fig 25

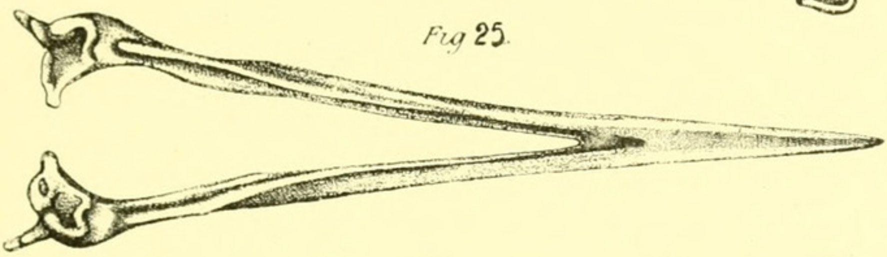


Fig 26

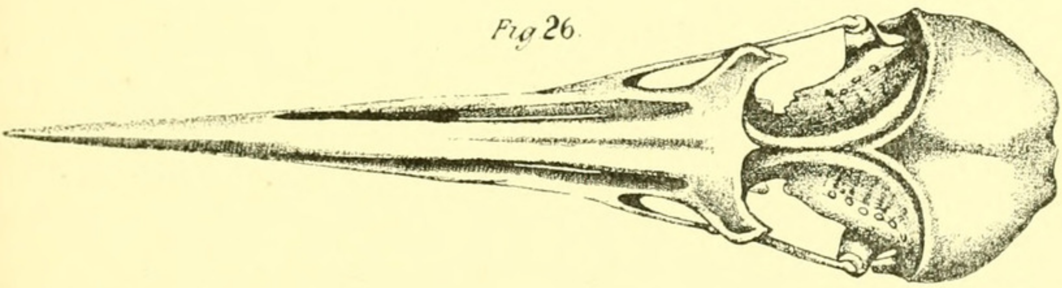


Fig 27

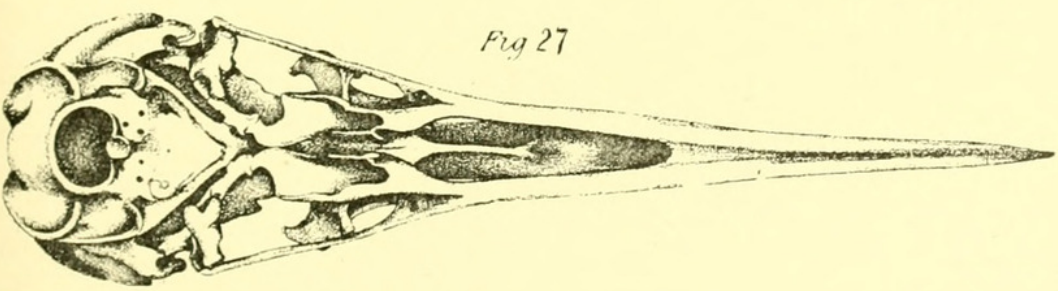


FIG. 24. Skull of *Hæmatopus backmani*, left lateral view; natural size.

FIG. 25. Mandible of *Hæmatopus backmani*, viewed from above; natural size.

FIG. 26. Skull of *Hæmatopus backmani*, superior aspect; natural size; mandible removed.

FIG. 27. Skull of *Hæmatopus backmani*, basal view; mandible removed; natural size.

FIGS. 24, 25, 26 and 27 are all drawn by the author from the skeleton of the same individual (No. 13,636 of the Smithsonian Collection).

bone is concave longitudinally for its entire length on the anterior aspect, and less so upon the posterior. The trochlear prolongations at the distal end are large, and the extremity much expanded, a feature still better marked in the swift-footed Oyster-catchers. When describing the skeleton in the Plovers I spoke of the fact of a number of the limicoline birds lacking the hind toes. This is the case with *Himantopus* and others. With respect to the Curlews, in number, the phalanges of the podal digits are arranged upon the common plan of the avian foot, and in no way offer us anything beyond the ornithic characteristics that pertain to the skeletal foot of a typical wader.

Now the writer has made many comparisons of the wing and leg bones of the *Limicolæ*, and has failed to find any very decided departures from what has been given above for the Curlews. Practically, the characters are the same throughout the suborder. Even those birds that show the more marked differences in other directions, as the Woodcocks and *Gallinago*, have the skeleton of the limbs typically limicoline. This does not apply to the comparative and relative lengths and calibers of bones, for such may differ, and probably do, among the various species and genera of shore-birds. Nor does the absence or presence of the claw on the pollex phalanx seem to go for much, for although entirely wanting in some forms, it is most rudimentary in others, while as we have seen, in *Numenius* it is a true claw, piercing the integuments and covered with a horny sheath. Such a claw never occurs, I believe, on the distal phalanx of index digit in any of the *Limicolæ*.

In so far as the osteology of the *Aphrizidæ* is concerned I have already given a full account of the skeleton of the Surf Bird in a paper entitled, "On the Affinities of *Aphriza virgata*," which appeared in *The Journal of Morphology* for November, 1888 (Vol. II., No. 2), and to it the reader is referred for such limicoline characters that are desirable to be taken into consideration with what is set forth in the present memoir. There are some few corrections the writer would like to make in the aforesaid paper, but they are not of sufficient importance to justify its republication as a whole. There is, however, one point I should like to invite attention to, and that is what I say in that paper in regard to the unreliability of the so-called notches in the sterna of some genera of birds. As a character it attracted the attention of Professor Alfred Newton, F.R.S., and he wrote me from Cambridge, England, under date of December 14, 1889, and said in connection with two sterna of the European Woodcock he kindly submitted me for examination, "but I send two to show how variable is the form of the posterior notches in this species; I have always maintained that characters drawn from this part of the sternum are *comparatively* of little value, and especially in the *Limicolæ*."

I now pass to a brief consideration of the osteology of the Jacanas.

NOTES ON THE SKELETON IN THE JACANAS (*The Jacanidæ*).

Jacanas are birds which have been considered by some as belonging to the family *Rallidæ* and by others placed in the present group. Their position here however, I think has now been most definitely settled, chiefly through the anatomical investigations upon numerous species of them, undertaken by Garrod and by Forbes. The former writer in his celebrated paper, "On the Value in Classification of a Peculiarity in the Anterior Margin of the Nasal Bones in certain Birds" has said that "*Parra* should be removed to the Charadriomorphæ," and the last-named talented anatomist in his excellent paper on "Notes on the Anatomy and Systematic Position of the Jacanas (*Parridæ*)." has very conclusively settled their taxonomic position for all time. I will use this paper of Forbes quite extensively here for what there is to be said about their osteology. He examined specimens of *Parra jacana* and *gymnostoma*, *Metopidius indicus*, *africanus* and *albinucha*, and *Hydrophasianus chirurgus*, and the present writer has closely studied a mounted skeleton of *P. gymnostoma*. Garrod figured the skull of *Hydralector cristata* (P. Z. S., 1873, p. 34, Fig. 5), and Forbes the skull of *P. jacana* (Coll. Sci., Memoirs, p. 224, Fig. 1).

In speaking of them as a family Forbes said in his paper: "There are well-developed basipterygoid processes, which are always absent in the Rails, though of very frequent occurrence amongst the 'Pluviales,' occurring in all the Charadriinæ and Scolopacinæ I have examined. In *Parra jacana* and *Metopidius albinucha*, the long, narrow, slightly decurved vomer is emarginate apically, as in certain Charadriidæ. In the *Rallidæ* it is, I believe, always sharp at the point."

"The maxillo-palatine processes are rather slender and directed backwards; they have the form of concavo-convex lamellæ, are not at all swollen, and do not unite by some way in the middle line, the vomer appearing between and (when the skull is viewed from the palatal aspect) below them."

[1] Garrod, A. H., P. Z. S., Lond., 1873, pp. 33–38. See page 37.

[1] Forbes, W. A., P. Z. S., Lond., 1881, pp. 639–647.

"There is no ossified internasal septum, nor any ossification of the narial cartilages. The lacrymal is small, anchylosed with the naso-frontal region of the skull above, and with the 'pars plana' below."

"On the posterior aspect of the skull there are no traces of the occipital fontanelles, which are found in so many birds related to the Plovers."

"The supraorbital impressions for the nasal glands, which are so conspicuous in most Plovers, the Gulls, Auks and many other birds, are absent in the Parridæ."

Forbes showed by a drawing how unlike the sternum of *Metopidius albinucha* was the bone as it is found in the *Rallidæ*, and added: "In the latter group the sternum is always peculiar in that the xiphoid processes exceed in length the body of the sternum, which tapers to a point posteriorly, and from which they are separated by very long and well-marked triangular notches. The carina sterni also is less well developed, and the clavicles are weaker and straighter, being less convex forwards than in the Parridæ. The sternum and clavicles of *Parra* and *Metopidius* in general form, on the other hand, resemble closely the type found in some of the Pluvialine birds (*e. g.*, *Thinocorus*, *Attagis*)."

"The pelvis, again, of the Rails presents certain well-marked peculiarities. If that of *Rallus aquaticus* be taken as a typical form, it will be found that the ilia are long and narrow, and but little expanded in their preacetabular part. The postacetabular portion of the pelvis is but little bent down on the preacetabular part; and the ischia and pubes are but little everted. The ischia are united by broad bony plates to about the three most posterior "sacral" vertebræ; between these plates and the expanded part of the ilia above are well-developed and deep fossæ, occupied, in the fresh state, by the posterior portion of the kidneys. Viewed from above, the well-marked "postacetabular" ridge, which divides off the dorsal from the lateral aspect of the pelvis, running from just behind the antitrochanteric eminence to the posterior spine of the ilium, presents, a little behind those two points, a strongly projecting process. The greatest breadth of the postacetabular part of the pelvis is therefore here, and not at the more anteriorly situated prominence, close to the antitrochanter. Viewed from the side, this ridge forms a sort of overlapping roof to the slightly excavated external pelvic fossa. The genera *Ocydromus*, *Aramides*, *Fulica* and *Porphyrio* do not essentially depart from this type." "In

Parra and *Metopidius* the ilia are wider and more expanded anteriorly. The postacetabular ridge has hardly any median projection; and the pelvis is widest, dorsally, just behind the antitrochanters. The plates of bone between the ischia and sacrum are narrower, and the posterior part of the renal fossæ less well developed, and more open in consequence. In all these points these forms thus approach the Limicoline birds."

After showing the peculiarly *expanded radius* present in some of the genera of the *Parridæ*, and illustrating it by a drawing of the wing-bones of *Metopidius albinucha* (Coll. Sci. Mem., pp. 227, 228, Fig. 3), he adds: "In *Parra jacana* and *P. gymnostoma* the radius presents the ordinary form; and the same is the case in *Hydrophasianus chirurgus*. . . . The 'claw' or 'spur' of the wing of the Jacanas has, it may be observed, no relation whatever to the 'claw' or nail of the pollex, which is also present, though small, in all the three genera I have examined. The 'spur,' in *Parra jacana* at least, consists of an external, translucent, yellow epidermic layer, which invests a central core of compact fibrous tissue, this in turn being supported by a bony projection developed at the radial side of the first metacarpal."

"As regards the position of the Parridæ in the group Pluviales, it appears to me that they form a well-marked family, with no very obvious relationships to any of the other families of that group, approaching, however, perhaps most nearly to the Charadriidæ, from which they are easily distinguishable by the absence of supraorbital glands and occipital foramina, by their enormously elongated toes, by the number of rectrices, and other points. A brief definition of the Parridæ may be given as follows:"

"Charadriiform birds, with ten rectrices, short cæca, and a tufted oil-gland; with the ambiens, accessory femoro-caudal, and accessory semitendinosus muscles developed, and with the obturator internus triangular; with a two-notched sternum, and with the digits, including the hallux, greatly developed; with the skull provided with basipterygoid processes, but lacking occipital foramina and supraorbital gland-depressions."

I am inclined to depart somewhat from this finding of Forbes, and although I believe that the Jacanas belong among the Limicolæ, as we have here placed them, I am inclined to think that their relationship to certain of the Sandpipers is closer than it is with any of the Plovers.

In the first place they are more strictly aquatic than are most of the Plovers, and many of the latter have but three toes (the anterior ones). The Jacanas have a two-notched sternum, so has *Rhyacophilus solitarius* and *Actitis macularia* and probably other *Tringæ*. In all the typical Plovers, I believe, the sternum is four-notched. Jacanas have a habit occasionally, when standing, of stretching the wings upwards to their full extent above the back, so that they nearly or quite touch each other. *Rhyacophilus* and other Sandpipers have the same peculiar habit, and it is not practiced by the Plovers. The skull of a Jacana is quite as much tringine as it is pluvialine, as is also its pectoral arch, and some other bones of its skeleton.

In the specimen I examined (*Jacana gymnostoma*) I found the postero-external angles of the palatines rounded; and the vomer anchylosed with those bones. The basipterygoid processes were present. The vomer long, slender and rounded anteriorly. Two vacuities occupied the interorbital septum. Maxillo-palatines were small, elongated, not swollen, and nearly hidden by the præpalatines. Descending process of lacrymal fused with pars plana, and the bone anchylosed with the frontal and nasal above. Schizorhinal in type, it likewise possessed twenty-one vertebræ between the skull and pelvis (Rails, as a rule, have twenty-two). Morphologically, both sternum and pelvis are tringo-ralline, with the *os furcula* tringine in type. As to the ribs, I found five hæmapophyses that reached the sternum, and one pair that did not do so. There are two pairs of cervical ribs which articulated with their vertebræ. A *patella* is present which sesamoid is absent in true *Rallidæ*.

SYNOPSIS OF THE PRINCIPAL OSTEOLOGICAL CHARACTERS OF THE LIMICOLÆ.

1. Excepting certain parts of the skull, the entire skeleton is non-pneumatic.

2. Bones of the facial region (premaxilla) may be shortened (pluvialine types) or lengthened (scolopacine types); and in certain of the latter it may be either recurved or deflected to one side.

3. The sphenoidal rostrum is elongated and slender, and the mesethmoid projects forward beneath the premaxilla.

4. All the forms are of the schizognathous type, as well as schizorhinal.

5. The vomer may be small and spiculiform (*Philohela*), or long

and lamelliform. It may be pointed anteriorly, or bifurcated (Avocets and *Hæmatopus*) or rounded, as in some of the *Jacanidæ*.

6. The maxillo-palatines are usually plate-like, concavo-convex scrolls, often nearly absorbed by perforating foramina. In *Hæmatopus* they are flat and thicker, and fuse with the palatines.

7. Basi-pterygoid processes are always present and functional.

8. The interorbital septum always shows a central perforation of greater or less size. This is least noticeable in *Macrorhamphus*.

9. The angle of the mandible may be either a sharp, recurved process or it may be lamelliform as in *Hæmatopus*. It may have its articular ends bent downwards as in the Woodcocks and *Gallinago*.

10. The sternum may have two pairs of xiphoidal notches (Plovers and others); or a single pair (*Actitis*, *Rhyacophilus*, Jacanas, Woodcocks and *Gallinago*). Its manubrium is never large, and the keel is deep. *Os furcula* is of the U-shaped pattern, and its hypocleidium small or nearly aborted.

11. Hallux usually much reduced in size, except in *Jacanidæ*, or may be entirely absent.

12. The phalanges of the anterior toes diminish in length from the basal to the penultimate.

ON THE AFFINITIES OF THE LIMICOLÆ.

Regarding this suborder as a whole, and selecting any genus of Plovers to represent its center, then by the aid of osteological characters alone, it is not a difficult matter to trace from them, through certain forms, to the *Laridæ* and their kin. On another line, and passing the Sandpipers, Willets, Godwits and Curlews in review, we find them also related to the Ibises and their relatives. Or from the Willets, through the Avocets and Stilts, they seem to lead to *Eurypyga*, and through such tringine forms as *Rhyacophilus* and *Actitis*, related as they are to the *Jacanidæ*, they lead to the *Rallidæ* of the suborder FULICARIÆ. Finally, W. Kitchen Parker has shown that through *Hæmatopus* and *Chionis*, their affinity with the *Tubinares* can be demonstrated.

In some respects the *Limicolæ* rank lower than the herodine and ralline types, while in other particulars they are undoubtedly higher.

Regarding the forms we have dealt with in the present chapter, and again selecting the Plovers as the center of the group, we find that through *Aphriza virgata* of the family *Aphrizidæ* they are linked most perfectly with the *Tringeæ*, as through the Turnstones of the Family *Arenaridæ* their kinship with the Oyster-catchers of the Family *Hæmatopodidæ* may easily be traced. Phalaropes are most nearly related to the Sandpipers ; and the Woodcocks and *Gallinago* in their shoulder-girdles, pelves, and less so in their sterna, show strong ties with larine stock, as in its skull does also *Hæmatopus*. The line from the Plovers through the Sandpipers — and *Micropalama* — *Macrorhamphus* — to the true Snipes and *Scolapax rusticola* is clearly indicated, and most distinct. And starting from the pluvialine center again, we once more pass through the *Tringeæ*, *Actitis*, *Rhyacophilus*, the Tatlers of the genus *Totanus*, through *Limosa* to the Curlews.

Some of these relationships cannot be definitely made out until we are in possession of a fuller knowledge of the anatomy in its entirety of many of the types which have been named in this memoir. At the present writing I am engaged upon preparing a provisional scheme of classification of Aves as a Class. In it I place the Charadriiformes (IX.) between the Lariformes and the group containing all the ralline types. They are then arranged in the following manner.

Supersuborder.	Suborder.	Superfamily.	Family.
X. Charadriiformes.	Limicolæ.		Charadriidæ.
			Arenariidæ.
			Hæmatopodidæ.
			Aphrizidæ.
			Scolopacidæ.
			Phalaropodidæ.
			Recurvirostridæ.
		Jacanoidea.	Jacanidæ.
	Cursoræ.		Thinocoridæ.
			Dromadidæ.
			Glareolidæ.
			Cursoriidæ.
		Otidoidea.	Œdicnemidæ.
			Otididæ.

Explanation of Plate.

Right lateral view of the skeleton of *Jacana gymnostoma*. Collection of the United States National Museum, No. 17,317. Nearly natural size.