Contribution to the study of the "Tree-Ducks" of the genus Dendrocygna.

By

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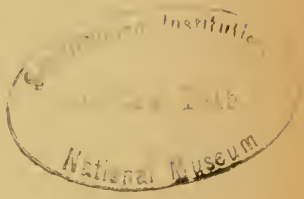
With Plates 1—16.



Taken in its entirety, the literature of the genus *Dendrocygna* is quite extensive, that is to say when we come to review what has been published on the several species of birds contained in the genus. Up to the present time, however, no special researches have been made upon the anatomy of the various members of the group, apart from some meagre contributions to the osteology of one or two of the species.

I have not seen "A Monograph of the Anatidae or Duck Tribe" by T. C. Eyton (London, 1838), as there is no copy of it in any of the Washington libraries; but I have before me the "Osteologia Avium" by the same author, together with its two Supplements (London, 1867, 1869, 1873). In Supplement I of this work, there are some fourteen Plates devoted to the skeletons of various ducks, geese, and swans, and other figures of tracheae and sterna of some of the species. Among these, on an unnumbered plate, we have a more or less complete skeleton of *Dendrocygna arcuata.* Like so many others of Eyton's representations of this class, however, it is but little more than a mere sketch, there having been no regard whatever paid to the portrayal of details with respect to any of the

bones. I refer especially to the executions on stone of the anserine birds made by Mr. G. Scharf.

Eyton, in his „Osteologia Avium", gives only a few skeletal characters of *Dendrocygna arcuata*, *D. autumnalis*, and *D. arborea*, which I shall refer to again further on in this paper. He places the genus between "*Casarka*" and *Anas*, the former being separated from *Cygnus*, by *Tadorna* and the rest of the true ducks following *Anas*. From this it is evident that he considered these "Tree-Ducks" of the genus *Dendrocygna* as belonging to the Anatinae and not to the swans or geese.

Salvadori, in the Catalogue of Birds of the British Museum, arrayed *Dendrocygna* with the Anatinae (1895, Vol. 27, p. 142—493). In giving the "Key to the Genera" on p. 142 of Subfamily VII (Anatinae), he states (a) "Lower portion of tarsus in front without transverse scutellae, but covered with small reticulate scales", and so we have (23) *Dendrocygna*; (24) *Chenalopex*; (25) *Tadorna*; (26) *Casarca*; (27) *Anas*; etc. In other words, this distinguished authority considers these "Tree-Ducks" to be Anatinae, and neither geese nor swans.

Sharpe, in his "Hand-List", arrays them in a similar manner, placing *Dendrocygna* at the head of the list of Anatinae, followed by *Alopochen*, *Tadorna*, *Casarca*, *Anas*, etc. This authority recognized nine species of the genus *Dendrocygna*, namely: (1) *D. viduata*, (2) *D. fulva*, (3) *D. arcuata*, (4) *D. javanica*, (5) *D. autumnalis*, (6) *D. discolor*, (7) *D. arborea*, (8) *D. guttulata* and (9) *D. eytoni*. These species are distributed over North and South America; Africa, including Madagascar, W. Indies, India; Celebes, Moluccas, N. Guinea, Australia, Philippines, New Zealand, and other localities. De Vis has described a fossil form, *D. validipennis*, from the Pleistocene of Queensland (in: Proc. Linn. Soc. N. S. Wales (2), Vol. 3, p. 1282; 1888).

Most American ornithologists now consider the Fulvous Tree-Duck, *D. fulva* of Gmelin, to be *D. bicolor* of Vieillot (*A. bicolor* in: Nouv. Dict. Hist. nat. Vol. 5, 1816, p. 136).

In the A. O. U. Check-List of North American Birds (Third. ed. 1910, p. 88), the two species of *Dendrocygna* are placed between the geese and the swans (Anserinae and Cygninae), entirely separated from the ducks, and the majority of American ornithologists have followed this classification. Coues, however, doubted the correctness of this; and, in speaking of *Dendrocygna*, he says: "The genus contains about 9 species (including *D.* [*Leptotarsus*] *eytoni*),

almost universally represented in tropical and warm-temperate regions of the globe. Its character is somewhat equivocal, as between Anserinae and Anatinae. I think it really belongs to the latter subfamily, in the vicinity of the Shieldrake group; with which expression of my views I leave it in the position it has occupied in former editions of the Key, as also in the A. O. U. Lists." (Key to N. A. B. Vol. 2, 5th ed. 1903, p. 906).

In my "Osteology of Birds", I placed the genus *Dendrocygna* with the Anatinae, after having compared the meagre osteological material I had, at the time the work was completed, with skeletons of other Anatidae (in: New York State Mus. Bull. 130, Albany, 1909, p. 339).

The published descriptions of the plumages, external characters, distribution, and habits of these birds are quite full, and in many instances wholly accurate. The plumages of the birds, with characters and colors of bills and feet, are most satisfactorily given in the Catalogue of Birds of the British Museum by Salvadori. Several American ornithologists have published excellent descriptions of *D. bicolor* and *D. autumnalis*, including eggs and nests, etc. Such figures as have appeared up to the present time are, however, for the most part very indifferent, and quite unrecognizable in some instances.

The figure of *D. guttulata* in the Catalogue of Birds of the British Museum is a long ways from a truthful representation of that species (Vol. 27, tab. 1). The figures given by Diggles (Orn. Austr., p, 114, fig. 2, *D. arcuata*, and p. 144, fig. 1, *D. eytoni*) I have not as yet seen, as there seems to be no copy of that work in the United States; while those published by Baird of "*D. fulva*" and *D. autumnalis* are extremely poor (Birds N. Amer. p. 770, 1858; id., op. cit. ed. 1860, tab. 63, fig. 1, and *D. autumnalis*, p. 770, tab. 63, fig. 2).

Some few other figures of different species of *Dendrocygna* may be extant, but if so, I have not seen them. Beyond Eyton's figure of the skeleton etc. of *Dendrocygna arcuata* cited above, and my figure of the cranium and part of the skeleton of the body of *D. autumnalis* (Rep. in "Osteology of Birds", p. 312, figs. 39, 40), I do not know of any other figures giving any part of the anatomical structure of these birds.

Taking into consideration, then, the little we know of the morphology of the birds of this genus; their external appearances

in life, and the wide differences of opinion existing at the present time relative to their position in the system and their affinities, — it would seem that a more extended knowledge of them, in the more important of these several respects, would be a welcome contribution to anserine ornithology. It was this task that I set myself when I undertook the present paper.

Upon inquiry, I found there were no skeletons of the United States forms of *Dendrocygna* in any of our public museums, beyond the imperfect one in the collections of the U. S. National Museum, which is the one I figured and cited in a previous paragraph. My desiderata in this respect have been finally met by Mr. F. B. Armstrong of Brownsville, Texas, who collected 5 specimens of these birds in that state, and with great courtesy and generosity placed them all at my disposal to be used in the present connection. From these I prepared, with his consent, disarticulated skeletons of both species and both sexes of *D. autumnalis* and *D. bicolor*; and when I refer to skeletons of these species in what follows, it is understood that the references are to the Armstrong specimens, unless the one in the U. S. National Museum is designated.

In the collections of the Department of Birds of the U. S. National Museum are many skins of every known species of *Dendrocygna*, — there being more or fewer of the different forms with respect to the representation in any particular case. There is also a very considerable collection of the skulls and skeletons of a great many different species of swans, geese, ducks and their allies in the same Department. To all this material I have been given the freest possible access and use by the Museum authorities, and for this assistance my grateful acknowledgments are here tendered. For more than this, however; for all such material, both skins and skeletons, as I desired to use at my home for the purpose of making illustrations and special comparisons, were selected by me and sent to me by the Museum.

For these latter kindnesses I am especially indebted to Dr. Charles W. Richmond of the Department of Birds of that institution, and to his assistant, Mr. J. H. Riley, and I take this opportunity to thank them for their prompt attention to my needs.

All the figures illustrating the present contribution were made by myself from the material just referred to, — that is, the Armstrong skeletons and what was loaned me by the U. S. National Museum. Specimens will be referred to by their museum numbers

and so on, in order that future students of this material may know of the identical skins or skeletons I had before me for description and comparison in the present connection.

To some of the skins of this genus of ducks, belonging to the collections of the U. S. National Museum, which were sent to my home for examination, I gave especial attention, and of them I made colored drawings, which drawings are here reproduced in Plates 1—2. It will be observed that they illustrate — either by the entire bird or by the head — every species found in the genus at the present time. This list is as follows, — the numbers given being the catalogue numbers of the U. S. National Museum; and where the name of the collector is not given, or the sex, such information in regard to any particular specimen was not known.

Dendrocygna viduata. ♂. Brazil, Exploration of the Parana, Captain T. J. Page, U.S.N., coll. July, 1859, 16540 (Plate 1 Fig. 1).

Dendrocygna arcuata. New South Wales, Australian Museum, 121312 (Plate 1 Fig. 2).

Dendrocygna javanica. ♂. Tenasserim, May 17, 1879, C. T. Bingham, 95526 (Plate 1 Fig. 3).

Dendrocygna discolor. ♂. Diamantina Creek, Brazil, June 17, 1887, C. B. Rikers, 121111 (Plate 1 Fig. 4).

Dendrocygna guttulata. ♀ ad. Zamboanga, Mindanao, March 17, 1906, Edgar A. Mearns, 200815 (Plate 1 Fig. 5).

Dendrocygna eytoni. ♂. N. S. Wales, 71635 (Plate 1 Fig. 6).

Dendrocygna eytoni. ♀. do., 71635 (Not figured).

Dendrocygna arborea. (♀ on orig. label, ♂ on Nation. Mus. label), Barbuda W. I., H. G. S. Branch, Nov. 16, 1903 (Plate 1 Fig. 7).

Dendrocygna bicolor. ♀ ad. Unlucky Lake, San Diego, Cal., Dr. Edgar A. Mearns, Apr. 30, 1894, 135590 (Plate 2 upper figure).

Dendrocygna bicolor. ♀ ad. do. (Not figured).

Dendrocygna bicolor. New Madrid, Mo., F. W. Sparks, „Autumn 1890", 120308 (Not figured).

Dendrocygna autumnalis. ♂. Lomita, Texas, George B. Sennett, July 31, 1880, 112428 (Plate 2, lower figure).

Dendrocygna autumnalis. ♀ ad. La Palma, Costa Rica, C. C. Nutting, 87513 (not figured).

As stated above, all of these species have been, in one place or another, more or less fully described in so far as their external characters are concerned. In all, I found the legs to be unusually long; the tibiae more or less extensively exposed below; hind toe

long; with the tarsi reticulate. In plumage the sexes are practically alike.

In all, the eyes are of some shade of brown or hazel, while the feet may be black, plumbeous, or very light flesh color or pinkish. The bill may be black or very light, and marked in various ways.

With respect to the plumage, the principal colors are black, white, various shades of brown, rich chestnut, rusty, tawny, rufous, gray, etc. Sometimes the plumage areas may be very sharply defined; while in some species the feathers may be dotted, or transversely banded, etc. or finely streaked, as on the neck of *D. bicolor*. Often there is a dark brown median stripe on the crown, which extends down on the neck behind. Generally, the nostrils are small and oval and situated in the basal half of the mandible.

As a rule, their wings are rounded and very ample. They nest in trees, and have peculiarities with respect to nidification. Their bills vary somewhat in form, but they are accurately outlined here in Plates 1 and 2, as I first photographed them all natural size, and from these photographs outlined the bills as shown in the Plates.

Upon the whole, the mandibles throughout the genus *Dendrocygna* are, morphologically, more like those structures as found among the Anatinae than they resemble the bills of any of the Geese proper. This is equally true of the general forms of these birds; in their general aspect they look a great deal more like ducks than they look like any of the true Anserinae.

Although the sexes are alike — or very probably alike — in *Dendrocygna*, the great variation of the plumage in them is more like the Anatinae and most Fuligulinae than is the case with typical Geese where black, white, and the grays prevail. It is to be noted, too, that in *Dendrocygna autumnalis* there is a large, white speculum on the wing, which again is a duck character, being found both in the Anatinae and Fuligulinae.

Dendrocygna may nest on the ground, as well as in the hollows of trees (*D. bicolor*); *Aix* among the Anatinae also nests in trees, and there is considerable variation in this respect among certain birds which we have arrayed among the Anserinae.

As a matter of fact — and so far as I am aware — the character which has led many avian systematists to relegate *Dendrocygna* to a place among the Anserinae, removing it from the nearer vicinity of the Sheldrake group, has been the reticulated tarsi found in all

the Tree-Ducks of the genus in question. And this is, in my opinion, quite outweighed by the many duck-like habits and the general external characters of these birds.

Some of the skins of *Dendrocygna*, belonging to the collections of the U. S. National Museum, which I have examined, present interesting characters worthy of record. For example, in the list given above, the *D. bicolor* (No. 120308) taken at New Madrid, Missouri, in the autumn of 1890, is the only bird of this species I have ever examined at all resembling it. The sex is not stated on the labels — which is unfortunate — notwithstanding the fact that the sexes are alike in the adults.

This is evidently a subadult bird in fall plumage; in it the crown is much darker than in the adult, — it being rather an earth-brown than a dark yellowish cinnamon. The under parts and sides of the head, instead of being a "pale cinnamon or yellowish brown", are of a dull, rather pale brownish clay color. The blackish brown of the back and wings is not as deep as it is in the adult, and the emarginations of the feathers on the former are very much less pronounced, and are of a decidedly duller shade. The feet are lighter colored, as is likewise the lower mandible and to some extent the upper. This particular plumage of *D. bicolor* I have never seen described in any ornithology I have ever read, and it has not the appearance of being a hybrid. The markings on the throat in the case of *Dendrocygna viduata* exhibit certain variations. It will be observed that in the male here figured in Plate 1 (Fig. 1), the mark is not a large white "chevron" with the angle pointing forward. In a specimen collected by W. H. Hudson at Bueno Aires — a female — (53077), the white "chevron" is replaced by an oblong white patch of some considerable size, and this area is connected with the white of the head by a longitudinal median line of white; while in a specimen of this species collected in Madagascar (A. Boucard, 1875, No. 148147), the white patch is absent, there appearing in its place a median longitudinal stripe of mixed black and white feathers. The sex of this example is not recorded.

Another male (55905) has a big, white, square patch with no connecting line with the white of the head; while still another specimen, wherein no sex, collector or locality is given on the label, the patch is connected by a broad isthmus of white with that of the head, quite one-third as broad as the patch itself.

On another specimen, a "cage bird", presented by Homer Daven-

port, there is the square patch and a narrow connecting line. Possibly the variations in this marking is indicative of sex — the adult males being without the connecting line; and possibly, too, it may be a year or more — perhaps several years — before the final outcome is completed, and a small, white "chevron" is the result, which may be present in both sexes.

In the case of *Dendrocygna guttulata* (No. 200815), the markings on the "flank feathers" vary. In some, nearest the median line, each feather has three large, white spots bordered with blackish, the three occupying nearly the entire area and are in close contact with each other. The longer and larger feathers nearer the back are practically black, with the three irregular white spots on them separated by considerable intervals. The feathers between these and those first described show all manner of variations of the two patterns, as is also the case as we proceed forwards toward the breast, where the feathers gradually become browner and lighter, with spots smaller and smaller, to finally become mere gray, emarginated dots on the little feathers of the "collar" around the smallest part of the neck. With the plumage in its normal condition, all these feathers — from neck to flanks — appear as though they were but single-spotted, and they have been so represented in published plates of this species. (Cat. Brit. Mus., Vol. 27, tab. 1; see also Salvadori's description in the same volume, p. 164.)

It would appear that *Dendrocygna discolor* is a good species, particularly if the plumage differences are always constant, as exhibited on the part of the two typical specimens I have compared, namely *D. autumnalis*, ♂, 112428, and *D. discolor*, ♂, 121111. (See above list.)

Superficially, the small species *Dendrocygna javanica* resembles most *D. bicolor;* but it lacks the fine, streaked, black-and-white minute feathers of the "collar" of the neck found in the latter. To a considerable extent, this is likewise true of *D. arcuata.* It is only in *D. viduata* and *D. autumnalis* that the entire abdominal area and lower breast is of an intense, shiny, black; though in other respects the plumages of these two species are widely different, — *D. viduata* departing the more from the conventional plumage-pattern of the genus. Perhaps the furthest removed from the centre of the group is the big West Indian form, *D. arborea. Dendrocygna arborea,* however, is no larger than some other species of true ducks;

and, externally, it by no means impresses one as being a near ally of *Anser*.

Through its now recognized nine known species, the genus *Dendrocygna* is represented throughout the lower-temperate and tropical regions of both hemispheres, including Australia (*D. eytoni*); and it is quite possible that still others remain to be discovered.

The comparative osteology of the "Tree-Ducks" of the genus *Dendrocygna*.

The skull. As in the case of all birds, there is found to be an individual variation for the skull of this duck, and this variation pertains to both sexes; though, wherever it may occur, it is never very great. This statement is made with respect to *Dendrocygna bicolor* and *D. autumnalis*, for I have not had the skulls of any of the latter to compare. In fact, my osteological observations, as set forth here, must unfortunately be confined to the skeletons of these two species, apart from a few notes which have been kindly supplied by others.

It is to be noted that some slight differences are also found to occur, when we come to compare the skulls of two individuals of the same species. Everything else being equal, the skull in the female is usually smaller, too, than in that of the male of the same species; while, upon the whole, were we to mix up fifty skulls of both sexes and both species of these ducks, and had we nothing to go by beyond what these skulls themselves presented, we would find it quite difficult to separate them again, and I very much question that it could be done.

A skull of a male (456) *D. bicolor* has a transverse zygomatic diameter of 28,5 mm, while that of a female of the same species measures but 25,0 mm. With respect to their mid-longitudinal lengths, however, these two skulls are about equal (from center of occipital condyle to end of superior mandible equals 91,0 mm).

For the purposes of a general description of the skull in the genus *Dendrocygna* it matters very little which one we select, and I therefore, from the several skulls before me, choose the very perfect one of a *Dendrocygna autumnalis* (454), and all my observations refer to it, unless stated to the contrary (see Fig. 12, Pl. 3; Fig. 15, Pl. 4; Fig. 54, Pl. 8, and several other figures on the Plates for the skull in *Dendrocygna*).

Regarded in its entirety, the skull (including the lower mandible and hyoid arches) in either of these species of Tree-Ducks has, in its general aspect, a much closer resemblance to the same parts of the skeleton in an average duck, than to the corresponding parts in the skeleton of any true swan or goose in existence. The truth of this statement will be readily appreciated after comparing the skull of *Dendrocygna autumnalis*, shown in Fig. 12 of Pl. 3, with the skull of the swan, figured on Pl. 7 Fig. 40, or the geese on Pl. 5 Figs. 24 and 25.

It is very evident that, in its general facies, the skull of the *Dendrocygna* more closely resembles the skull of such a true duck as is shown on Pl. 6 Fig. 32. This is even more apparent when we come to turn our attention to such comparisons with respect to the skulls viewed upon their superior aspects; for example, the *Dendrocygna* skull shown in Fig. 15 of Pl. 4 has a much closer general resemblance to the upper view of the skull of the mallard shown in Fig. 36 of Pl. 6, than it has to a similar view of the skull in any of the average swans or geese. In making such comparisons as these, it would obviously be inadmissible to take into consideration the skulls of such ducks as the one shown in Fig. 26 Pl. 5, or the skull of such a goose as we find in Fig. 17 on Pl. 4. The unusual cranial peculiarities of such species mask anything that we might hope to gain through such comparisons.

Regarded upon its superior aspect (Fig. 15, Pl. 4), it is to be observed that the cranial vault of the skull in *Dendrocygna autumnalis* is smooth and rounded, with a median, longitudinal furrow moderately indenting it, and carried forward to be lost in the depression of the fronto-nasal region.

The superior margins of the orbital peripheries are rounded, with the edges thin, though not what might be termed sharpened. There is a minute backward-extending lacrymal process, and the frontal region is somewhat broader here than it is immediately over the center of the orbits. The fronto-nasal area is lozenge-shaped and considerably depressed. Posteriorly, it merges into the aforesaid median longitudinal furrow; while anteriorly, it is carried forward to disappear on the upper surface of the superior mandible, over the anterior arcs of the narial apertures. Here the bridge is very narrow, and the superior nasal borders are thickened, especially posteriorly.

The superior mandible is uniformly convex, broadly rounded

anteriorly, in which locality there invariably is present an extensive group of foramina for the capillary supply of the mandibular theca.

This view of the cranium of a *Dendrocygna* is repeated, in so far as its general characteristics go, in many of the ordinary wild ducks, among the Anatinae as well as the Fuligulinae, and this holds true for species all over the world. It is seen, for example, in the elongated skull of the Canvas-back (*Marila valisineria*) (Pl. 6 Fig. 34); but here the superior orbital peripheries have the appearance of having been shaved off, and the group of foramina at the distal extremity of the superior mandible are conspicuously abundant.

This upper view of the skull in *Dendrocygna autumnalis* is, character for character, almost identical with what we find in a Mallard (*Anas platyrhynchos*, Pl. 6 Fig. 36), and not so very different from what is to be found in such other ducks as *Anas rubripes*; the Teals of the genera *Nettion* and *Querquedula*; *Spatula clypeata* and *Dafila acuta*; the various species of *Marila*; *Chaulelasmus streperus*; the Widgeons and, indeed, many other typical ducks. In a general way, it agrees with some swans (Pl. 7 Fig. 39); but, in so far as I have observed, the fronto-nasal region of the Cygninae, on this view of the skull, is always more or less tumerous, very conspicuously so in such swans as *Cygnus olor* (No. 19432, Coll. U. S. Nation. Mus.).

Turning to the skulls of some of the geese and brants, as *Anser*, *Chen* and *Branta*, the principal differences seen in these genera are: that the cranial vault is higher and more capacious in them, and the superior mandible tapers off to more narrow dimensions anteriorly, which is especially well marked in *Anser* and *Chen* (Pl. 4 Fig. 19; Pl. 5 Figs. 24, 25).

Far greater differences are to be observed when we come to compare the superior view of the skull of *Dendrocygna* with the corresponding one in such Anatidae as *Chloephaga hybrida*, *Cereopsis novae-hollandiae*, *Tachyeres cinereus* (No. 1818, 1819, Coll. U. S. Nation. Mus.), and some of the eiders, as *Somateria v-nigra* (No. 7332, Coll. U. S. Nation. Mus.) (Fig. 17, Pl. 4; Fig. 29, Pl. 5, and Fig. 35, Pl. 6). In other words, when seen from above, the skull of any of these "Tree-Ducks" not only resembles, but actually is very much more like the same aspect of the skulls in certain of the Anatinae, as the Mallard, Black Duck, the Teals, Gadwall,

and so on, than it is when so compared with the same view of the skull in the Swans, Geese, or most of the Fuligulinae. In nearly all these forms, when the skull is so viewed, the backward-extending median processes of the premaxillaries are clearly defined on a small area in the cranio-facial region by more or less open slitlets. This character is generally entirely absent in *Netta rufina*, in most of the genus *Marila*, and in many Swans and Geese. It is a prominent feature on the upper view of the skull of such a species as *Chloephaga hybrida*. *Dendrocygna* and most species of the genus *Anas* agree in this particular.

In some of the smaller and medium-sized ducks, the frontal region on the superior aspect of the skull, between the upper margins of the orbits, is extremely narrow, as is the case in the Teals *(Querquedula)*, the Widgeons *(Mareca)*, and in some of the Scaups *(Marila)*. For instance, *Marila marila* has a skull 90 mm long; while the shortest transverse diameter in the same skull measures but 6 mm between the peripheries of the orbits on the superior frontal region. In fact, in this species the fairly well-marked supraorbital depressions, as exemplified in this particular skull, are separated mesially by the longitudinal furrow, which here is less than a millimeter wide. In this particular, again, *Dendrocygna* agrees with the more typical Anatinae, that is, the genus *Anas*.

This is likewise true with respect to the posterior aspect of the skull, upon which, in the Tree-Ducks, in the typical species of the genus *Anas*, *Marila valisineria*, *Chaulelasmus*, and allied forms, we find a largely developed 'supraoccipital prominence', with a rather large foramen opening into the brain-case on either side of it. The size of these foramina are, as a rule, larger in *Anas* than in *Dendrocygna*, in which latter genus they may occasionally be quite small; while in some swans *(Cygnus olor)* they are absent, and always very small in proportion in *Chen* and *Branta*.

The crotaphyte fossae never meet superiorly in the median line in any of the Anatidae, while the occipital area is invariably clearly defined by a more or less raised and sharp limiting crest. This crest is best marked in any of the true River Ducks, and perhaps the least defined in *Chen* and such species as *Chloephaga hybrida* and its nearest congeners.

In *Chenonetta jubata* of Australia, the foramen magnum is unusually large, as compared with the size of the bird; the supraoccipital prominence small; the foramen on either side of it large

and vertically elliptical; while the occipital crest nearly meets in the median line above, being separated there by only 2,5 mm. One of the remarkable features of the skull of this species is the extreme shallowness, and the almost entire lack of definition of the crotaphyte fossae. It may be noted here that the superior mandible of this interesting form is conspicuously short as compared with the rest of the length of the skull. Presumably, this is likewise the case with the lower mandible; but for that I cannot vouch, as it is missing from the incomplete skeleton at hand (No. 19213, Coll. U. S. Nation. Mus.) (see Pl. 10).

In *Anser* and *Cereopsis*, especially in the latter, most of the characters to be seen on the posterior aspect of the skull are but feebly pronounced. With respect to *Cereopsis novae-hollandiae*, the hinder part of the cranium is considerably rounded, in conformity with the lateral and superior regions, thus subordinating all sharpness of definition. This famous goose has the crotaphyte fossae almost eliminated; the supraoccipital prominence scarcely at all defined; the lateral foramina minute, and the occipital crest low and thin (Fig. 11, Pl. 3; Fig. 17, Pl. 4).

In *Hymenolaemus malacorhynchus* the foramen magnum is of great size; the crotaphyte fossae unusually spacious below; the condyle extremely small, and the paroccipital processes broad, thin and platelike.

Passing next to a comparative study of the characters to be found upon a lateral view of the skull of *Dendrocygna autumalis* (454) with the corresponding ones in various species of Ducks, Geese and Swans, we again note the general resemblance of the skull of the Tree-Duck to that of a Mallard *(Anas platyrhynchos)*, or to several other species of that genus. (Fig. 12, Pl. 3; Fig. 38, Pl. 6; compare also with Fig. 27 of Pl. 5 and Fig. 32 of Pl. 6).

Nearly all Anatidae exhibit an unusual enlargement or development of the lacrymal bone. In fact, at the present writing, I can recall but a single exception to this rule, and I refer to *Chenonetta jubata* of Australia. In that peculiar little species, the descending process of the lacrymal is slender and small, with its extremity but very moderately expanded. In most anatine fowls, this apophysis is not only greatly elongated, flattened from side to side, and expanded at its backward-extending extremity, but makes an extensive articulation with the frontal of the same side, and posteriorly is often produced backwards, upwards and outwards as

a more or less distinct process. This latter process is quite insignificant in *Dendrocygna;* sometimes entirely absent, as in *Anas platyrhynchos*, to become a very prominent spur in such species as *Tachyeres cinereus*, and still more of a one in the Pacific Eider *(Somateria v-nigra).*

In the Old-squaw *(Harelda hyemalis)* both the postero-superior process of a lacrymal and the descending one are rather long and delicately constructed, especially the latter (Figs. 28 and 29, Pl. 5; Figs. 60 and 61, Pl. 9). Cygninae have the postero-inferior process of a lacrymal expanded into a considerable plate of bone, which affords not a little protection to the soft parts lying between it and the ethmoid (Fig. 40, Pl. 7).

In all the Anatidae, in so far as I have examined their skulls (various species of some 33 genera of them), the squamosal process is, in nearly every species, quite aborted, and if present, a mere insignificant little spine *(Anas rubripes*, No. 1606, Coll. U. S. Nation. Mus.); on the other hand, the sphenotic or post-frontal process is invariably developed to a greater or less degree. This may be well appreciated by a study of the lateral views of the skulls of ducks, geese and swans on a number of the Plates of the present memoir.

As I have elsewhere pointed out, however, in *Dendrocygna* — in so far as they have been examined by me — a very unusual condition obtains: the well-developed, inferior process of the lacrymal is carried backwards to meet the apex of the produced sphenotic process, to extensively and thoroughly coossify with it at the center of the lower periphery of what now forms a complete orbital ring.[1]) This condition is clearly shown in Fig. 12, Pl. 3; in Fig. 44, Pl. 8, and it may be compared with the skulls of other ducks, geese and swans on the Plates.[2])

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1) Shufeldt, R. W., Osteology of Birds, in: Mus. Bull. 130. N. Y. State Mus. Albany, 1909, p, 311, 312, Fig. 39. Also, in: Proc. Acad. nat. Sc. Philadelphia 1898, p. 489—499. Through an error, the lateral process of the skull, which extended forward to meet the lacrymal, was said to be the „squamosal", which is not the case, it being the sphenotic, as correctly set forth above (see Parker & Bettany Morphology of the Skull, London 1877, p. 254, fig. 72 *pf*).

2) Eyton, T. C., Osteologia avium, p. 207, London 1867, and the Supplement, London 1869. Unnumbered Plate of *Dendrocygna arcuata* (sic!) (arcuata?). All that this author says in reference to the skull of *D. arcuata* is given in a line and a half of text, thus: „Cranium.

I have made several attempts to obtain the skulls of other species of *Dendrocygna* in order to ascertain if this completed orbital ring was present in them, but for the lack of means I have been unable to command such material.[1]) Nevertheless I have, in one instance, been most courteously assisted in this matter, — I refer to the data sent me by R. H. Burne, Esqr. of the Royal College of Surgeons of England, who, in reply to a letter of mine, wrote me on the 4th of November, 1912, and sent me a sketch of the orbital ring as it obtained in two specimens of *Dendrocygna javanica* at the Royal College. The sketch is of No. 1433 of that extensive collection. Mr. Burne states that "in *D. javanica* the osseous periphery of the orbits is complete". It is clear from his lucid sketch, which I very much regret I cannot reproduce here, that it agrees, in all essential particulars, with the orbital ring in *D. bicolor* and *D. autumnalis*. Mr. Burne also sent me some helpful sketches of the sterna in the ducks with notes about them, and these latter I will introduce further on in this contribution. I am greatly indebted to him for his prompt response to my inquiries, and I have pleasure in acknowledging it here.

When I was examining the skins of the various species of the genus *Dendrocygna* at the U. S. National Museum, I could sometimes feel the lower arc of this bony ring of the orbit just below the eye by means of a little pressure with my finger; so I think it is safe to predict here that it will be found to be the case, in all true representatives of this genus, that the orbital ring is complete, — fully as much so as in the American forms of the group.

In the Snow Goose (*Chen h. hyperboreus*), which has a skull very unlike that part of the skeleton in *Dendrocygna autumnalis*, — or probably any of the Tree-Ducks for that matter, — no such orbital ring exists; in fact, the apex of the lower process of the lacrymal is directed forwards instead of backwards, which is very good

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The space between the upper edges of the orbits much wider than in *Tadorna*; orbits very small." And, although in the Supplement he gives a full-page Plate of the skeleton of *D. arcuata*, in which the orbit has been drawn by his artist as completely encircled by bone, Eyton himself did not seem to be aware of the fact.

1) One American dealer in fancy fowls asked 36 $ per pair for living specimens of *Dendrocygna viduata*. I will say, however, that he has promised me the body of the first specimen of this species that dies on his extensive game preserves.

evidence that there is in it no inclination even to extend to — or join with — the end of the sphenotic process of the same side of the skull. This is also pretty much the case in *Branta c. hutchinsi* and in others of that genus; while in some of the swans, as in *Olor* and *Cygnus*, the case is different. In these the enormous inferior process of the lacrymal extends far back toward the long, stout sphenotic process, but fails to reach it by quite an interval (Pl. 7 Fig. 40).

The inclination of the apices of the two processes to again join is seen in anserine forms, in no way particularly related to *Dendrocygna*, as in *Cereopsis* and *Chloephaga hybrida*, but not in *Chloephaga poliocephala* (Fig. 11, Pl. 3, and Fig. 35, Pl. 6).

Among the ducks, the osseous ring is nearly completed by the uniting of the two apophyses aforesaid, in such species as *Clangula islandica*, the true teals (*Querquedula*), and quite frequently in the skulls of the mallard (*Anas platyrhynchos*) (No. 17537, U. S. Nation. Mus. ♂). Indeed, it is in species of the genus *Anas* that the inclination to meet, on the part of these two processes, seems to be most evident, and the least so in the genus *Chen*, in so far as true geese are concerned.

In all Anatidae, the zygoma or infraorbital bar is an almost straight, delicate rod of bone, of a size in proportion to the skull to which it belongs. Its maxillary extremity is more slender than its quadrato-jugal portion, while the entire rod is much flattened from side to side, and generally develops a small, triangular, spine-like elevation on its upper edge, opposite the descending process of the lacrymal. Such ducks as *Mareca americana*, and *Oidemia perspicillata* have a zygoma of extremely delicate proportions. This is also true of the ducks in the genus *Aix*, including *Aix galericulata*. In passing, I may say that not only the skull, but the entire skeleton of *Aix* is quite different from the skeleton in *Dendrocygna;* while at the same time the skull in *Aix sponsa* agrees, in all particulars, with the skull of *Aix galericulata*, except in the matter of size, — the latter being about one-third smaller than it is in the Wood Duck; so that breeding in trees, on the part of different genera among the Anatidae, has in no way any weight in determining nearness of relationship.

As to the morphology of the superior mandible in *Dendrocygna autumnalis*, and its appearance on a lateral view, we could have nothing better to demonstrate it than the illustration of it

which I offer in Fig. 12 of Plate 3 of this paper. Here it will be appreciated how very different this part of the skull in the Tree-Ducks is, as compared with the superior mandible of other Anatidae shown on the same Plate, as *Cereopsis*, *Hymenolaemus*, and *Chloephaga poliocephala*. In fact, without making any extended comparisons, it is clear, upon comparing the superior mandible of *Dendrocygna autumnalis* as seen, not only upon this lateral but on any view, that is it, morphologically, more like the superior mandible of such a duck as *Anas platyrhynchos* (Fig. 38, Pl. 6) than like this part of the skull in any of the Swans or Geese, or even some other Anatinae, as for example *Marila marila* or *Oidemia velvetina*. Such a form as *Spatula clypeata* need not be mentioned in this connection, as the form of its superior mandible is unique, absolutely, among true ducks. This fact I have fully demonstrated in previous publications, particularly in my "Osteology of Birds", published by the State Museum of Albany, and "Observations upon the Osteology of the North American Anseres" (in: Proc. U. S. nation. Mus., 1888).

The free dentary margin of the side of the superior mandible is more or less concave between distal extremity and the naso-maxillary termination posteriorly in *Chen*, *Anser*, and other geese, while this border is convex in *Dendrocygna*, *Anas*, and many other ducks.

All Anatidae, in so far as I have examined their skulls, possess large, open, subelliptical external narial apertures, with no osseous nasal septum standing between them mesially. These apertures are differently located in the different genera of the Anatidae. Tree-Ducks, Mallards, Black ducks (*Anas rubripes*) etc. have the narial opening on either side high up in the basal half of the mandible. In *Anser*, where they are very large, they encroach on the middle third; while in such as form as *Chloephaga hybrida*, they occupy the middle third of the side of the mandible (Fig. 35, Pl. 6). Their comparative size and position in other anserine fowls may easily be seen by examining the various skulls of the Anatidae on the Plates illustrating the present paper.

Throughout this entire assemblage of birds, on the lateral view of the cranium posteriorly, the external aural aperture is a conspicuous feature. Morphologically, this opening and its surrounding region varies with the species; but the differences presented shed but little light upon the question of probable affinities.

Dendrocygna has the aperture rather large in proportion to the

rest of the skull, with the floor of the meatus fairly performed in bone. Above, to a little extent and posteriorly entirely, the tympanic periphery is extended on to the large, inferiorly produced tympanic plate of the exoccipital, terminating at its postero-inferior apex below. All of this well shown in Fig. 12 of Plate 3, and a similar conformation of this part of the skull is found in *Chen hyperboreus*; *Cereopsis* (Fig. 11); Swans of the genus *Olor*; other Geese of the genus *Chen*, and identically the same in *Branta* (Fig. 19); very nearly the same in *Oidemia perspicillata*, the only difference here being that the tympanic plate of the exoccipital extends rather more posteriorly, a difference which, in *Harelda*, is even better marked (Fig. 66, Pl. 9), while at the same time, the floor of the meatus is more extensively ossified. What we find in *Harelda hyemalis* is repeated in *Charitonetta albeola*, *Spatula*, and several other species of ducks. In *Chaulelasmus* the aural aperture is small, subcircular in outline, the floor of the meatus entirely ossified, and the exoccipital plate much produced posteriorly (Fig. 32, Pl. 6). Still other Anatinae have the meatal floor complete and produced well outwards, — the free external margin being bent upwards. This modification is best seen in *Anas platyrhynchos* and *A. rubripes*; *Tachyeres cinereus*; *Marila collaris* and in other species.

As I have elsewhere pointed out, the interorbital septum in the skulls of Anatidae rarely presents any vacuities, while in *Dendrocygna* such foramina seem to occur more or less frequently. When present, it is, without exception — so far as I am aware — a single foramen or vacuity as shown in Fig. 12 of Pl. 3, and Fig. 44 of Pl. 8. Most adult ducks and geese commonly exhibit in the interorbital septa of their skulls the three usual foramina shown in the skulls presented in Fig. 27 (Pl. 5) and 38 (Pl. 6).

Comparatively few of the Anseres ever seem to have the pars plana developed in bone. Of the large array of skulls of the representatives of the group under consideration before me at this writing, I only find it very large and completely developed, on either side, in *Erismatura jamaicensis* (No. 11220, U. S. Nation. Mus.), and equally as extensive in *Dafila acuta* (No. 4989, U. S. Nation. Mus.). In the specimen of *Erismatura*, the lacrymal is a very large, thin, quadrilateral lamina of bone, entirely lacking in processes, and which, in the adult, coossifies mesially with the big and somewhat spongy pars plana. In some other Anseres, the partes planae are scroll-like and more or less deficient in function, as in *Anas rubripes*,

and occasionally in the Mallard and Canvas-back. When entirely absent, its place is filled, to a slight degree, by an osseous process thrown off from the mesial surface of either lacrymal. Such a process is present in the skull of a specimen of *Chen hyperboreus* before me (No. 7360, Coll. U. S. Nation. Mus.). Nothing of the kind is ever found in the skull of *Dendrocygna autumnalis* or *D. bicolor*, and I doubt that it occurs in any other species of Tree-Duck, as I likewise doubt that any of the true species of that genus will be found to posses, even very old birds, ossified partes planae in their skulls.

In my "Osteology of Birds," cited above (p. 313, fig. 41) I state, when describing a skull of *Chloephaga poliocephala*, that a "lacrymal bone has almost completely anchylosed with the frontal and nasal of the same side; and at the lower extremity of this bone we find an ossicle, similar in every respect to the one I described as occurring in the skull of *Larus argentatus*. This little bone shows well in the figure, extending backward from the lower expanded portion of the lacrymal." I do not find this minute and free ossicle attached to the lower end of the lacrymal in a specimen of *Chloephaga poliocephala* at hand at this writing, nor in any other skull of the representatives of the Anseres before me.

The skull referred to in my "Osteology of Birds" is now in the State Museum of Albany, and was collected by Surgeon Thomas H. Streets of the United States Navy, in the Strait of Magellan, many years ago. At one time, I believe I regarded this ossicle as the os uncinatum. Parker had something to say on this point in one of his most able and classic memoirs; but I do not think he quite cleared the matter up. He stated that[1]) "In his earlier Paper on *Alca* in which the skeleton *Alca torda* is described[2]), Dr. Shufeldt mentions a little bone attached to the lacrymal, and which he supposes is the one called by me "os uncinatum" in my Paper in the Encyclopaedia Britannica, vol. 9, art. Birds, p. 714. The bone referred to is, however, merely a limited ossification which takes place in the hind part of the coiled inferior turbinal. This bone in my specimens is an elegant open ring, the bony deposit having affected the whole coil to a short extent; it is formed in

1) Parker, William Kitchen, On the morphology of the Duck and the Auk tribes. „Cunningham Memoirs", No. VI, in: Royal Irish Acad., 1900, p. 71, 72.

2) in: Journ. Anat. Physiol., Vol. 23 (Vol. 3, n. s.), p. 166—171, tab. 7 and ibid., Vol. 23, p. 8, tab. 1.

front of the pars plana, where these two parts are confluent (See Fowl's Skull, tab. 86 figs. 6 and 8, pp. 1—16). But the true remnant of the os uncinatum is formed in the intero-external angle of the pars plana which is the homologue of the ethmo-palatine of the frog." („Remnants and Vestiges" in: Proc. Roy. Soc. London, Vol. 43, Febr. 23, 1888, pp. 400, 401).

"Besides the special middle turbinal centre which ossifies nearly all the pars plana of these birds, there is formed in the adult a small midioline bone in the angle just where the lacrymal ends below. There are two such nuclei on the right side, some on the left in one of my specimens of the skull of *Uria troile*, and one the rest of my Alcidae, namely, *Alca torda* and *Fratercula arctium*. In gulls of the first year this angle remains unossified; but in old specimens it becomes a distinct os uncinatum, almost as well developed as in the albatross. In an old *Larus argentatus* it is triangular, and the lower and longer side which is notched, is two millims. in extent." This is likewise the ossicle I found in *Larus argentatus* (referred to above), and which corresponds exactly with the same ossicle in *Chloephaga poliocephala*, but does not seem to be the ossification I have elsewhere described for the Albatrosses.[1]) This last seems to agree with Dr. Parker's description of the os uncinatum in those birds; and in my paper on them in the Proceedings of the U. S. National Museum for 1888 I give quite an extensive notice of it. If the true os uncinatum occurs in any of the Anatidae, it is undoubtedly lost in the average museum specimens of skulls of that group, and I have never found it present in any of them.

When we come to study the osseous structures (and the characters they present) to be seen upon a basal view of the cranium in *Dendrocygna* (Fig. 53, 54, Pl. 8), the fact is soon appreciated that each and any of them practically agree with the corresponding ones found in this part of the skull in *Anas platyrhynchos*, — in fact, most of them are identical both in form and relative position, and further, they are, in one way or another, different in the skulls of other kinds of ducks outside the genus *Anas* and the larger anserine fowls.

Upon comparing the base of the skull in our specimen of *Dendrocygna autumnalis* (454) with that of a Mallard (*A. platyrhynchos.*

1) Shufeldt, R. W., Observations upon the osteology of the order Tubinares and Steganopodes, in: Proc. U. S. nation. Mus., 1888, p. 253—315, figs. 1—43.

No. 17118, Coll. U. S. Nation. Mus.), we note that the basitemporal in each is a convex, rounded arc, carried to a sharp, minute spine anteriorly, above which the Eustachian entrances are exposed. In each, the temporal plates of the exoccipitals (paroccipitals) are large and triangular in form, being perpendicular to the cranial base. The condyle is mesially notched above, and a concavity is found in the basioccipital anterior to it.

A quadrate in either of these ducks is large for the size of the bird, as compared with the quadrate in many other species possessing a skull of equal size.

There are two facets placed in line transversely, on its mandibular part, they being separated by a valley from the hinder part of the bone, which latter is rounded. Above this, on the postero-auricular margin of the quadrate, there is usually developed in *Dendrocygna* a small up-turned apophysis. This process is barely to be perceived in the Mallard, while it is found in other anserines, not especially related, as in *Somateria v-nigra*, and in some of the species of *Oidemia*, as *O. perspicillata*.

The articular head of the mastoid process of the quadrate in both *Anas* and *Dendrocygna* presents a double facet, with a sharp grove standing between them; while the orbital process in both these genera is triangular, pointed an individualized. Below it is the small hemiellipsoidal facet for the pterygoid of the same side.

A pterygoid in any of the Anseres is a very distinctive bone, and to this neither *Anas* nor *Dendrocygna* form any exception. Its anterior extremity is more or less massive, and presents, at its apex, a hemispherical cup for articulation with the hemispherical facet on the palatine of the same side. A process is developed both above and below this cup, while on the upper border of this end of the pterygoid is a large, elliptical, longitudinal facet for articulation with the similar one on the presphenoidal rostrum. When the skull is held horizontally, this latter is directed upwards and forwards, to coossify, anteriorly, with the massive mesethmoid, which underlies the frontals posterior to the cranio-facial hinge.

A palatine in either of the ducks now being considered and compared, is expanded anteriorly, compressed from above, downwards, being wedged in between the maxillary and maxillo-palatine of the same side, with which bones it very extensively coossifies. Mesially, the bone curls upwards, inwards, and then outwards, to terminate in a sharpened margin, which latter is lost on the aforesaid flattened

portion of the bone anteriorly. The infero-external border of the palatine is also sharp, terminating at the angle behind in a distinct process, and is, for its entire, length, concaved inwards. These bones have an extensive interarticulation posteriorly, and here, either one of them develops a delicate spur that, for a greater or less distance, fuses with and forms the upper, rounded margin of the vomer; in the skulls of adult Anseres, the fusion between the two is usually complete, with all sutural traces obliterated. This is not invariably the case, however; for in the skull of an adult Pacific Eider at hand, these palato-vomerine sutures can be easily made out though their fusion is quite complete.

In *Dendrocygna autumnalis*, and doubtless in all others of the genus, the vomer is an elongated lamina of bone, very thin from side to side, and arched, so that its thickened, upper, palato-vomerine border is convex from end to end, — the lower, sharpened one being correspondingly concaved. The thickened superior margin is produced anteriorly as a sharp, little spine, which usually rests either upon the fused maxillo-palatine mass directly in front of it, or coössifies with the same, or, finally, may not reach that far at all, but freely projects into the postero-rhinal chamber. This is the rule for the anterior extremity of the vomer throughout the Anseres, where its morphology will be found to be much the same; though in some species interesting differences are to be observed, and these will be noted further on.

Dendrocygna has the general concavity, on this nethermost aspect of the superior mandible, very profoundly concaved, with its sharp tomial margins quite parallel to each other. This is the case in *Anas*; but here the concavity is not as deep, proportionally, while the external margins diverge very slightly as they proceed forwards. In *Spatula*, this divergence is great, for the reason that the elegant scroll-like osseous superior mandible in this duck is so marvellously expanded at its distal extremity.

Both in *Anas* and *Dendrocygna* there is a subelliptical foramen of very considerable size in the mandibular roof, it being situated mesially in the posterior third of the space in question. It opens into the rhinal chamber, opposite the external narial apertures above. Its extent and form varies greatly throughout the Anseres. For instance, in *Erismatura jamaicensis*, it may be nearly obliterated by the extension forwards of the maxillo-palatine mass and the greater amount of ossification of the premaxillaries (Fig. 33 Pl. 6).

In the Mallard, it is sometimes partially divided in the longitudinal direction, mesially, by the development of a nasal septum (No. 4975, Coll. U. S. Nat. Mus.). In *Chloephaga poliocephala* this foraminal aperture is extensive, and situated at the middle of the short superior mandible of that goose; while in *Harelda hyemalis,* it is completely closed over by a thin, osseous layer, composed, apparently, of an independant ossification formed in the roof of the mouth in this duck.

In *Branta c. hutchensi*, the maxillo-palatines are spongy and produced far forwards. They form the sides of this foramen, which latter, in this species, is narrow and elongated. Skulls of *Branta canadensis* at hand possess a conformation similar to this.

Thus it will be observed, as already stated above, that all the osseous structures occurring at the base of the cranium in *Dendrocygna* are essentially as we find them in the several representatives of the genus *Anas*, especially in *A. platyrhynchos* and *A. rubripes.* Next to these, in the matter of such agreement, come such species as *Marila valisineria;* the teals (*Nettion* etc.), and *Mareca.*

In *Chen hyperboreus* there is, on the under surface of the superior mandible, on either side, just within the tomial margin, a chain of elevated, roughened tubercles, which are biggest posteriorly, and shade off to disappear entirely at some distance from the apex. In these geese, the general concavity, on the nether side of this mandible, is notably shallow. The osseous tubercles just described are not to be found in the skulls of any other species of geese examined by me.

Many variations occur in the morphology of the anterior extremities of the palatines. The simplest form of one of these bones is seen in *Dendrocygna*, either *bicolor* or *autumnalis* (Pl. 8, Figs. 53 and 54). Here the mesial margin of the bone is nearly straight and entirely devoid of any projections.

Passing to the Mallard (*A. platyrhynchos*), we are to note that a palatine, just before arriving at the maxillo-palatine mass, throws off a short, blunt, little process, which is directed forwards to abut against the aforesaid mass, thus creating a distinct foramen to its outer side. This foramen, in some skulls of the Mallard, may be formed by the process itself, the latter only reaching the maxillo-palatine in part, and the remainder closing in the foramen (No. 4995, Coll. U. S. Nation. Mus.). In the Canvas-back, a palatine is straight, with both borders smooth, and very slightly enlarged at its anterior

end. It is short in *Erismatura*, and the process described in the Mallard is here found to be a separate and free ossification of no great size. In *Branta c. hutchensi*, the process is a fine, sharp spine, situated on the inner margin of a palatine, at some distance posterior to the maxillo-palatine of the same side.

In *Oidemia perspicillata*, the palatine has an entirely different form; the proximal end is expanded, and when duly articulated, its surface about two-thirds faces the corresponding surface of the fellow of the opposite side. The distal flattened end of either of these bones is in the horizontal plane, and underlies the enormously swollen maxillo-palatine. The minute process described above is on the outer border of the bone, extremely fine and sharp, and directed backwards instead of directly forwards, as in the other ducks mentioned above.

In fact, this Surf Scoter has a remarkable skull, and in it the vomer is quite different from that bone as it occurs in ordinary ducks; for, while it is a thin, laterally compressed bone, it is small at its palatine articulation posteriorly, and gradually increases in depth as it proceeds forwards, where it terminates in a conspicuous spine above, though, in this anterior situation, it in no way comes in contact with the other osseous structures in front of it.

Charitonetta albeola has the anterior palatine process on the mesial side of the bone standing out very distinctly, and not in contact with the maxillo-palatine. It is absent in *Aix*, or barely indicated in *Aix galericulata*. This is the case in *Harelda*, where the palatine is short, and its anterior third deflected outward.

Olor likewise has a straight, flat palatine, with much of a form as we meet with in *Dendrocygna*; indeed, in the case of *Olor columbianus*, the general morphology of the bones, seen upon the inferior aspect of the cranium, agree with the corresponding ones in the skull of *Dendrocygna*, in most all their characters (Compare Figs. 53, 54 of Pl. 8 and the skull of the Swan shown in Fig. 41, Pl. 7). This agreement is not as close, however, as it is with *Anas platyrhynchos*, especially in the matter of the large elliptical foramen in the roof of the mouth, which is sometimes almost filled in with bone in *Cygnus olor*, and the rounded off posterior external angles of the palatines in the Cygninae, where a well-defined apophysis is developed both in the "Tree-Ducks" and in the Mallard.

Attention is called, however, to the near approach of the backward-extending lower end of the lacrymal, and to the apex of the long

sphenotic process in *Cygnus olor*; though, as a matter of fact, the lower free portion of the lacrymal in the Swan is more like what we find in species of the genus *Anas* than it is in *Dendrocygna*, where this part is narrow, long and somewhat slender.

With respect to the mandible in the Anatidae, I have already contributed, in my "Osteology of Birds", cited above, a brief account of this bone as it occurs in a number of anserine forms. Illustrations will also be found there, giving the mandibles of *Spatula clypeata* and *Clangula islandica*, seen upon upper view (p. 280, 281, figs. 19 and 20).

There will be found upon the Plates in the present contribution numerous figures of the mandible, as we find it among the ducks, geese and swans. These are so clear that the bone hardly requires any further description.

Dendrocygna has a lower mandible agreeing, in its several characters, with any of the typical ducks, and especially with those of the genus *Anas* (Compare Fig. 12, Pl. 3; Fig 110, Pl. 16; Fig. 27, Pl. 5; Fig. 38, Pl. 6, and others). On the other hand, the mandible of *Dendrocygna autumnalis* (455) has identically the same character, in every detail, as that bone has as we find it in *Olor columbianus* (Fig. 40, Pl. 7; Figs. 42, 43, Pl. 7). In the swan, however, the vascular longitudinal groove on the outer side of the ramus, from the juncture of the middle and posterior thirds to the symphysis, is, comparatively, much deeper than it is in the "Tree-Duck". But this is not invariably the case, for this groove is deep in specimens of *D. autumnalis*. It is also very well marked in Mallards and Canvas-backs, and, indeed, in the majority of the Anseres. They nearly all, too, have a deep and extensive fossa, that opens to the inner side of either backward-extending angular process, which fossa underlies the entire articular facet (and beyond) for the quadrate. This cavity is small in *Branta*, *Chloephaga*, *Tachyeres cinereus*, and is not present in *Cereopsis*.

Branta c. hutchensi, *Cereopsis*, *Chloephaga poliocephala*, *Tachyeres cinereus* and some other species have the backward-extending processes of the articular ends of the mandible sabre-shaped, and only gently curved (Figs. 11, 14 and others of Plate 3). *Polysticta stelleri* has these processes of a most remarkable form, each being a long, deep, quadrilateral plate, scarcely turned up at all at the posterior ends. I know of no other duck that has them of this form (Fig. 87,

Pl. 11). This Steller's eider has a peculiar skull in any event, and in it the lacrymals are conspicuously small for an anserine bird.

Many years ago, I made a drawing of the "hyoid bones of a goose" for Dr. Elliott Coues, who published it in several editions of his Key to North American Birds (5. Ed. Vol. 1, p. 173, fig. 72, Boston, 1903). To the best of my recollection, the bones of the hyoidean apparatus there figured were those of a specimen of *Branta canadensis*, which I shot in Wyoming, about forty years ago. In any event, they correctly present the osseous elements of that arch in an adult anserine, and they will save me the labor of reproducing them for the work now in hand. Morphologically, these hyoid bones in the Canada goose agree very closely with the corresponding ones as we find them in *Dendrocygna autumnalis*, in *D. bicolor*, and probably in all the other species of "Tree-Ducks". I have also compared them with the same elements in a Swan and have met with no marked differences.

The bony glosso-hyal is large and much elongated, with a characteristic facet at its posterior end for articulation with the basihyal, and a small concavity at its distal end for the reception of a cartilaginous prolongation of the glosso-hyal. This, I believe, exists in all the Anseres. The basihyal and basibranchial or urohyal fuse into one piece in the adult, and the latter is produced posteriorly by a cartilaginous tip, which varies in length in different species and genera.[1]) The ceratobranchials are very long and but slightly curved; whereas the shorter epibranchials are considerably so, in that they may conform to the back of the skull, behind which they curl up during the life of the individual. As combined, on either side, the ceratobranchial and epibranchial form a long, curved thyro-hyal; or one of the two limbs of the "greater cornea".

Upon a comparative examination, we find that the characters of the hyoidean apparatus in *Dendrocygna*, *Olor*, and the typical wild geese, as well as in the true ducks (*Anas* etc.) present no noteworthy variations, as is the case with some I have examined, and probably with others which I have not. For example, in *Oidemia perspicillata* the glosso-hyal is broadly elliptical in outline, much concaved from before, backwards, superiorly, and correspondingly convexed beneath, while transversely, above, it is convexed and

1) Shufeldt, R. W., Osteology of Birds, p. 282 and 314, fig. 42.

correspondingly concaved from side to side below. The usual facets are found at its anterior and posterior ends; and, mesially, just anterior to the latter, we find a perfectly circular foramen, having a diameter of about two millimeters. This glosso-hyal foramen I have not previously described, and it is possible that it may be found in the same bone in the tongues of other scoters, or, perhaps, other ducks related to them.

In this Surf Scoter the first basibranchial is short, rather broad, and markedly compressed from above, downward, — a compression which causes the articular facet at its anterior end to appear unusually prominent. The thyrohyal elements are much the same as we find them in other ducks, or as they have been described above (No. 81712, Coll. U. S. Nation. Mus.).

I have given no especial attention to the comparative morphology in the Anseres, and have examined the circlet of sclerotal plates, as found in the eye, in only a few species. There is a general description of this last and one for *O. perspicillata* in my Osteology of Birds (p. 282). They have the general characters as we find them in the group *Dendrocygna*, and within the group have but very slight value in the matter of determining relationships.

Osteology of the Respiratory and Vocal Organs.

Notwithstanding the fact that they are mere sketches, some of the best illustrations extant of the ossifications, which occur in the vocal organs and the respiratory apparatus generally of the Anseres, are to be found in T. C. Eyton's „Supplement" to his Osteologia Avium.

These are, as a rule, life size, and present very fair representations of these structures as they occur in *Cygnus, Alopochen aegyptiacus, Querquedula crecca, Anas platyrhynchos, Nyroca leucophthalmus, Harelda glacialis, Clangula clangula, Mergus serrator, Chloephaga magellanica, Carina moschata, Tadorna belloni (tadorna?), Arctonetta fischeri, Aix sponsa;* and others known to him as *Querquedula formosa, Cyanopterus circia, Micropterus patachonichus*, and *Bernicla antarctica.*

Often there is a remarkable difference in the morphology of these parts, in so far as they ossify in the two sexes of the same species. In some species, the male may have the lower larynx very elaborately developed and ossified, while the female of the same

species will have one of a most simple construction. This is well exemplified in the lower part of the trachea of *Sarcidiornis melanonota*, as described and figured by Garrod.[1])

Forbes, who also paid considerable attention to the tracheae of birds, was the first to point out certain peculiarities of the trachea in the Erismaturinae.[2])

Fortunately for the science of avian anatomy, Macgillivray published, in Audubon's "Birds of America", both descriptions and figures of these parts of the air passages, which ossify or present peculiar formations in the two sexes, of quite a number of North American ducks. The work is most carefully done, and by one who understood the structure of birds and the value of a comparative study of those structures in classification, which Audubon certainly did not. These descriptions of the trachea in the Anseres by Macgillivray it will well repay the student of the anatomy of this group to investigate.

The extraordinary convolutions and morphology generally of the tracheae in the Cygninae is too well known to be brought up here, beyond mentioning it.

There are several excellent pages on this subject in the

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1) Garrod, A. H., On the form of the lower larynx in certain species of ducks, in: Proc. zool. Soc. London 1875, p. 151—156. We find here excellent figures and descriptions of the lower larynx of *Sarcidiornis melanoata* (♂ et ♀), *Rhodonessa caryophyllacea* (♂ et ♀), *Metopiana peposaca* (♂, 2 views). The latter have a large, circular enlargement, just above the middle of the trachea, previously pointed out by Dr. P. L. Sclater (in: Proc. zool. Soc. London, 1868, p. 145) as „a large bulbous expansion in the windpipe".

2) Forbes, W. A., Note on some points in the anatomy of an Australian duck (Biziura lobata), in: Proc. zool. Soc. London, 1882, p. 455—458 (figs. 1 and 2). In this paper he remarks that „In the non-development of a bulla, whether osseous or partly membraneous, and in the perfectly simple character of its trachea, *Biziura* differs from all the forms of ordinary Ducks known to me, all the genera of these that have been as yet examined exhibiting, in the male sex, either one or other of (or, more rarely, both) these peculiarities. The condition of the male *Biziura* is nearly identical with that found in the females of other Ducks. Very probably it may be that characteristic of all the *Erismaturinae*, of which, however, only *Erismatura rubida* has, so far as I know, been examined as regards this point. In that species the syrinx, judging from Macgillivray's description (Audubon, Orn. Biography, Vol. 4, p. 331), is quite similar to that of *Biziura*, there being no tympanum whatever, but simply a long box formed of several rings united."

5th Edition of the "Key to North American Birds" by Dr. Elliott Coues (p. 207—213), which is illustrated by Macgillivray and myself.

I have also given descriptions of these parts in many of the Anseres in my "Osteology of Birds" (in: N. Y. State Mus.), in a section entitled Modifications of the Larynx and Trachea among the Ducks (p. 297—301, illustrated).

I have examined the ossifications which take place in the structure of the respiratory and vocal organs of male and female specimens of *Dendrocygna bicolor* and *D. autumnalis*, and I find that they are of the more simple arrangement as they occur in many of the ordinary ducks, as for example *Anas platyrhynchos* and others. As the material examined by me in this regard had been salted and dried for partial preservation during transportation, I could not make as satisfactory examinations as I should have wished. Still, I have before me at this writing the entire trachea, including its extremities, of a specimen of *Dendrocygna bicolor* (457), and it is ample to prove the correctness of the statement just made.

Owen has given us an excellent chapter on the "Air-passages in Birds", in which he presents a figure of the tracheal coils and lower larynx of Bewick's Swan, and three different views of the lower larynx of *Mergus serrator*.[1])

Eyton gives us no descriptions of these parts in his Osteologia Avium; but as to whether he does or not in his more formal work on the Anatidae, I am not prepared to say, as that volume is not to be found in the libraries of the city of Washington, which it certainly should be.

Remainder of the axial skeleton in *Dendrocygna*.

Under this heading there will be considered the vertebral column, the ribs, the sternum, and the pelvis of the "Tree-Ducks", the same being made comparative as far as necessary. After these have been treated, I shall pass some observations on the pectoral arch or shouldergirdle of the forms under consideration, completing the comparative account with descriptions of the bones of the pectoral and pelvic limbs. In my "Osteology of Birds", previously cited, I present a very full description of the osteology of

1) Owen, Richard, Comp. Anat. and Physiol. of Vertebrates (Vol. 2, p. 217—225).

Mergus serrator, the same being compared with *Lophodytes cucullatus* and other species. In that work there is also given a full description of the skeleton of *Spatuala clypeata*, which is likewise compared with the skeletons of a number of anserine species. In these descriptions, an imperfect skeleton of *Dendrocygna autumnalis* was duly included, and very full ones of *Olor columbianus*, *Branta*, *Chen*, *Anser*, and other genera and species. Some of all this data will be used in the present connection, especially as it is needed to make more thorough osteological comparisons in the case of *Dendrocygna bicolor* and *D. autumnalis*, complete skeletons of which have not previously been at hand for the purpose, — at least not in so far as some of the most important parts of them are concerned.

On p. 284 of my "Osteology of Birds" it was stated that I had "examined the vertebrae and ribs in the genera *Anas*, *Spatula*, *Dafila*, *Aix*, *Netta*, *Marila*, *Clangula*, *Charitonetta*, *Harelda*, *Polysticta*, *Somateria*, *Oidemia*, and others, and am satisfied that they vary to such an extent that the data obtained therefrom can not be used with quite as much effect in the matter of taxonomy in this group, as can other parts of the skeleton." The truth of this statement will be further tested in the present contribution, and I am inclined to think that a more extended study of the trunk skeleton, in the above and other species and genera, will throw not a little light on the systematic position of *Dendrocygna*, with respect to the relationships of the members of that genus to other anserine groups.

It will by no means be necessary for me to reproduce here all the facts brought out and recorded, with respect to the osteology of so many of the Anseres, as are to be found in my "Osteology of Birds"; but rather to keep it in mind, as additional information is here presented, which is made possible through a study of the skeletons of other species which were formerly not available. Chief among these are more or less complete skeletons, or parts of skeletons, of *Cereopsis novae-hollandiae*, *Erismatura jamaicensis*, *Hymenolaemus malacorhynchus*, *Chenonetta jubata*, *Aix galericulata*, *Olor buccinator*, *Mareca*, *Histrionicus histrionicus*, with a little additional material illustrating the osteology of certain geese.

It is unfortunate that there is no skeleton of the Emperor Goose (*Philacte canagica*) in the collections of the U. S. National Museum; especially in view of the fact that large series of skins of that species have been brought there by a number of our Arctic ex-

plorers, — any one of whom could easily have secured all the skeletons of *Philacte* that could be desired.

Before giving a detailed description of any of the parts, or the bones of the trunk skeleton, of *Dendrocygna* and other anserines I propose to present here a Table, giving comparative data of the vertebrae, ribs, etc. in a number of the Anseres, in that we may see how they compare in these respects, and especially with regard to the Tree-Ducks in such matters.

With respect to the number of vertebrae in the spine of *Dendrocygna*, in so far as the two North American species are concerned, it will be observed from the following Table that these birds most nearly agree with such a species as *Netta rufina;* while on the other hand, what is far more important, it is quite clear that from a numerical standpoint, as applied to the vertebrae, these two dendrocygnine species, at least, belong with the Anatinae, and not with the Anserinae, or much less with the Cygninae.

To institute comparisons of the vertebrae, then, in the case of any two species of ducks, swans or geese, it is very obvious that the two forms thus compared should have exactly the same number of vertebrae in their spines, or else such a description would become practically useless after passing the atlas and axis. For example, it would be useless to make a comparative description of the cervicodorsal vertebrae of a *Dendrocygna* with that of an Aix, the first having 22 vertebrae in that division of the spine, and the latter only 21. The 19th vertebra, for example, in the spine of *Dendrocygna autumnalis*, might be the 19th in *Aix sponsa*, or it might not; the chances are that it is not, and for the reason just given above. Even still more useless and unscientific would it be to compare, vertebra for vertebra, in the spine of any representative of the genus *Dendrocygna* with those in the spine of a swan, such as *Olor buccinator*, and for exactly the same reason.

There is considerable data on the axial skeleton of the Anseres in my above cited work on the "Osteology of Birds", and some of this refers to a specimen of *Dendrocygna autumnalis* (Coll. U. S. Nation. Mus. No. 1491). This will be included with what is set forth here, in the light of far more complete and extensive material.

In a skeleton of *Dendrocygna autumnalis* (454), collected in Texas by Mr. F. B. Armstrong, the atlas presents the same characters that it does among the Anatinae generally, and in some respects

Table giving number of vertebrae in certain anseres.

Species	Number of cervical vertebrae without free ribs	Vertebrae that bear free ribs not reaching the sternum	Dorsal vertebrae (inclusive)	Sacral vertebrae coossified with the pelvis	Free caudal vertebrae (to which the pygostyle is to be added)
Netta rufina	16	17th	18th to 22d		Seven
Clangula islandica	15	16th and 17th	18th to 21st	22d to 37th	38th to 43d
Charitonetta albeola	15	16th	17th to 21st	22d to 37th	38th to 45th
Harelda hyemalis	15	16th	17th to 21st	22d to 36th	37th to 44th
Histrionicus histrionicus	15	16th	17th to 21st	22d to 37th	38th to 44th
Polysticta stelleri	15	16th	17th to 21st	22d to 36th	37th to 43d
Somateria mollissima	15	16th	17th to 21st		Six
Oidemia perspicillata	15	16th	17th to 21st		Seven
Querquedula discors	15	16th	17th to 21st	22d to 37th	38th to 43d
Spatula clypeata	15	16th	17th to 22d	22d to 37th	38th to 44th
Aix galericulata	15	16th	17th to 21st	22d to 37th	38th to 43d
Aix sponsa	15	16th	17th to 21st	22d to 37th	38th to 43d
Hymenolaemus malacorhynchus	14	15th and 16th	17th to 21st	22d to 37th	38th to 44th
Dendrocygna autumnalis	16	17th	18th to 22d	23d to 36th	37th to 42d
Dendrocygna bicolor	16	17th	18th to 22d	23d to 36th	37th to 43d
Olor columbianus	22	23d	24th to 28th	29th to 45th	46th to 52d
Olor buccinator	22	23d	24th to 28th	29th to 45th	46th to 52d
Cereopsis novae-hollandiae	18	19th and 20th	21th to 24th	25th to 43d	44th to 48th
Branta canadensis	18	19th and 20th	21th to 24th	25th to 43d	44th to 49th
Chen h. nivalis	18	19th and 20th	21th to 24th	25th to 41st	42d to 47th
Anser albifrons	18	19th	20th to 24th	25th to 41st	42d to 47th

with the atlas as we find it in certain swans for example, as in *Olor columbianus* the articular cup for articulation with the condyle of the occiput is not ossified superiorly, the interval having a strong ligament spanning it in life. Both of these birds, too, possess, on either side of the atlas, a foramen for the passage of the vertebral vessels. In *Cereopsis*, the articulatory cup of the atlas is completed in bone, and the vertebral foramina are barely closed in laterally. They may even be open in some ducks, as in *Polysticta* and doubtless in others. As to the neural arch, it is generally broad antero-posteriorly and of uniform width; to this, however, such a form as *Hymenolaemus malacorhynchus* is an exception.

No haemal spine whatever is present on the atlas in *Dendrocygna*, while that process is quite well developed in *Olor*, to some extent in *Branta*, and quite conspicuously so in such a duck as *Hymenolaemus malacorhynchus*.

Aix possesses an atlas much as I have described it for the Tree-ducks, while in some of its details it varies throughout the Anseres.

Passing to the axis of *Dendrocygna autumnalis* (454), we find its odontoid process well developed, being flat above and convex beneath. Below it, the facet for the atlas is transversely elliptical and moderately concave. The vertebral canals are formed by thin, lateral laminae of bone, the postero-inferior angle of either of which is inclined to be drawn out into a process, which in *Olor columbianus* is very conspicuously the case. Above, the neural arch is thick and broad, increasingly so as we proceed backwards. It supports a median, low, thick, neural spine, while the haemal spine below is extensive, much compressed from side to side, and slopes away posteriorly. At the middle of the base of the haemal spine, it is pierced, from side to side, by an irregular foramen. This is also present in *Olor*, but not in *Chen* or *Branta*.

In some of the Sea Ducks, as in *Charitonetta*, the haemal spine of the axis vertebra is narrower antero-posteriorly at its base than in most Anatinae, thus, to a greater extent, invidualizing this apophysis.

The third cervical vertebra in the spine of *Dendrocygna* has the neural process set far back on its arch; while the haemal one, with much of the form it has in the axis, exhibits considerable reduction in size. On either side, the vertebral canal is more extended and more tubular. Posteriorly, either transverse process is

produced backwards as a sharp spine. This is also a feature of the fourth cervical vertebra, in which, too, both the haemal and neural spines begin to be reduced, the former entirely disappearing until the thirteenth cervical is arrived at, when it reappears as a thin, median apophysis of some size.

Dendrocygna, in common with so many other Anatinae, has the centra of the fourth to the seventh cervicals conspicuously flat and broad, and to a greater or less degree, this is to be observed in all Anseres. It is a very striking feature of the cervical vertebrae in *Polysticta stelleri*, where, in the the case of the seventh, eighth, and ninth cervicals, the centra below are concaved, and nearly as broad as long. Hypapophyses gradually appear, however, for the formation of carotid canals, at the extreme anterior border of the centrum of each vertebra, being most complete in the twelfth cervical. After that, a blade-like process supplants it, which in turn becomes smaller on the 13th to the 15th inclusive, and tricornuate on the 16th cervical.

In this skeleton of *Dendrocygna autumnalis* (454), I find a pair of free ribs on the 15th cervical, which are short and without epipleural processes. There is another pair articulating with the 16th cervical which are much longer and have the epipleurals. This is not the rule; for the 15th cervical in these Tree-Ducks is usually without them, the fused and outstanding pleurapophyses, forming the lateral vertebral canals, occupying their place. Long since, I have shown in some of my publications on the osteology of birds that even in the same species, there is no hard and fast rule with respect to either cervical or pelvic ribs in that Class of the Vertebrata, and here is another instance of it (see Table above).

The dorsal vertebrae in *Dendrocygna* are locked together in articulation with great closeness. Above, the broad, neural spines are practically in continuous contact by their anterior and posterior margins, giving the appearance of one continuous neural crest. Extensive ossification also takes place in the tendons of the muscles of the back, and these, together with the highly developed metapophyses, tend still more toward the rigidity of this division of the spinal column in these ducks.

On either side, near the middle of the centrum of any one of these much laterally compressed dorsal vertebrae, we observe a pneumatic foramen in some specimens (453) that may be very small, or altogether absent in other skeletons, either on one side, or both

(454). When present in the dorsals, it is generally present and much larger in the cervicals. Three or four of the dorsal vertebrae in *Dendrocygna autumnalis* possess haemal spines or processes. The first one on the first dorsal is small, with its inferior border dilated. On the next two following they are much longer and broader antero-posteriorly, their lower borders being produced forwards and backwards. The last one, if present, is shorter, but is formed like the other two on the middle dorsals just described.

That there may be very decided differences in the arrangement, or what really amounts to number of the ribs in *Dendrocygna autumnalis*, with variations in the ultimate cervical and the dorsal vertebrae, the material before me at this writing abundantly proves.

In the skeleton of this species of the genus in the Collection of the U. S. National Museum (No. 1491), I find there are five dorsal vertebrae that support ribs connecting with the sternum by costal ribs. Either costal border of the sternum of this skeleton possesses seven facets for articulation with costal ribs; two of these are evidently intended for the costals of the pelvic ribs, and this I find to be the case. Posterior to these, in this skeleton, there is also another pair of extremely slender pelvic ribs, which probably possess equally slender "floating ribs" that do not reach the costal border of the sternum on either side. The first three dorsal vertebrae here possess haemal spines, — the first one being low and bifid; the next deep and broad and directed forwards; while the ultimate one is shorter, narrower and directed backward. This arrangement is shown in fig. 40 of my "Osteology of Birds" (in: N. Y. State Museum) on p. 312.[1])

One of the skeletons of *Dendrocygna autumnalis* (454), collected for me by Mr. F. B. Armstrong, has an arrangement altogether like this, with but one exception, namely: either costal border of the sternum possesses but six facets for articulation with costal ribs (haemapophyses), and this is accounted for by the fact that the leading pair of pelvic ribs is the only pair articulating with the sacrum that connect with the sternum by means of costal ribs. The pair next behind them have long, slender haemapophyses, which do

1) In this specimen, the anterior portion of the pelvis and the last dorsal vertebra are twisted, — a condition which is probably pathological, though there is no evidence of disease.

not quite reach the costal border of the sternum. The ultimate pair of pelvic ribs, noted in the museum skeleton above, are absent here.

Passing to another skeleton of *Dendrocygna autumnalis* of the Armstrong series (453), a female, I find seven facets on both the costal borders of the sternum, with two of the three pairs of pelvic ribs having haemapophyses that reach the sternum for articulation. The last pair, while they possess long, delicate, sweeping haemapophyses, they do not, upon either side, reach the costal sternal border.

In this skeleton, four of the dorsal vertebrae possess haemal spines, the last one being thoroughly developed and 4 or 5 mm, long. Thus, in this skeleton, it is only the last dorsal vertebra that lacks a haemal spine; while in the museum specimen (No. 1491) and 454 described above, the last two dorsal vertebrae are entirely devoid of haemal spines.

In another skeleton of *Dendrocygna autumnalis*, a male, of the Armstrong series (455), there are seven facets on each of the sternal costal borders; two pair of the pelvic ribs articulate with the sternum through costal ribs; the haemapophyses of the third pair of pelvic ribs are long and sweeping, but do not reach the sternum; finally, the leading four dorsal vertebrae have well developed haemal spines, while the fifth or last one has none.

Such variations as these are interesting, and I have found them present in many other species of birds. They may occur in all vertebrates up to man, in whom I have found not only a pair of lumbar ribs, but a pair of well developed ribs on the seventh cervical vertebra.

As to the ribs themselves in *Dendrocygna*, they present nothing especially peculiar, although they have, to be sure, characters of their own, which, although perhaps insignificant, still pertain strictly to this genus of ducks, and are different, character for character, from what we find in other species. These ribs are somewhat broad, considerably compressed from side to side, and, together with the last pair of free, cervical ribs, all support rather large epipleural appendages. The epipleurals of the last pair may be very small (454), or nearly as large as the others (455).

Both the morphological characters of the ribs and the characters of the vertrebrae in *Dendrocygna* differ very widely from the corresponding ones in any particular rib or vertebra in such forms as *Harelda hyemalis*, *Polysticta stelleri*, *Hymenolaemus*, or any of the

Anserinae or Cygninae. They come much nearer to those bones in such a species as *Aix sponsa* than that of any other skeleton I happen to have at this time, but this does not include *Aix galericulata*.

The Pelvis and Coccygeal Vertebrae (Fig. 51, Pl. 8; Fig. 55, Pl. 8; Fig. 68, Pl. 9; Fig. 69, Pl. 10; Figs. 79 and 80, Pl. 10; Fig. 84, Pl. 11; Fig. 111, Pl. 16 and Fig. 112, Pl. 16). Apart from the mere matter of size, the pelvis of *Dendrocygna autumnalis* and *D. bicolor* practically agree both in their general and special characters. The pelvis in *bicolor* is somewhat larger than it is in *autumnalis*. Anteriorly, in the former, the iliac bones are broader, and their antero-lateral angles are more widely rounded off; but I am inclined to think that this is an individual difference and not a specific one.

When viewed upon its dorsal aspect, the pelvis in *Dendrocygna* is seen to be very distinctive, in that it differs from the pelvis of any other duck known to me, in its being so narrow for its length. This fact will be appreciated by examining and comparing the numerous figures of anatine pelves on the Plates cited above.

Seen upon this view, the preacetabulum portion of the pelvis (454) is narrower in the middle than it is either anteriorly or at the transacetabular diameter. This surface is for the most part concave, the infero-external border being quite so for its entire length, while the supero-internal one is convex and fused for nearly its entire length with the superior border of the neural crest of the anterior portion of the sacrum.

The sides of the postacetabular portion face almost directly outwards, and but very slightly upwards.

The internal iliac border is in close contact with the sacrum for its entire length, all to a short distance posteriorly. Here, too, it usually has the first caudal vertebra, between its mesial posterior angle and the same angle of the ilium of the opposite side. Anteriorly, the ilia shut the sacrum out of sight all to the "crista", of which latter we can see the superior border. In the postacetabular area, the sacrum occupies almost the entire space, its surface being somewhat concave throughout, and the vertebrae forming it completely fused together, with foramina remaining here and there among the transverse processes (Fig. 55, Pl. 8).

An ilio-ischiatic posterior border of the pelvis is entire; its first or mesial half is concave forwards, while the outer half is convex posteriorly.

On a lateral view, we are to note the large, circular acetabulum, with its mesial periphery but slightly smaller than its outer, with a conspicuous antitrochanter occupying its usual site in the postero-superior arc of the latter.

As in all Anatidae, a well-marked prepubic spine is present, while the pubic element itself is long and very slender. It assists in closing a small, elliptical obturator foramen, and a long, rather narrow obturator space. Its free end, posteriorly, is not in any way dilated, as in the Geese and Swans, but of the same uniform width as in the true ducks. For about the distance of a centimeter, more or less, it is in contact with the free margin of the infero-posterior border of the ischium (Fig. 112, Pl. 16).

Agreeing with most Anseres, a spacious ovo-elongate ischiac foramen monopolizes a large part of the post acetabular space on the lateral aspect of this pelvis. Its broad end is immediately behind the antitrochanter.

Ventrally, the pelvis of *Dendrocygna* has a distinct anterior portion lying beyond the prepubic spines. This is narrow, and almost entirely filled in with the coössified anterior sacral vertebrae, the six or seven pairs of transverse processes of which extend outwards to almost reach the free margin of the ilium on either side. Posteriorly, the pelvic basin is deep and narrow, its mesial portion being occupied by the remainder of the sacrum, the transverse processes of the vertebrae of which stand out with marked prominence, they being directed backwards and outwards.

The caudal vertebrae are small, and their usual spines and processes very indifferently developed. They terminate as a very much elongated and by no means insignificant pygostyle.

This pelvis of *Dendrocygna* I have compared, character for character, with the pelves of many species of ducks, mergansers, geese and swans, and it seems to have in its composition a curious and interesting mixture of them all. It has the elongate general form of the pelvis of the swan (*Olor*); but the latter has the immensely dilated distal ends to its pubic bones, and there is a deep ilio-ischiac notch on the posterior pelvic border, which, in *Branta canadensis*, is converted into a foramen by the ilium and ischium again closing in behind it. *Olor* may have as many as five pairs of pelvic ribs; *Branta* four, and *Dendrocygna* never more than three as in *Mergus serrator*, *Harelda* and other ducks.

But the pelves of most Anatinae are narrow for their

preacetabular portions and spreading behind (Fig. 69, Pl. 10, and Fig. 84, Pl. 11). We have seen that this is distinctly not the case in the pelvis of the Tree-Ducks, wherein this composite bone is narrow and elongate, as in the case of *Mergus*. As a matter of fact, the pelvis of *Dendrocygna bicolor* or *D. autumnalis* agrees much better, indeed, very much better with the pelvis of *Mergus serrator* than it does with any duck, goose or swan with which I am at present acquainted.

To appreciate this, one will have but to turn to p. 265 of my "Osteology of Birds" (in: State Mus. N. Y.) and note there figs. 7 and 8, — the first being of *Mergus serrator*, and the second *Somateria dresseri*. They are my own drawings and upon dorsal view. Now *Somateria* possesses an unusually elongate pelvis for a duck, the more ordinary form being seen in *Spatula clypeata* (fig. 21 of the same volume), or in Fig. 84 of Pl. 11 of the present paper, which is the pelvis of *Aix galericulata*. Moreover, in the pelvis of *Mergus serrator*, the posterior ilio-ischiac margin or border is entire; it possesses three pairs of pelvic ribs, as in a Tree-Duck, and in general form and character the bone, in these two species, is almost identical.

Apart from the pelvis, however, all the rest of the skeleton of *Mergus serrator* is very unlike that of *Dendrocygna*, — a fact the osteologist, who knows anything of the skull, trunk skeleton and limb-bones of the mergansers, will recall.

The Shoulder Girdle. Fundamentally, as well as actually, the several bones composing the pectoral arch, in either species of the two American Tree-Ducks, are different from the corresponding ones as they occur in any true swan (*Olor*, *Cygnus* etc.)

In *Olor columbianus* the os furcula is highly pneumatic, with groups of pneumatic foramina upon the outer aspect of either clavicular limb, and the lower part of the arch is modified in form in order to admit of the passage of the trachea to the thoracic cavity. In *Dendrocygna* no such modification is present in the os furcula, and, moreover, the bone is non-pneumatic; the clavicular limbs flattened from side to side, the whole having a broad, U-shaped form, as in all the Anatinae. *Branta* has the furcula of a narrower U-arch, with the free ends of the clavicular limbs drawn out into pointed extremities, as in all Anserinae and Anatinae. Either clavicular limb, on the upper border of its arch, at some little distance anterior to its free end, there is a distinct tubercle present

in ducks and geese, it being practically absent in swans. It is individualized and conspicuous in *Mergus serrator* (see fig. 5, Osteology of Birds).

Among the Anseres, as a rule, the furcula lacks a hypocleidium, or, if present, it is but a mere rudiment of one (*Aix*); while in some of the geese, as well as in *Dendrocygna*, we find, on the posterior aspect of the arch below, at its middle, a V-shaped area, formed by a line on either side, where the externo-posterior surface of the furcula terminates. This is also faintly marked in *Polysticta stelleri*; and, while this is likewise the case in *Chen hyperboreus nivalis*, in the latter the os furcula has the major portion of either free clavicular extremity as in *Olor*, in the matter of form as well as in the complete pneumaticity of the bone, — the groups of the large pneumatic foramina being on the outer sides, at about a centimeter from the sharp-pointed end.

Harelda hyemalis has a slender and broad U-shaped furcula, with its clavicular extremities markedly produced. Both *Chenonetta jubata* and *Mergus serrator* have the arch still broader and more slender; but the free ends of the clavicles are short in the former, and long in the merganser, while both possess the process on the superior border, small, but very much individualized, and hence a conspicuous character (fig. 5 "Osteology of Birds", and Fig. 67, Pl. 9; Fig. 75, Pl. 10 of the present paper).

Comparative ornithotomists have long known that the three bones composing the pectoral arch in birds articulate in different ways with each throughout the Class. These various methods of articulation are more or less characteristic of the families and the higher groups, and to this the Anseres form no exception.[1])

This has been most exhaustively and beautifully demonstrated by Max Fürbringer in his magnificent work Untersuchungen zur Morphologie und Systematik der Vögel, the second and third Plates of the second volume of which presents over one hundred figures of the articulations of the bones of the pectoral arch in Birds. These beautiful engravings are all lettered, and constitute a most instructive series. The Anseres are exampled by *Mergus*, *Somateria*, *Anas*, *Fuligula*, *Cygnus*, *Cereopsis* and *Cnemionus*.

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1) See „The Pectoral Arch" under the article „Skeleton" in Alfred Newton's A Dictionary of Birds, Pt. 4, p. 856—858, Illus. by Prof. Hans Gadow.

Fürbringer calls the process on the superior clavicular border I refer to above, the processus acrocoracoideus claviculae, and figures it for *Mergus*. The long, pointed, free end of the clavicle he designates as the processus acromialis claviculae.

For the Anseres, the free end of either clavicular limb, when articulated as in life, rests its outer surface at a point about opposite the processus acrocoracoideus claviculae, while the processus acromialis claviculae rests for a more or less distance upon the supero-median border of the anterior extremity of the corresponding scapula. As thus articulated, a most perfect foramen triosseum is formed for the passage of the tendon of the pectoralis secundus muscle.[1])

This is the mode of articulation of the os furcula in *Dendrocygna bicolor* and *autumnalis*, and in the Anseres generally.

The position of the os furcula, with reference to the distance it is from the coracoids and sternum, when normally articulated as in life, varies to some extent among Ducks, Geese and Swans. For example, it is rather close to these bones in *Cereopsis novae-hollandiae*; while in such a species as *Hymenolaemus malacorhynchus* it is far removed from them (Fig. 95, Pl. 12 and Fig. 96, Pl. 12).

Always large and well developed in the Anseres generally, the scapula in *Dendrocygna* is a long, narrow, arched bone, its chord having an average length of some 64 millimeters. It articulates with the os furcula, as described in the foregoing paragraph, and with the entire width of the precoracoid process of the coracoid. Distally, it is acutely truncate, with the distal apex formed into a rounded little nib. For the first two-thirds of its length, its external border is rounded, — the remaining distance to the apex being sharp, as is also the internal margin for its distal half, the rest being somewhat rounded. The shaft of the blade curves outward, thus causing the outer border to be concave, and the inner correspondingly convex.

So far as I have examined them, the bones of the pectoral arch in the Anatinae and the Merginae are all non-pneumatic; in the Cygninae the scapula alone is non-pneumatic; while in *Chen* and *Cereopsis* all the bones of this arch are completely

1) Shufeldt, R. W., The myology of the Raven, London 1890, p. 72, and fig. 32 on p. 89.

pneumatic, — only the coracoids and scapulae being so endowed in *Branta*.

It will thus be noted that the Anseres vary considerably in this respect.

In *Branta canadensis* the anterior moiety of the scapula is very thick owing to the presence of the pneumatic cavity within that division of the blade. Pneumatic foramina, usually single, are found at the distal end of the bone, close to the middle of the border, and both above and below. The distal apex of the bone is squarely truncated, but is more rounded in *Olor columbianus*. Of very much the same proportions and form, the scapula of this swan can at once be distinguished from that of the Canada Goose by its being completely non-pneumatic, and by the absence of the pneumatic foramina. This is a valuable character when we have fossil scapulae of swans and geese of various sizes to refer.

Among the various Anatinae, the scapulae assume a great variety of forms, varying with respect to their relative lengths; distal terminations; amount of curvature; width and thickness of the blade, and morphology of the anterior extremity.

The scapula in *Dendrocygna* differs from *Branta* in being non-pneumatic, and in the form of its distal third, differing, in this latter particular, from the scapula in *Olor*. As a matter of fact, the scapula of *Dendrocygna autumnalis* is anatine in character, and, in most respects, closely resembles the scapula of such a duck as *Aix sponsa* (No. 18612, Coll. U. S. Nation. Mus.). This should not have much weight, however, in so far as affinity is concerned, especially when we find a scapula in such a duck as *Polysticta stelleri* having all the characters, apart from mere size, of the bone as we find it in *Olor columbianus*.

The general form of the coracoid among the Anseres is well known to the avian osteologist, and so need not be very elaborately described in detail here. Its pneumatic or non-pneumatic state in swans, geese and ducks has already been touched upon above, and its general form, as it occurs in this group, is well shown in Figs. 57, 63, 74, 90, 91, 96 and 108 of the present paper.

Both in *Olor* and *Branta*, the mesial side of the head of the scapula (acromium) is produced downward as an osseous veil, overhanging the conspicuous group of pneumatic foramina in that locality. Posterior to this in *Branta* there is a deep fossa, at the base of which occurs numerous other pneumatic openings. This

fossa is not present in *Olor*, while in *Dendrocygna* none of the foregoing characters are present, the coracoid in that locality being either flat, or very slightly raised, with thin, lower border, and non-pneumatic. It is flat in *Aix sponsa*, or, as in *Aix galericulata*, a pit may be present in that locality. *Cereopsis* in this regard agrees with other Anserinae. It is slightly raised in *Chenonetta jubata*; but the coracoid in that species is non-pneumatic as in all ducks which I have examined.[1])

At the distal end of the coracoid in *Dendrocygna* there are two facets for articulation with the sternal groove, on the anterior border of the sternum. When thus naturally articulated, on either side, the long axis of the coracoid is about in the same plane with the surface of the body of the sternum of the same side; and were the imaginary lines, representing the long axes of both coracoids, produced, — the bones being normally articulated, — they would intersect at a short distance posterior to the anterior border of the sternum, and somewhat above the dorsal surface of the sternal body.

At the expanded sternal extremity of a coracoid of *Dendrocygna* we note a short, antero-posteriorly concaved facet at its anterior mesial angle. This is intended for articulation with a similar facet on the lower lip of the coracoidal groove of the sternum. There is also an elongated concave facet on the posterior aspect of the expanded lower end of the coracoid, bounded by the border below, that runs to the outer angle, with an average width of a few millimeters. This is likewise intended for articulation with the sternum at the upper lip of its coracoidal groove of the same side. Now this posterior coracoidal facet in *Dendrocygna* in divided into two by a faint line running parallel to the inferior, free border of the bone. The lower portion of the divided facet is carried out to

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1) In the left coracoid of a skeleton of *Branta canadensis* (Coll. U. S. Nation. Mus., No. 17980) the ligament, passing from the precoracoid process of the left coracoid to the sternum — the sterno-coracoidal ligament — has become ossified for the distance of a centimeter at its coracoidal end, the ossification forming a sharp, spine-like process, thoroughly coossified with the bone and directed downwards. A similar ossification took place, with respect to the ligament of the opposite side, on the right coracoid, but the spine is broken off. The disposition for this ligament to ossify in very old individuals is evident in other skeletons at hand, as in the case of *Cereopsis*.

the outer angle of the coracoid; but the upper stops short of it by about one-fourth the width of the bone at this part of its sternal and. Nothing of this kind is to be seen in *Branta canadensis*, where this posterior facet for the sternum is broad and very deep, and in no way divided. In *Olor columbianus*, however, it is much shallower than in the Canada Goose, and very thoroughly divided into two facets. Of these, the inner one is broad and deep, and occupies rather more than half the width of the bone; the other is very shallow and narrow, of an elliptical outline, and separated from the larger one by an interval of two or three millimeters. Sometimes, in the coracoid of *Aix sponsa*, there is a faint indication of such division, while most ducks agree in this particular with *Branta*, *Chen* and other geese.

In *Polysticta stelleri*, however, the division of this facet is even better marked than we find it in *Dendrocygna autumnalis;* so that its significance, with respect to affinity, is certainly very obscure, even if there be any. Moreover, the manner of the division is quite different in *Olor*, as compared with what it is in a Tree-Duck or in *Aix*. Indeed, the division is practically the same in *Dendrocygna* and *Aix*, the two differing from what we find in the Swan.

In all Anseres, the coracoid is a proportionately large, stout bone with a big head, broad, expanded sternal end, with a well marked "neck" between the two.

On the whole, then, the bones of the pectoral arch in *Dendrocygna* — if we may judge from the two North American species of the genus — are more anatine than they are either anserine or cygnine.

The Sternum. Unfortunately I have not at hand, at this writing, any embryos of Ducks, Geese and Swans from different parts of the world; for, were such material available, the study of the sterna in them would be likely to throw more light upon anserine affinities, with respect to the groups, than with any number of comparisons of the breast-bones of adults. Especially do I refer to the development of the fore part of the sternum in the chick; for, with but few exceptions, too much weight has often been attached to the morphology of the posterior moiety of that bone, as compared with the far more important characters that are presented on the part of its anterior portion.

So far as the sternum in adult Anseres is concerned, there are a number of figures of it given on the Plates of the

present paper, — not only of *Dendrocygna* but of other ducks and some of the geese.

As for the Cygninae, the morphology of the sternum in them has long been known through many figures and descriptions of it, which have, from time to time, been published. It is very different from the sternum as we find it in *Dendrocygna autumnalis* or *D. bicolor*, and a comparison of the bone, in the case of these Tree-ducks, with the sternum of *Olor columbianus*, for example, would be a more or less profitless task. Beyond each possessing a „pair of notches" in the sternal body, posteriorly, no other characters in any way agree.

Briefly it may be said, however, that in *Olor* the sternum has a large manubrium; eight facets on either costal border; the entire keel is hollow to admit a loop of the trachea, which latter is coiled in an osseous box on top of the sternal body, — to say not a word with respect to other differential characters.

In *Dendrocygna autumnalis* there may be six or seven articular facets on either costal border for the costal ribs, as I have already shown when describing the latter above. The first two are close together, while the rest are each separated by an oblong, shallow concavity, in each of which small, pneumatic foramina appear. Quadrilateral in outline, the thin, superior border of either costal process — the processus lateralis anterior of Gadow — has, at its middle, a low but distinct process, which is more conspicuously developed in *Branta*. This process is rather broad, too, in *Aix sponsa*, but not in *Harelda*, *Aix galericulata* and many other ducks. It is of unusual form in *Polysticta stelleri*, as not only its angles are produced as processes, but the aforesaid apophysis is spine-like, and there is still another one, also spine-like, on its anterior sharp border. In *Olor* they are low, with their inner surfaces looking almost directly upward. *Mergus* has them much as they exist in *Dendrocygna*, though the little process on the upper border is absent.[1])

Seen upon its dorsal aspect, the body of the sternum in *Dendrocygna autumnalis* (454) is very much concaved, this concavity being deepest anteriorly, and very gradually diminishing, as we proceed backward, to an indefinite, transverse line between the anterior points in the contours of the "notches", where it is shallowest, and

1) Shufeldt, R. W., Osteology of Birds, figs. 3 and 4, 24, 26, 27 and tab. 2 of the Anseres.

from which locality it deepens again to the termination of the bone posteriorly. Anteriorly, the thickened border is convex outward, and rounded throughout. Down the median line, and all round within the costal borders, are little groups of pneumatic foramina, for this bone is highly pneumatic. Sometimes, within the anterior border in the median line, there is a deep, oval, circumscribed concavity, with the pneumatic foramina at its base (*D. autumnalis*, 455). This varies in its form, or may be replaced by a large, single pneumatic foramen.

Prof. R. H. Burne, of the Royal College of Surgeons of England, to whom I am greatly indebted for having examined the sterna of *Dendrocygna fulva*, *D. javanica*, *D. eytoni* and *D. arborea* in the collection of that institution, has, with great kindness made and sent me sketches of this locality in the bone for those several species. His figures show that, in a specimen of *D. (fulva) bicolor*, this "pit" is deep, and divided by a median central "bar", which latter is absent in *D. eytoni* (No. 1430), while in *D. javanica* (No. 1432) the character exists as in *D. fulva (bicolor)*, but the pit and bar are not so marked. The pit is very slightly marked in *D. arborea* (No. 1434).

In *Branta canadensis* (No. 17980, U. S. Nation. Mus.), this "pit" or fossa may be distincly circumscribed, very deep, of an oblong shape (placed lengthwise); with shallow fossae on either side of it, all having pneumatic foramina at their bases. There is no fossa in a specimen of *Aix galericulata*, and only a clean-cut, single, circular pneumatic foramen present. This is the case in a specimen of *Harelda hyemalis;* but in it the foramen is a mere pinhole (No. 18627, Coll. U. S. Nation. Mus.). *Aix sponsa* (No. 18612, Coll. U. S. Nation. Mus.) agrees with *Aix galericulata* (No. 18271, Coll. U. S. Nation. Mus.). In *Mergus serrator* it is a clean-cut, deep, circular pit, with a minute foramen at its base in the middle line; though I am inclined to think that this sternum is non-pneumatic. *Chenonetta jubata* has a medium-sized, circular foramen there, but no pneumatic opening elsewhere in the bone. *Polysticta stelleri* has no fossa there at all, nor foramen, as the sternum of this eider is completely non-pneumatic. In *Olor columbianus* there is a raised median bar sloping backward from the anterior border, with a few foramina upon either side of it. *Cereopsis* has a circumscribed fossa with a group of small pneumatic foramina at its base; while in *Hymenolaemus malacorhynchus* there is a single pit of small size, and the sternum is non-

pneumatic. Without doubt this character varies throughout the Anseres, not only within the genera, but, as in the case of *Dendrocygna*, even the same species may have it quite different in all respects.

Prof. Burne's sketches of the arrangement and character of the xiphoidal processes in *Dendrocygna* are both accurate and interesting. They show that there is always a single pair of "notches" present, and the posterior lateral processes thus formed are always longer than the middle broad one, the postero-lateral angles of which latter may be somewhat produced outward, as in *Dendrocygna arborea* (No. 1434) and *Dendrocygna autumnalis* (454) and 1431 of the Collection of the Royal College of Surgeons of England.

Prof. Burne's sketch of the xiphoidal extremity of *D. javanica* (1432) shows that, in that species, the postero-lateral xiphoidal processes are both longer and broader than in other species, with their distal ends somewhat expanded.

This character in *D. eytoni* (1430) my correspondent shows agrees very well with what we find in *D. bicolor*.

There is very considerable variation in this matter throughout the Anseres; but the variations consist in the relative lengths of the lateral processes; the form of the mid-xiphoidal process; whether there is a pair of large, elliptical foramina present, or a pair of notches, and the form of the distal ends of the processes, — that is, whether they are expanded or otherwise. Now very decided differences may be found to exist in the same genus; for instance, in *Aix galericulata* there are a pair of elongate elliptical foramina present, with a nearly straight transverse xiphoidal border; while in *Aix sponsa* there is a pair of notches present, the mid-xiphoidal process is broad, and its postero-lateral angles produced as long, sharp projections. The posterior lateral processes are long and slender, with their extremities somewhat expanded. This is the condition in *Hymenolaemus malacorhynchus* and other forms.

Already I have shown, in my Osteology of Birds, that *Mergus serrator* (figs. 3 and 4) has large, elliptical foramina instead of notches, which is also true of *Clangula islandica* (fig. 26), and I can now add that it is likewise true of *Charitonetta albeola*, where the foramina are very large and oval, and posteriorly come close to the edge of the long, transverse posterior border of the body of the bone (No. 16627, Coll. U. S. Nation. Mus.).

Eyton has shown that a pair of foramina also exist in "*Clangula vulgaris*", "*Fuligula cristata*", "*Mergus albellus*"; but notches of varying dimensions in "*Rhynchaspis clypeata*", "*Cairina moschata*", "*Tadorna belloni*", and in species of *Anser* and *Cygnus* (Osteologia Avium, Supp. figs. 4—11).

In *Dendrocygna* the sternum is entirely devoid of a manubrium, in fact, there is a well marked, vertical notch occupying the site where, in *Branta canadensis* for instance, there is a laterally compressed, squarish manubrial process of some size. It is thick and trihedral in the Swans (*Olor* etc.), and rather small and insignificant in *Chen* of several species.

Cereopsis novae-hollandiae has no such process whatever on its sternum, nor has *Aix sponsa*, *Aix galericulata*, *Harelda hyemalis*, *Mergus serrator*, or *Charitonetta albeola*, while there is a small, peg-like one on the sterna of *Polysticta stelleri* (where it projects almost directly upwards and very slightly forwards), on *Chenonetta jubata*, *Hymenolaemus malacorhynchus*, in which last it resembles *Polysticta*.

In *Olor* the extensive base of the big manubrial process stands between the articular surfaces within the coracoidal grooves, on the outer anterior border of the sternal body; while, as a rule in other Anseres, these facets for the coracoids meet in the median line at their base, but separated by a mere notch above and below.

In *Dendrocygna autumnalis* the carina of the sternum is deep anteriorly, and it slopes gradually away to within a few millimeters of the hinder margin of the mid-xiphoidal process posteriorly. This is also the case in *Branta*, *Chen*, *Cereopsis*, and others; but in *Aix*, especially in *Aix sponsa*, the keel extends to the very free edge of the sternal body behind. Anteriorly, the carinal angle juts considerably forwards beyond the body of the bone, and it may be acute or rounded off in the same species (*D. autumnalis*, 454, 455), the border above being smooth or jagged.

In *Branta canadensis* the protrusion forwards of the carina is very moderate, while the fore part, from the coracoidal grooves, down about half way to the angle, it is much thickened. This is also the case in *Dendrocygna* and other species.

In *Mergus serrator* the carina is shallow and the angle very acute, projecting far beyond the body of the the bone (fig. 4, Ost. of Birds, p. 261). While the sternum of *Dendrocygna autumnalis* (454) might answer for that bone in almost any ordinary duck, not

far removed from such a species as *Aix sponsa*, still, apart from the presence of a small manubrium in the Goose, it bears a closer resemblance to the sternum of a specimen of *Chen hyperboreus nivalis*, than to the sternum of any other one of the Anseres before me at the present time (No. 18611, Coll. U. S. Nation. Mus.). This resemblance is not only apparent but actual, to the extent of matching, character for character, almost throughout; but this in no way applies to the remainder of the skeleton in these two birds.

The appendicular skeleton.

The Pectoral Limb. As the two North American representatives of the genus *Dendrocygna* are pretty good fliers, — though not as powerful ones, perhaps, as some others of the Anatinae — teals and garrots, for instance they have the skeleton of a wing very well developed indeed. The long bones composing it are strong and of large caliber and proportions, while the two carpals are correspondingly so.

The humerus possesses all the usual ornithic characters as found among the Anatinae generally; although upon comparing the bone in the two sexes of *Dendrocygna autumnalis* and *D. bicolor* and different specimens, some differences are to be observed, both in regard to lengths and other particulars. For example, in a female *D. autumnalis* (454) of the Armstrong series, this bone has a length of 10,4 cms, and is completely pneumatic with a large, subcircular pneumatic foramen occupying its usual site. Another specimen of the same species (455 ♂♂) has a length of 10,1 cm, with a similar pneumatic foramen; while a female, also of this species (453), has a like pneumatic humerus, which possesses a length of but 9,8 cm. The female, No. 457 of this series, of *D. bicolor* unfortunately has both humeri so shattered by shot as to be rendered useless for the purposes of accurate measurement. However, the bone is pneumatic like the rest. In a male of this species (*D. bicolor*, 456) the shaft of the bone is somewhat slenderer than it is in *D. autumnalis*, and it has an extreme length of 10 cm. The same large, pneumatic opening exists at the base of the pneumatic fossa, and air — as in all the previously described ones — is admitted to the entire cavity of the bone.

The *D. autumnalis* (No. 1491) of the osteological collection of

the U. S. Nation. Museum (sex not known) has a humerus that has a length of 9,7 cms, and is likewise pneumatic; but the fossa is very shallow, and only one or two very minute foramina are to be found at its base.

The shaft of the bone is smooth and exhibits the usual sigmoidal curves. It is somewhat compressed from side to side, so that it is ellipsoidal on sections at the shaft's middle. On its upper side, proximally, the radial or superior crest, though well developed, is short, and extends down the shaft hardly more than does the crista inferior or ulnar crest (Fig. 47 and 52 Pl. 8).

Other features of this extremity of the bone are notably salient in character, as the caput humeri and the tuberculum internum, with a deep, oblique incisura capitis between them. At the distal end the radial and ulnar trochleae are very pronounced; while the ectepicondylar and entepicondylar processes are much reduced, as they seem to be in most all Anseres.

In *Aix sponsa* and *Aix galericulata* the humerus is likewise highly pneumatic, — the bone in these species being short and stout and but moderately curved. The caput humeri is made very prominent by the unusual depth of the incisura capitis and conspicuous tuberculum internum.

The depth of the pneumatic fossa in the humerus of *Chenonetta jubata* is remarkable, and I have never seen its equal in the humerus of any bird of its size before. The bone is pneumatic, and a nutrient foramen is to be found at the middle of the shaft. From all appearances, the humerus in *Polysticta stelleri* seems to be non-pneumatic, and its radial or superior crest is short but prominent. The distal trochleae are very protuberant and elegantly rounded off. (No. 15272, U. S. Nation. Mus., Ost. Coll.). Having similar characters, pneumatic withal; smaller radial and ulnar tubercles, and a slenderer shaft, — the humerus of *Harelda hyemalis* has a length of 7,5 cms.

In *Chen hyperboreus nivalis* the bone is highly pneumatic, with a large, subcircular entrance in the pneumatic fossa. The projections at the ends of the shaft forming its usual characters are not so prominently developed as in the humeri of most Anatinae, the radial crest being low and produced somewhat further down the shaft. This latter exhibits the usual sigmoid curves, and is large in caliber, being almost cylindrical at its middle third.

Cereopsis, with a very prominent pneumatic humerus, has its

processes, tubercles and other characters still more subordinated. However, the radial crest here is lofty and long, being much curved toward the palmar side. In *Olor*, this crest is much lower, and extends still further down the shaft. The elegant humerus in skeletons of any of this genus is highly pneumatic, and extremely light for its size. *Olor columbianus* has the bone measuring 23,2 cms in length; while in *Olor buccinator* it averages 25,5 cms in length.

Everything else being equal, apart from the matter of size, it differs from the humerus in *Dendrocygna* and the Anatinae generally in having the superior or radial crest so low, and extending down the shaft so much beyond the inferior or ulnar one, whereas in the latter, or the ducks, the radial and ulnar crests are of about equal length, the former being, as a rule, but very slightly longer, — that is, it extends down the shaft a trifle further.

It would appear that, in a number of ducks, the humerus may be non-pneumatic, as it is in *Charitonetta albeola* and *Polysticta.*[1])

The peculiarity of the humerus in *Dendrocygna* is its unusual length for the relative size of the bird. In *D. autumnalis* it averages 22 mm longer than the keel of its sternum. In *Polysticta stelleri* its humerus is several millimeters shorter than the keel of its sternum; while in *Aix sponsa* its humerus is 17,5 mm shorter than the keel of the bone in that species. This is also the case in most all ducks; though in such a species as *Chenonetta jubata*, the humerus of its skeleton measures 14 mm longer than the keel of its sternum. However this may be, the bone in Swans and Geese is always very much longer than the keel of the sternum of the skeleton of the same individual wherein the measurement is made; while in the Anatinae, with perhaps a few exceptions, it is always more or less shorter.

With respect to the bones of the antibrachium and manus,

1) In my Osteology of Birds, published by the State Museum at Albany, N. Y., I have briefly described a few more humeri of the Anseres; and, in referring to the humerus of the goose figured in Newton's Dictionary of Birds (pt. 2, p. 439), I remark that it must have been drawn from one furnished by the common domestic goose, as the characters are quite different from what we find among the wild species of that genus or genera generally. It illustrates the article „humerus" by Dr. Hans Gadow, and not by Mr. Beddard as there stated (p. 325).

they are always completely non-pneumatic, as they are among the Anatinae generally. In *Chen*, the ulna may be pneumatic, though the foramina at its proximal end are very minute. Then, too, the radius and carpo-metacarpus appear to be so in this species, though I have failed to locate the foramina. *Branta canadensis* has a pneumatic ulna, and the radius and carpo-metacarpus, I believe, also enjoy that condition, though I have succeeded only, in the case of the latter bone, in locating a single minute air-hole. It is at the base of the fossa on the palmar side of the head, posterior to the there-existing process formed by the united first distal carpal.

Among the Cygninae, as far as I have examined them, the humerus is the only bone of the pectoral limb that is pneumatic, — agreeing with the Anatinae in this respect.

In *Dendrocygna autumnalis* (454) it has an extreme length of 118 mm. Its shaft is moderately concaved toward the interosseous space, the arc being most evident for its proximal third. The "quill-butts" for the insertion of the secondary wing-feathers are but feebly developed down the palmar aspect of the rather stout subcylindrical shaft. At the extremities of the latter, we find the usual enlargements and articular cavities, or other surfaces, for the humerus and radius proximally, and the ulnare carpal distally.

From end to end, the smooth, somewhat slender shaft of the radius is nearly straight, while its extremities offer the usual articular surfaces and facets for the humerus and ulna proximally, and for the radiale carpal distally. At its widest part, which is at the proximal thirds of the bones of the forearm, the interosseous space, at its widest interval, measures 7 mm.

From what has gone before it will be noted that the bones of the antibrachium are, in *Dendrocygna*, but slightly longer than the humerus. In *Olor columbianus*, the ulna and the humerus are about of equal length, and this is likewise the case in *Chen hyperboreus nivalis* and nearly so in *Cereopsis;* while in *Polysticta stelleri*, *Aix sponsa*, *Chenonetta jubata*, *Hymenolaemus malacorhynchus*, and in the Merginae the humerus is, as is probably the case in many other ducks, considerably longer than the ulna in any particular wing of any species. Presenting nothing worthy of especial note, the ulnare and radiale of the carpus have the usual character of those bones among the Anseres generally. Doubtless, were they to be critically compared, with respect to comparative pro-

portions for the Ducks, Geese and Swans, some few differences might be met with; but in the present work I have not undertaken such comparisons.[1])

There seems to be considerable similiarity, with respect to the several bones of the manus throughout the Anseres, in so far as the morphology of them is concerned. Proportionately, they are found to differ in lengths, with respect to the bones of the arm and forearm in any particular species; but this has nothing to do with the characters they present.

Dendrocygna autumnalis (454) has the carpo-metacarpus very long, in agreement with the other long bones of its wing. It measures 59 mm in length, and in its general facies and character it closely resembles the corresponding bone in *Olor columbianus*, which latter has a length of 120 mm. The shafts of second and third metacarpals are quite straight and nearly parallel to each other. Among the Anatinae the third metacarpal is almost always inclined to be more bowed, the concavity being toward the main shaft of the bone. This is decidedly the case in ducks with relatively short carpo-metacarpals, as *Chenonetta jubata*, *Aix sponsa*, and probably many others. The proximal head of the bone is always large, and the coossified first metacarpal prominent, especially in the Swans, where we find, too, that, at the distal end of the bone, the shaft of the third metacarpal is somewhat longer than the second, which is likewise the case in *Dendrocygna*, but not in *Chen* and most Anatinae. Pollex digit has a length of about two centimeters in *D. autumnalis*, and is much compressed from side do side, though only its anterior border is at all sharp. Distally, it bears a small, free claw, as do both the ducks and the swans.[2])

There is also a free claw articulating with the extremity of the distal phalanx of the index digit, which latter is somewhat smaller, but has much the same form as the pollex digit. The small, free phalanx of third metacarpal has a length of some 12,5 mm, and has a low, rounded elevation upon the middle of its posterior border. This phalanx does not bear a claw in *Dendrocygna*.

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1) Most of the skeletons of the Anseres in the collection of the U. S. National Museum are ligamentous preparations; and in such, these two bones of the carpal joint are firmly encased in the surrounding ligaments, making proper examinations or observations impossible.

2) Parker, W. K., On the morphology of the Duck and Auk tribes, tab. 2 figs. 4 and 7, tab. 3 fig. 7.

With its usual ornithic characters, the proximal phalanx of the first finger is narrow and elongate, and its flattened posterior portion presents no vacuities as it often does in other birds.

The Pelvic Limb. Fifty-six millimeters is about the length of the femur in a specimen of *Dendrocygna autumnalis* (454), and the bone is thoroughly non-pneumatic. Superiorly, the small, semi-globular head, the flat summit, and the upper margin of the antero-posteriorly broad trochanter major are in the same plane, caput femoris being separated from the summit merely by a shallow groove. There is scarcely any "neck" to the head, and upon the latter the pit for the ligamentum teres is very small.

The femoral shaft is nearly straight and subcylindrical, while the linea aspera upon it, and that of the femuro-tibial attachment, are very well marked. The tubercle for the insertion of the loop of the biceps cruris is quite prominent, while the fossa poplitea is but moderately excavated. Either condyle is of good size, and the intercondylar groove of some depth, and in fact the femur in *Dendrocygna* presents no very peculiar characters, it having all the usual ornithic features as seen in the average pelvic limb of the Anseres generally (Fig. 45, Pl. 8; Fig. 73, Pl. 10; Fig. 82, Pl. 11 and Fig. 21, Pl. 4).

Proportionately, the femur in *Olor* is much stouter and shorter than it is in either species of the North American "Tree-Ducks"; but, otherwise like it, it is completely non-pneumatic. Short and very straight, the bone is *Cereopsis* has the proximal extremity, including the trochanter and head, large, with practically no neck to the latter.

In *Chenonetta* the superior border of the trochanter major is slightly raised above the summit, and is concave toward the femoral head. In this duck, the inner condyle is much elevated, and the antero-intercondylar channel deep and broad (Fig. 73, Pl. 10).

Chen hyperboreus nivalis has a femur 78 mm long, and in it we find the dendrocygnine characters all repeated; but this might, with almost equal truth, be said of the femur of *Aix sponsa*.

My investigations, as far as I have carried them, incline me to believe that the patella never ossifies in any of the Anseres, and in *Dendrocygna* it consists of a large, dense piece of cartilage, having both the form and fulfilling the part of a good-sized patella; this also obtains in other anserine birds.

Measuring from the highest point on the entocnemial process

of the tibio-tarsus of *Dendrocygna autumnalis* (454) to the lowest point on the inner condyle at the distal end of the shaft, this bone of the leg is seen to have an extreme length of 114 mm, while the fibula has a length of but 60 mm.

The tibio-tarsus is nearly straight from end to end, the shaft between the extremities being subcylindrical in form, and somewhat compressed antero-posteriorly. Proximally, the cnemial processes are very conspicuous, the entocnemial one being a broad lamina of bone, reared above the shaft's summit, and projecting directly forwards. On the other hand, the ectocnemial process is triangular, smaller, and with convex, thickened, free superior border projects directly inwards, towards the median plane, the pelvic limb being articulated as in life. This process, or rather its inner angle, stands directly in front of the head of the fibula in the articulated skeleton. The summit of the shaft presents the usual concavities for the condyles of the femur, and the fibular ridge is prominent on the outer side of the shaft for rather more than its superior third. At the lower part of the shaft in front, we find the usual "tendinal canal", which is deep distally, where it is spanned by a bridgelet of bone, which in life hold certain tendons in the aforesaid channel (Fig. 82, Pl. 11).

The condyles are of about equal size, the outer one being somewhat more circular in outline than the inner, the latter being kidney-shaped. Both anteriorly and posteriorly they are well separated from each other by the intercondylar space or groove.

At a short distance below the fibular ridge on the outer aspect of the tibio-tarsal shaft, the very slender distal moiety of the fibula meets the latter, to have its extremity fuse with it. This takes place at a point about at the junction of middle and lower thirds, below which point no trace of the fibula is to be seen.

At its proximal end, the head of the fibula is rather large, comparatively speaking, with respect to the balance of the bone, and compressed from side to side. On the posterior aspect of its shaft, at a point about opposite the middle of the fibular ridge on the tibiotarsus, we find the usual tubercle for the insertion of the tendons of the biceps flexor cruris (No. 99, Myology of the Raven).

In *Branta canadensis* the fibula may be traced as far as the ankle-joint; though from the middle of the shaft of the tibio-tarsus it is thoroughly fused with the shaft of that bone. Distally, it

terminates in a distinct, elongate tubercle, corresponding to an "external malleolus".

The characters of the tibio-tarsus in *Branta* agree with the corresponding ones in *Dendrocygna.*

In *Chen* the cnemial crests are somewhat reduced, and do not rise so much above the shaft's summit as is usually seen among the Anseres. The fibular ridge in the genus is thick and short and placed high up on the tibio-tarsal shaft.

Apart from the matter of size — the swan's being much the larger of course — the tibio-tarsus and fibula in *Olor* agree very well with those bones as I have described them for *Dendrocygna.*

In *Charitonetta albeola* the cnemial processes of the tibio-tarsus take on a form somewhat resembling the form they assume in some of the smaller grebes, only the combined process in the duck is not so lofty, — though for a duck, its cnemial process, on either side, is extended notably above the summit of the bone from which it projects, — the ectocnemial and endocnemial processes meeting, proximally, at a common point. This is also true of *Clangula* (Osteology of Birds, p. 302), in which genus the processes „are carried up in such a manner as almost to rival the grebe in this particular, having very much the same form."

As compared with the rest of the skeleton of the pelvic limb, the tarso-metatarsus in *Dendrocygna autumnalis* (454) is unusually long and stout, and, proportionately, notably more so than in *D. bicolor.* On the internal lateral border of its summit it sends up quite a conspicuous process, which, in the articulated limb, is applied to the inner side of the internal condyle of the tibio-tarsus.

Low, short, and bulky in form, the hypotarsus is 4-times longitudinally grooved for the passage of the tendons passing down behind the shaft for insertion below. The outer groove is shallow and short, while the inner one is largely overarched by the inner side of the hypotarsus rising up and curling over it.

Anteriorly, the shaft is concaved longitudinally above; while posteriorly it is flat and marked by three longitudinal ridges running down its entire length, for the better guidance of tendons.

The distal trochleae are large, especially the central one, which is placed much the lowest on the shaft; next comes the outer one, while the elevated small internal one is placed posteriorly and

directed backward. An accessory or first metatarsal is comparatively large and attached by ligament in the usual manner.

First joint of hallux is long, having a length of 17 mm, and the claw to this toe is likewise of good size, though somewhat smaller than any of the claws on the anterior toes.

Although presenting nothing worthy of especial note in their morphology, it is to be noted that the joints of the three anterior phalanges of pes are all straight, stout, and long bones.

In my Osteology of Birds (p. 330, cited above), I give the measurements for all the joints of the four toes in *Branta canadensis*; some for *Olor*, and others for certain Anatinae; and, as these pedal joints do not differ much in character, it will not be neccessary to make a record of much more upon this subject.

In ordinary Anatinae, the skeleton of the feet is generally far more delicately constructed than it is in *Dendrocygna*. This is very noticeable in such species as *Polysticta stelleri*, *Aix sponsa*, and others; while in such a fuliguline duck as *Charitonetta albeola*, the basal joint of hallux is of extreme slenderness, and those of the other toes are of markedly small calibers with respect to the size of their shafts.

The proportionate lengths of the basal joints of the three anterior toes vary among the Anseres, as we would naturally expect. For examples of this I submit the following data in the subjoined Table.

Lengths of the basal joints of pedal digits in certain Anseres in millimeters.

	Outer toe	Middle toe	Inner toe
Dendrocygna autumnalis	23,5	30,5	28,0
Olor buccinator	42,5	51,0	48,0
Branta canadensis	32,0	40,0	40,0
Aix sponsa	15,0	19,0	19,0
Polysticta stelleri	18,0	23,0	23,0
Hymenolaemus malacorhynchus	20,0	25,0	24,0
Charitonetta albeola	15,0	20,0	20,5

Judging from these measurements, it would appear that, everything else being equal *Dendrocygna autumnalis* comes nearer to *Olor buccinator* in the proportional lengths of the basal joints of the anterior phalanges of pes, than it does to any of the ducks wherein

the length of the basal joint of the inner toe equals that of the basal joint of the middle one — or very nearly equals it; while in *Olor*, as well as in *Dendrocygna*, the length of the basal phalanx of the inner toe is always less than that of the basal phalanx of the middle toe.

This is also the case, however, in *Cereopsis novae-hollandiae*, and *Branta canadensis*, too, agrees in this matter with the ducks.

Brief recapitulation of the skeletal characters in *Dendrocygna* as compared with those of other Anseres.

In the skull, *Dendrocygna* has a character not found — in so far as I know up to the present time — in any other known anserine bird, and that is: its orbits are completely surrounded by bone, through a meeting and extensive coossification of the extremities of the sphenotic process and the lacrymal bone of either side. An approach to this condition is found in both ducks and swans in certain genera, as in *Clangula* and in *Olor*.

Apart from this character, the skull of *Dendrocygna* agrees, in most particulars, with the skull in any typical species of the genus *Olor*; while, at the same time, it differs in many important points with the skull in all the genera of geese examined by me. It comes very much nearer the skull of such a duck as *Anas platyrhynchus* than it does to that of any goose or swan.

Dendrocygna is, in the matter of the morphology of its respiratory and vocal organs, more closely related to certain ducks, than it is to any of the geese, and in this respect has no affinity with any of the Cygninae with which I have compared it.

It is an important as well as a very significant fact that, in its vertebral column and ribs, *Dendrocygna* distinctly agrees with certain Anatinae, and not with any of the geese or swans.

With respect to its pelvis, it may be said that, in its general form, it resembles the pelves of some Cygninae, and to a less degree that of certain Anserinae. This refers especially to the bone being long and narrow, while in other particulars the pelvis of *Dendrocygna autumnalis* distinctly agrees with that part of the skeleton in certain ducks, and, as a matter of fact, comes very much nearer the pelvis of *Mergus serrator* than it does to the pelvis of any of the latter.

Dendrocygna has the bones of its pectoral arch more anatine in character than cygnine.

Dendrocygna autumnalis has a sternum that might answer for that of any ordinary duck, as for example *Aix sponsa;* while on the other hand, it agrees with the sternum of *Chen hyperboreus nivalis*, all but the difference that the latter bird possesses a small manubrial process upon its sternum, which that bone lacks entirely in *Dendrocygna.*

With respect to the characters to be found in its appendicular skeleton, *Dendrocygna autumnalis* presents an interesting mixture indicating anatine, anserine and cygnine affinities, first one and then another preponderating as various comparisons are made. It would be almost safe to say that these Tree-Ducks, in so far as the appendicular part of their skeleton goes, and the comparable characters it presents, are just as nearly related to the Anatinae as they are to the Anserinae or Cygninae, or to either of the latter as they are to the former.

On the whole, however, the characters presented on the part of the skeleton in *Dendrocygna autumnalis* point very clearly to the fact, that it has a closer affinity with the Anatinae, than it has with either the swans or the geese, and probably the other members of the genus are similarly related.

On the Systematic Position of the Tree-Ducks.

Having demonstrated that representatives of the genus *Dendrocygna* are, morphologically, more nearly related to the Anatinae than to any other subfamily of the Anatidae, it now but remains to present a taxonomical scheme, which will indicate the position they occupy in the system.

Almost without exception the most eminent ornithologists and avian taxonomers of the Old World have, long ago, relegated them to a place where they belong among the Anatinae, recognizing, as they do, the fact that they are certainly neither swans or geese.

In the first part of this paper I have already presented the views of some of the authorities on this question, as Sharpe, Eyton, Salvadori, and others.

More than three years ago, I pointed out in my "Osteology of

Birds" the fact that *Dendrocygna* belonged with the ducks among the Anatidae.

Coues, among American ornithologists, came very near arraying the genus with its true congeners in the last edition of his "Key"; but in this he failed, as he sometimes failed otherwise, when he undertook to succeed through misrepresentation. As he was responsible for the classification of Birds, set forth in the Century Dictionary, it is now clear that he was in error when he said of *Dendrocygna* that it was "A genus of arboricole duck-like geese", (Vol. 2, p. 1532) which they most assuredly are not.

In the third edition (1910) of the A. O. U. Check-List of North American Birds, the genus *Dendrocygna* of Swainson is placed between the Anserinae and the Cygniae; but for what reason I have been unable to ascertain. As accurate as that excellent work is, in the matter of species and subspecies, defintion, and the ranges of North American birds, I hardly think that the avian morphologist is prepared to take the classification it proposes in any way seriously.

My present views upon the classification of the Anseres are as follows:

Suborder	Families	Subfamilies
Anseres	Anatidae	1. Cygninae 2. Anseranatinae 3. Plectropterinae 4. Cereopsinae 5. Anserinae 6. Dendrocygninae 7. Chenonettinae 8. Anatinae 9. Fuligulinae 10. Erismaturinae 11. Merganettinae 12. Merginae
	Gastornithidae (extinct: provisional)	Not determined

The Dendrocygninae may be characterized as an arboricole subfamily of ducks, with very long legs; tibio-tarsi distally more or less denuded; mid toe considerably more than one-third the length of the tarsus; thecae of leg and tarso-metatarsus, reticulated; superior mandible longer than skull, its theca terminating distally

in a conspicuous decurved nail; orbits of the cranium completely surrounded by bone, and having but seventeen cervical vertebrae.

As thus constituted, this subfamily of ducks occupy, in any lineal scheme of classification, or in any sequential classificatory presentation — apart from a phylogenetic tree of birds — a place in the Anatidae, between the Anserinae and the Chenonettinae, which is the position they hold in the system by virtue of the morphological characters they present in their structure.

Explanation of the Plates.

The colored Plates are reproductions of drawings made by the author, who likewise made all the photographs for the half-tone illustrations. Both the colored Plates and the figures of the bones of the skeletons on the other Plates were made direct from material in the Collections of the United States National Museum, which was loaned the author for the purpose.

Plate 1.

Fig. 1 (upper figure). Head of *Dendrocygna viduata*, ♂ ad. Right side. (From skin No. 16540, U. S. Nation. Mus.) Natural size.

Fig. 2 (next below Fig. 1). *Dendrocygna arcuata* (No. 121312, Coll. U. S. Nation. Mus.). Adult. Nat. size (sex not recorded).

Fig. 3 (third from top.). *Dendrocygna javanica*, ♂ ad. (No. 95526, Coll. U. S. Nation. Mus.). Natural size.

Fig. 4 (lowermost one). *Dendrocygna discolor*, ♂ ad. (No. 121111, Coll. U. S. Nation. Mus.). Natural size.

Fig. 5 (top figure). *Dendrocygna guttulata*, ♀ ad. (No. 200815, Coll. U. S. Nation. Mus.). Natural size.

Fig. 6 (middle figure). *Dendrocygna eytoni*, ♂ ad. (No. 71635, Coll. U. S. Nation. Mus.). Natural size.

Fig. 7 (lowermost figure). *Dendrocygna arborea* (ad. ♀ on original label; ♂ on Nation. Mus. label.) (No. 16, 1903, Coll. U. S. Nation. Mus.).

Plate 2.

Fig. 8 (upper figure). *Dendrocygna bicolor*, ♀ ad. Reduced. From skin in Coll. U. S. Nation. Mus., No. 135590.

Fig. 9 (lower figure). *Dendrocygna autumnalis*, ♂ ad. From skin in Coll. U. S. Nation. Mus., No. 112428.

Plate 3.

Fig. 10. Right lateral aspect of the head of *Dendrocygna bicolor*, ♀ ad. Photograph by author of skin, No. 135590, Coll. U. S. Nation. Mus. Natural size. Collected April 30, 1894 by Dr. Edgar A. Mearns at Unlucky Lake, San Diego, California.

Fig. 11. Right lateral view of the skull and mandible (detached) of *Cereopsis novae hollandiae*. Slightly reduced. Extreme length of skull 92 mm (No. 19711, Coll. U. S. Nation. Mus.).

Fig. 12. Right lateral view of the skull and mandible (detached) of a specimen of *Dendrocygna autumnalis*, ♀ (No. 454). Slightly reduced. Extreme length of skull 98 mm. F. B. Armstrong collector (Texas).

Fig. 13. Right lateral view of the skull and mandible (detached) of a specimen of *Hymenolaemus malacorhynchus*, ♀ ad (No. 19024, Coll. U. S. Nation. Mus.). Slightly reduced. Extreme length of skull 90 mm.

Fig. 14. Right lateral view of the skull and mandible (detached) of a specimen of *Chloephaga poliocephala*, ♀ ad. (No. 18202, Coll. U. S. Nation. Mus.). Slightly reduced. Extreme length of skull 81 mm. The extreme lengths of these four skulls were measured, in each case, from the most anterior median point of the superior mandible on a direct straight line to the most posterior median point on the summit (externally) of the occipital protuberance.

Plate 4.

Fig. 15. Superior aspect of the skull of *Dendrocygna autumnalis*. Mandible removed. Same skull as shown in Fig. 12, Plate 3.

Fig. 16. Superior view of the skull of *Hymenolaemus malacorhynchus*. Mandible removed. Same skull as shown in Fig. 13, Plate 3.

Fig. 17. Superior view of the skull of *Cereopsis novae hollandiae*. Mandible removed. Same skull as shown in Fig. 11, Plate 3.

Fig. 18. Superior view of the skull of *Chloephaga poliocephala*. Mandible removed. Same skull as shown in Fig. 14, Plate 3.

Fig. 19. Right lateral view of the skull and mandible of a specimen of *Branta canadensis*, adult. Somewhat enlarged (No. 17980, Coll. U. S. Nation. Mus.). Extreme length of skull 123,5 mm.

Fig. 20. Os furcula of *Branta canadensis*. Right clavicle shows external view. Slightly enlarged (No. 17980, Coll. U. S. Nation. Mus.).

Fig. 21. Anterior view of left femur of *Branta canadensis*, adult (No. 17980, Coll. U. S. Nation. Mus.). Slightly enlarged. Extreme length 87,5 mm.

Fig. 22. Left scapula; dorsal surface of *Branta canadensis* (No. 17980, Coll. U. S. Nation. Mus.). Slightly enlarged. Extreme length (chord of its arc) 111,5 mm.

Fig. 23. Index digit of right pectoral limb of *Branta canadensis* (No. 18980, Coll. U. S. Nation. Mus.). Palmar aspect. Slightly enlarged. (A portion of the quill of a feather of the alula covers the distal phalanx, having been allowed to remain by the one who prepared the skeleton.) Total length of this digit 83 mm.

Plate 5.

Fig. 24. Right lateral view of the skull and mandible (detached) of a specimen of *Anser albifrons gambeli*, ♀. Adult (No. 7327, Coll. U. S. Nation. Mus.). Natural size.

Fig. 25. Right lateral view of the skull and mandible (detached) of a specimen of *Branta canadensis hutchinsi*. Adult (No. 7357, Coll. U. S. Nation. Mus.). Natural size.

Fig. 26. Superior view of the skull of a specimen of *Oidemia perspicillata*. Adult (No. 81712, Coll. U. S. Nation. Mus.). Natural size. Mandible removed. Shows the post-narial mandibular enlargements which normally occur in this scoter.

Fig. 27. Left lateral view of the skull and mandible (detached) of a Canvas-back duck (*Marila valisineria*). Nat. Size. Adult ♂ (No. 5040, Coll. U. S. Nation. Mus.). [1])

Fig. 28. Right lateral view of the skull and mandible (detached) of a specimen of *Somateria v-nigra*. Adult. Natural size (No. 7332, Coll. U. S. Nation. Mus.).

Fig. 29. Superior view of the skull of *Somateria v-nigra*. Mandible removed. Nat. Size. Same skull as shown in Fig. 28.

Plate 6.

The extreme length in the case of any one of the skulls in Figs. 30—34 is increased by about 2 mm, making the enlargement very slight. All are from adults and all from the Coll. U. S. Nation. Mus. Numbers alone will be given under the Figures.

Fig. 30. Right lateral view of the skull and mandible of a specimen of *Charitonetta albeola* (No. 19035). Part of the horny mandibular theca has been allowed to remain attached.

Fig. 31. Left lateral view of the skull and mandible (detached) of *Aix sponsa* (No. 192).

Fig. 32. Right lateral view of the skull and mandible of a specimen of *Chaulelasmus streperus* (No. 17149).

Fig. 33. Inferior or basal view of the skull of a specimen of Ruddy Duck (*Erismatura jamaicensis*) (No. 11220). Mandible removed.

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1) Named for Antonio Valisneri, an Italian naturalist, and it was Wilson who inaugurated the list of orthographic blunders made in the case of the specific name of this bird.

Fig. 34. Superior view of the skull of a Canvas-back. Mandible removed. Same specimen as shown in Fig. 27, Pl. 5.

The skulls in Figs. 35—38 are all from adult specimens; the figures are all natural size. They belong to the Collections of the U. S. Nation. Mus. Numbers alone are given under the several Figures.

Fig. 35. Left lateral view of the skull and mandible (detached) of a specimen of *Chloephaga hybrida* (No. 1820).

Fig. 36. Superior view of the skull of a specimen of the Mallard (*Anas platyrhynchos*). Adult. Mandible removed (No. 17118).

Fig. 37. Right lateral view of the skull and articular mandible of a specimen of *Nettion carolinensis* (No. 19469).

Fig. 38. Left lateral view of the skull and detached mandible of a Mallard; the same specimen as shown in Fig. 36 of this Plate.

Plate 7.

Fig. 39. Superior view of the skull of a specimen of the Whistling Swan (*Olor columbianus*), mandible removed. Adult. Natural size (No. 19411, Coll. U. S. Nation. Mus.).

Fig. 40. Same skull as shown in Fig. 39. Right lateral view with mandible detached (see Figs. 41—43).

Fig. 41. Basal view of the skull of *Olor columbianus*. Mandible removed. Same specimen as figured in Figs. 39 and 40. Nat. size.

Fig. 42. Mandible from the skeleton which furnished the skull of the Swan shown in Figs. 39, 40, and 41 (*O. columbianus*, No. 19411). Seen from above. Nat. size.

Fig. 43. Same mandible as figured in Fig. 42. Seen from below. Nat. size (*O. columbianus*, No. 19411).

Plate 8.

Bones of a skeleton of a specimen of *Dendrocygna autumnalis*. Adult. Reduced. Extreme length of skull measures 95 mm. No. 1491, Coll. U. S. Nation. Mus.).

Fig. 44. Right lateral view of skull and detached mandible.

Fig. 45. Left femur; anterior view. Length of this bone equals 53,5 mm.

Fig. 46. Right carpo-metacarpus; anconal aspect. Lower end of bone exhibits pathological enlargement. Length 55 mm.

Fig. 47. Left humerus, anconal side. Extreme length of this bone 97 mm.

Fig. 48. Anterior aspect of the right tibio-tarsus and fibula. Extreme length of the tibio-tarsus equals 95,5 mm.

Fig. 49. The sternum seen upon left lateral aspect. The first costal rib of the left side articulated in position. Length 86 mm (from carinal angle to mid-posterior point of the body of the bone).

Fig. 50. Anterior aspect of the right tarso-metatarsus. Extreme length equals 62 mm.

Fig. 51. Dorsal aspect of pelvis; some of the posterior dorsal and pelvic ribs; and the last cervical vertebra and the five dorsal vertebrae. When viewed from above, as in the figure, it will be observed that the anterior part of the pelvis of this skeleton is curiously twisted to the left. This distortion is still more perceptible upon the ventral aspect of the bone, as it exhibits the way in which the leading sacral vertebrae are involved.

Fig. 52. Right pectoral limb of a specimen of *Dendrocygna autumnalis*, ♀ (453), viewed upon anconal aspect. Collected by Mr. F. B. Armstrong, Brownsville, Texas. Natural size.

Fig. 53. Basal view of the skull of a specimen of *Dendrocygna bicolor*, ♂. Mandible removed. Nat. size. Adult. Collected by F. B. Armstrong (456).

Fig. 54. Basal view of the skull of a specimen of *Dendrocygna autumnalis*, ♀. Adult. Nat. size. Mandible removed. Collected by F. B. Armstrong, Brownsville, Texas (454).

Fig. 55. Dorsal aspect of pelvis and caudal vertebrae including pygostyle. *Dendrocygna bicolor*, from the same skeleton which furnished the skull shown in Fig. 53 of this Plate. Nat. size.

Plate 9.

Fig. 56. Left tarso-metatarsus, anterior surface, of a Steller's Eider (*Polysticte stelleri*). About natural size. Adult (No. 15272, Coll. U. S. Nation. Mus.).

Fig. 57. Oblique antero-superior view of the shoulder girdle of *Polysticte stelleri*. Same skeleton as the one which furnishes the other bones of this eider here figured.

Fig. 58. Left pelvic limb (femur, patella, tibio-tarsus and fibula) of *Polysticte stelleri* (see Figs. 56, 57). About nat. size; external aspect.

Fig. 59. Superior view of the lower mandible of *Polysticte stelleri*. About nat. size. Adult (Figs. 56—58).

Fig. 60, 61. Left lateral views of skulls, leading cervical vertebrae etc. of specimens of Old-squaw Ducks (*Harelda hyemalis*) Almost natural size. Adults. (Both have the same number, i. e. No. 19467, Coll. U. S. Nation. Mus.) The sclerotal ring of bones is in situ in Fig. 60, and in it the mandible is articulated. It also has attached to it the atlas, axis, and third, fourth and fifth cervicals. This note also applies to Fig. 61; but here the sclerotal ring has been removed, and there is one less cervical vertebra (the fifth). Portions of the horny covering have been left on the upper mandibles. Nat. size.

Fig. 62. Left humerus of Steller's Eider (*Polysticte stelleri*).

Very slightly enlarged. From skeleton No. 15272, Coll. U. S. Nation. Mus. Anconal aspect. Extreme length 72 mm.

The bones figured in this Plate are of a specimen of the Old-squaw Duck (*Harelda hyemalis*). Adult (No. 18627, Coll. U. S. Nation. Mus.). They are somewhat reduced; the extreme length of the humerus in Fig. 65 being 76 mm.

Fig. 63. Left coracoid and scapula; oblique anterior view.

Fig. 64. Right lateral aspect of the sternum, with costal ribs of that side, all to the first one.

Fig. 65. Left humerus, anconal aspect.

Fig. 66. Left lateral view of the skull and mandible.

Fig. 67. The os furcula seen upon right lateral aspect. The left clavicle shows beyond, — its mesial surface.

Fig. 68. Dorsal view of parts of the trunk skeleton, with the bones seen normally articulated. The right pubic element is broken off. Five dorsal vertebrae are in position with their vertebral ribs. There are also two pairs of sacral ribs. This pelvis is very delicately constructed, and the postacetabular sacral vertebrae remarkably individualized.

Plate 10.

The bones of *Chenonetta jubata* figured in this Plate are of a specimen in the Collections of the U. S. Nation. Mus., No. 19213. They are probably subfossil, having been found in a cave, and they came from Otago, N. Zealand. Adult. Natural size. The bones shown in Figs. 69 and 76 are broken and imperfect.

Fig. 69. Dorsal view of pelvis.

Fig. 70. Dorsal view of left scapula. Note the absence of the pneumatic foramen at its anterior extremity.

Fig. 71. Right carpo-metacarpus; palmar aspect.

Fig. 72. Left tarso-metatarsus; anterior surface.

Fig. 73. Left femur; anterior surface.

Fig. 74. Left coracoid; seen from in front.

Fig. 75. The os furcula; direct anterior view, exhibiting the marked circularity of the arch.

Fig. 76. The skull from above. Superior mandible broken off and only partially in position. Zygomas gone and mandible removed. This figure, however, gives the general form of the skull on its superior aspect.

Fig. 77. The right humerus; anconal aspect.

Fig. 78. Direct ventral view of the sternum.

Fig. 79. Dorsal aspect of the pelvis and attached ribs of the Canada Goose (*Branta canadensis*). Adult. Much reduced (No. 17980,

Coll. U. S. Nation. Mus.). Median longitudinal length of sacrum equals 154 mm.

Fig. 80. Dorsal aspect of the pelvis of *Chen coerulescens* Adult (No. 18613, Coll. U. S. Nation. Mus.). Much reduced. Median longitudinal length of sacrum equals 110 mm.

Fig. 81. Ventral aspect of the sternum of *Branta canadensis* with the costal ribs of the left side attached thereto. Much reduced. From the same skeleton which furnished the pelvis shown in Fig. 79 of this Plate, and reduced in the same proportion.

Plate 11.

Fig. 82. Inner aspect of the left pelvic limb of a specimen of *Dendrocygna autumnalis*, adult ♀. Collected by Mr. F. B. Armstrong, Brownsville, Texas. Complete and natural size. Introduced to show the difference of the podothecae of the feet as compared with that in the Wood Duck (Fig. 83). Preparation partly ligamentous.

Fig. 83. Inner aspect of the left foot of a specimen of the Wood Duck (*Aix sponsa*). No. 18512, Coll. U. S. Nation. Mus. Introduced for comparison with the foot shown in Fig. 82 of this Plate. In *Dendrocygna* the tarsi are largely reticulated, while in *Aix* they are scutellated.

Fig. 84. Dorsal view of the pelvis of a specimen of the Chinese Mandarin Teal (*Aix galericulata*). Adult; natural size (Coll. U. S. Nation. Mus. No. 18271).

Fig. 85. Imperfect skull of *Aix galericulata*; superior view. Nat. size (Coll. U. S. Nation. Mus. No. 18271). Imperfect. Mandible removed. Same bird that furnished the pelvis shown in Fig. 84.

Fig. 86. Inner surface of left tarso-metatarsus of Steller's Eider (*Polysticta stelleri*) (No. 15272, Coll. U. S. Nation. Mus.). Nat. size. Same bone as the one shown on anterior view in Plate 9 Fig. 56.

Fig. 87. Left lateral view of the skull and mandible (detached) of *Polysticta stelleri*. Adult. Nat. size. Occipital area cut away; otherwise perfect (No. 15272, Coll. U. S. Nation. Mus.).

Fig. 88. Antibrachium and manus of *Polysticta stelleri*. Palmar aspect. Nat. size. From the same skeleton that furnished the skull shown in Fig. 86 and other bones.

Fig. 88'. Anconal side of right humerus of an extinct Brant (*Branta propinqua* Shuf.). Fossil from the Oregon Desert. Nat. size. Nearly perfect.

Fig. 89—92. Bones from fossil specimens of *Anser albifrons gambeli*. Fig. 89, anterior surface of a right femur; Fig. 90, anterior surface of a right coracoid; Fig. 91, posterior surface of a left coracoid; Fig. 92, proximal part of a right carpo-metacarpus, anconal view. All natural size. Figs. 88—92 photos by the author from the specimens, and illustrate his work on fossil Pleistocene birds of Oregon.

Plate 12.

Fig. 93. Right lateral view of the skull and detached mandible of a specimen of *Charitonetta albeola*. Natural size. Adult. Coll. U. S. Nation. Mus. No. 17168. The thecae of the mandibles left on in part.

Fig. 94. Left lateral view of the skull and detached mandible of a Scaup Duck (*Marila marila*). Adult; nat. size (No 19220a, Coll. U. S. Nation. Mus.).

Fig. 95. Right lateral view of the trunk skeleton, including bones of the shoulder girdle of a specimen of *Hymenolaemus malacorhynchus* (New Zealand). Slightly reduced. Adult, ♀ (No. 19024, Coll. U. S. Nation. Mus.). Note small proportions of the os furcula, and the shallow keel to the sternum.

Fig. 96. Left lateral view of the trunk skeleton including shoulder girdle of *Cereopsis novae-hollandiae*. Two-thirds natural size (No. 19711, Coll. U. S. Nation. Mus.). Pygostyle proportionately very small; scapulae short; pelvis large and strong.

Plate 13.

Fig. 97. Dorsal aspect of the trunk skeleton and articulated shoulder girdle of the *Cereopsis* goose (*C. novae-hollandiae*). Same as the one shown in Fig. 96, Pl. 12. About two-thirds natural size.

Fig. 98. Anterior view of the trunk skeleton of a specimen of a Wood Duck (*Aix sponsa*) (No. 18612, Coll. U. S. Nation. Mus.). Shows the pattern of the large sternum in this species of River Duck (see Fig. 99).

Fig. 99. Left lateral view of the trunk skeleton of *Aix sponsa*. About natural size. Adult (No. 18612, Coll. U. S. Nation. Mus.). Shoulder girdle removed. Note large sternum and massive caudal skeleton.

Plate 14.

Fig. 100. Left lateral view of the trunk skeleton of *Polysticta stelleri*. Adult; nat. size. Shoulder girdle removed (No. 15272, Coll. U. S. Nation. Mus.). See former figures.

Fig. 101. Ventral view of the sternum of a specimen of *Aix galericulata*. Very slightly reduced (No. 18217, Coll. U. S. Nation. Mus.). See Plate 11 Fig. 84 and 85.

Fig. 102. Ventral view of the sternum of a specimen of *Harelda hyemalis*. Very slightly reduced (No. 18627, Coll. U. S. Nation. Mus.). See Plate 9 Fig. 64.

Fig. 103. Ventral view of the sternum of a specimen of *Dendrocygna autumnalis*, ♀. Nearly natural size. Collected by Mr. F. B. Armstrong, Browsville, Texas (454).

Plate 15.

Fig. 104. Left pectoral limb of *Cereopsis novae-hollandiae*. Adult; nat. size. From the same skeleton as shown in former figures and Plates (No. 19711, Coll. U. S. Nation. Mus.).

Fig. 105. Left lateral view of the skull and articulated mandible of a specimen of *Tachyeres cinereus* (Falkland Islands). Adult; nat. size (No. 1818, Coll. U. S. Nation. Mus.). Malar bone of zygoma displaced.

Fig. 106. Left pelvic limb of *Cereopsis novae-hollandiae*. About two-thirds natural size (No. 19711, Coll. U. S. Nation. Mus.). Other bones of this skeleton shown on preceding Plates of this paper.

Plate 16.

Fig. 107. Outer view of the right tibio-tarsus and fibula of a specimen of *Dendrocygna autumnalis*, ♂. Nat. size. Collected by Mr. F. B. Armstrong (455).

Fig. 108. Left lateral view of the shoulder girdle of a specimen of *Dendrocygna bicolor*, ♂. Adult; nat. size (F. B. Armstrong coll. 456).

Fig. 109. Anterior aspect of the right pes of *Dendrocygna autumnalis*. Adult, ♀. Nat. size (F. B. Armstrong coll. 453).

Fig. 110. Upper view of mandible of *Dendrocygna bicolor*, ♂. Adult. Nat. size (F. B. Armstrong coll. (456).

Fig. 111. Ventral view of the pelvis and caudal vertebrae of *Dendrocygna bicolor*, ♂. Adult. Nat. size (F. B. Armstrong coll. No. 456).

Fig. 112. Left lateral view of the trunk skeleton of *Dendrocygna autumnalis*, ♂. About natural size. Shoulder girdle removed (F. B. Armstrong coll. No. 455).

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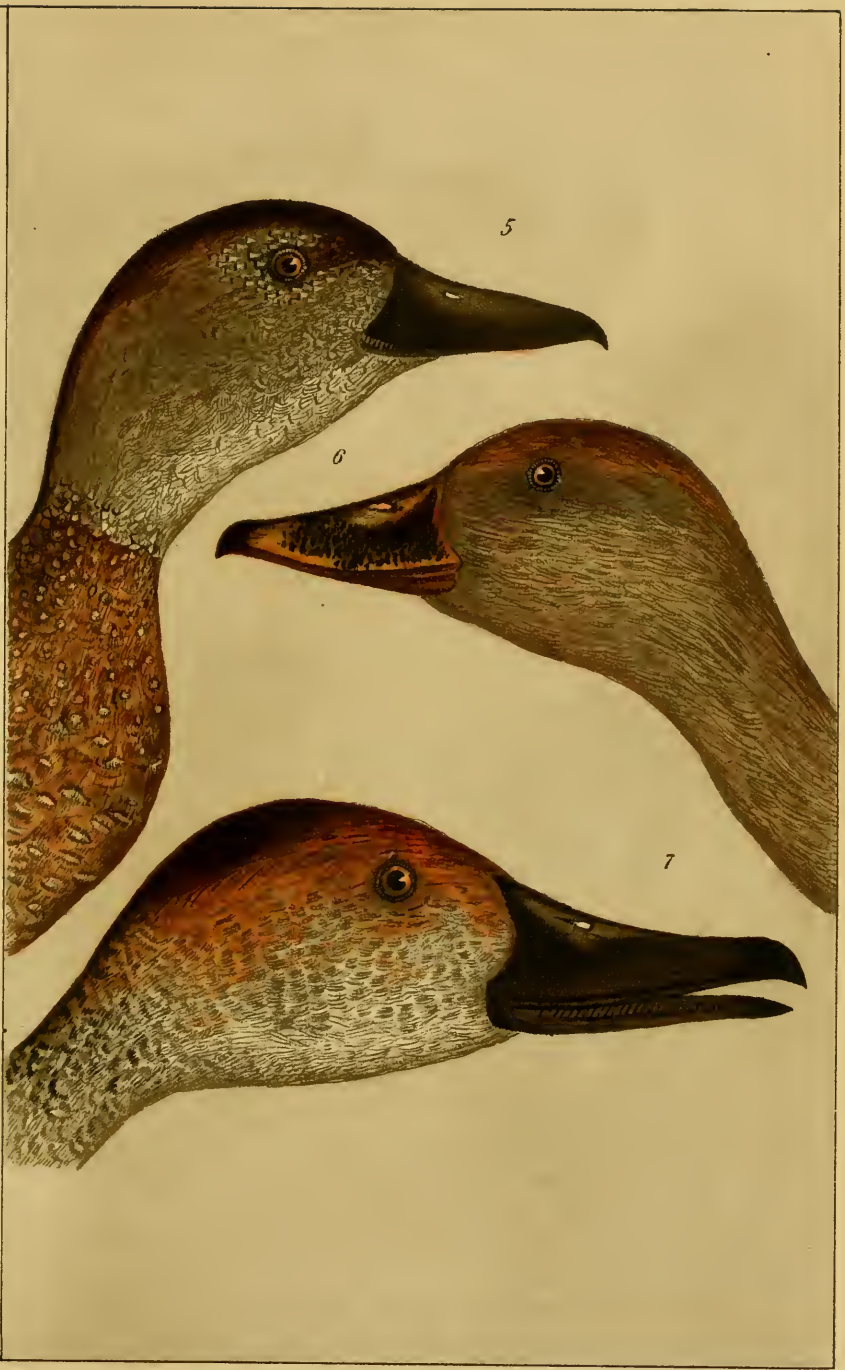

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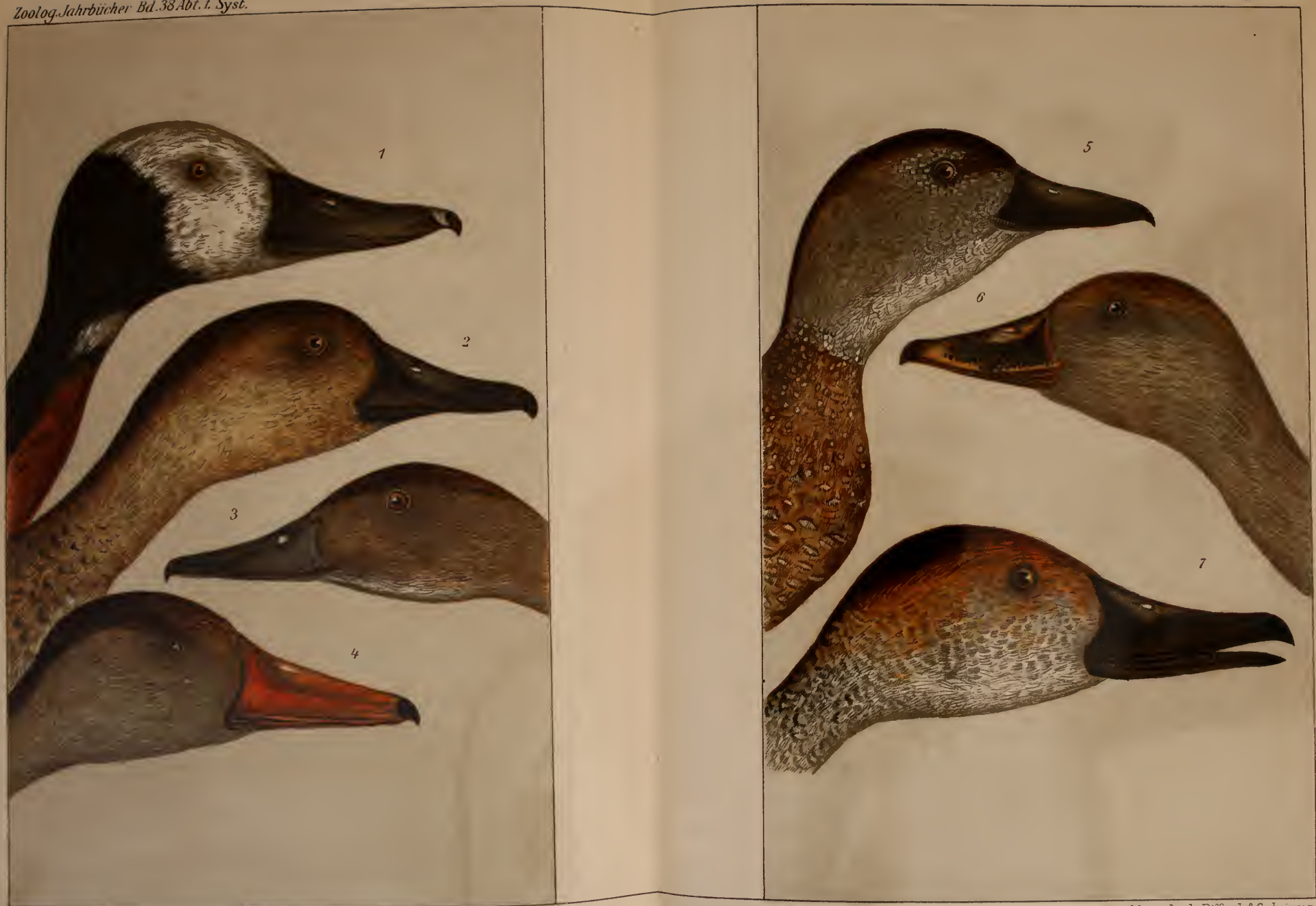

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DENDROCYGNA BICOLOR. ♀. *(above.)*
DENDROCYGNA AUTUMNALIS. ♂. *(below.)*

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Fig. 10.

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fig. 10.

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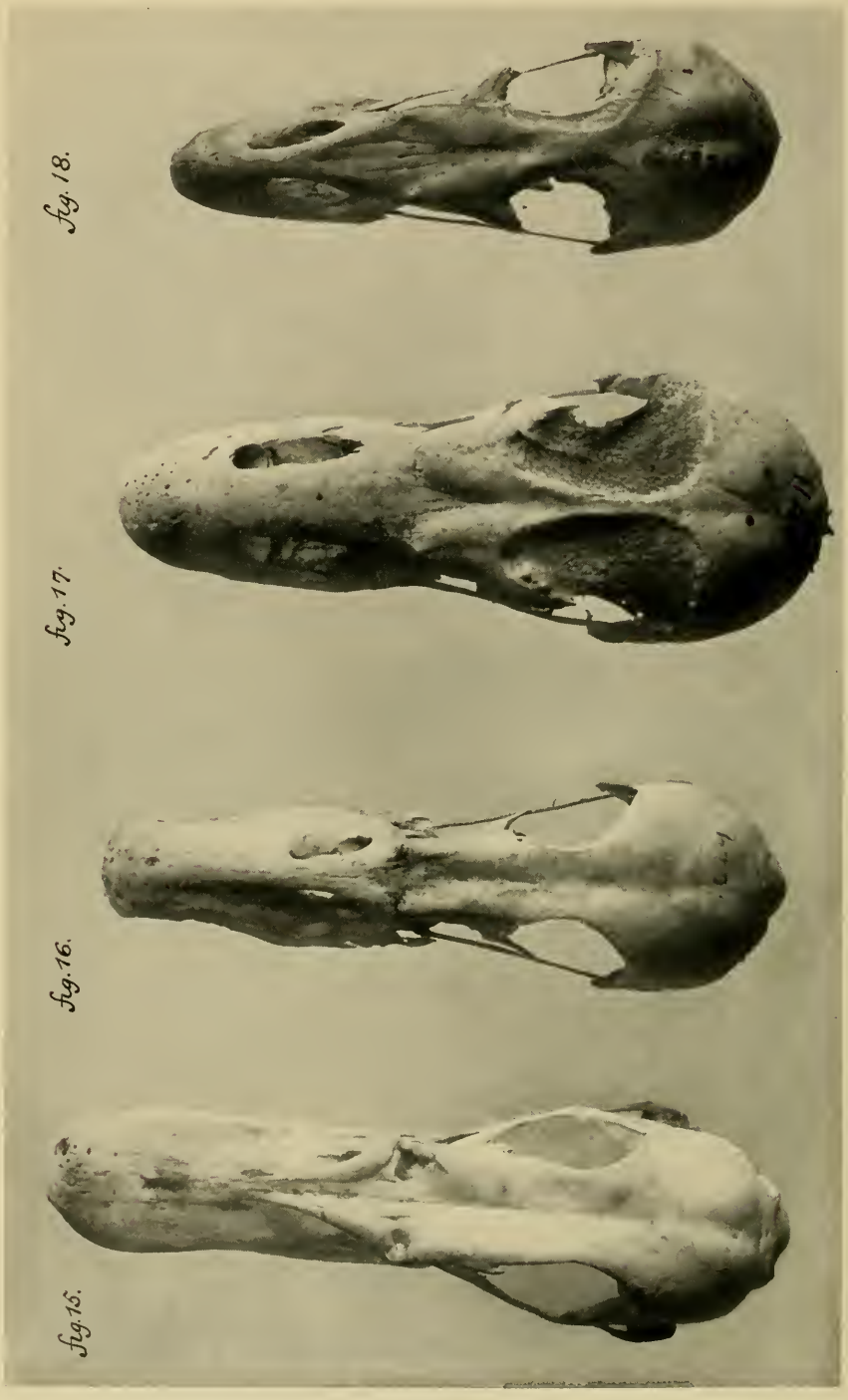

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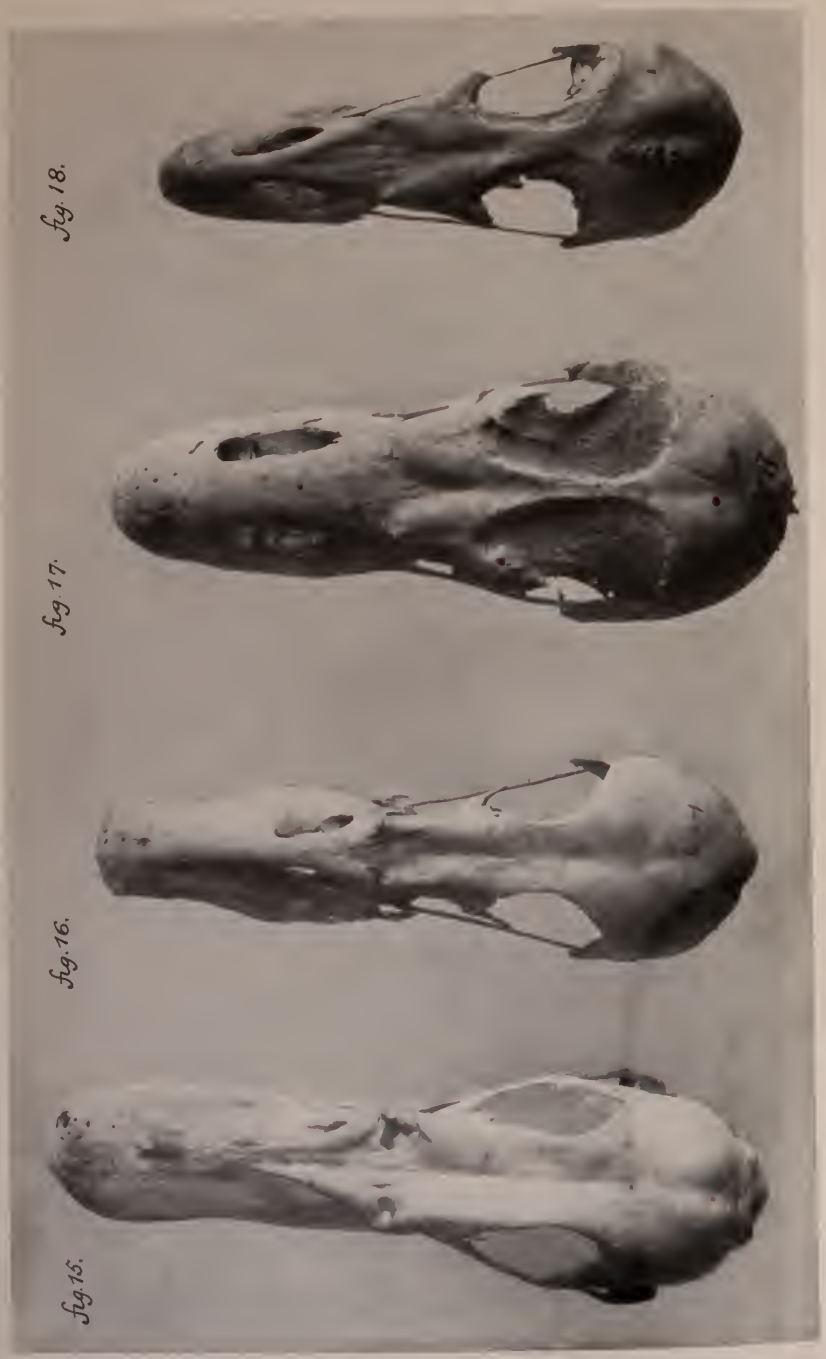

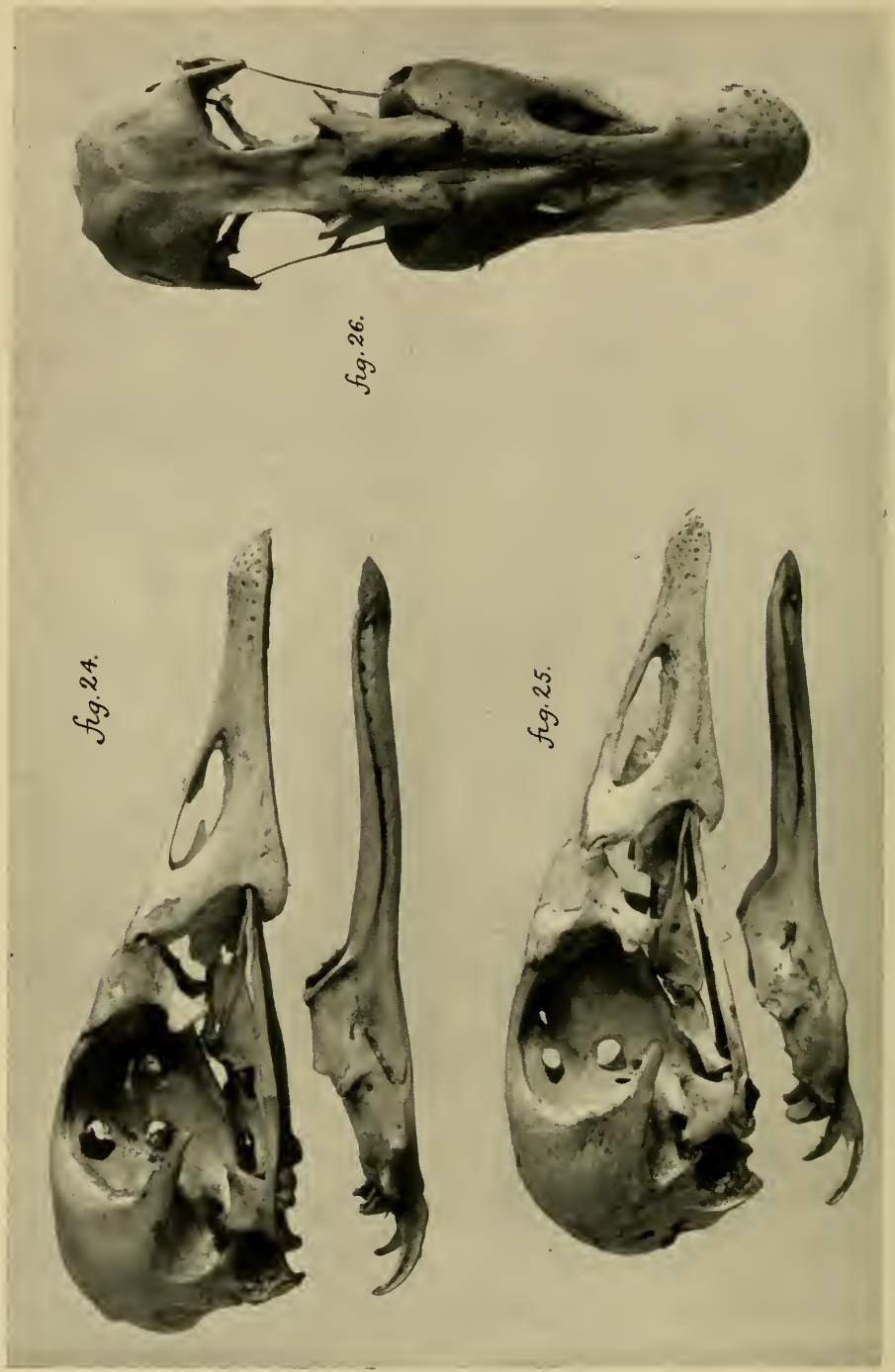

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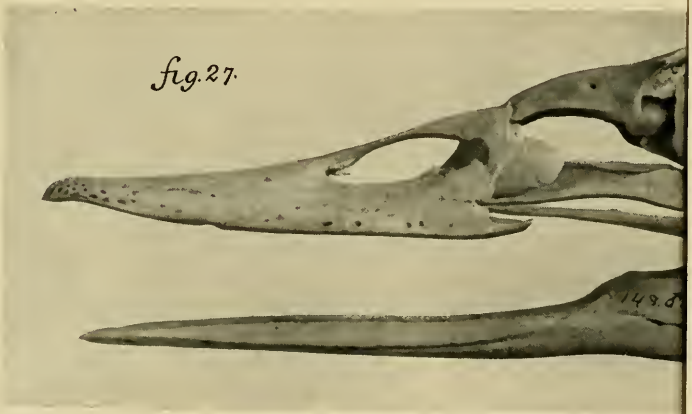

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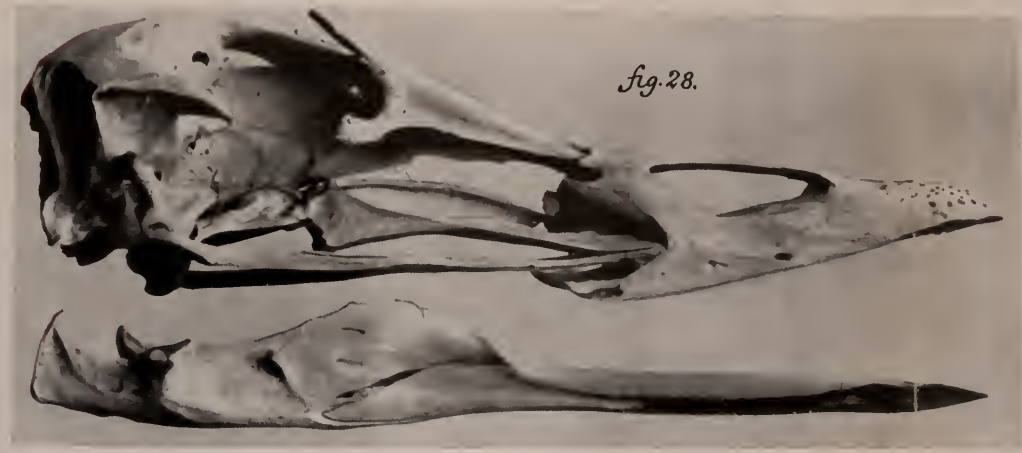

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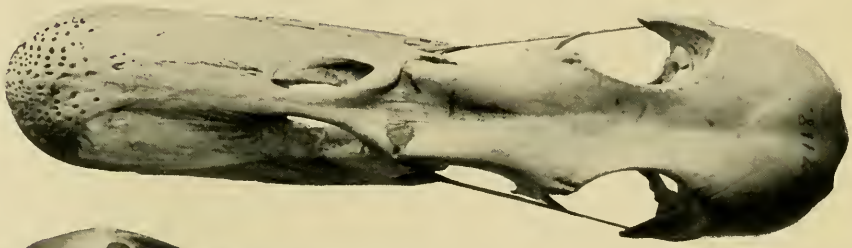

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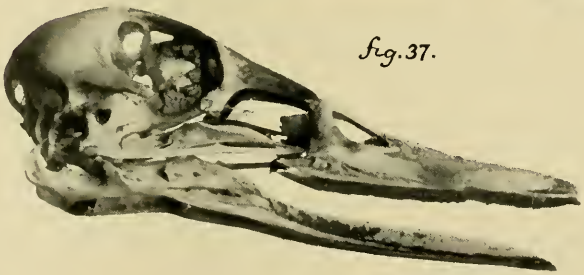

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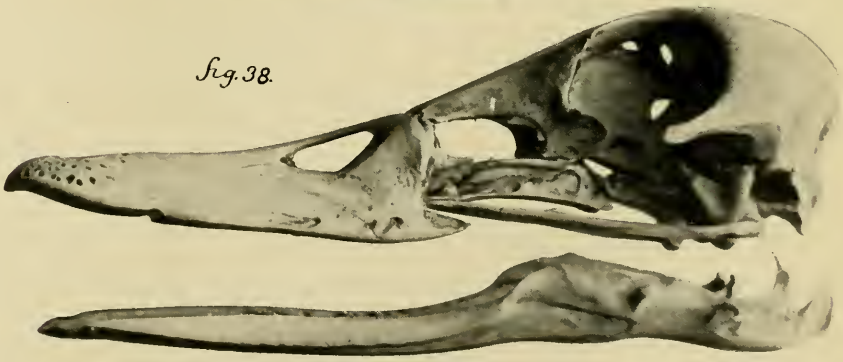

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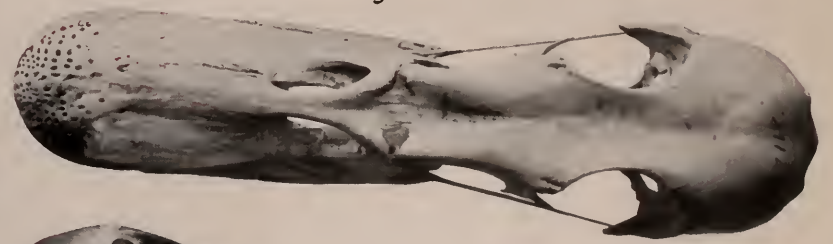

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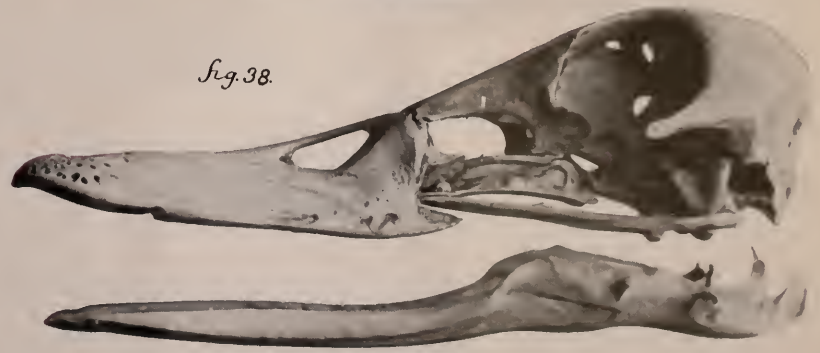

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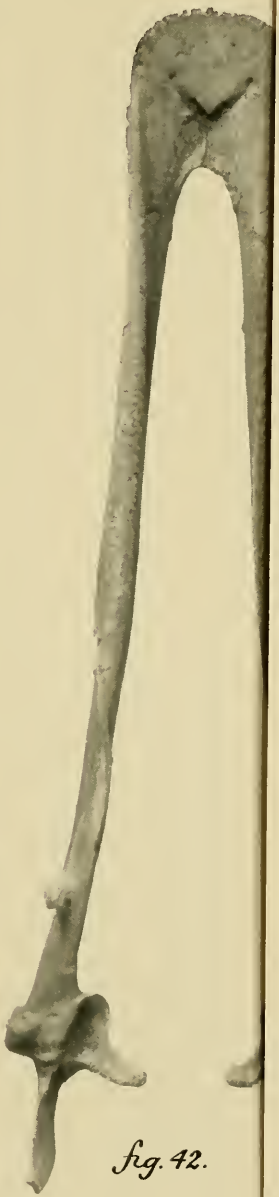

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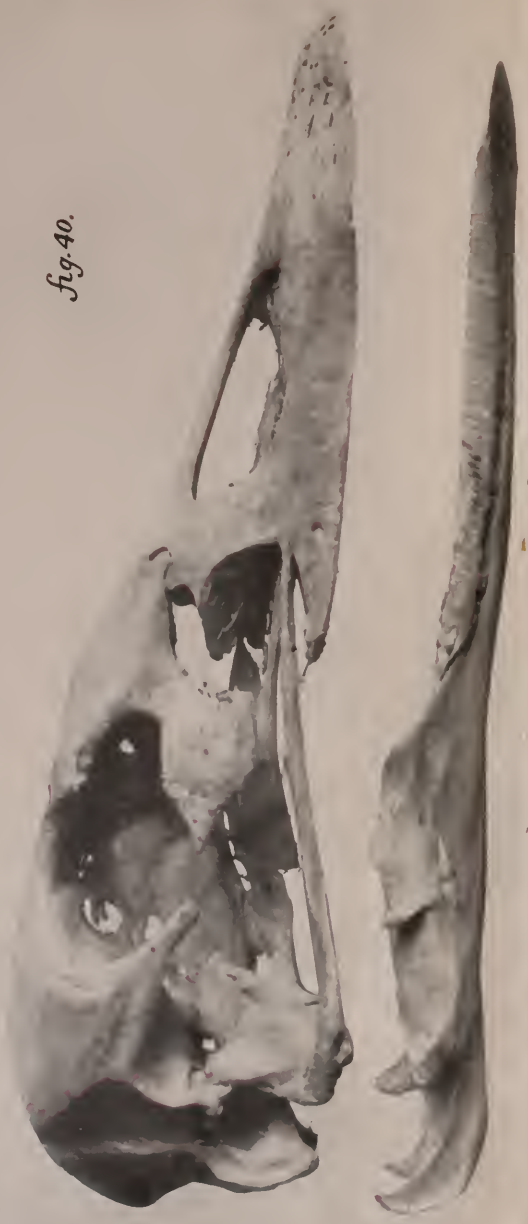

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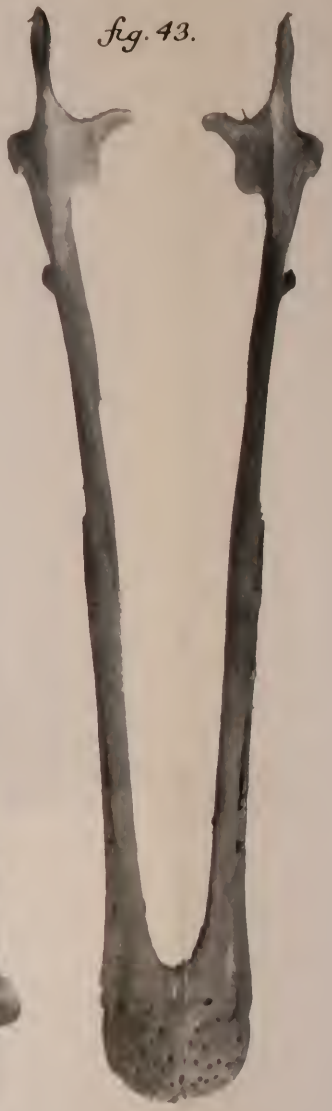

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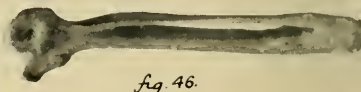

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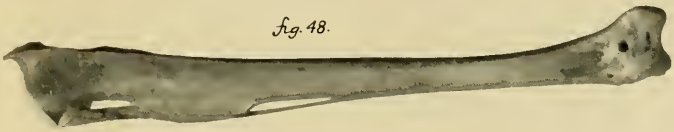

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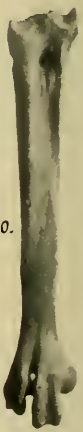

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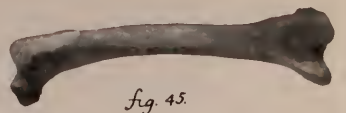

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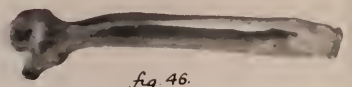

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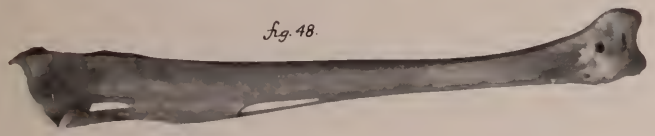

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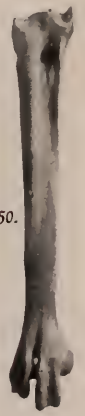

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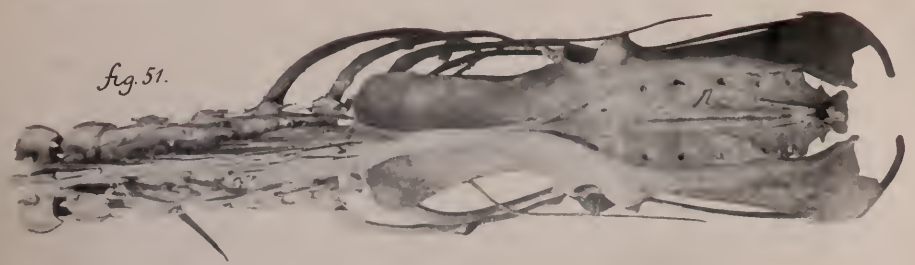

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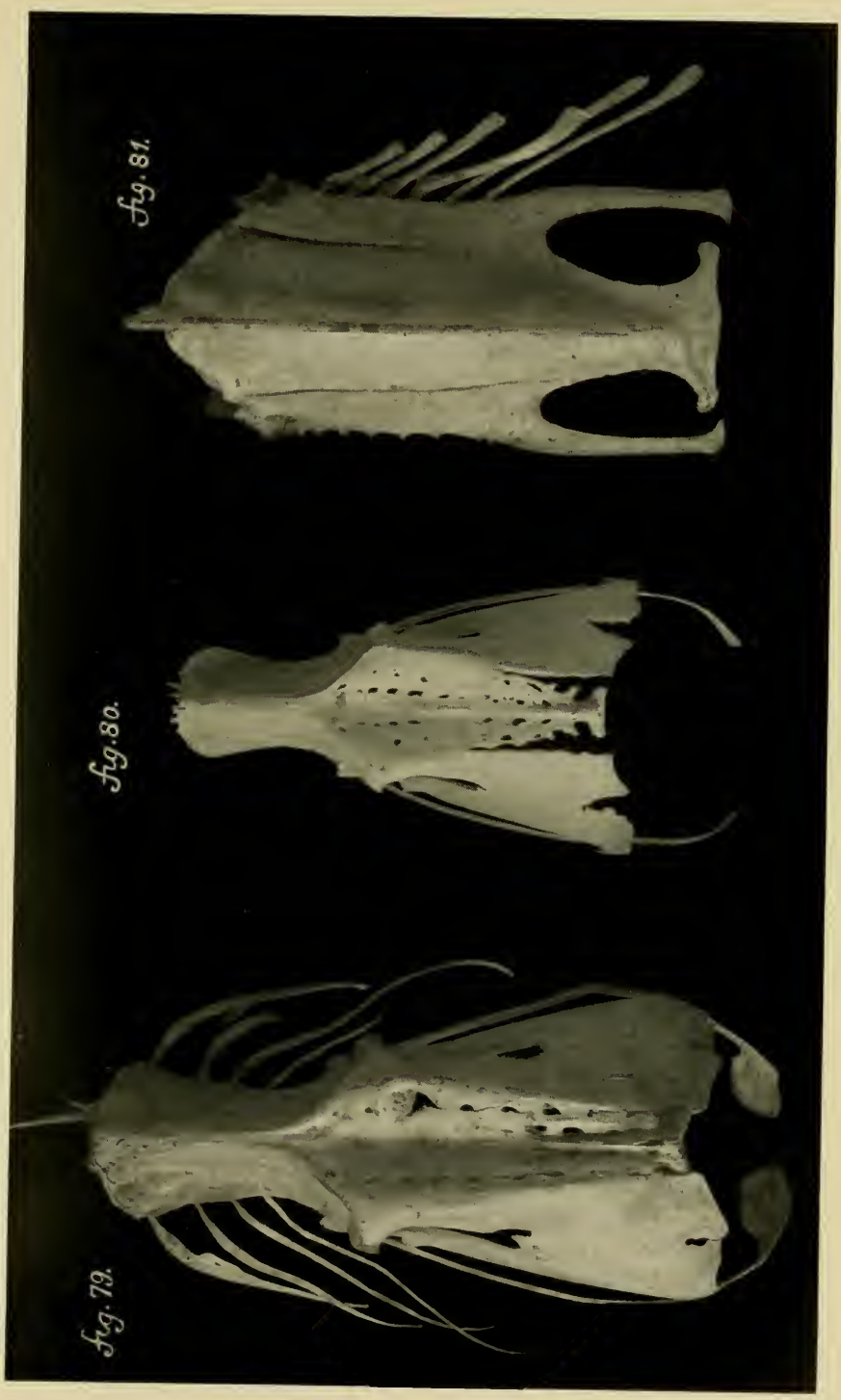

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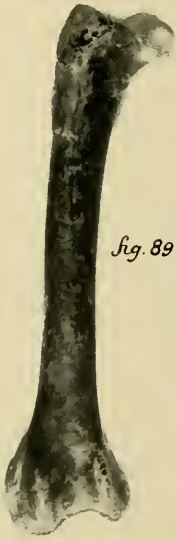

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Fig. 94.

Fig. 93.

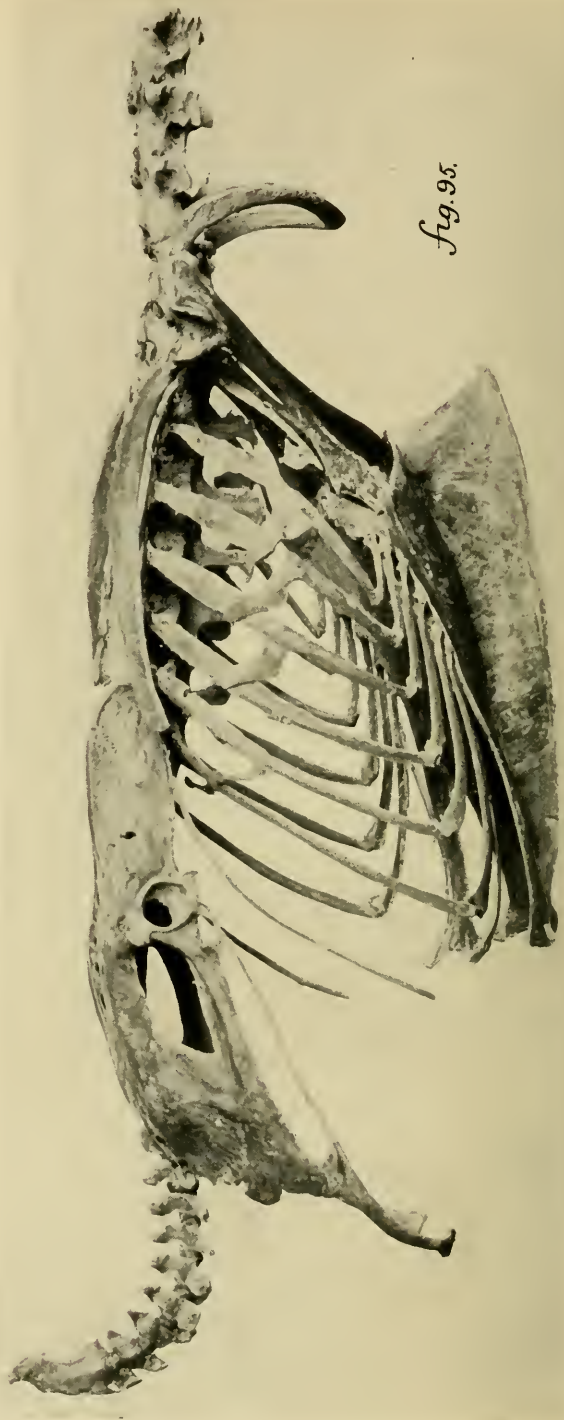

Fig. 95.

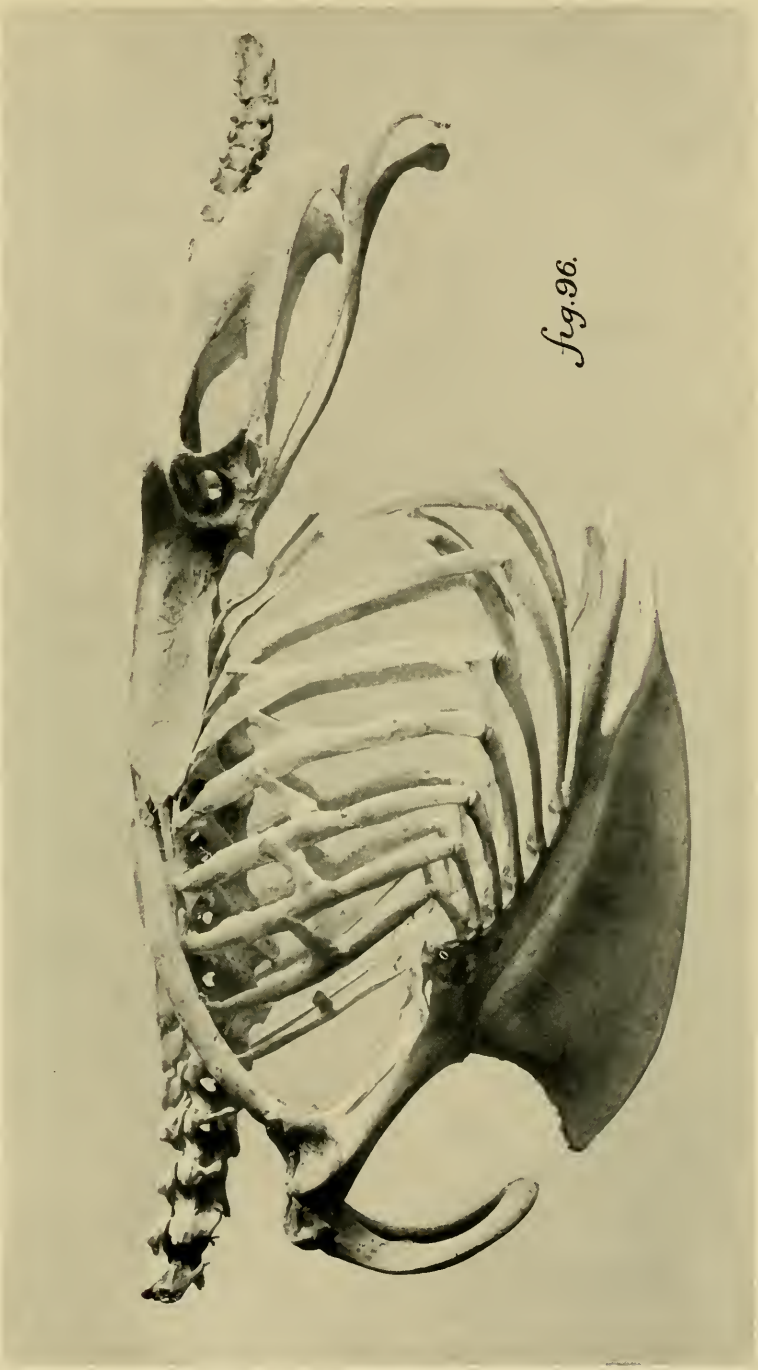

fig. 96.

fig. 94.

fig. 93

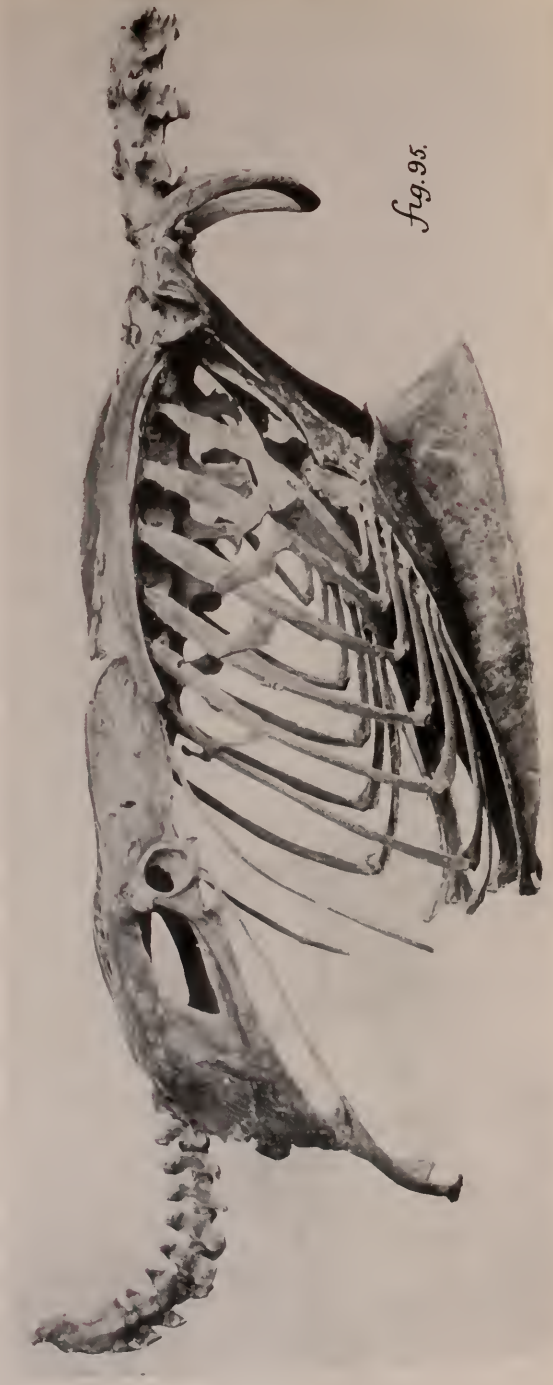

fig. 95.

fig. 96.

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Fig. 97.

Fig. 98.

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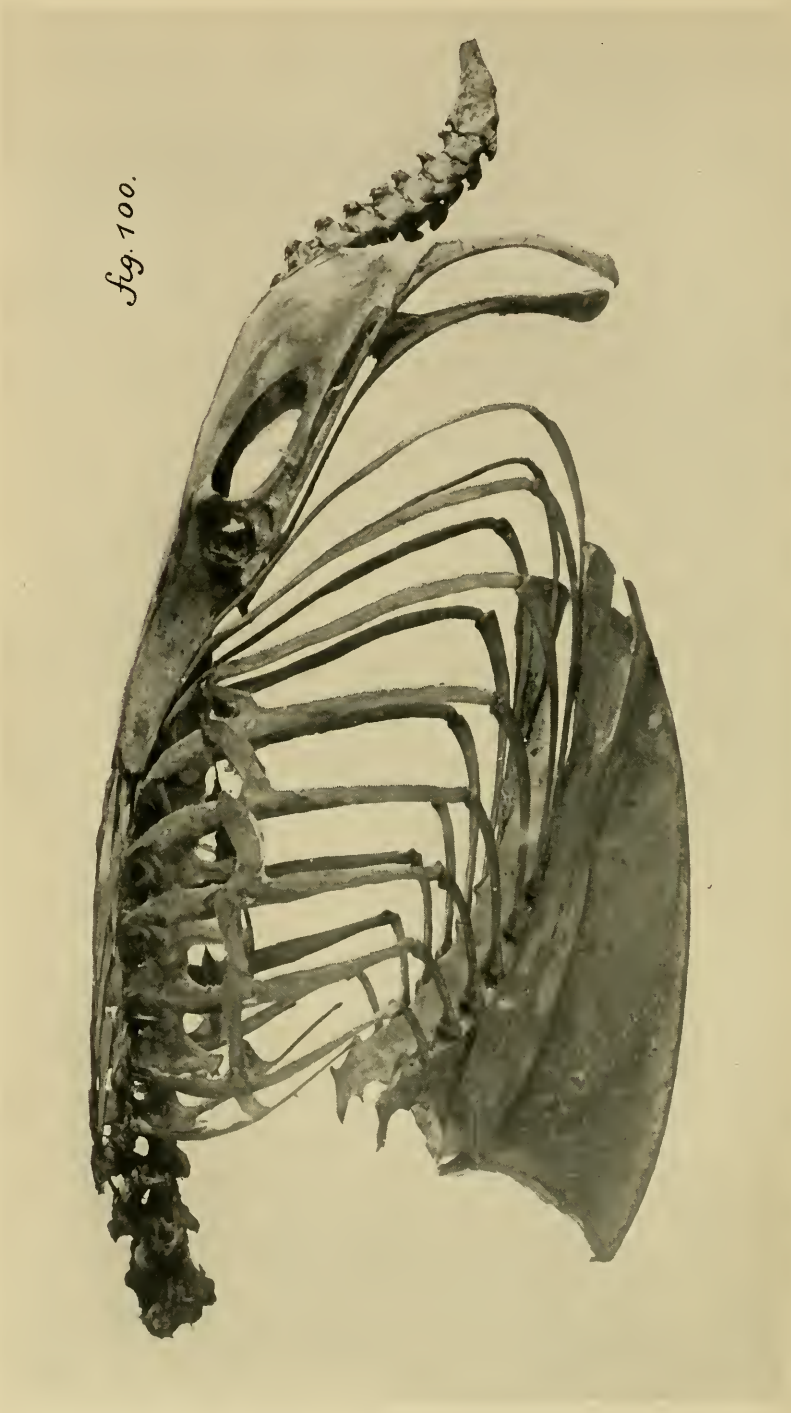

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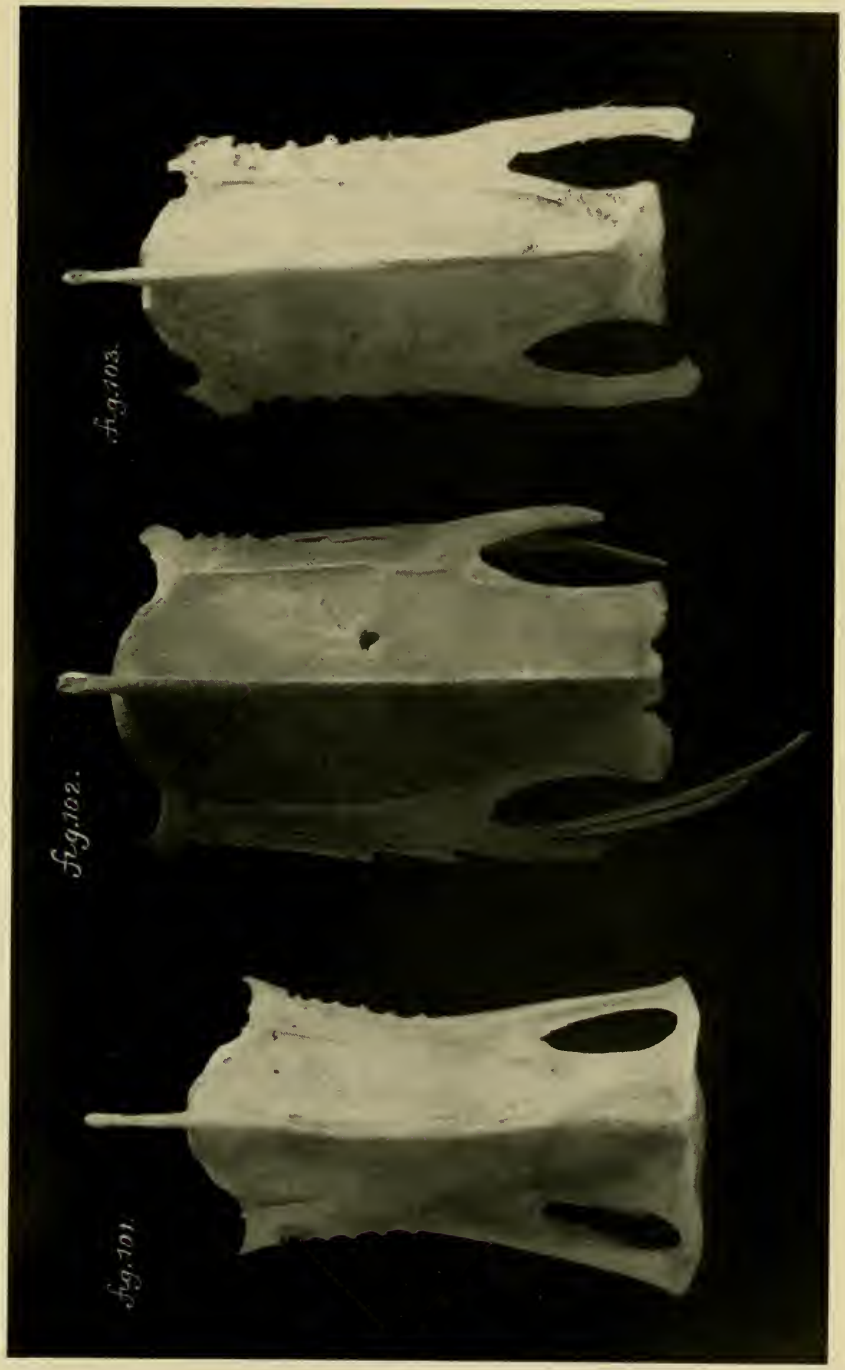

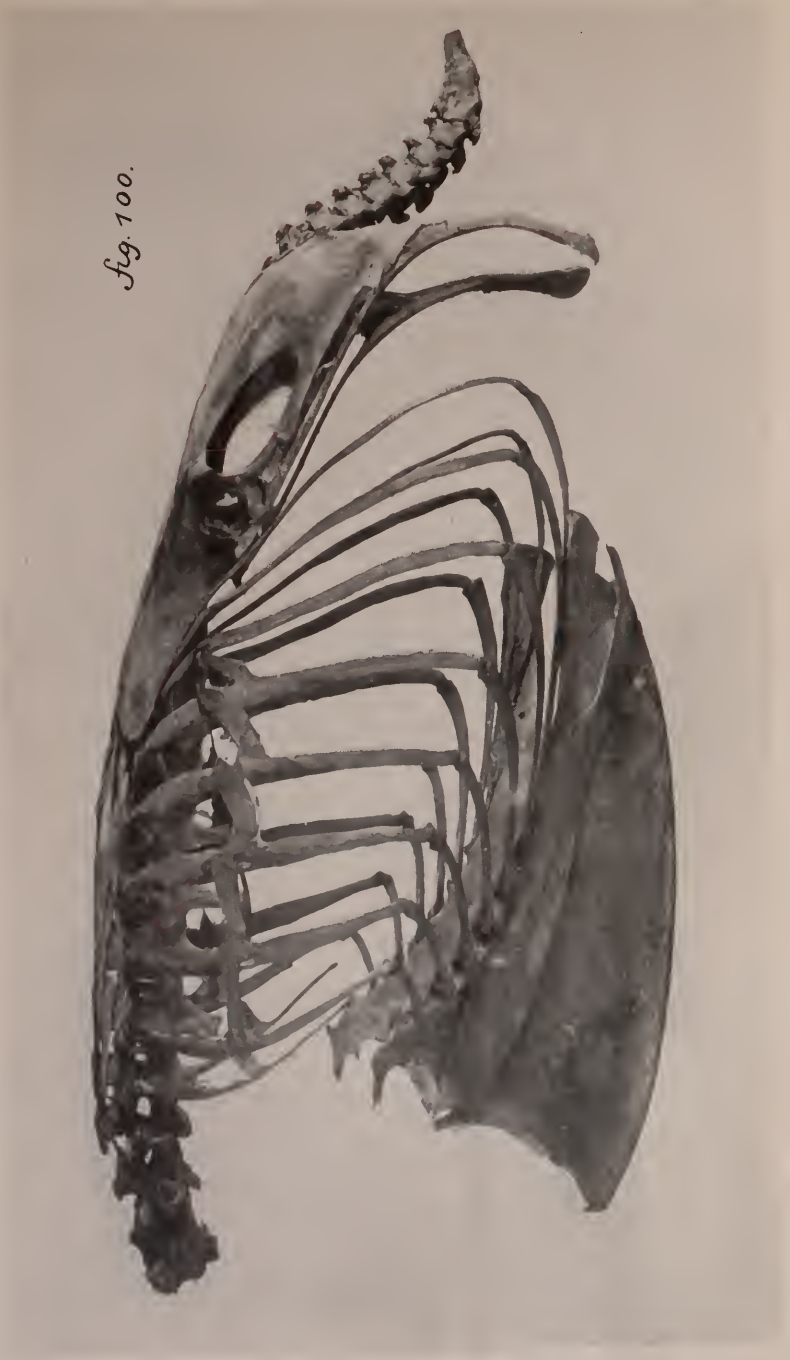

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Fig. 105.

Fig. 106.

Fig. 104.

Fig. 105.

Fig. 106.

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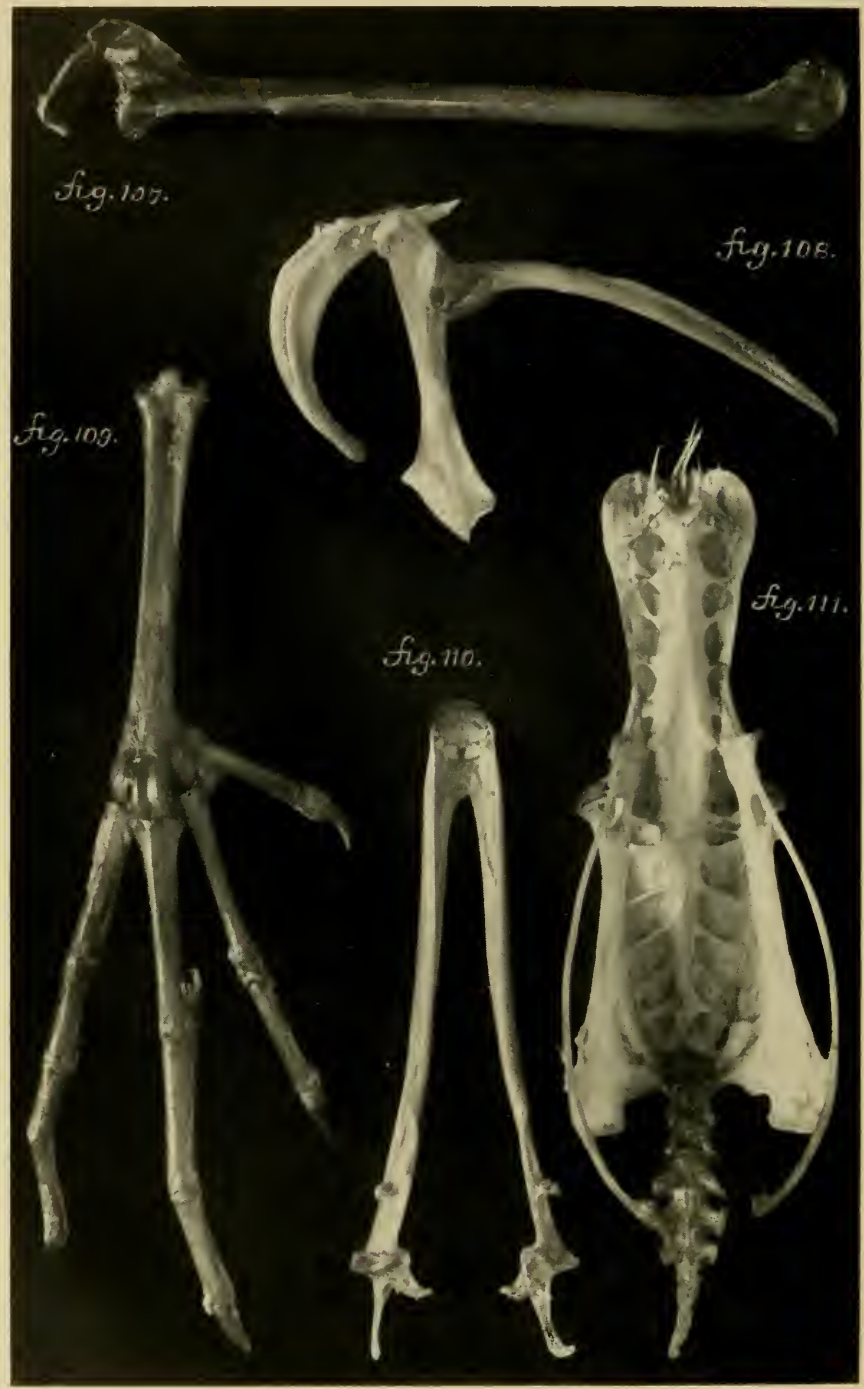

Fig. 112.

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