ON THE AFFINITIES OF *APHRIZA VIRGATA*.

[Based upon a comparative study of its skeleton.]

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DURING the latter part of November, 1885, Surgeon Thomas H. Streets of the United States Navy, then naturalist of the United States Exploring Steamer "Patterson," kindly sent me a skeleton of the Surf-bird, the subject of the present memoir; and again in August, 1886, the same distinguished officer forwarded me a fine pair of skeletons of this species, representing both sexes, adult. All of this material was collected by Dr. Streets in Alaska, and I am indebted to him also for skeletons of *Charadrius squatarola* and *Arenaria melanocephala*, the former taken in San Francisco Bay, the latter at Port Townsend, Washington Territory, and placed at my disposal for comparison with the skeletons of *Aphriza*.

As additional material for the osteological comparisons the writer here proposes to make, I find I have at my command two skeletons of adult specimens of *Hæmatopus bachmani* (Nos. 13,636 and 13,637), belonging to the Smithsonian Institution of Washington; and finally, in my own cabinet several skeletal preparations of the *Charadriidæ* and *Tringæ*, all of which will be of assistance in the work now in hand.

Aphriza virgata constitutes but another one of those forms around which centres so much that is of interest to the systematic ornithologist, owing to the fact that even after more than a mere superficial examination we discover not a little in its anatomy that is inclined to puzzle one, when called upon to pronounce as to its kinship with more or less nearly related groups or types.

Of the first skin that he ever examined, Audubon wrote: "The remarkable bird here represented, which in form and size bears a considerable resemblance to the Knot [*Tringa canutus*], was procured by Mr. Townsend on the shore of Cape

Disappointment, and proved to be a female.”¹ And Dr. Coues remarks, in defining the genus, — “General character of plumage, in its pattern of coloration and seasonal changes, as in *Tringæ*. One species, a remarkable, isolated form, perhaps a plover, and connecting this family with the next by close relationships with *Strepsilas*, but with hind toe as well developed as usual in Sandpipers, and general appearance rather sandpiper-like than plover-like. *Aphrizinæ* might go under *Hæmatopodidæ* next to *Strepsilas*; or, perhaps better, *Aphriza* and *Strepsilas* might together constitute a family APHRIZIDÆ, next to, but apart from, *Hæmatopodidæ*.”²

Two years after the publication of the doubts here candidly expressed by this eminent authority, the American Ornithological Union issued its official Check-List, wherein the arrangement proposed was adopted; and we find the *Aphrizidæ* with its one species, *A. virgata*, including the sub-family *Arenariinæ*, the Turnstones, standing between the Plovers on the one hand, and the Oyster-catchers on the other,³ an arrangement which probably meets with the views of the majority of avian taxonomists of the present time.

Believing that under these circumstances a full account of the skeleton of *Aphriza* will prove an acceptable contribution to the literature of the family, as well as a useful work to the better understanding of the osteology of the *Limicolæ* generally, it was in view of this that I undertook the task. So far as my material at hand will admit of it, the study will be made thoroughly comparative, and in the end it may go to show that, for osteological considerations at least, the position selected in the system by ornithologists may be the most natural one to create for our Surf-bird, or a somewhat different light may be cast upon the problem; in any event we are satisfied that more light in such matters is a thing most to be desired, and this alone morphology has the power of affording.

The Skull. — When we come to submit the skulls of adult specimens of certain true *Tringæ* to moderately prolonged maceration in water, we invariably find that the premaxillary bone detaches itself, as does the dentary of the mandible, leaving in

¹ *Birds of America*, Vol. V., pl. 228.

² Coues, E, *Key to North American Birds*, 2d. ed., p. 605. 1884.

³ *Check-List of North American Birds*, pp. 160–166. New York, 1886.

the first case the long, thread-like extremities of the palatines and median processes of the nasals freely projecting forwards, and in the latter instance, a similar condition of the mid-ramal elements of the lower jaw. *Tringa*, *Actitis*, and others have their skulls behave in this manner, under similar circumstances, and it is quite characteristic of them; whereas, on the other hand, macerate the skulls as long as we may, no such detachment ever takes place in the Surf-bird, nor in Turnstones and Oyster-catchers, nor in such forms as *Gallinago* and *Philohela*. Indeed, this peculiar feature seems to be restricted to the more typical Sandpipers, and it is worthy of our notice that in *Aphriza* it never happens, and I may add that one never observes it to be the case in any of the Plovers.

Aside from this fact, the general *facies* of the form of the superior osseous mandible in *Aphriza*, carried back as far as the rhinal chamber and frontal region, is more as we find it in such a species as *Actitis*, for example, or some of the genus *Tringa*, than it has any semblance to either *Arenaria*, or much less *Hæmatopus*. Even when we come to compare the individual parts, this assertion holds true, including in the observation the extensive outline of the triangular aperture, on either side, of the external nares; and the superior ends of the fronto-maxillary processes of the nasals not overlapping, mesiad, the outer and juxtaposed margins of their premaxillary processes; which latter condition obtains both in the Turnstones and in Oyster-catchers. Again, in *Aphriza* we note that the extremity of the superior mandible in the skull is somewhat tumefied, and marked over with minute pits, as we find it to be in *Gallinago*. This character is absent in such a form as *Actitis* and other Sandpipers, nor do we find it to be present in *Charadrius*, *Arenaria*, and *Hæmatopus*.

In Bachman's Oyster-catcher (*H. bachmani*) the superior osseous mandible is about seven centimetres long, the remainder of the cranium being something over 3.5 cm. long, measured along the median line. Taking these same distances in the Black Turnstone, we find the first to be 2.5 cm., and the latter 2.3 cm.; but barring this difference in proportion between beak and cranium in these two species, the superior osseous mandible in the Turnstone is almost the perfect miniature of that part of the skull in an Oyster-catcher. We are to note, however, one

other difference, and that is, in *Hæmatopus* the anterior extremities of the palatines fuse across the median interspace much further back than they do in the Turnstone, but essentially, as I say, the plan of these parts in the two birds in question is the same, and quite different from the corresponding structure in *Aphriza*. Plovers in this particular seem to stand between the Surf-bird and *Arenaria*.

Taking next these several skulls upon their superior aspects, and comparing them with the same view in *A. virgata* (Fig. 1), we find that the latter bird again agrees with such a Sandpiper as *Actitis macularia*, or with such a species as *T. minutilla*. The cranium being very narrow in the frontal region between the superior orbital margins, while the vault of the brain-case is externally rounded, smooth, and ample, being occasionally marked in some of the Sandpipers by a median, longitudinal furrow.

In both, the lacrymals jut out about in the same proportion, and much in the same manner, as they do in a Turnstone. *Aphriza* and *Actitis* show scarcely any tilting upwards of the superior orbital peripheries, a feature so very conspicuous in *Charadrius squatarola*; less so in *Hæmatopus*, and again quite absent in *Arenaria*.

Oyster-catchers exhibit their strong larine affinities in their prominent out-jutting lacrymal bones, and still more in their deep and sharply defined glandular fossæ over the orbital roofs. These latter depressions are but fairly well marked in Turnstones, while in *A. virgata*, again agreeing in this respect with most, if not all true *Tringæ*, they are entirely absent.

Passing to the basi-posterior aspect of the cranium, the Surf-bird is seen to possess, in common with all North American *Limicolæ*, a well-marked supraoccipital prominence, which shows one on either side, the supraoccipital vacuities being larger in this species than they chance to be in any Sandpiper at my hand. Plovers have them next largest, they being very minute in *Arenaria*, and not present in any of the skulls of the genus *Hæmatopus* before me, although these latter have large supraoccipital prominences.

In this last-named genus, too, the "occipital area" is sharply defined by a very strong and raised crest, of a subcircular outline. This crest is very much mellowed down in *Charadrius*;

more manifest again in the Turnstones, in which genus the occipital area is proportionately much smaller; and finally, in Sandpipers and *Aphriza* the crest is present only as a raised line, which in them also bounds an occipital area of a subcircular outline, the extremities of the boundary line terminating, on either side, at the apex of a paroccipital process.

Most limicoline types have the plane of the foramen magnum nearly coincident with the horizontal plane; and so it is in all the skulls of the species now before me. But the outline of this great foramen of the occiput differs considerably in the several genera, being perfectly cordate in the Surf-bird, with the prominent posterior apex standing well in between the pair of vacuities of the supraoccipital prominence, which condition is enjoyed by most *Tringa*; while in *Arenaria* and the Plovers there is a slight tendency for this aperture to become rounder, its circularity becoming quite evident in *Hæmatopus*. In all these species, the condyle of the occiput is proportionately very small in each and every species, it being of a hemispherical form, and unnotched.

So in general pattern, taken as a whole, the basi-posterior aspect of the cranium is more nearly alike in *Aphriza* and any true tringine form; while in Turnstones the approach is towards the Oyster-catchers. And Plovers in this particular seem to maintain sort of a mid-position between the two latter groups. *Hæmatopus* is notorious for the restricted confines of its basi-temporal area at the base of the cranium,¹ and this space is never very wide and deep in any of the *Limicolæ*.

Figure 3 of my drawings in the plate shows the skull of *A. virgata* upon direct lateral view, and here we have a number of points to examine. First, it will be observed that the *pars plana* is of a quadrilateral outline, thoroughly ossified, and with its superior and inferior borders not in contact with either the orbital roof above or the maxillary bar below. The out-jutting *lacrymal* sends down a spicula of bone, which diminutive process turns backwards to have its lower end anchylose with the *pars*

¹ Had not the writer already fully figured the skeleton of the Black Oyster-catcher (which figure and its description has been accepted for publication by the *Journal of Anatomy* of London), I should have taken pleasure in presenting drawings of it in the present connection, as it constitutes a wonderfully interesting form for comparison in this way with species now under consideration.

plana, on its anterior aspect at a point below, and to the inner side of its externo-superior angle. I am thus particular in describing in detail the point of attachment of this extremity of the descending process of the lacrymal, for the reason that in some Sandpipers it is found to be attached to the very angle above referred to, while just before arriving there it sends forwards another small, pointed spine, the extremity of which latter is free, and directed somewhat inwards towards the rhinal chamber. No little variety, however, is to be met with in this particular among the *Tringæ*, and in such a form as the solitary Sandpiper (*R. solitarius*) the free end of the lacrymal is attached at a point corresponding to the site of its attachment in *Aphriza*. With the true Plovers the case is still different, for in them the *pars plana* is quite small and with rounded angles, while the lacrymal has a long, slender, descending process terminating in a free point below, and likewise has the anterior-projecting spine coming off from a mid-point of its continuity.¹

Arenaria has a large square *pars plana*, and in this form the lacrymal soon fuses at its lower end with the supero-external angle of the osseous lamina in question; while in *Hæmatopus* the *pars plana* is again found to be small, and the lacrymals very large, with their descending processes thick and strong, being fully ankylosed with the outer border of the *pars plana*, and projecting a short distance below that plate, though not arriving at the maxillary bar.

From all this I should say, then, that in *Aphriza*, *Arenaria*, and most true Sandpipers the *pars plana* and the lacrymal bones were more or less alike, having much the same relation to each other; but in Plovers and Oyster-catchers these structures are essentially very different; not only do they differ with each other, but with the aforesaid mentioned types, and in a manner set forth in the last paragraph.

Limicoline birds are notorious for the large vacuities that occur in their interorbital septa, rendering that osseous partition in the vast majority, if in not all the species, a very deficient bulwark between the orbits. *Hæmatopus* has it most entire, while in *Aphriza*, the Turnstones, Sandpipers, and Plovers, it commonly

¹ For an excellent figure of this arrangement of the lacrymal, see Huxley's figure of the enlarged skull of *C. pluvialis* in his paper, "On the Classification of Birds." *P.Z.S.*, 1867, p. 427, Fig. 7, L.

presents two large deficiencies, or often one imperfectly divided by a backward-extending remnant of the septum springing from the mesethmoid (Fig. 3).

In the Sandpipers (*Actitis*) the entire anterior wall of the brain-case is, mesiad, wonderfully lacking in bony support; on the other hand, in the black Oyster-catcher the foramina for the first pair, as well as for the optic nerves, are entire and completely encircled by bone. All the species that we have thus far mentioned in this memoir possess a straight and slender *infra-orbito maxillary bar* of nearly uniform calibre throughout.

Figure 1 of the plate will show the peculiar orbital processes of the *quadrates* in the Surf-bird, and indeed they are nothing less than unusually enlarged, thin, and compressed lamina of bone, which in no small degree contribute to the floor of the orbit on either side. We also find the two remaining apophyses of a quadrate to be more than commonly large and stout, and each of these bones has a double mastoidal facet; two mandibular facets, the inner one being as good as two in *Aphriza*, though less markedly divided in Turnstones, Oyster-catchers, or Sandpipers; and finally, a proportionately large pterygoid facet situated upon the internal aspect of the bone, just above mandibular articulation. Few departures are to be detected from this almost common pattern of the quadrate among the *Limicolæ*; where, too, I may add, this bone is always found to be perfectly pneumatic, as is the greater share of the skull itself among these shore-birds. Still confining ourselves to the lateral aspect of the skull, we are to note the long, spicula-form, sphenotic process possessed by *Aphriza*, and the less conspicuous and bifurcated squamosal apophysis; both of which features are far better marked in this species than they are in any of its allies now before me. Turnstones show quite deeply marked *temporal fossæ* that lack something less than a centimetre of meeting posteriorly over the supraoccipital prominence. *Hæmatopus* also show these, but here they are strictly confined on either side to the squamosal region, and do not encroach in the slightest degree upon the posterior aspect of the cranium. *Charadrius* likewise faintly displays the same feature, a feature which is so prominently seen in any of the skulls of the *Laridæ* and their kin.

Careful search through my material fails to detect the presence

of such fossæ, either in the Surf-bird or among the Sandpipers. *Actitis* has a skull as free from any such depressions in its temporal region as the veriest Thrush that ever lived, and the same remark fully applies to our least Sandpiper and others of its genus. Another interesting point to notice in the cranium of *A. virgata* is the marvellous degree to which a tympanic cavity is exposed, as well as the external opening of the Eustachian tube within it. These parts seem to depend upon the large quadrate anteriorly, and the somewhat arching paroccipital process behind, for their protection, in so far as any osseous surrounding defence is concerned.

This condition obtains in varying degree in the allied forms we have under consideration; it being notably the case in Turnstones and in *Hæmatopus*, though Plovers and *Tringa* are but little better off in this respect, perhaps the former of these last being the better provided of them all.

And now, finally, turning to the nether aspect of the skull in *Aphriza*, we are at first struck with the diminutive size of its pair of *pterygoid* bones. These are short, compressed from above downwards, sharpened all along their anterior margins; while behind they are characterized by strong basipterygoid processes, which articulate in the usual fashion with the facettes designed for them at the base of the sphenoidal rostrum.

In the black Oyster-catcher, a pterygoid is no longer than the mandibular aspect of the corresponding quadrate is wide, and this statement holds true for the other skulls we have been examining in connection with *Aphriza*.

For the Plovers the pterygoids are well shown in Professor Huxley's figure of *Charadrius plumialis*,¹ although they are comparatively much smaller in such a species, for instance, as *C. squatarola*, or others of our North American *Charadriidæ*.

Upon comparing the *palatines* of *A. virgata* with those bones in the allied forms before us, we meet with several excellent distinctive characters, especially when we include in this comparison the *maxillo-palatines*. In Plovers, Sandpipers, Turnstones, and Oyster-catchers, the postero-internal angles or heads of the

¹ *Ibid.* P. Z. S., 1867, p. 427, Fig. 6. These bones are also represented in my figure of the base of the skull in the Mountain Plover (*Æ. montana*); *Jour. of Anat. and Phys.* London, October, 1883, Pl. V., Fig. 3, *pg.*, where their relatively small size can at once be appreciated.

palatines, each turns outward as it articulates with the anterior end of the corresponding pterygoid ; nor do these palatine heads meet each other in the medium plane. With this common feature, *Aphriza* agrees ; but when we come to examine the postero-external angles of these bones, we find them obliquely truncated in our subject, or at least the hinder ends of the palatines themselves thus obliquely truncated, forming obtuse postero-external angles, which angles are rounded off in *Actitis*, *Charadrius*, and in *Arenaria*, while in *Hæmatopus* a moderate, backward-extending and rounded process is found at their site. In this latter species, too, the internal and external laminae of a palatine bone are very conspicuous, as they are, though less so, in the Surf-bird, Spotted Sandpiper, and the Black Turnstone. Plovers have this character much subdued. Mesiad, the superior and at the same time, internal borders of the palatines, beyond the "pterygoid processes," along the rostrum, come in contact with each other in all of the enumerated species ; and in all completely fuse anteriorly with the hinder limbs of the vomerine bifurcation. Coalescence, again, is most thorough in all these forms among the anterior ends of the palatines and those parts of the maxillaries and premaxillaries with which they come in contact, upon either side (Fig. 2). From this description, then, of the palatines, it is clear that *A. virgata* possesses them in a form essentially its own, and further that the pattern varies in all the allied groups or species.

Not so, however, is this altogether the case with the *maxillo-palatines*. One of these in *Aphriza virgata* is seen to be a shell-like process ; extending backwards, concave externally ; the reverse being the case upon its mesial aspect ; perforated by a few foramina ; and finally, *not united along its inferior border with the palatine of the same side* which extends beneath it. *Charadrius* also possesses a maxillo-palatine almost identical with this, and in the last-named feature, the true Sandpipers also agree, but in these latter birds the bone is much narrower and more curved.

Passing to the Oyster-catchers and Turnstones, a very different state of affairs is to be met with ; for in *Hæmatopus*, for instance, we find a maxillo-palatine to be quite a thick, laterally compressed and unperforated lamina of bone, which completely fuses with the corresponding palatine for the *entire length of its inferior*

margin, appearing in the adult to be a part of the palatine itself. A similar arrangement is to be found in *Arenaria*, — so that in this character, Turnstones and Oyster-catchers agree, while the Surf-bird, Plovers, and *Tringa* are fundamentally alike; in the first, the maxillo-palatines have, in the adult individual, coalesced with the palatines, each on its own side; while in the three last-mentioned families the maxillo-palatines are independent and freely projecting processes.

Aphriza agrees with all the allied types before us, in having a long, slender *vomer*, its posterior limbs anchylosing with the palatines behind, and a median carination extending for its entire length along its nether aspect. With the exception of *Hæmatopus*, the bone in all is pointed anteriorly, and in the expected genus it is at that end distinctly bifurcated.¹

In the form of its *mandible*, *A. virgata* substantially agrees with the Plovers and Sandpipers. The upturned, slender process at the angle is well developed, and the inturned ends of the articular cups are quite prominent, showing the usual single pneumatic foramen at each extremity. Two vacuities occur in either ramus, a small surangular one, and a long, semi-closed, splenial one, the sides of the jaw in this region being vertical and rather deep. The symphysis is rounded beneath, concaved above, and equals in length about one-fifth the length of a ramus. In the Black Oyster-catcher the symphysis equals more than a third of the ramus, and is scarcely at all excavated above, while it is decidedly wedge-shaped below. *Arenaria* also has a deep symphysis to its mandible, but here again it is concaved above and rounded beneath, and the larger of the two ramal vacuities is represented by a very open, subelliptical foramen.

Among the more ordinary types of existing birds, the *hyoidean apparatus*, as we know, presents but few differences when we come to compare it for the various families. Our subject forms no exception to this statement, and little need be said here in reference to this part of the skeleton in *Aphriza*. We find the arches alluded to to be very delicately constructed, and have the basibranchials in two separate pieces, the second one being very short and finished off behind in cartilage. The cerato-

¹ Here we have a departure from the rule laid down by Huxley, who has said that in *Schizognathous* birds, "the vomer, sometimes large and sometimes very small, always tapers to a point anteriorly." *P. Z. S.*, 1867, p. 426.

hyals largely coalesce, but the ossification proceeds but a limited distance into the glosso-hyal, which latter element in the adult is found to be in cartilage only. Thyro-hyals are notably slender and of considerable length; they, too, being posteriorly tipped with cartilage throughout the life of the individual. Most Sandpipers possess a hyoidean apparatus similar to the one I have just described for *Aphriza*; and, indeed, no material difference can be detected for the allied species from other groups.¹

Upon carefully examining the special ossifications of the ear in a skull of *A. virgata*, I fail to detect anything worthy of detailed record; the form of the *stapedial plate* and the coössified shaft of the *columella* have much the same pattern as we find these parts in the Fowl, and so clearly drawn for us by Parker.² Dr. Streets, in preparing my skeletons of *Aphriza* for me, threw away the eye-balls, so I am unable to make any observations here upon the sclerotal plates in this species; they have also been lost from my skeletons of *Hæmatopus*, the Turnstones, and Plovers.

This completes what I have to say here in reference to the comparative osteology of the skull and its associate parts of the skeleton in *Aphriza virgata*, and such deductions as may be drawn from the study the writer proposes to defer making until the closing paragraphs of the memoir are arrived at, when the skeleton as a whole, in this species, will be passed in review, and the proper comparisons made with the others we have been considering.

Remainder of the Axial Skeleton. — Since the days that anatomists first took to counting the total number of vertebræ in the spinal column of any of our existing *Carinata*, there have been difficulties and differences upon that point; and as to the differences, these have been but multiplied by the many attempts that have been made to state exactly the num-

¹ Unfortunately the hyoid arches of both my specimens of *Hæmatopus bachmani* have been lost, and I am unable to add, by way of comparison, anything about them here. I am inclined to believe, however, that if any essential difference is to be hereafter detected in these arches for adult specimens of various representations of the *Limicola*, it may be that some form will show a fusion of the first and second basibranchials; but I look for nothing more than some such a difference as this, and even it may never be found to exist.

² Parker, W. K., *Morphology of the Skull*, p. 258, Fig. 74, *m.st.* and *st.*

ber of cervical vertebræ, and the number of true dorsals, in any particular species. In the case of the total count for the vertebræ in any adult bird of the kind alluded to, the trouble is with the pelvic sacrum, and the skeleton of the tail. In nearly every example it is almost impossible to decide with certainty as to the number of vertebræ that have been incorporated in its fusion; while in the case of the tail, the pygostyle is the stumbling-block, for sometimes in representatives of the same species this bone in one individual will thoroughly appropriate to itself a terminal caudal vertebra, that will perhaps remain free in the other, thus making an additional segment for a bird of the same species. Then, again, it is pretty well agreed that when we come to define the line between cervical and dorsal divisions of the column, we look chiefly to the ribs for assistance; yet these are by no means to be always relied upon; as sometimes, in the same species, an additional pair may remain free at the further end of the cervical region, or an additional pair (always at the anterior part of the dorsal division) may connect with the sternum by a pair of hæmapophyses. So that one observer might state that the first pair of free ribs in a certain species of bird were to be found upon the 13th cervical vertebræ, while another observer, equally careful, finds an individual of the same species wherein it is the 14th cervical that has the leading pair of free ribs. Thus it is that confusion and doubt creeps into the work.

After having paid no little attention to the osteology of birds for more than ten years, now, I am fairly convinced that there is but one safe or very nearly safe method of arriving at the total number of vertebræ in the spinal column of any particular species of the class, and to do it we should have the prepared skeletons of the young of the species, two, or, better, three, of them, made just at the time when fusion is about to take place among the vertebræ, which eventually go to form the pygostyle in the adult, and when the vertebræ composing the pelvic sacrum are all still individualized. Then the count can be made with certainty, and we should not fail to have by us at the time several skeletons of the adult of the same species for comparison. Finally, our remaining difficulty, it is evident, cannot be settled in any such manner, and the only course left to pursue here, is to state, if possible, *the general rule* and *the noted*

exceptions. For instance, we may say in a certain species, it has been found as a general rule that free ribs occur upon the 13th and 14th vertebræ, and that upon the 15th, the ribs connect with the sternum by costal ribs, but examples have been found in the same species where free ribs were found upon the 12th, 13th, and 14th vertebræ; or again, a specimen of the same species showed free ribs on the 12th and 13th vertebræ, while the ribs on the 14th connected with the sternum. This is by no means a fanciful description, as I have studied cases quite like it, and it only goes to show the utter hopelessness of laying down hard and fast lines in describing the cervical and dorsal divisions of the vertebral column in existing birds. On the other hand, I am inclined to believe that if the *total number* of vertebræ be counted in the skeleton of the chick of any particular species, the number will be found to be quite constant. Now I believe, after carefully re-counting the vertebræ in the skeleton of the tail in the Mountain Plover (*Æ. montanus*), there should be a quære placed after the number I have given in my memoir upon the osteology of that species,¹ as I believe it should be seven, *not* counting the pygostyle; further, I am inclined to think I made another miscount, for some reason, in my specimen of *Hæmatopus*, and too many vertebræ have been mentioned as forming the skeleton of its tail in another paper of mine.²

At the present writing I have not at hand the immature skeletons of any of the species we have here under consideration, and consequently am unable to carry out the suggestions made in the foregoing paragraphs, so I can candidly admit that the number of vertebræ given below as found in the sacra of the birds there enumerated must be taken *cum grano salis*; although I will add that I counted them to the best of my ability: the process can often be assisted by holding the pelvis up to a strong light, with the *dorsal* aspect towards you.

In my female specimen of *A. virgata*, the "epipleural appendages" are present upon the pair of free ribs on the 15th vertebra, the reverse being the case in the skeleton of two males

¹ *Ibid.*, p. 97.

² Shufeldt, R. W., "Osteology of *Numenius longirostris*, with notes upon the Skeletons of other American *Limicola*." *Journ. of Anat. and Phys.* London. Vol. XIX., October, 1884, pp. 71, 72.

of the same species. *Charadrius squatarola* seems to have the usual cervical vertebræ (6th to 9th inclusive) modified beneath for the carotid canal; while in a Killdeer before me, the series so modified includes the fifth cervical. Only the *free* caudal vertebræ have been counted in the subjoined "Table," omitting in every case to include the pygostyle; a bone that may include several more, and *perhaps vary for the species* here given.

TABLE.

SPECIES.	Number of cervical vertebræ without free ribs.										The first cervical vertebra that has free ribs.		The second cervical vertebra that has free ribs.		The third cervical vertebra that has free ribs.		The first vertebra that has ribs which reach the sternum by costal ribs.		Number of vertebræ that possess ribs which reach the sternum by costal ribs.		Pairs of sacral ribs (they do not reach sternum).		Number of vertebræ in pelvic sacrum.		Number of free caudal vertebræ.		Total number of free pre-pelvic vertebræ.		Total number of vertebræ in column exclusive of pygostyle.		Carotid canal in following cervical vertebræ (inclusive).					
	13	14	15	..	16	6	1	13	8	21	42	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th
<i>Aphriza virgata</i>	13	14	15	..	16	6	1	13	8	21	42	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th
<i>Charadrius squatarola</i> .	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	13	8	21	42	6th to 9th
<i>Actitis macularia</i>	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	13	8	21	42	6th to 9th
<i>Hæmatopus bachmani</i> .	12	13	14	15	16	6	1	14	7	21	42	6th to 9th	12	13	14	15	16	6	1	14	7	21	42	6th to 9th	12	13	14	15	16	6	1	14	7	21	42	6th to 9th
<i>Arenaria melanocephala</i>	13	14	15	..	16	6	1	13	8	21	42	6th to 9th	13	14	15	..	16	6	1	13	8	21	42	6th to 9th	13	14	15	..	16	6	1	13	8	21	42	6th to 9th
<i>Rhyacophilus solitarius</i>	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th	13	14	15	..	16	6	1	12	7	21	40	6th to 9th

We find nothing especially noteworthy in the vertebræ of *Aphriza virgata*, as they in a general way are fashioned upon the usual ornithic pattern of those bones among ordinary birds. The *axis*, and the three cervical vertebræ that follow it, are especially conspicuous for their prominent neural and hæmal spines, and their postzygapophyses, which latter extend upwards, outwards, and backwards, as strong processes in the second and third cervicals. This last feature is not so manifest in *Aphriza* but becomes more so in *Arenaria*, and in *Hæmatopus* arrives at its maximum development, for in this species the postzygapophyses of the axis and the vertebra next behind it are nearly as lofty as the great neural spines upon these vertebræ, giving them the appearance of being tricornuted upon their dorsal aspects. Oyster-catchers have comparatively short parapophy-

ses in the cervicals, while in both the Surf-bird and in Turnstones these are quite long and spicula-form in the fourth, fifth, sixth, and seventh vertebræ; and these last species differ with *Hæmatopus*, in that in this bird the vertebræ of the entire column are unusually large in proportion to the size of their owner. Free ribs in all the species before us possess both capitula and tubercula; the leading pair being of diminutive size, and gradually increasing as they near the ribs of the dorsal region. The last pair usually do not develop unciform appendages, though they may do so, as in the skeleton of my female Surf-bird, and an Oyster-catcher before me. In the dorsal region only the first two, or at the most, three, leading vertebræ possess hæmapophyses, while ossified metapophyses link their transverse processes together above. *Aphriza* has the neural spines of its dorsals very low, they being more lofty in the Turnstone, and still more so in *Hæmatopus*. Plovers and *Tringæ* have them of a medium height. We find few or no especial distinctive differences in the true dorsal ribs of the several species before us, to render any aid as pointing to near or remote kinship in the case of any two species compared. Agreeing with the majority of limicoline birds, these parts are for the most slender, curved as usual, and rather long, with uncinatè processes that do not completely anchylose with the several ribs to which they belong.

Elsewhere, as I have already said above, I have presented figures of the *pelvis* of the Black Oyster-catcher, and it can be said here now that this bone in *Hæmatopus* very markedly differs from the pelvis either of *Aphriza* or of *Arenaria*. Indeed, in some respects, the pelvis of an Oyster-catcher reminds us not a little of the pelvis in *Gallus bankiva*; it lacks, however, the propubic spine, and the antero-median borders of the ilia do not fuse with the sacral crista. Further, it is noted for having a certain solidity and thickness of the several bones that compose it, quite in keeping with the other parts of the skeleton of this powerfully built bird. It differs with the general plan of the pelvis in *Aphriza* (Fig. 21), and in the Turnstones, in that in *Hæmatopus* the ilium forms a ledge, overhanging to some extent the ischium and the ischiadic foramen; the postpubis is far separated from the lower ischiadic margin, and is truncated almost immediately after passing the ischium behind; finally, anchylosis is very strong between all the several bones making

up the pelvis in the Oyster-catcher, so that prolonged maceration does not tend to separate them.

One skeleton of *Hæmatopus* at my hand shows a curious dilatation of the latter third, or less, of the postpubis of the *left* side, not present in any other specimen, nor upon the opposite side of the same individual. All these points and characters are very different in the pelvis of the Surf-bird, wherein this bone is remarkable for its breadth, and for being, as it were, flattened out in the vertical direction, — shallowed ; its sides narrow, and ilia more or less spread. As among Plovers, and most or all Sandpipers, it shows a double row of interapophysial foramina down the sacrum (Fig. 21) ; and the anterior ends of the ilia are subtruncated and embellished with a delicately raised rim, nearly always to be seen in limicoline birds. Between the hinder ends of ilium and ischium, a rounded notch occupies the entire margin of the bone, which notch in *Hæmatopus* is angulated. Postpubis is in contact, more or less, for its entire length with the lower border of the ischium above it ; and is carried beyond for some little distance to a pointed extremity, much the same being the case in the Turnstones.

The ischiadic foramen is of considerable size, and of a subelliptical outline ; this vacuity being unusually large in an Oyster-catcher, and such a species as the Killdeer Plover.

Without, then, further entering upon a fuller discussion of minor details, although they have all been carefully noted and weighed by the writer, I would state that in so far as the *Hæmatopodidæ* are concerned, the pattern of the pelvis in that group, as represented by the bone from the skeleton of *H. bachmani*, is of quite a different style from the pelvis of either *Aphriza* or *Arenaria*. That when we come to study the pelvis of *A. virgata*, and compare it with the bone in allied types, we discover that notwithstanding the fact that it exhibits many characters held in common by the limicoline forms generally, still it is impressed with a character of its own, being proportionately broader and shallower than the generality of either charadrine or tringine pelvises. It is most nearly approached by the pelvis of a Turnstone, while this latter bird shows in its pelvis a marked shading towards the style of the bone in the Plovers.

Again, *Actitis* and *Egialitis vocifera* possess pelvises almost identically alike in their general form ; and in both these

species the postpubis is separated by more or less of an interval from the lower margin of the ischium of the same side, along the middle of its continuity.

Figure 20 of the Plate shows the form upon lateral view of the pygostyle in *A. virgata*, and that is not far departed from by the representatives of nearly affined *Limicola*. In Oyster-catchers it varies, because in them the ultimate caudal vertebra usually is coalesced with the bone, giving it the different shape. The Surf-bird and its allies show the diapophyses of the caudal vertebræ to be spreading in the first few leading ones; then in mid-course they become shorter and bend downwards; then long and more flaring again, to terminate by an aborted one just before coming to the pygostyle. The ultimate two or three may develop bifid hæmapophyses, which anteriorly stand between the joints of the centra as chevron bones; this feature is well marked in *H. bachmani*.

Oyster-catchers have the neural spines of the caudal vertebræ notched in front, while *Aphriza*, *Charadrius*, and the majority of the *Tringæ* possess these apophyses as plain points.

That time-honored standby of avian skeletologists, the *sternum*, presents among the birds we have been noticing in this memoir but few insignificant departures from a common pattern, except in the cases of *R. solitarius* and *Actitis*.

Aphriza has the bone (Figs 12 and 15) doubly notched on each side posteriorly, the outer notches being fully twice the dimensions of the inner ones, — the outer pair of xiphoidal processes thus formed having a tendency to flare outwards; otherwise, the outline of the sternal body is quadrilateral, being much concaved above and correspondingly convexed upon its pectoral aspect. Either costal border shows six hæmapophysiscal facettes for the costal ribs, while extensive "costal processes" of a triangular outline rear above these in front.

The manubrium is small and sessile, being sharp beneath and blunt above, and directly between coracoidal grooves, thus preventing the coracoids in the articulated skeleton from infringing upon each other; the reverse being the case in Oyster-catchers and *Arenaria*, wherein these bones are in contact posterior to the manubrium, when the former are *in situ*. Returning to the sternum of *Aphriza*, we are to note its ample carina, which extends the entire length of the sternal body, being thickened for

the upper two-thirds of its anterior border, sharpened below, and concaved throughout. Along its lower margin a thickened rim defines its edge, which is outlined by a long, gentle convexity from carinal angle in front to mid-xiphoidal process behind (Fig. 12).

Viewing the bone upon its pectoral aspect, a muscular line—the *interpectoral muscular line* we will call it here—extends, on either side, from the boundary of the costal fossa beneath, to the inner of the pair of xiphoidal notches behind, to the mesial edge of the same. This line occurs sharply defined in both Plovers and Oyster-catchers, where it is similarly drawn, as it is likewise in a Turnstone.

Arenaria has a sternum, which, excepting the fact of its being a size smaller, is the perfect counterpart of the bone in *A. virgata*, though in the latter species the sternal keel seems to be comparatively a trifle deeper in proportion.

When I published my *Osteology of Numenius longirostris*, I therein stated that the sternum to a skeleton of the Spotted Sandpiper (*A. macularia*) possessed two notches upon either side, a large outer pair and a very small inner pair. Those skeletons were prepared and the species diagnosed by a very incompetent man, and at the present writing I am not prepared to vouch for the correctness of the statement. I have had to regret many times since, the confidence I placed in the identification of the skeletons which went to make up the collection of the vertebrate series in the Museum and Library of the Surgeon General's Office of the Army at Washington; they were the cause of a number of oversights creeping into my avian osteology in early days, which now are being corrected in my more recent papers. So I am inclined to believe that the *four-notched sternum* of *Actitis* may be a specimen from the same category; it was "on file" in the same institution. At any rate, we have before us now an excellent skeleton of *Actitis* of my own collecting, and it possesses but a *pair of notches* in its sternum, otherwise the bone has the general pattern of the *Limicolæ* at large.

In a few days *The Auk* for July (1888) will be issued, and in there, in a letter to its distinguished editors, I point out the fact that the Solitary Sandpiper is another species which has but a pair of notches in its sternum, and suggest that its old

genus, *Ryacophilus*, be restored for it (at the present writing it is a subgenus of *Totanus*). But the majority of *Tringæ*, as for example, all the true representatives of the genus *Tringa*, have the "four-notched" sternum, and the fact that *Actitis* and *Ryacophilus* have each only a pair of notches, may be of more significance in so far as the true *affinity* of those two species is concerned, than some of their external characters (that are so very subject to change from minor causes), but which have alone been relied upon thus far by the systematist, to classify them.

Finally, then, the fact may be broadly stated, that with respect to the sterna of *Aphriza* and *Arenaria*, they are to all intents and purposes the miniatures of that bone as we find it in *Hæmatopus bachmani*; and although this is very interesting, the circumstance goes to prove, in the light of other skeletal characters of these species, we would utterly fail were we to rely upon this bone alone as any indication of family, or much less, generic, affinities.

All the sterna that the writer has examined from the skeletons of North American *Limicolæ* were non-pneumatic bones, and if it is ever found to be otherwise, we must believe that it is the exception. In a specimen of *Tringa minutilla* in my collection, the bone is so thin that a large perforation occurs on either side of the keel in the sternal body, and one through the keel itself, high up in front.

Speaking of the pneumaticity of the skeletons of the several species we are here considering, I am strongly inclined to believe that the skull is the only part in any of them where air gains access to the interior of the bones, and as a rule to no very great extent, comparatively, there.

Turning our attention next to the *shoulder girdle* (Figs. 11, 16, and 17) in *Aphriza virgata*, we meet with a *scapula* having much the form that that bone assumes among the Shore Birds, generally, being shaped a good deal like the blade of a miniature cimeter, and when *in situ* in the articulated skeleton bearing the usual relations to the clavicle and coracoid of its own side. A *coracoid* is conspicuous for its short, sub-cylindrical shaft; its head being tuberosus and much crooked over towards the median plane, while the sternal extremity of the bone is not only thickened from before, backwards, but much expanded lateral-wise, showing at its outer angle a prominent lamelliform process, com-

pressed in the antero-posterior direction, and curved somewhat upwards. *Os furcula* typifies the U-shape form of the bone, and has in all *Limicolæ*, that the writer has ever studied, the merest apology for a hypocleidium, below. Its limbs are of nearly uniform calibre throughout, being slightly heavier above than below, and moderately compressed transversely for their entire lengths. Their heads, that is, the free ends of the clavicular limbs, are much elongated, and when articulated *in situ*, reach far back to the heads of the scapulæ. Viewed upon direct lateral aspect, it will be noticed that the *os furcula* is very considerably, though gracefully, curved in the antero-posterior direction, the convexity of the curvature being to the front.

In *Hæmatopus* the shaft of a coracoid is pierced by a small oval foramen, from before, backwards, and just below the scapular process, that does not occur in either the Surf-bird or among Turnstones.

Now, aside from the exceptions of this foramen, and differences as to the method of articulation of the coracoids with the sternum, already alluded to, and finally, the mere matter of size, — the description of the shoulder girdle here rendered for *Aphriza*, will apply almost equally well to the shoulder girdles of the *Tringæ*, the Turnstones, and the Plovers, and no doubt to many other Shore Birds. Were we to depend for characters, upon which to base distinctive differences, on the shoulder girdle alone in *Aphriza*, *Arenaria*, and a true Plover of a corresponding size, we should surely be disappointed, for the bones of this arch do not offer them in the genera enumerated.

OF THE APPENDICULAR SKELETON.

The Pectoral Limb. — The majority of the bones of this part of the skeleton in *Aphriza* are shown by my drawings in the Plate, as already stated above. The corresponding parts for *Hæmatopus* and Plovers have been given in other connections.

It will be seen that in the *humerus* of our Surf-bird, both "radial crest" and "ulnar tuberosity" are strikingly well developed, while the articular humeral head between them is rather small (Figs. 18 and 19). The pneumatic fossa is an extensive excavation, although the bone itself is not pneumatic. As to the shaft, it shows but little curvature, is smooth, and subcylindrical in form. At the distal extremity of the bone, a conspicu-

ous "ectocondyloid process" is to be observed; and at the extreme end, the oblique and radial tubercles, or condyles, stand out with more than their usual boldness, a condition which is enhanced by the fact that just above them there exists a fossa of some considerable depth. When the bones of this limb are articulated, and the arm tightly closed, the head of the radius accommodates itself to this latter depression at the distal end of humerus. Upon the anconal aspect of this extremity of the bone, we also find strong and powerfully impressed grooves for the passage of the tendons of muscles inserted upon it, and at the shoulder joint, during the life of the individual.

Neither *radius* nor *ulna* exhibit any very great degree of curvature, and as a consequence the interosseous space in the articulated arm is not very wide. The latter bone develops down its shaft a row of some eight or nine papillæ, for the quill butts of the secondaries of the wing, a feature common to so many of our Shore Birds. Comparatively speaking, the distal extremities of these bones of the antibrachium in *Aphriza*, as in all *Limicolæ* which the writer has examined, are small, though to this fact the Oyster-catcher seems to offer an exception.

The carpal segments are two in number, as usual, and present nothing, either in their size, form, or method of articulation, in any way different from what we usually find.

In the pinion (Figs. 13 and 14), the *carpo-metacarpal* bone is long, large-headed, and with its coalesced shafts straight, and more than commonly close together. As a negative character, we miss the overlapping process at the proximal end of the mid-metacarpal, — an apophysis which characterizes this bone in all true *Gallinæ*. Prominent and upturned, the pollex metacarpal supports a phalangeal joint that is clawless; the same being the case with the distal phalanx of the digit of the succeeding finger.

Regarding the expanded and proximal phalanx of this last digit, it is to be noted that its somewhat narrow blade, although more or less scooped out upon either aspect, is never perforated as we find it in some of the *Laridæ*. At its further end a little process protrudes, against which, in life, the head of its following phalanx plays; this latter joint being very long and slender, as in some Plovers and Sandpipers. The little phalangeal joint of the remaining digit is crooked so as to accommodate itself to

the outline of the posterior border of the blade of the proximal joint of index finger.

Equal correspondence of characters in the pectoral limbs of Plovers, Sandpipers, and Turnstones, as compared with the bones of the skeleton of the arm, in *Aphriza* seem to prevail, as they were found to prevail among the shoulder girdles and sterna of the same species. Practically, the description I have just given for the arm bones of the Surf-bird will answer all purposes of exactness for the representatives of the genera *Tringa*, *Arenaria*, and most, if not all, true pluvialine types. This, of course, does not apply to the mere question of the difference of size, but to the salient features only. Our engaging little *T. minutilla* has a pectoral limb, the skeleton of which corresponds, in so far as its available taxonomic points are concerned, with the same parts in the Surf-bird, to a degree of nearness most exasperating to the comparative anatomist, and discouraging to one eagerly searching for strong diagnostic distinctions in the structure of such types. Turning to the skeleton of the black Oyster-catcher we find but one sure point of difference that can be relied upon, apart from its size, as distinguishing the fundamental plan of the structure of the skeleton of its arm from the above species. In this bird we find *a claw* upon the end of the pollex phalanx, which, by the way, is also found in some Curlews.

Aside from this character, then, we might, were it possible, reduce the arm bones of this Oyster-catcher until they equalled in size those of a Surf-bird, and it would puzzle the best of us to correctly decide to which species either belonged, after such a hypothetical reduction.

These limicoline birds all seem to lack the *os humero scapulare* at the shoulder joint, and I have yet to find in any of them the sesmoidal ossicles at the elbow, such as we do find, for instance, in some of the Puffins.

Of the Skeleton of the Pelvic Limb. — In *Aphriza virgata* the femur possesses only a moderately sized, semi-globular head, with barely any depression on the top of it for the insertion of the teres ligament. The trochanter is lofty and thick, reaching conspicuously above the articular summit of the bone, which latter is broad and smooth. Little or no curvature is met with as we descend the shaft, and this is quite cylindrical for its

middle third. As to the condyles, we find nothing worthy of special note, as they are fashioned much as we generally find them in ordinary birds; the external one being the larger and lower, while it shows behind the usual vertical groove for the head of the fibula.

In the leg the *fibula* is free, not anchylosing with the tibio-tarsus, being but a trifle longer than the half of this latter bone. Its lower two-thirds are almost hair-like in proportion, and as for that matter it would seem that this delicate osseous filament can add next to nothing to the skeletal support for the structures of the limb (Fig. 8).

Tibio-tarsus also has very nearly a straight shaft, but commonly shows, as in *Hæmatopus*, a curvature in the transverse plane, being gently bowed outwards towards the fibular side. Its procnemial process is much the larger of the two laminar crests in front of the head of the bone, and it is pointed almost directly forwards, while the ectocnemial process is turned outwards, and curves downwards, as a pointed hook.

They both rear slightly above the articular summit of the proximal end of the shaft. Occupying the middle part of the upper third, the fibular ridge stands out quite boldly at the outer aspect, as in all birds. Proceeding to the distal extremity of the shaft we find a marked difference in the form of the two condyles, the outer one being decidedly uniform in outline, and the inner one more elongated and showing compression in the vertical direction. Between, and at the same time above them, in front, we detect the usual little osseous bar for tendinal confinement. A *patella* is absent in the Surf-bird, the case, I believe, in all *Limicolæ*—at least the writer is not aware of any exception to the rule.

Having a length just equal to that of the femur, the *tarso-metatarsus* exhibits at its usual site at the upper end and back part of its shaft a stumpy hypotarsus, that appears to be both pierced and grooved, for the guidance of tendons. Two minute foramina in this locality also perforate the bone in the antero-posterior direction, which is also the case in an Oyster-catcher. A mid-section of the shaft of tarso-metatarsus would show a quadrilateral outline, but the calibre increases, and this form changes as we pass to its distal extremity, where we find three large and prominent trochleæ, the middle one of which is the

biggest and placed the lowest on the bone. The ones upon either side of it are directed to the rear. At its usual site, above the innermost one, is faintly to be discerned the facette for the articulation of the *os metatarsale accessorius*, of hallux phalanx. Already the ornithologist has placed at our command the fact that the arrangement of the joints of pes in this species, as in *Arenaria* and many *Tringæ*, is upon the most common plan of 2, 3, 4, and 5 bones from hind toe to outermost digit, respectively, and a study of these in the skeleton reveals nothing peculiar in them.

The Black Turnstone being a somewhat smaller bird than *Aphriza*, it has a correspondingly smaller pelvic limb and skeleton; aside from this fact, however, the several bones of that extremity are fashioned quite as they are in our Surf-bird, and present no decided differences in any particular. This statement applies with equal truth to various Sandpipers, and would to *Charadrius* were it not that in the latter genus a disproportion, and a disproportion merely, exists in the hallux, — that toe being much smaller in the Plover, though all the other bones of the limb are remarkably similar in all their essential features, bone for bone, as we have described and figured them for *Aphriza virgata*. Hallux is also missing in *Hæmatopus*, where we sometimes find a process of bone ankylosed to the shaft of tarso-metatarsus, at a point where the accessory metatarsal is commonly attached by ligament. In a specimen of *H. bachmani* before me, such a process is to be found upon the shaft of the tarso-metatarsus of the right pelvic limb, but is missing from the corresponding bone in the opposite limb of the same individual. Strange to say, this is precisely the state of affairs in the skeleton of a second specimen at my hand, — the process is present in the right, absent in the left. It may prove of interest to look further into this point with additional specimens. Returning to our comparison between the pelvic limb of this Oyster-catcher, then, with the same part of the skeleton in *Aphriza*, we may say in brief that beyond the few exceptions mentioned the limb in the former is simply an amplification of the limb in the latter species, — its bone for bone, character for character, — the same thing over again, only the mould happened to be several sizes larger wherein the skeleton of these parts in our Oyster-catcher were cast.

Having now briefly passed over the more salient characters to be found in the skeletons of *Aphriza*, *Arenaria*, *Hæmatopus*, and several representative Plovers and Sandpipers, we are, I think, in a position to offer our conclusions upon the affinities of the Surf-bird, in so far as they seem to be indicated through this study of its osteology.

CONCLUSIONS.

Taking the skull as the part of the skeleton, I would invite attention to the peculiar form of the superior osseous mandible in *Hæmatopus*; and in the cranium of the same bird to the deeply sculpt, supra-orbital, glandular depressions; to its bold, outstanding lacrymal bones, and their mode of meeting the *pars plana* on either side; to its vomer, which is forked at its anterior extremity; to the absence of the supra-occipital foramina; to the complete coalescence of the maxillo-palatine, with the palatine of the same side; to its cranial foramina in front for exit of the first and second pair, they being completely surrounded by bone; and, finally, to the subelliptical outline of its foramen magnum. All these points, and many minor ones in its skull, are totally different in *Aphriza*, and alone are sufficient to warrant us in at least drawing strong lines of family distinction between these two types. Equally clear is the difference between the skull in *Hæmatopus* and *Charadrius*, but when we come to compare it in the former with the skull of *Arenaria*, a faint indication of affinity may be made out, which indication is principally seen in the Turnstone, having similarly formed nasals; feebly developed supra-orbital glandular depressions; a somewhat similar superior osseous mandible; and, lastly, in that its maxillo-palatines unite along their entire lower margins with the corresponding palatine on either side below them.

The differences presented to us, however, in the skulls of *Hæmatopus* and *Arenaria*, amount at least to family distinction. So, too, when we come to compare the skulls of *Arenaria* and *Charadrius*, they are very different, and undoubtedly belong to representatives of distinct families.

Comparing next the skull of a Turnstone with that of the Surf-bird, we are at first struck with the radical differences

exhibited in the superior osseous mandibles of the two species. Then in the former the maxillo-palatine fuses, in a manner already described, with the palatine, and finally, the "crotophyte fossæ" are pretty well defined in *Arenaria*, whereas in *Aphriza* not a vestige of them is to be seen. The posterior external angles of the palatines are obliquely truncated in *A. virgata*, rounded in the Turnstone; and finally, the mandibles of these two types are essentially very different, both as to form and structure, as in the Turnstone a large vacuity persists between the forks of the dentary, which is nearly absent in the Surf-bird.

Taking it all and all, the skull, mandible, and associated parts of the skeleton of the head in *Aphriza* agree more nearly with the corresponding structures in the skeleton of the head of some of the larger *Tringæ* than with any other class of limicoline birds. I have arrived at this point by carefully comparing this part of the skeleton in the numerous species at my hand, and I am fully convinced of the truth of the assertion.

Passing next to the remainder of the axial skeleton, and without enumerating the differences that have been dwelt upon quite at length when under review, it is evident from the arrangement and number of the ribs that *Hæmatopus* differs essentially from the several types we have been examining, and agrees only with *Arenaria* in the number of its free caudal vertebræ. If we were to be guided in this matter by the *total* number of vertebræ, as shown by these several species of birds, providing our count is correct, it would seem that in this respect *Hæmatopus*, *Arenaria*, and *Aphriza* fall together, while some Plovers and some Sandpipers are thus associated. *Hæmatopus* has a very different style of pelvis from the other species we have enumerated, while the pattern of this bone is not a little different when compared in *Aphriza* and *Arenaria*. Were we allowed the expression, it might be said that in so far as the pelvis goes in the genera *Aphriza*, *Charadrius*, *Actitis*, *Arenaria*, and some few others, the pluvialine design seems to be impressed with more or less strength upon them all. This statement will not apply to the pelvis in an Oyster-catcher.

The sternum and shoulder girdle do not materially assist us in this matter; we found it with but *two* notches in such

species as *Actitis macularia* and *R. solitarius*, and in the other forms it is of a markedly pluvialine stripe throughout.

As to the appendicular skeleton, a marvellous sameness of style—barring the question of mere difference in size—seems to pertain to the skeleton of the limbs in Surf-birds, Turnstones, Sandpipers, Plovers, and others. *Hæmatopus*, as we saw, possesses a claw upon its pollex phalanx, while some of the species possess but three toes, as in the last-named genus and in *Himantopus* and others.

To sum up, then: my comparative studies of the osteology of *Aphriza virgata* lead me to believe that in the first place its affinity with *Hæmatopus* is by no means a close one, the Oyster-catchers forming a very well-marked and distinct family of limicoline birds by themselves, showing by the structure of certain parts of their skeletons strong larine derivation.

Secondly, the skull in *Arenaria* is in some respects more upon the plan of the skull in *Hæmatopus* than it in any way approaches the structure of that part of the skeleton in *Aphriza*; indeed, so far as the skulls are concerned, the skulls in *Charadrius*, *Arenaria*, and *Aphriza* might be represented as each occupying the angle of an equilateral triangle, each sharing certain characters in common and each removed from the other, equally distant by an equal set of others, not possessed by either of the other species. Were the skulls of *Hæmatopus* and an average *Tringa* introduced into this hypothetical figure, the skull of the Oyster-catcher would be, as far as the characters they hold in common are concerned and for no other reason, on the line joining the skulls of the Turnstone and Surf-bird, and considerably nearer the first species than the last. The Sandpiper's skull would be on the line joining the skulls of *Aphriza* and the pluvialine type, and considerably nearer the former species than the latter. Aside from the skull, the remainder of the skeleton of *Arenaria* would answer fully for the skeleton of an equal-sized Plover, but hardly so for *A. virgata*.

To conclude: the sum total of the skeletal characters of *Aphriza virgata* place this species nearer the *Tringæ*—say some typical large-sized *Tringa*, with a four-notched sternum—than it does to the Plovers; less so to *Arenaria*, and far less so to *Hæmatopus*. Some pluvialine forms, however, are not so dis-

tantly removed from *Aphriza*, if we may be allowed to judge from osteological premises.

There is not the slightest doubt in my mind that had such a form as *Charadrius squatarola* been the sole representative of the *Charadriidæ* in the entire world's avifauna, and been found taking the place, the habitat, of *Aphriza*, modern systematists of the class would surely have grouped it with the Turnstones as forming a family *APHRIZIDÆ*. We must believe that the fashion is far too prevalent, that when an isolated form like *Aphriza* is met with, to lay about and endeavor to hit upon a family, a corner, where best to stow it away, without creating, as in the majority of cases should be done, a separate family for it.

Now *Aphriza* is no more nearly related to *Arenaria* than is *Charadrius* related to *Arenaria*, and as at present classified by American Ornithologists, by no means indicates its true position in the system. I would propose then, in view of the anatomical facts brought out in the present memoir, that the family *APHRIZIDÆ* be made to contain the sole representative of it, *Aphriza virgata*; and that another family, the *ARENARIDÆ*, be created to contain the Turnstones.

It would seem that *Aphriza* in some way connects the Plovers with such *Tringæ* as may possess the hallax and a four-notched sternum; while *Arenaria* links the Plovers with *Hæmatopus*, albeit that the Turnstone is much nearer the Plover than the far more remotely affined Oyster-catcher would in any way appear to be.

EXPLANATION OF PLATE XXV.

NOTE. — The figures in this Plate were all drawn by the author from the skeleton of a single individual, an adult male, and are all of natural size.

- FIG. 1. The skull of *A. virgata*, seen directly from above; mandible removed.
 FIG. 2. The skull of *A. virgata*, seen upon basal aspect; mandible removed.
 FIG. 3. The skull of *A. virgata*, seen upon direct lateral view; right side, including the mandible.
 FIG. 4. The mandible of *A. virgata*, direct superior view.
 FIG. 5. The right tarso-metatarsus of *A. virgata*, anterior view.
 FIG. 6. The right radius of *A. virgata*, palmar aspect.
 FIG. 7. The right ulna of *A. virgata*, palmar aspect.
 FIG. 8. The right fibula of *A. virgata*, inner side.
 FIG. 9. The right tibio-tarsus of *A. virgata*, mesial aspect.
 FIG. 10. The right femur of *A. virgata*, anterior surface.
 FIG. 11. The os furcula of *A. virgata*, seen obliquely from the right side.
 FIG. 12. The sternum of *A. virgata*, seen upon right lateral aspect.
 FIG. 13. The right carpo-metacarpus of *A. virgata*, anconal surface; pollex phalanx *in situ*.
 FIG. 14. The right proximal phalanx of the index digit of *A. virgata*, anconal side.
 FIG. 15. The sternum of *A. virgata*, seen upon direct anterior view.
 FIG. 16. The left coracoid and scapula of *A. virgata*, outer aspect, and articulated *in situ*.
 FIG. 17. The right coracoid of *A. virgata*, seen upon direct anterior view.
 FIG. 18. The left humerus of *A. virgata*, palmar aspect.
 FIG. 19. The left humerus of *A. virgata*, anconal aspect.
 FIG. 20. The four last vertebræ of the skeleton of the tail of *A. virgata*, and the pygostyle, seen upon the right lateral aspect.
 FIG. 21. The pelvis of *A. virgata*, dorsal view.