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AUTHOR'S EDITION.

DEPARTMENT OF THE INTERIOR.

UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY.

F. V. HAYDEN, U. S. Geologist-in-Charge.

CONTRIBUTIONS TO THE ANATOMY OF BIRDS.

BY

R. W. SHUFELDT, M. D.,

Captain, Medical Department, U. S. A., member of the Philosophical, Anthropological, and Biological Societies of Washington, Honorary Curator of the Section of Avian Osteology of the Smithsonian Institution.

EXTRACTED FROM THE TWELFTH ANNUAL REPORT OF THE SURVEY.

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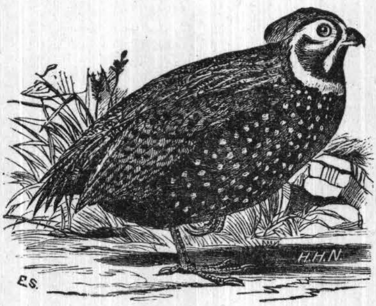

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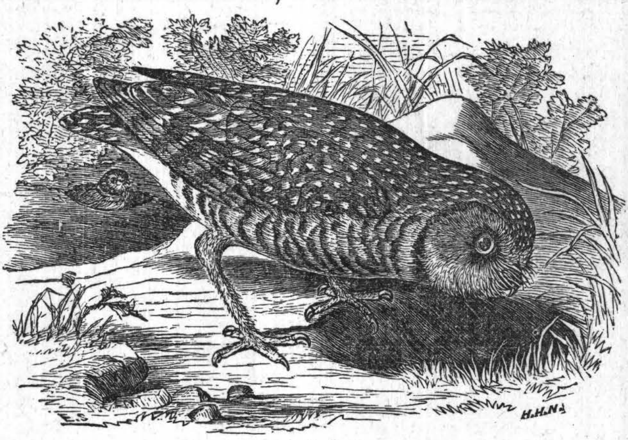
OSTEOLOGY OF SPEOTYTO CUNICULARIA HYPOGÆA.

By R. W. Shufeldt, M. D.,
Captain, Medical Department, United States Army.

At the present writing we know of but one species of the so-called Burrowing Owls inhabiting America, and this is represented by three existing races, the typical and largest of these being the *Athene cunicularia*, a species confined to South America, while its two varieties occur within the limits of the United States. Little difference seems to exist between these latter, *S. cunicularia floridana* being of nearly the same size as the subject of this paper, but darker in plumage, with fewer feathers upon the tarsi, so that, with the exception of certain measurements, the description of the skeleton of any one of them will answer pretty well for them all. To those unacquainted with the habits of these owls, both the English and technical names might be misleading, giving one to suppose that the birds actually *burrowed*; such, we believe, is never the case, they all having the like habit of resorting to the villages of many of the species of marmot squirrels, and occupying their deserted burrows for the purpose of nidification; several families of these owls often being found in the same village. *S. cunicularia hypogœa* occurs upon the open and treeless prairies west of the Mississippi River, where the writer has had abundant opportunity to study its very unique and interesting habits as well as to secure unlimited material for the purposes of dissection.

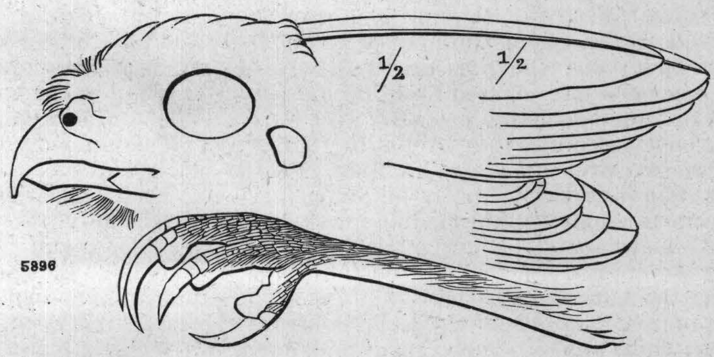


Speotyto cunicularia hypogœa.

We are well aware, however, that other naturalists have believed, to a greater or less extent, that *Speotyto* really, under certain circumstances, burrows for itself, but owing to the fact that it has never actually been known to construct an entire burrow, or what I must believe any part of one, and in face of the apparent inadaptability of its small feet and not overpowerful beak to accomplish such a task, we can hardly accredit the statement. This idea has no doubt been brought about by the fact that sometimes a few families of prairie dogs (*Cynomys*), for instance, will start an independent village, which, from some cause or the other, they are afterwards led to desert; whereupon the owls are only too glad to avail themselves of the empty burrows, and the traveller is very likely to find one or two such peaceful colonies in the course of his rambles, as the writer has, where the owls are present, but all signs of the rodents obliterated, in some cases even the grass and flowers having grown again to the very entrances of the burrows.

Speotyto, unlike the majority of the members of the great family to which it belongs, is not strictly nocturnal in its habits, but on the contrary one may find them wide awake and active, in the villages where they are found, at almost any hour of the day; indeed, as a rule they are quite wary, and one may often resort to all of the stratagems his experience has taught him before he succeeds in securing a specimen. In powers of flight they are weaker than most owls, a fact largely due no doubt to the lack of exercise of this privilege.

As we pass to the study of the skeleton of this interesting species, we shall, no doubt, find several instances wherein it has been modified and received certain impressions due to the mode of life and habits of the owner, that we have so briefly called the reader's attention to. We add here also a cut showing some of the external characters of this bird.



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In enumerating and describing the separate bones of our subject, the smaller ones of the ear have not been taken into consideration, as they more properly come to be treated in the study of the organ of hearing; certain very small sesamoids may also, with propriety, be overlooked.

The skull.—As a general rule, it is only in the young of the Class *Aves* that the many bones of the skull can be separated from one another; the majority of the primitive segments of ossification of the four vertebræ[1] that go to form this, the superior expansion of the vertebral col-

[1] My reader will no doubt remember that this monograph, accompanied by another of about equal size, upon the Osteology of *Eremophila alpestris*, appeared in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. vi, No. 1, Washington, February 11, 1881, being followed in the same year, September 19, in No. 2 of the same volume, by my monographs upon the *Osteology of the North American Tetraonidæ* and *Lanius ludovicianus excubitorides*. In one and all of these papers I considered the cranium as composed of four vertebræ, as many of the old school comparative anatomists had done before me, and in adopting this theory I likewise adopted the nomenclature of the elements as given by Professor Owen, in his Anatomy and Physiology of Vertebrates. When I was first privileged to enter upon my anatomical studies, comparative and otherwise, this theory was the then prevailing one, and my mind became imbued with its fascinating precepts, its plausibility and appa-

umn, being firmly anchylosed together, with their sutures completely obliterated when the bird has attained maturity. This is eminently the case in the adult skull of the species we have before us, so much so, in fact, that, with the exception of certain bones that remain permanently free during life, we will undertake to describe the skull only as it presents itself to us in the adult as a whole. In referring to certain points for examination, then, in this part of the skeleton, we will have to rely largely upon the reader's familiarity with general anatomy, and the extent and position of the bones as they occur in the variously shaped heads of immature birds. The major part of the occipital lies in the horizontal plane, only that portion which originally constituted the superoccipital segment and the posterior third of the exoccipital segments curving rather abruptly upwards to meet the mastoids and parietals. All its primary parts are thoroughly coalesced, and its articulations with the surrounding bones obliterated, save a fine ridge, running transversely, just anterior to the condyle, separated from it by a depression which seems to indicate the remains of the occipito-basi-sphenoidal suture. Posterior to the foramen magnum the bone rises and displays a well-marked "cerebellar prominence," with a depression on either side of it. On the summit of this prominence, in the median line, just before we arrive at the foramen magnum, we find the superoccipital foramen. This foramen varies in size and shape in different individuals—in size, from one to two millimetres; in shape, from a circle to a transverse ellipse, though it is usually small and circular. It is said to be formed by a thinning of the bone due to muscular pressure from without and the pressure of the cerebellum from within; in the fresh specimen it is covered by a thin membrane. Lying in the horizontal plane, anterior to the cerebellar prominence, is the foramen magnum. In shape it resembles a square with the four angles rounded off. Its average measurement is five millimetres transversely and four millimetres antero-posteriorly, the latter diameter being encroached upon by the occipital condyle in the median line. The occipital condyle is sessile, though raised above the level of the basis cranii, hemispheroidal in form, with a minute notch marking it posteriorly in the middle. Immediately beyond the condyle appears a depression, on either side of which are seen the precondyloid foramina for the transmission of the hypoglossal nerves; they are extremely small, and open anteriorly. External to these, lying in the same line transversely, is seen a group of usually three foramina for the passage of the glossopharyngeal and vagus

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rent universal adaptability; in fact, its truth became one of the treasured results of my university education. Several years elapsed before I was again allowed to renew my favorite study, during which time the vicissitudes of my life allowed but little opportunity to follow the many advances in this important science, and when the day finally came, and the above monographs were written, and I drew the plates illustrating them, I was many hundreds of miles, and for several years, removed from all that one has access to in large cities and scientific circles. From this standpoint they must be judged, then, and for this reason did errors and theories creep into them that are "so dangerous to the credit of comparative anatomy." It is believed that the *Osteology of the Cathartidæ* will be largely exempt from such errors. The author deems it entirely unnecessary to enter upon the merits or demerits of any theory here, simply announcing in connection with what has already been said above, that he believes the vertebral theory of the cranium to be untenable in the light of modern science, and incompatible with modern thought. Aside from the theory involved, it is hoped that the purely anatomical facts will be found to be correct as given, and as any attempt to eradicate the theory from these memoirs would simply result in a rewriting of the whole, the author has allowed them to stand substantially as they first appeared, simply offering his reader the above explanation and making such changes as he deems best through the medium of foot-notes; introducing into the body of the paper only such material and facts as he has been able to gather since, bringing the whole up to the standard of a revised edition.

nerves and the internal jugular vein. The lateral terminations of the occipital, the paroccipital processes, are large, thin, pointed forwards, and on a lower level than the rest of the bone, forming a large part of the floor of the tympanic cavity. The semi-elliptical contour of the cranium, regarding it from a basal view, is well carried out laterally by the wing-light and attenuated mastoids. They contribute largely to the formation of the walls of the tympanic cavity internally, and externally assist in some degree towards completing the temporal fossæ. These fossæ are deep; commencing posteriorly on either side at the external borders of the depressions already mentioned that bound the cerebellar prominence laterally, they take a course upwards and outwards, terminating at a foramen that lies just within the posterior periphery or the orbit, which foramen allows the passage of the tendon of the temporal muscle. From the upper boundary of the temporal fossæ to where the frontals suddenly abut against and even overhang, to some extent, the nasals, the external and superior surface of the skull is of a pearly whiteness and very smooth in the dry skeleton, presenting not a trace of the sutures between the bones that go to form it, the frontals and parietals. This surface is divided by a well-marked furrow, that extends in the median line between the cerebellar prominence and the upper mandible. It is deepest in the parietal region. Close inspection of this area reveals minute ramifying grooves for the lodgment of vessels, one set running in the direction of the temporal fossæ and another toward the orbits. In the "bird of the year" the skull cap is very thin and brittle in the dry condition; but a very different state of affairs presents itself when we remove a section of the cranial vault from above, in the adult, where the skeleton is full-grown, such as we have before us. We find exposed to our view one of the common characteristics of the family; the two tables are light, thin, but compact, with a goodly supply of diploic tissue between them, attaining a thickness in some localities, notably above the exit of the olfactories, of two millimetres or more. Owing to the large orbital cavities, the brain-case is crowded to the rear to such an extent that the fossæ for the cerebral hemispheres are situated immediately over the cavities intended for the other encephalic lobes. We find the internal opening of the foramina, already described, at the base of the brain. The *petrosals* have the appearance of two white leaves, harder than the surrounding bone, slightly turned upon themselves, with their stems leading towards the fossa for the hypophysis. They present for examination the openings for the portio dura and portio mollis, the former foramen being on a lower level and anterior to the latter. In the median line running from the cerebellar fossa to the exit of the first pair of nerves along the roof is a raised crest, grooved on its summit for the longitudinal sinus. It sinks for a little distance, in the fresh specimen, into the cerebral interspace. The "sella turcica" is deep, its long axis being perpendicular to a plane passing through the foramen magnum. It has at its base the openings for the carotids. Immediately beyond its anterior superior border is seen the optic groove, with its foramen at either end, for the passage of the optic nerves and lodgment for the optic chiasma. Above the optic foramina, situated still more anteriorly, is a conical pocket, pointing forwards and a little upwards, with the olfactory foramina at its apex, two in number, giving passage for the nerves to the orbits. The *basi sphenoid* is thoroughly united with all the bones it comes in contact with, except the pterygoids, palatines, and tympanics. Its anterior process—the basipresphenoid—loses itself in the interorbital septem, not a trace remaining of the original margins of the two bones. Its wings, the orbito-sphenoids and the ali-sphenoids share the same fate with the bones that surround them. They form the larger part of the posterior wall of the orbital cavities. With the body of the bone the ali-sphenoids assist in closing in the tympanic cavities. We cannot positively state that this owl possesses a true boney *vomer*. The "pterapophysial" processes of the basi-sphenoid are present; they are short, thick, and elliptical on section, crowned by facets of the same figure at their distal extremities, which look downwards, forwards, and outwards, articulating with a similar facet at the middle third and posterior border of each pterygoid. The bone also presents for examination the usual nervous and arterial foramina and grooves for the Eustachian tubes, the foramina being particularly worthy of notice on account of their marked individuality, all of them being distinct and nearly circular. The *tympanics* are free bones, and carry out all the usual functions assigned to them. The mastoid condyle is long, affording by its extension an additional margin at the under side at the end of the bone for attachment of the ear-drum; the neck between it and the orbital process is somewhat constricted, and presents a large pneumatic foramen on the inner surface. The pointed orbital processes extend upwards, forwards, and inwards, slightly clubbed at their extremities; they project into the space half way between the pterygoid and wing-like post-frontal. The mandibular condyle is double; the inner one is a semi-ellipsoid, placed transversely; the outer an irregular figure, and separated from the inner by a shallow pit. The oval, cup-shaped cavity for the reception of the tympanic extremity of the squamosal looks directly forward. Between the orbital process and inner mandibular condyle, on the free edge of the bone, is seen a small articular surface for the tympanic extremity of the pterygoid. The *pterygoids* diverge from each other towards the tympanics by a very open obtuse angle. They are slender and scale-like, being compressed from above downwards, twisted on themselves at their tympanic extremities, causing the long axis of the articular facets for the articulation with these bones to be vertical. As already described, they have a mid-posterior facet, which meets the pterapophysial process of the basi-sphenoid. Anteriorly they do not touch each other, but articulate with the extremities of the palatines, and the combined four bones touch, and in the living bird glide over for a limited distance the lower border of the rostrum of the basi-presphenoid. The anterior ends of the *palatines* articulate by an anchylosed schindylesial articulation between the lower surfaces of the maxillaries and the thin upper surface of a bony process extending backwards from the intermaxillary. From this point they slightly diverge from each other and become broader, being broadest about their middles; they then rather abruptly approach each other posteriorly, where they form the joint with the pterygoids already described. Their posterior ends are kept slightly apart by the lower border of the presphenoid. They are flattened from above downwards throughout their entire extent. Their outer borders are sharp, and form from one end to the other a long convexity. As the inner and concave borders approach each other posteriorly they develop a raised rim on their under sides, thereby affording a greater surface for muscular attachment. Above, near their middles, they aid the maxillaries (and in large part developed from them) in supporting on either side an irregular spongy bone, that serves the double purpose of narrowing the apertures of the posterior nares and adding bony surface to the roof of the mouth by constriction of the palatine fissure.[1] As is the rule in nearly all birds, the tym-

[1] These are the maxillo-palatines of Huxley, and the reader is referred to that author's invaluable paper upon the Classification of Birds, etc. Proc. Zool. Soc. Lond., 1867, p. 441, where these bones are shown in *Otus vulgaris*, fig. 26.

panic end of the *infraorbital bar* is on a lower level than the maxillary extremity; it is received into the cup-like articulating cavity on that bone. The two oblique sutures, persistent in many birds, and denoting the original division of this bony style into three separate bones, the maxillary, malar, and squamosal, are here entirely effaced. As a whole, it is compressed from side to side, and of ample size in comparison with other bones of the head. At about the locality of the malo-zymotic suture the bone throws upwards a thin expansion that meets the descending postfrontal, thus completing the orbital circumference at that point. Its anterior and fixed extremity is made up by the maxillary. Here it forms externally a portion of the posterior surface of the bill, while internally it assists in forming the roof of the mouth and floor of the nasal cavities, and otherwise behaves as already described. The *lacrymals* are extremely spongy in texture, covered by an outside delicate, compact bony casing. They articulate above by a ginglymoid joint with the posterior border of the nasals, resting below on the spongy bones developed from the superior surfaces of the maxillaries. They are limited to a slight movement inwards and outwards, and aid in separating the orbital cavities from the rhinal chamber. Externally they present for examination a shallow groove traversing the bone obliquely downwards and forwards and a little inwards for the lacrymal duct. The orbital cavities are very large, and remarkable for the completeness of their bony walls and the near approach their peripheries make to the circle, any diameter of which measures the merest trifle above or below two centimetres. The septum in the adult bird has rarely more than one small deficiency of bone in it. This usually occurs in about the position shown in Pl. I. The sutures among the various bones have entirely disappeared, nothing being left to define the exact outline of the vomer especially. The groove for the passage of the olfactory nerves forward is well marked, the cranial foramina for them being distinct, one in each orbital cavity. This also applies to the openings for the optic nerves. The extent of the roof is increased on either side by a superorbital process (shown in Pl. II, Fig. 1) that points downwards, backwards, and outwards, and serves for membranous attachment. The posterior walls are marked by ramifying grooves for vessels. They have a direct forward aspect, which is enhanced by the low descent of the broad and thin postfrontals. Anteriorly, the aperture between these and the rhinal vacuities is diminished by the lacrymals externally and by a wing-like plate thrown off from the prefrontal internally. This latter bone here terminates in a sharp concave border, with a descending ridge on either side just within it. The floors of the orbits are more complete than is usually seen in the class, due to the flatness and position held by the pterygoids and palatines, the wing-like process of the ethmoid just referred to, and the pterapophysial processes of the basi-sphenoid. The *sclerotals* number from fifteen to sixteen, all of them being about the same length, but varying as to their width; in figure they are trapezoidal and universally oblong, with the short parallel side in the circumference of the cornea and the opposite one resting in the periphery of the posterior hemisphere. We have never observed one that was wide enough to appear square. They are rather thin, concave outwards, very slightly movable at their opposed edges, and carry out their usual function of maintaining the form of the optical apparatus. The *upper mandible* of this bird is made the more conspicuous and distinct from the remainder of the skull by the abrupt way in which it is attached and the much firmer texture of the bone. The mandibular culmen is perfectly convex from the tip of the sharp-pointed extremity to where it suddenly terminates under the slightly overhanging frontals, or, more correctly, the minute surface appearance of the prefrontal, for although it is not evident in the adult that that bone makes itself visible at this point, yet it may be demonstrated in skulls of younger specimens. The culmen, as in other birds, is formed by the intermaxillary, which is here firmly united with the nasals, and the two in conjunction form the peripheries of the truly elliptical external nasal apertures or nostrils, the first bone bounding them anteriorly, while the latter completes their arcs in the rear. These in the dry skull measure through their major axes seven millimetres, and through their minor ones barely five millimetres. They have a distinct ring raised around their circumference, which is wanting, however, where they nearest approach each other anteriorly at the culmen. The plane of the nostril faces upwards, outwards, and forwards; the nostrils are completely separated from one another by a vertical bony septum, developed from the intermaxillary, not a common occurrence in birds. They have, in addition, a concave bony floor, that rises behind into a posterior wall leaving really two semicircular openings just beneath the culmen, separated from each other by the vertical septum. The osseous mandibular tomium, also a part of the intermaxillary, is as sharp as when the bill is sheathed in its horny integument. The arc is concave, and falls off rapidly as it approaches the tip of the beak. Occasionally, in very old birds, the *ethmo-turbinal* bones in the nasal passages may ossify. The *nasals* form here the sides of the bill, and are firmly anchylosed to the bones they meet, except the lacrymals. The movability of the fronto-mandibular articulation is limited. The dry skull is extremely light and brittle, giving one the sensation in handling it that he might experience while examining an egg from which the contents had been removed. A line drawn from the tip of the upper mandible to the outermost point of one tympanic, around the arc of the cranium to a similar point on the opposite side, and back to the point of departure, describes nearly the sector of a circle. The longest radius, which is in the median line, measures four and one-half centimetres, the cord between the tympanics about three centimetres.

The hyoid arch.—The hyoid arch is suspended from the base of the skull by its usual attachments. In this Owl it consists of but six very delicate little bones, involving five articulations. The tips of the upturned posterior extremities are about opposite the lower borders of the temporal fossæ, its two limbs diverging from each other at an angle equal to that made by the lower mandible. The cerato-hyals are rather large in comparison with the other bones. They are joined both anteriorly and posteriorly by bony bridges, forming a fenestra between them, to be filled in by a thin membrane. The amount of divergence they make from each other is less than that made by the hypo-branchial elements of the thyro-hyals. Anteriorly, the bone connecting them supports a cartilaginous glosso-hyal, while the posterior connection presents for examination the usual smooth articulating surface that enters into the arthrodial joint it makes with the basi-hyal. The basi-hyal and urohyal are confluent, not a sign of the point of union remaining. The latter bone is continued a short distance posteriorly by a tip of cartilage. The anterior end of the basi-hyal is devoted to the articular surface for the bone connecting the cerato-hyals, forming the joint mentioned above. It is concave from above downwards, convex from side to side, the lower lip being the longer. It will be plainly seen that this combination grants to the tongue a movement in the vertical and horizontal planes. The anterior articulating heads of the hypo-branchial elements of the thyrohyals are opposite each other, each being received into the diminutive acetabulum intended for it at the side of the united basi- and uro-hyals, and most probably at the junction of the two latter bones. These two elements are long bones having a cylindrical shaft, terminating at either end in an articulating head. They are the longest bones in the hyoid arch, and have a gentle curvature upwards throughout their extent. Their inner heads form an arthrodial joint on either side with the outer heads of the cerato-branchial elements of the thyro-hyals. These, the last bones of the arch, are joined in the manner already shown above. Their inner ends are quite pointed, even as far as the bone goes, the extreme points being finished off with cartilage. They curve upwards from about their middle thirds, and, like the first elements of the thyro-hyals, they are long bones, but with curved cylindrical shafts, the outer end, however, being the only true articulating one.

The lower mandible—(Pls. I and II, Fig. 3).—That portion of the bone which originally was separate as the dentary element, and as far back as to include the interangular vacuity, is firm and compact, while the remainder has much the same character as the bones of the cranium, being cellular and light, having only a very thin outside layer of the harder tissue. All of the primary segments are firmly knitted together, the only sutural trace to mark the margins of any one of them being the posterior border of the dentary elements as they bound the fenestra before and slope away beneath it. The articular extremities are some little distance below the upper outline of the bone. Their superior surfaces are indented so as to accurately receive the condyles of the tympanics on either side, forming the joint that allows the opening and closing of the mandibles. Their under surfaces are smooth and rounded, having a fine ridge running across them transversely. Internally they are drawn out gradually into subcylindrical processes that point upwards, inwards, and a little forwards, exhibiting superiorly on each, about the middle, an oval pneumatic foramen. The upper edge rises rather abruptly from the articular ends, presenting as it arrives near the general level a rudimentary coronoid for the insertion of the tendon of the temporal. With the exception of a little elevation where the dentary element meets the surangular, the superior outline is unbroken; it falls away rapidly as it approaches the symphysis, where, with the opposite border, it completes a little notch at the extremity. The tomium is not as sharp as in the upper bill, and the mandibles do not fit nicely to each other until covered with their horny sheaths. The inferior border is rounded throughout its extent, and on a level at its posterior commencement with the under surfaces of the articular ends and running nearly parallel with the superior. The curve described by the rami before they meet at the symphysis inferiorly approaches the parabola in outline. The sides of the jaw are nearly smooth internally and externally. The vacuity that occurs in so many birds at the junction of the middle and inner thirds is rather large, long, and spindle-shaped, and filled in, in the fresh state, by an attenuated membrane.

Professor Huxley, in his Classification of Birds (Proc. Zool. Soc. Lond., 1867, p. 462, 5 *Ætomorphæ*), presents us with some of the most important cranial characters of the *Strigidæ;* and we find through the literature of the subject not a few authors who have touched upon the osteology of this interesting group of birds. The attention of ornithologists and others has been directed on several occasions to the asymmetry occurring in the skull of certain species of Owls, notably in *Nyctale.* In 1870, Dr. T. H. Streets, of the United States Navy, noticed this point and published his observations. (Proc. Acad. Nat. Sci. Phil., 1870, p. 28.) In the next year, Robert Collett, esq., of Norway, noted the same thing in *N. tengmalmi.* (P. Z. S., 1871, pp. 739–743.) Figures showing this condition are given by Mr. Collett in an interesting paper of his that he kindly sent me upon the Craniets og Oreaabningernes Bygning hos de nordeuropæiske Arter af Familien Strigidæ. Mr. Ridgway has likewise figured the skull of *Nyctale richardsoni* in the North American Birds. In *Ulula cinerea* we have another variety of cranial asymmetry; in the specimen before me the post-frontal wing is thrown farther outward on the right side; this is not the case in *Strix nebulosa*, a species that has a perfectly symmetrical skull. This characteristic occurs in other Owls. In *Surnia funerea* we find the osseous nasal septum well perforated at its upper and inner part, very much as it is in *Circus*. The Hawk Owl has likewise superorbital processes of the same form as those we have described above for *Speotyto*. The periphery of the orbit above in *Surnia* is slightly rounded, not nearly as much though as it is in *Strix nebulosa*, much less than in *Asio*. These borders are very sharp in *Scops*, while in *Aluco* they nearly merge into the orbit. This latter Owl has a skull that is at once strikingly different from other forms of the family, being long and narrow, the orbits being separated by a great, thick, spongy septum, the wings of the ethmoid are likewise spongy cylindrical masses, and the lacrymals are very large, being composed of the same material. For a family where the skulls of the various forms vary so much, differ so much from each other, we note quite an exception in the crania of *Nyctea* and *Bubo*, owls that have skulls strikingly alike, except in point of size, and a few minor differences.

The spinal column; cervical portion.—There are fourteen cervical vertebræ, each one having a more or less free movement with the one beyond and behind it, maintaining in all positions some variation of the usual sigmoid curve observable in the division of the vertebral column throughout the class. The arrangement, as well as the direction, of the planes of the zygapophysial articular surfaces allow considerable rotary movement and bending in the vertical plane, with combinations of the two. It is a common habit of this bird, among other of his antics, to duck his head smartly downwards and again upwards, several times in succession, upon being approached. The relative position of the cervicals has been figured in Plate I from the dead bird, placed in the act of this particular manœuvre, in a specimen after careful dissection. The calibre, as well as shape, of the neural canal in this portion of the spinal column varies at different points. It originates at the atlas as a transverse ellipse, with a major axis of four millimetres and a minor axis of a little less than three millimetres; this is about the maximum capacity throughout the entire canal. From the atlas to the sixth or seventh vertebra the ellipse gradually approaches the circle, with a marked diminution in size, its diameters being at the seventh about two millimetres in any direction. From this point to the twelfth, inclusive, it rises as it fell from the atlas, and in the same manner, when we again discover a transverse ellipse, perhaps a jot smaller than the one described in speaking of the atlas. In the thirteenth the canal is smaller than, though in all other respects resembles, the twelfth, but an abrupt change takes place in shape as we pass to the fourteenth or last cervical, where the form of the neural tube suddenly approximates the circularity of the dorsal vertebræ. The vertebral canal begins, circular, on either side at the third cervical vertebra, most of its length being immediately beneath the prezygapophyses of each segment. It is formed in the usual manner by the di- and par-apophysial processes uniting laterally with the pleurapophysial elements. Small at the cephalic extremity of the column, its calibre gradually increases in each vertebra as we proceed toward the thoracic extremity, until it attains its maximum capacity at the eleventh vertebra. In the twelfth the integrity of its walls is lost by a parting of the par- and pleur-apophysial elements, with a disappearance of the former, leaving it no floor, so that in this vertebra it ceases to be a closed canal. The most prominent object presenting itself for examination in the atlas, superiorly, is the deep reniform cavity for articulation with the occipital condyle of the basi-cranii. It makes up to the entire superior articulating surface of what would first appear to be the centrum of this vertebra, unless we should not consider such to be the case until the odontoid process of the vertebra next below, the true centrum of the atlas, lends its assistance, in which event the surface of this articulation is only complete when made so by the extremity of the process just alluded to. A membrane sometimes stretches across this interspace, separating the extremity of the odontoid from the condyle of the occiput; this is not invariably the case, however, as in many of the individuals we have examined a minute vacuity exists, allowing the process to come in immediate contact with the condyle at one point. Below and posteriorly there is another articulating surface, convex for the centrum of the axis and concave for its odontoid process, accurately meeting the opposed surface of this vertebra and forming the atlo-axoid articulation. A lip of bone, a portion of the hypapophysis of the vertebra we are now describing, projects downwards and shields this joint in front, overlapping, indeed, a good part of the axis. The neurapophyses of the atlas are slight in structure. The concave postzygapophyses articulate with the convex prezygapophyses of the axis. The bone is devoid of a neural spine. In the axis we find both an hypapophysis and neural spine developed, the former being produced from the ridge on the anterior aspect of the centrum of the bone. The odontoid process arises vertically from the posterior margin of the upper surface of the centrum. Its summit and anterior face are convex and articulating, while behind it is flat and continuous with the spinal canal. The facet for articulation with the centrum of the third vertebra looks downwards and inwards, is convex from side to side and concave in the opposite direction. The postzygapophyses are concave, look downwards and outwards, the conditions in the prezygapophyses being exactly the opposite; this is the rule throughout the cervical portion of the column. After we pass the atlas and axis, we find in the third cervical vertebra, here, as in most vertebrates, parts that are common to the series of this portion of the column, deviating but slightly from each other as we examine them *in seriatim;* but gradually as this deviation proceeds, some requisite condition is brought about when the climax is attained. The fact of the presence of a neural spine on the axis is conveyed, though in a less marked degree, to the third or next vertebra below, where it occupies a position about in the middle of the bone. As we descend, this process becomes less and less prominent, being found set further back on each successive vertebra; it disappears about entirely at the tenth, after which it rapidly begins to make its appearance again, assuming its former position in the middle of the vertebra, being quite evident in the twelfth in the shape of a pointed spine, while in the fourteenth it bears the quadrate form, with extended crest, being the first step towards an assumption of that notorious feature found further on in the dorsals. In the third vertebra the space between the pre- and post-zygapophyses is almost entirely filled in, a minute foramen on either side alone remaining, by a lamina of bone extending from one process to the other, giving to this vertebra a much more solid appearance, which in reality it possesses above that attained by any of its fellows. This bony lamina is reduced in the fourth vertebra to a mere "interzygapophysial bar" connecting the processes, while in the next succeeding one or two vertebræ it occurs only on the prezygapophyses more as a tubercle, being directed backwards, then disappearing entirely, is to be found again only on a few of the last cervicals as an ill defined knob, still retaining its original position. The diapophyses at first project nearly at right angles from their respective centra, then approach the median line by being directed more backward near the centre of the cervical division of the column, and on nearing the dorsals again gradually protrude more and more directly outward. The prezygapophyses of the ninth cervical support well-marked anapophysial tubercles, which are feebly developed also on a vertebra or two both above and below the ninth. The joints between the bodies of the cervicals of this Owl are upon the same plan as those found throughout the class; the anterior facet being concave from side to side, convex from above downwards, the reverse being the case with the posterior facets, and when articulated fitting accurately into each other. The pleurapophysial elements, well marked in all the cervicals after passing the axis, become in the thirteenth vertebra a free cervical rib, about three millimetres in length, without neck or true head, being merely suspended on either side from the diapophysis of the vertebra, and freely movable on its exceedingly minute articulating facet.

Attached to the last cervical we find the second pair of free pleurapophyses, about two-thirds as long as the first pair of dorsals or true ribs of the thorax, terminating in pointed extremities and articulating with the vertebra by both capitula and tubercula, the former on elliptical facets, placed vertically on either side of the centrum at the anterior margin of the neural canal, and the latter on rounded facets beneath the diapophyses. The tubercle on one of these ribs is nearly as long as the neck; at the junction on the posterior side is found a pneumatic foramen of considerable size. These ribs are more or less flattened above from before backwards, being convex anteriorly, concave posteriorly, becoming rounded below. From the third to the ninth vertebra, inclusive, appear beneath the vertical canal anteriorly well-developed styliform parapophysial processes, directed backwards and downwards. They are best marked on the segments of the middle of the neck. There is no instance in this bird of these processes being produced so far backwards as to touch the next vertebra below; their tips, as a rule, about overhanging the middle of the centrum of the vertebra to which they belong. We have found in specimens of *Bubo virginianus* the parapophyses of the fourth vertebra overlapping and touching the fifth, for a millimetre or more. The third and fourth cervicals have, beneath in the median line posteriorly, strongly developed hypapophyses, quadrate in form, a process that exhibits itself on the fifth vertebra, anteriorly, merely as a small tubercle. On the sixth this tubercle has disappeared, and has been supplanted by two others that are now found just within the periphery of the anterior facet of the centrum on the parapophysis of each side, beneath and inclined toward each other. These processes, now a double hypapophysis apparently developed from the parapophyses, continue to increase in size and inclination towards each other on the next three vertebræ, so that on the ninth, where they last appear, they nearly form a closed canal. The passage between them is intended for the carotids, to which they afford protection. The hypapophysis of the tenth, eleventh, and twelfth vertebræ is single, large, quadrate, and directed forwards and downwards. There are three on each of the last two vertebræ, each having an independent root, the two lateral ones directed downwards, forwards, and outwards, with characteristics similar to the one in the median line. Several pneumatic and nutrient foramina perforate each cervical vertebræ at various points, except in the axis and atlas, where, after diligent search, aided by the lens, we have signally failed to discover them.

Dorsal vertebræ; vertebral and sternal ribs; sternum.—The dorsal vertebræ number five; the anterior one articulates with the last cervical and the last dorsal with the first sacral. Although the dorsals of this bird fit very snugly to each other, it requires no further maceration to separate them from one another than it does to remove the ribs from their attachments. This close interlocking, however, greatly diminishes the movement of this division of the spinal column, bestowing upon it a rigidity only exceeded by the anchylosed vertebræ of the sacrum; yet, it must be understood, they do enjoy, in this Owl, a considerable degree of movement, especially laterally. The neural spines have here attained their maximum development, forming, when taken together, an elevated and compressed median crest, with a thickened summit, and having a firm hold upon the remainder of the vertebræ below. Taken separately, the last is the smallest, the fourth next, the first next, and the second and third the largest. Their anterior and posterior borders are concave, allowing, when articulated, spindle-shaped apertures to exist among them, while their summits are produced backwards and forwards, thickened, and wedged into each other. This wedging is performed in the following manner: The posterior extremity of the crest forming the summit of the neural spine of the first dorsal divides and receives the anterior extremity of the crest of the second. This same arrangement exists between the second and third, and at the summit between the third and fourth, but the fourth immediately below the junction also divides for a little distance and receives the edge of the posterior rim of the third, just beneath the union of the crests. This latter method of joining is feebly attempted between the fourth and last. (See Pl. I.) The neural canal is nearly cylindrical in the dorsal region, its calibre being less at the sacral extremity, and rather compressed from side to side, as are the centra as we approach that end, each one being a little more so than its neighbor beyond. Viewing these five vertebræ from above in the articulated skeleton, we observe the spinous crest already described; we are struck with the regularity with which the postzygapophyses overlap and adjust themselves to the prezygapophyses from before backwards, like the scales in some fishes, the facets of the former facing downwards and outwards, the opposed surfaces of the latter facing upwards and inwards. The neurapophyses are horizontally compressed and rather broad; the diapophyses jut from them at right angles from points about their middles. There is an inclination for the latter to be directed slightly backwards as we near the sacrum. The diapophysis of the first dorsal is the shortest and stoutest, that of the last the most delicately constructed. Superiorly, these processes support metapophysial ridges at their extreme outer borders. These ridges on the diapophyses of the first dorsal are the largest, rounded at both ends, extending a little both backwards and forwards, but far from touching the ridge either in front or behind them. The metapophysials of the last dorsal are smaller, sharp, styliform, and project only forwards, though they do not by any means touch the diapophyses in front of them. On the intermediate vertebra they change gradually between these two extremes, but in no instance meet the diapophyses of the vertebra before or behind them, and thus constitute an additional aid to the rigidity of the back, as it does in other species of this family and in many other birds. The centra increase in depth beneath the neural canal the nearer they are to the sacrum. In the first dorsal the body measures about one millimetre, the vertical diameter of the canal being three; in the last dorsal it equals the diameter of the canal. The interarticular facets are in the vertical plane, with their concavities and convexities opposed to each other, as they were described when speaking of the last cervical vertebræ. The bodies are about of a length, constricted at their middles and expanding towards their extremities. The first two dorsals each bear in the median line, beneath, an hypapophysial process of considerable size, affording abundant surface for attachment of some of the muscles of the neck. The process of the first dorsal has one common trunk, with a compressed midprong and two lateral and pointed subprocesses. (See Pl. II, Fig. 5.) The second dorsal possesses a single long hypapophysis, quadrate in form, dipping into the chest further than the first. There is not a trace on the remaining dorsals of this appendix. Parapophysial processes, so prominent in nearly all the cervicals, afford in the dorsal vertebræ simply articulating facets for the capitula of the pleurapophyses situated just within the anterior margin of the neural canal of each centrum, never extending to the vertebræ beyond, forming the demi-facet of andranatomia. Immediately above these facets, on either side, may be noticed a group of pneumatic foramina of various sizes and shapes, and again, anterior to these foramina, the rim of the body of the vertebra for a limited distance becomes sharply concave, being opposite to a like concavity in the next vertebra, the two, when opposed and articulated, forming the oval foramen for the exit of the dorsal nerves. Elliptical articulating facets for the tubercula of the pleurapophyses, looking downwards and outwards, are seen on the inferior ends of the diapophyses with a midridge running from each facet to the base of the process, to be expanded and lost on the sides of the centra. As there are five dorsal vertebræ, so are there five *pleurapophyses* articulating with them and with the hæmapophyses below. Each rib is attached to a single vertebra, as shown while speaking of the dorsals. The necks of these ribs become more elongated the nearer they are to the pelvic extremity of the body, the first possessing the shortest. This is exactly reversed in regard to the pedicles bearing the tubercula, being the longest in the first pleurapophysis and shortest in the last. This contraction of the pedicles is progressively compensated for by the lengthening of the corresponding and respective diapophyses of the vertebra to which they belong. Viewing the ribs from the front, in the skeleton, the curve they present resembles the quadrant of a shortened ellipse, the vertex of the major axis being situated at the base of the neural spines; viewed laterally, the curve is sigmoidal, though a much elongated and shallow one, with the hæmapophysial extremity looking forwards and the facet of the tubercle backwards. The first rib is the shortest and generally, though not always, the broadest; the last being the longest and most slender, the intermediate ones regularly increasing in length and diminishing in breadth from the first to the last. In form, the ribs of this Owl are flattened from side to side, widest in the upper thirds, narrowest at their middles, and club-shaped at their lower extremities, where they articulate with the sternal ribs by shallow facets. On the inner surfaces we find the necks produced upon the bodies as ridges, running near their anterior margins and becoming lost at about the junction of the upper and middle thirds in the body of the rib. Pneumatic foramina, from two to three in number and of considerable size, are found just within the commissure between neck and tubercle, posteriorly. All the vertebral ribs bear a movably articulated epipleural appendage, each resting in a shallow cavity designed for it upon the posterior borders. They leave the rib at right angles, but soon turn upward with a varying abruptness. The appendage of the first rib is situated lowest of any on its rib, that of the last the highest; the facets of the others are found in the line joining those of the first and last. They all make acute angles with the bodies of the ribs to which each belong, above their points of insertion. The angle made by the last is the least, and it increases to the last. The epipleurals of the leading pleurapophyses are the widest and generally the longest (the one on the second rib in a skeleton of this bird now before me is as wide as the rib at the point from where it starts), the one on the last rib being always the smallest.

Clubbed at their superior extremities, each one overlaps the rib behind it, and in this manner add stability to the thoracic parietes, which is undoubtedly one of the functions these little scale-like bones were intended to fulfill. The *hæmapophyses* connect the vertebral ribs with the sternum. There are six of them, one articulating with each vertebral rib and having a concave facet to receive it, while the last meets the sacral rib above and articulates with the posterior border of the fifth below. The first one is the shortest the most slender of all; the fifth is the longest. With the exception of the last, their superior ends are enlarged and compressed from side to side, while below their middles they become smaller; then turning upon themselves, suddenly enlarge again, so as to be flattened from before backwards, when each terminates by a transverse articular facet for articulation with the hæmal spine. Quite an interspace exists between their points of contact with the sternum. They all make a gentle curve upwards just before meeting their respective ribs. The hæmapophysis that articulates with the sacral rib is inserted in a long, shallow groove on the posterior border of the sternal rib that articulates with the last dorsal pleurapophysis, but does not meet the sternum—simply terminating in a fine point on the posterior border of the sternal rib mentioned. From before backwards the sternal ribs make a gradually decreasing obtuse angle with the vertebral ribs, while the angle they make with the sternum is a gradually increasing acute from the fifth to the first. On the anterior surfaces of their expanded sternal ends are to be found on each a minute pneumatic foramen or two. The anterior third of the lateral borders of the sternum is the space allotted for the insertion of these bones.

The Burrowing Owl being a bird not possessed of any considerable power of flight, a circumstance arising from the life it was destined to lead, or the necessity of having that flight ever long sustained, we would naturally expect to find, in the course of a study of its anatomy, those characteristic modifications of the various systems which pertain to species of the class in which that gift has always been a secondary consideration. Nor are we disappointed in this expectation, for a single glance at the size of the sternum of this Owl, when compared with the remainder of its skeleton with regard to areas for muscular attachments, reveals to us the disproportion of the surface supplied by that bone for the attachment of the pectorals. That its dimensions are relatively contracted is proved by actual, comparative, and proportional measurements of the bones with other species of its family, individuals of which, at the best, are not noted for their powers of flight, and consequently the sternum does not present so prominent a feature of the skeleton as it does in other species of the Class *Aves* where vigorous flight is habitual. Life-size figures of this bone, viewed from the three principal positions for the purpose of study and measurement, are offered to the reader in Pl. I and Pl. II, Figs. 5 and 6. The concave dorsal aspect of the body is smooth, being traversed in the median line by a very shallow groove that lies immediately over the base of the keel. This groove terminates, within five millimetres of the anterior border, in a little depression, at the bottom of which are discovered pneumatic foramina, two or more in number, leading to the anterior thickened vertical ridge of the carina beneath. Other minute openings for the admission of air into the interior of this bone are seen among some shallow depressions just within the costal borders. The bone does not seem to be as well supplied in this respect as it is in some other Owls. The costal borders supporting the transverse articular facets for articulation with the hæmapophyses occupy about one-third of the entire lateral border on either side anteriorly. At the bases of the majority of the depressions that occur between these facets are found other pneumatic foramina. The anterior border is smooth and rounded, with a median shallow concavity occupying its middle third. At its extremities, laterally, the costal processes arise with a general forward tendency at first, but with their superior moieties directed backwards. The costal borders terminate at the posterior borders of the processes, at a higher level than the anterior sternal margin does at their anterior borders. The coracoid grooves are just below the anterior border. They are deep, continuous with each other, having a greater depth behind the manubrium in the median line than observed at any other point. Their general surface is smooth and polished, looking upwards and forwards, and lying principally in the horizontal plane. They melt away into the body of the bone laterally, at points opposite and not far distant from the posterior articulations on the costal borders. The margin that bounds them below is sharp, travels at right angles from the median line at first to a point posterior to the costal processes, then making a little dip downwards, then again curving upwards, disappears gradually with the groove it bounds. That portion of it from the point where it changes its direction to its termination is described by authors as the subcostal ridge. The manubrium, occupying its usual position in the middle line, is comparatively small, quadrate in form, compressed below, slightly notched and flattened above, its posterior surface forming the inner anterior surface of the coracoidal groove. All the borders bounding the posterior parts of the bone are sharp; the lateral one, taken from the apices of the costal processes to their other and lower terminations, are concave. As is the arrangement generally among Owls, the xiphoidal extremity of the sternum is four-notched, two on either side, the outer notches being the deeper. Both have rounded bases, and the processes that separate them are ample and possess rounded extremities. The border upon which the keel ends posteriorly is square, though we have met with specimens in which it was slightly notched in the median line. The body is oblong, and, if we include the xiphoidal processes on either side, has a length half as long again as its width. The ventral and convex surface, like the dorsal, is smooth and presents but two points for examination. The pectoral ridge, faintly marked throughout its extent, originates on each side at a point near the outer borders of the coracoid grooves, running inwards and backwards, and dies away at the base of the keel near its middle. This little ridge denotes the line between the pectoralis major and minor. The keel is moderately well developed, the distance from the base of the manubrium to the carinal angle being equal to the distance from the same point at the base of the manubrium to the base of either costal process or outer anterior sternal angle. It is compressed, smooth, and thin, but its stability is greatly aided by the carinal ridge on either side, which commences strong and well marked at the base of the manubrium, just within the anterior border running parallel with the latter, and disappears as it approaches the carinal angle. The anterior border of the keel is sharp and concave; the inferior border is convex, with the edge slightly thickened. The point of intersection of these two borders anteriorly is rounded and forms the carinal angle. The inferior border expands posteriorly, and the keel terminating a short distance before arriving at the posterior sternal border, the two become blended with the surface of the body of the bone.

Sacral vertebræ; pelvis; and coccygeal vertebræ.—In the sacrum of the Owl now under consideration, with the exception of a few faint lines indicating the original individuality of the vertebræ, these bones are thoroughly anchylosed together and to the ossa innominata. From inspection of this compound bone in immature birds, we find the usual number of sacral vertebræ composing the sacrum to be thirteen. The anterior face of the first possesses all the necessary elements for articulation with the last dorsal. The neural spine has a thickened crest that soon meets the ilia on either side; its anterior edge is thin, and gives attachment below to the interspinous ligament. The neural canal is circular, and the prezygapophyses well marked. The articular facet of the centrum is in the vertical plane, with its curvatures similar to those ascribed to the anterior facet on the centra of the dorsals. The neurapophyses are broad and the diapophyses are strong and raised, with their enlarged extremities expanded upon and firmly united with the iliac bones. There is but one pair of free sacral pleurapophyses; these are long and slender, articulating with the first vertebra in the usual manner, but the relation is much more intimate, as they touch the diapophyses for some little distance beyond the tubercula towards the capitula. The lower extremities of these ribs are terminated by little roundish knobs, which articulate with the hæmapophysis on either side, described as being inserted in the posterior border of the fifth sternal rib. Viewing the bone dorsal-wise, it is to be seen that the thickened crest of the neural spine of the first vertebra protrudes from the angle made by the ilia meeting it anteriorly to a greater or less distance. This broad and compressed crest, then continued backwards, is firmly wedged between the ilia until we pass the third vertebra; at this point the ilia diverge from each other to another point just anterior to the acetabula, then converge, terminating in the posterior sacro-iliac border within five or six millimetres of each other. The sacrum completely fills in the lozenge-shaped space thus formed from the third vertebra—first, by continued broadening and compression of the neural spine, that soon becomes one with the neurapophyses; and, secondly, by the expanded extremities of the di- and par-apophyses, the processes themselves also taking due part. The integrity of the surface is unbroken, save posteriorly, where a few pairs of foramina exist among the expanded transverse processes, increasing in size from before backwards. Anterior to a line joining the acetabula this surface is in the horizontal plane; posterior to this line there is a decline, which declination is accepted also by the innominate bones; this gives the entire pelvis a shape that seems to be characteristic of the majority of both the diurnal and nocturnal *Raptores*. The "ilio-neural" canals, here present, open by small apertures posteriorly, at about the point where the ilia commence to diverge, passing obliquely downwards and forwards; their anterior openings are large enough to allow a view of their internal walls. The neural spine that divides them throughout is compressed from side to side; the ilia which form their outer boundaries are convex; the neuro-spinal crest forms the roof, the basal surface being deficient, formed merely by the spine-like di- and par-apophyses of the vertebræ and the confluent neural arches. This first vertebra occupies the lowest level, the bird supposed to be standing as in Pl. I. Now, a line drawn mesial on the centra below, from the first centrum to the last gradually rises until opposite the anterior borders of the ischiadic foramina, then curves rather abruptly downwards to its termination. The centra of the first two or three vertebræ are compressed from side to side to such an extent as to cause them to appear wedge-shaped, the common apex or edge being below; after that, however, they rapidly broaden, become compressed vertically and more cellular in structure; they are very broad from the fourth to the ninth, inclusive—then as rapidly become contracted as they approach the coccyx. Minute but numerous pneumatic foramina are seen at or near the usual localities. The largest foramina for the exit of the roots of any pair of sacral nerves is generally in the fifth vertebra; they decrease in size as they leave them either way. In the young, only the last few of these foramina are *double;* they are all double in the adult and placed one above another, a pair on the side of each centrum at their posterior borders, for the exit of the roots of the sacral nerves. The diapophyses of the anterior five sacral vertebræ are thrown out against the internal surfaces of the ilia, to which they are firmly attached, and act as braces to hold the engaged bones together. The parapophyses of the first, form facets for articulation with the sacral ribs; the second and third have none; in the fourth and fifth they also act as braces in the manner above described, joining the ilia just before their divergence commences. Reliance seems to have been placed entirely in the completeness of the sacro-iliac union in the last vertebræ, for the apophysial struts terminate in that portion of the pelvic vault formed by the sacrum itself, except in the last two vertebræ, where the parapophyses abut against the iliac borders. The parapophyses of that vertebra which is opposite the acetabula are prominent, they being long and ample, reaching to the border and re-enforcing that part of the pelvis that requires it the most, the vicinity of the leverage for the pelvic limbs. In other *Strigidæ* several apophyses are thrown out at this point. The posterior opening of the neural canal in the last sacral vertebra is subcircular, its diameters being about a millimetre in length. This vertebra also possesses small postzygapophyses, looking upwards and outwards for articulation with the prezygapophyses of the first coccygeal vertebra; the articulating facet of the centrum is also small, long transversely, notched in the median line, the surface on either side being convex. At every point where the sacrum meets the iliac bones union is firm and complete, though both upon the internal and external surfaces the sutural traces are permanently apparent. The anterior iliac margins, as they diverge from the sacral spine, form an acute angle, concave forwards; they have a well-marked rim or border, nearly a millimetre in width, raised above the general surface of the bone, which disappears on the outer borders as we follow them backwards. The two anterior and outer angles overhang the sacral and fifth or last dorsal pleurapophyses. From these last the marginal boundaries, which necessarily give the bones their form, are produced backwards and outwards to a point opposite the centrum of the third sacral vertebra, then backwards and inwards, forming at the above points two lateral angles. From the apices of the two lateral angles to where the borders terminate on either side in front of the acetabula with the pubic bones, the direction is such as to form a concavity on each side; the line joining the bases of these concavities, points opposite the posterior openings of the ilio-neural canals, being the narrowest part of the pelvis. The upper and at the same time the inner margins of the bones in question, from the anterior and median angle, at first approach, soon to diverge from each other, and form the gluteal ridges and borders of those scale-like projections of the posterior portion of the ilia that overhang the acetabula. Produced now as the "gluteal ridges," they tend almost directly backwards, though very slightly inwards, to terminate in the ischial margins. The preacetabular dorsal iliac surfaces are generally concave, while the postacetabular, and at the same time that surface which occupies the higher plane, is flat, having a slope downwards and backwards, with a ventral reduplication after forming the rounded and concave posterior boundary of the pelvis. The preacetabular superficial iliac area is nearly double the extent of the postacetabular. The antitrochanterian facets that surmount the cotyloid cavities have the usual backward direction, though their surfaces look downwards, outwards, and a little forwards. The external surfaces of the *ischia* look upwards and outwards, having just the reverse direction ventrally. Posteriorly, these bones are produced beyond the ilia into finely pointed extremities, tending to approach each other. The slender pubic bones, after closing in the obdurator foramen on either side, touch and unite with the inferior borders of the *ischia* as far as the pointed ends of the latter, beyond which they are produced nearly to meet behind. The interval between the free extremities of the pubic bones in some individuals, notably "birds of the year," is very slight, less than a millimetre sometimes, approaching a closed pelvis. The circular and thoroughly perforated acetabula are formed in the usual manner by the three pelvic bones. They have a diameter of about three millimetres, and their circumferences are in the vertical plane. The ischiadic foramina are elliptical and large; they are, as usual, posterior to the acetabula and above the obdurator foramina. These last are also elliptical, and about one-third the size of the others. Should the major axes of these two ellipses be produced backwards, they would intersect and form an acute angle just within the posterior pelvic border. Viewing the pelvis ventralwise, we observe, in addition to points mentioned when speaking of the sacrum, the reduplication of the ilia, forming pockets behind and internally, that open outwards through the ischiadic foramina and inwards into the general pelvic cavity. The pelvic passage is subcircular, unclosed, with an average diameter of 1.7 centimetres vertically, and a little less transversely. The narrowest part of the pelvis measures 1.2 centimetres, the widest 2 centimetres, being taken between the iliac projections over the acetabula; the average length, including anterior neural spine, is 3 centimetres. Pneumatic foramina occur in the shallow anfractuosities, between the antitrochanters and gluteal ridges in the ilia. None of the *caudal vertebræ* are grasped by the pelvis, the posterior extremity of the sacrum always assisting to form the curve of the pelvic passage. The usual number of these vertebræ is seven, though occasionally an additional one is found, making eight in some individuals. This enumeration does not include the modified and ultimate coccygeal vertebra, the pygostyle. They are all freely movable upon one another, and the first upon the last sacral vertebra. The articular facets upon the centra vary in shape throughout the series; that upon the first is long transversely, with a double convexity so arranged as to accommodate itself to the one on the extremity of the sacrum; they soon become uniform, to pass to the subcircular one existing between the last vertebra and the pygostyle, on which it is concave.

The pleurapophyses and parapophyses are very rudimentary or entirely suppressed. Each vertebra bears a prominent neural spine, which, from the first to the sixth, inclusive, is bifurcated; in the last two it appears as a mere primitive knobule. The transverse processes are all deflected downwards and outwards, very small in the first and still more so in the last; are largest in the fifth and sixth. Prezygapophyses are well marked; they reach forwards and articulate with the feebly developed postzygapophyses. In a few of the posterior segments there appears to be an effort on the part of the neurapophyses to overlap the vertebra next beyond them. The neural canal is pervious throughout, commencing in the first with a calibre equal to that in the end of the sacrum; it gradually diminishes, and terminates in a minute, blind, conical socket in the pygostyle. Hypapophyses are produced downwards in a few of the ultimate vertebræ. They hook forwards and articulate with the centrum of the vertebra next beyond them. Sometimes they are observed to be free, or rather resting upon a facette on the anterior margin of one centrum and extending over to the anterior margin of the centrum of the vertebra anterior to it, to meet a similar facette, as a tiny styliform process. The spinal column is completed posteriorly by the *pygostyle*—that ploughshare-shaped segment that articulates with the last coccygeal vertebra. Above its cup-shaped facet this bone arises as a laterally compressed plate, extending backwards and bifurcated at its extremity, as if to imitate the neural spines of the vertebræ of the series of which it is an ultimate appendage. Below the facet it projects forwards and completes the median sequence of hypapophyses of the centra, being rather larger than any of them. The posterior curve is simply inflected downwards and forwards from its apex.

The scapular arch—(See Pl. I).[1]—The three elements that constitute this arch are all represented, and all independent or free bones; the *coracoids* articulate with the sternum and scapulæ; coracoids and clavicle, connected by ligaments, lend their share to form or strengthen the shoulder-joints. The *coracoid*, comparatively large and strong, forms in the usual manner an arthrodial joint of restricted movement with the sternum, its lower end being in the coracoid groove on the anterior part of that bone. The inner angle of its base is about 2 millimetres from the mesial line, and 4 millimetres intervening between it and its fellow of the opposite side in the groove. This extremity is broad, its outer angle being beneath the third sternal rib at its point of meeting the costal border; it is compressed from before backwards. The articular facet, looking downwards, backwards, and a little inwards, is transversely concave, with a slight dividing ridge, running antero-posteriorly, converting the general concavity into two smaller ones. The coracoid when in position is produced upwards, forwards, and outwards, making, with the vertical line through its base, rather an acute angle. A limited portion of the middle third of the bone only is subelliptical on section and at all shaft-like, due to the fact that the coracoid in this bird being perhaps less than the average length as compared with the size of the bird, and, secondly, to the unusually enlarged extremities, features observable, more or less, in *Raptores* generally. The anterior groove of the upper extremity, that is arched over by the head of the clavicle above, is deep, and occupies fully the upper third of the bone. The coraco-clavicular process springs, thin and compressed, from the inner

[1] It will be seen that in this figure, corresponding limbs, and other parts that are alike on either side of the body, have not been reproduced, it being thought the better way, as the bones on the side towards the observer would necessarily obscure the more remote ones, complicate the figure, and show nothing additional.

side of the shaft of the bone, at junction of upper and middle thirds, to turn upon itself, so as to be projected upwards, forwards, and a little outwards, terminating with an elliptical facet for articulation with the clavicle. The upper border of this process is concave lengthwise and articulates throughout its extent with the inferior margin of the acromial process of the scapula. The lower and thin edge of the coraco-clavicular process tends obliquely downwards, to be lost on the inner surface of the shaft of the bone near its middle. The outer wall of the anterior groove is formed by the coracoid itself, the process just described being really nothing more than a wing-like extension forming the inner boundary of the groove in this bird; it terminates above both clavicle and scapula in a rounded, tuberous head. Below this head, anteriorly and still more inwardly, the coracoid affords a vertical, elongated facet for the clavicle, while behind, looking a little outward, is the concave elliptical facet that constitutes about one-third of the glenoid cavity for the humerus, internal to which, and running first directly upwards, then making a right angle and continuing forwards, a little upwards, and outwards, the last direction being the upper margin of the coraco-clavicular process, is another facet, for the scapula. Behind and below, this bone displays one or two lines and depressions, boundaries of muscular attachments. In the middle of the anterior groove, opposite the base of the coraco-clavicular process, the shaft of the bone is perforated; this perforation is elliptical lengthwise with the shaft, and passes directly through to make its appearance on the posterior convex surface just below the scapula. This foramen transmits a branch of that cervical nerve coming from between the twelfth and thirteenth cervical vertebræ. This nerve branch, after passing through the bone, is distributed to the under surface of the pectoralis minor muscle, and its filaments ascend among its fibres. This foramen is observable also in other Owls, as *Bubo virginianus*, and in some of the diurnal *Raptores*, as in *Accipiter cooperi;* in very many birds it is absent. The *scapula* presents little that is unusual in that bone among the class generally. It lends the additional two-thirds of articular surface to form the glenoid cavity with the coracoid; internal to this the acromion process extends forwards, touching the coracoid as described, and having a limited bearing on the clavicle. Posteriorly its blade-like length is produced, expanding, turning slightly outwards to terminate in an obliquely truncate extremity, with its point over the second dorso-pleurapophysial interspace.

What the scapula lacks in interest is amply made up by the changes observed in the last bone of the group, the clavicle. This element is broad above, much compressed from side to side throughout; it spans the anterior groove of the coracoid and touches the scapula as described above, rapidly diminishing in size as it is produced downwards and inwards by a gentle curve towards the fellow of the opposite side. The upper extremities in adult birds are separated by an average distance of 2.3 centimetres. If the sternum pointed to feebleness of flight in this little Owl, it is still further carried out by the ill-developed clavicles, which constitute that arch in birds, where they are thoroughly and firmly united below, that assists to resist the pressure of the humeri when the wings are depressed in flight, and send them back to their former position after the completion of the action. In examining again Pl. I, which represents the skeleton of an old male, we find this bone to be simply a pointed styliform process; in other individuals, and adults too, it does not even attain the length here shown; but, as if to bid defiance to all law or invariable rule governing it, we again find in very young birds cases where it becomes confluent with its fellow, forming a broad U-shaped arch, though never a very strong one. In a case of this kind the bone was finely cancellous throughout, with an extremely attenuated layer of compact tissue outside, scarcely covering it. In Pl. I, and other individuals like it, the clavicles were pneumatic. Again, in both young and old, it may have any of its lower parts completed by cartilage; it never displays a mesial expansion of bone at the point of confluence. We believe in the Barn Owl (*Aluco*) it anchyloses with the sternum at the carinal angle, by its bending backwards and meeting it at its lowest and median point. As already shown, the superior entrance of the anterior groove on the coracoid is a complete circuit, formed by the three bones of the group. The head of the coracoid overhangs it above; next below is the clavicle, closing it in anteriorly; lowest of all the scapula behind. A plane passed through the superior margins of this aperture would look upwards, inwards, and backwards. All the bones of the scapular arch are pneumatic, with the exception sometimes seen in the clavicle, and the foramina, to allow the air to enter their interiors, look into the inclosed groove of the coracoid just described. In the scapula the foramen is usually single and in the acromion process; single again in the clavicle, it is seen in the broadest part of the head, while in the coracoid there is generally a group of these little apertures, situated in the depression on the surface that overhangs this entrance to the coracoidal groove.

As in many others of the family, in common, too, with not a few of the diurnal *Raptores*, this Owl possesses, particularly the older individuals, an *os humero scapulare*, of the usual form, that increases the articular surface of the shoulder-joint for the humerus.

Of the upper extremity.—The upper extremity consists of ten distinct bones in the full-grown bird, omitting minute sesamoids that might exist. These are the humerus of the arm, the radius and ulna of the forearm, two free carpals, the metacarpal, and four phalanges. (See Pl. I.) The *humerus* is a long, extremely light and smooth bone, and when viewed from above in its position of rest, with the wing closed, it reminds one of the curve in the small italic letter *f*, being concave above towards the scapula; and this bone is so twisted that this same curve is exhibited, though not quite as well marked, when viewing it laterally. The humerus is 5.5 centimetres long, subcylindrical on section at mid-shaft, at which point a minute aperture exists for the passage of the nutrient vessels that are distributed to the osseous tissue and its internal lining. This foramen enters the bone very obliquely, its external orifice being nearest the proximal extremity. This end is well expanded and surmounted above by a strongly developed radial crest that overhangs the shaft slightly towards the palmar aspect. It occupies a line on the bone from the articular facet for the shoulder-joint to an extent shown in Pl. I. The ulnar crest, or lesser tuberosity, incloses quite an extensive fossa below, which acts also as a partial screen to the pneumatic foramina, for the humerus is highly pneumatic. They usually consist of one circular opening, surrounded by a group of many smaller ones. In young birds a very large foramen is generally present; this closes in as age advances. Between the two tuberosities is the vertical and elliptical convex facet for articulation with the glenoid cavity of the shoulder-joint, constituting the "head of the humerus." The radial crest displays palmad, a ridge for the insertion of the tendon of the pectoralis major. The distal end of the humerus is also expanded in the vertical plane and gently convex anconad, the reverse condition of the proximal extremity. It presents, for examination, the articular facets for the ginglymoid joint it forms with radius and ulna, and the superior and inferior condyles. The larger, and at the same time the superior, of these two facets is intended for the cup-shaped depression in the head of the radius, as well as a portion of the articular surface on the ulna. It is ovoid in form and placed obliquely on the bone, the inferior end of the long axis of the oval being situated the nearer the proximal extremity of the shaft. This facet is separated from the trochlea surface for the ulna by a well-marked depression; this latter is a knob-like tubercle when compared with the radial facet. The condyles and the entire articular surface are about in the same plane posteriorly; that is, neither increases the length of the bone, one more than another. Passing from the trochlear surface for the ulna towards the inner aspect of the shaft, there is to be observed a shallow depression, which corresponds to the olecranon fossa of human osteology, and in full extension of the limb allows room for that process of the ulna in this bird. The *radius* has an average length of 6.6 centimetres, and the *ulna* a corresponding length of 6.8 centimetres, so that their distal extremities, when articulated, as we examine them in the closed wing, extend beyond the head of the humerus. In this position also the radius occupies a higher level than the ulna, and is the innermost bone of the two. The radius is slender, the transverse diameters of its subcylindrical shaft varying but little throughout its extent, though its extremities are expanded. From the elbow-joint, when the two bones are in position, it at first diverges from the ulna at a moderate curve, to approach that bone again by a more gentle inclination to nearly absolute contact at the junction of middle and distal thirds; from this latter point it lies parallel with the ulna to the wrist. The head of the radius is elliptical, being crowned by a depression for articulation with the oblique facet on the distal end of the humerus. Beyond, below, and to the outer aspect of this facet is another of similar form, though convex for articulation with the ulna, while still more advanced toward the distal end we find the bicipital tuberosity, and still more distally, the minute nutrient foramen; all of the bones beyond the humerus being non-pneumatic. The distal extremity of the bone in question is terminated by a little fan-like expansion that caps the ulna and articulates by its anterior convex margin with the scapho-lunar of the wrist. It is marked above by the longitudinal groove for the tendon of the extensor metacarpi radialis longus. The shaft of the ulna is nearly three times as large as that of the radius. Its outer half is straight, its inner curved towards the humerus, thereby increasing, at the proximal moiety, the interosseous space, by the assistance of the opposite curve made by the radius. The stronger end is the one involved in the formation of the elbow-joint; here is to be observed the depression for the head of the radius, or the lesser sigmoid cavity, while the articular surface beyond that occupies the entire end of the bone, directed downwards, inwards, and backwards, presents for examination the greater sigmoid cavity, the olecranon and coranoid processes, and the cavity for articulation with the oblique facet of the humerus. The greater sigmoid cavity is subcircular and of some depth; its lower and produced lip represents the coranoid process, as does its upper, better marked, and more tuberous prolongation represent the olecranon of andranatomia. Extending radiad is another concave, quadrate, articular facet for the oblique tubercle of the humerus, as the first-mentioned concavity articulates with the ulnar tubercle or trochlea. A little beyond this articular surface are various small tuberosities and depressions for the origin and insertion of muscles. Approaching the wrist, the shaft is seen to be generally smooth, and diminishes in calibre at junction ot middle and proximal thirds, in the locality of the nutrient foramen, while along its entire length, at certain intervals, are the slight elevations for the apices of the quills of the secondaries. The distal extremity of the ulna enters into the formation of the wrist-joint; it is not nearly as large as the proximal end. The articulating surface has a deep mesial cleft in the vertical direction, limited externally by an elliptical curve, internally by a double, tuberous knob for articulation with the irregularly formed cuneiform of the carpus, while above is a roughened surface that is covered by the expanded end of the radius.[1]

The *carpus* is composed of the *scapho-lunar*, *os magnum*, and *cuneiform*. The *scapho-lunar* articulates with radius, os magnum, and ulna. The radial articulation is a rather deep and elliptical concave facet, its lower border gliding over the ulna, while the distal end of the radius plays in the concavity. The opposite face of this six-sided little bone is also smooth, and is a nearly flattened surface that articulates with os magnum. The upper and lower surfaces, as well as the ends, are simply roughened and fashioned to give the proper form to that part of the joint into which it enters, and for the attachment of ligaments. *Os magnum* has become confluent with the mid-metacarpal, forming its trochlear surface for articulation with scapho-lunar, cuneiform, and ulna. The *cuneiform* is an extremely irregularly shaped bone; it appears to be rather the larger of the two free carpals, and is the lower in regard to position. It articulates with ulna and os magnum, simply. Its outer ulnar facet is elliptical and shallow, monopolizing the entire face of the bone; its inner facet is very irregular, being formed so as to accommodate itself to the ulnar tubercles, with which it articulates. Projecting towards the metacarpus, this little bone has two prongs or limbs, the inner aspect of the extremities of each possessing a subcircular facette that articulates, the outer and shorter limb with the internal trochlear margin of os magnum, on the same side; the inner and longer limb straddles the metacarpal and glides over the surface, during movements of the joint, at a point about where magnum becomes confluent with mid-metacarpal. The cuneiform has also attached to it ligaments that enclose the wrist-joint beneath—capsular ligaments of the carpus.

The *metacarpus* is formed in the usual manner, by the amalgamation of the index, medius, and annularis metacarpals, the first, second, and third, respectively. It is 3.3 centimetres long, articulating with scapho-lunar, ulna, and cuneiform at its proximal extremity by means of os magnum, that has become anchylosed with mid-metacarpal and the pha-

[1] In the October number of the Bulletin of the Nuttall Ornithological Club, for 1881, Cambridge, Mass., I published an article entitled "On the ossicle of the Antibrachium as found in some of the North American Falconidæ"; wherein I described a very interesting sesamoid that was found above the carpal articulation, on the radius, in a specimen of *Circus hudsonius*. This sesamoid I named the *os prominens*, but subsequently ascertained that it had been noticed by Milne-Edwards, and after this naturalist, by Mivart (Lessons in Elem. Anat., p. 320, Lond., 1877). My attention was afterwards called to its occurrence in the Owls, by Mr. Forbes, prosector to the Zoölogical Society of London, and again by Mr. F. A. Lucas, of Rochester, New York, the latter observer finding it in *Bubo* and *Nyctea*. Subsequently I found it in other American Owls, and have no reason to doubt but that it will be found in *Speotyto*, though I have not material at hand, now, to confirm it. Additional literature and remarks upon this sesamoid will be found in following numbers of the Bulletin quoted above; one in the January number, 1882, by Mr. J. A. Jeffries. It does not show in the carpus of *Bubo virginianus* (Plate III, Fig. 11), accompanying this article, because at the time I drew the figure I was not aware of its occurrence in that Owl, or the joint represented would have been placed so as to exhibit it.

langes at its distal end. The first metacarpal is short, and fused with the second just anterior to the boundary of the trochlear surface of os magnum; it makes an angle with the shaft of the second metacarpal, its extremity being directed upwards. At its base, close to the shaft of mid-metacarpal, it bears a uniform facette for articulation with the index phalanx, a free, three-sided, pointed little bone, about 9 millimetres in length. The second metacarpal is straight; its enlarged proximal extremity is formed chiefly by the confluent os magnum; its shaft is inclined to be subtrihedral, with its broadest face looking forwards; its distal extremity is terminated by a knot-shaped enlargement, that is still further enhanced by the confluence with the third metacarpal. It bears a digit composed of two phalanges, the proximal one bearing on its posterior border, for nearly its entire length, a quadrangular expansion, that has a raised margin, leaving a single concavity radiad; a similar concavity occurs on the ulnar side, but is there divided by a ridge, sloping downward into two shallow depressions. This little bone somewhat reminds one of a cleaver, with the end of its handle attached to the metacarpus. It supports at its distal extremity the second phalanx of this digit, a bone having very much the same appearance and shape as the index digit,[1] only being longer and more pointed. The proximal ends of all the phalangeal segments are more or less expanded, in order to support the ample facets of articulation that occur among them, and the metacarpus. The third metacarpal is expanded transversely above, slender below, where it falls a little beyond the medius after its confluence with it. It also has a small, pointed phalanx, freely attached to its distal extremity, and lying in that recess formed by the shaft and posterior expansion of the first phalanx of the second digit. At a very early date, comparatively, in the life of this Owl, ossification is normally extended to many of the tendons of important muscles of the antibrachium and pinion.

Of the pelvic limb.—The lower extremity is composed of twenty distinct segments, including the patella, or just double the number found in the pectoral limb. This increase will not surprise us when we recollect the greater number of small bones devoted to the foot above those found in the hand. Its most striking feature, next to those osteological characteristics common to the family, is its extreme length, due principally to the tibia and tarso-metatarsus. All the bones of the lower limb in this species are non-pneumatic. The *femur* is comparatively of good size and strong; articulated in the usual manner, it measures 4 centimetres in length and 7 millimetres across the condyles at their widest part. At the proximal extremity, externally, above the shaft, there is a flat and roughened surface, bounded above by the curved trochanterian ridge. This surface forms the major part of the great trochanter. There is no trochanter minor present. The trochanterian ridge is the highest part of the bone, when it is held vertically; it lies in the antero-posterior plane, with the femur in its natural position, the bird standing erect; from it, sloping directly inwards and occupying the remainder of the summit between it and the head, is a smooth articular facet, broadest externally, merging into the globular head internally.

[1] Mr. J. A Jeffries, in a very interesting article entitled "On the Fingers of Birds" (Bull. Nutt. Ornith. Club, January, 1881, p. 6), endeavors to settle the argument upon the homology of this joint. This author says: "Whether the metacarpus are the I–III or the II–IV has been a mooted question, Rolleston, Huxley, and Gegenbaur holding the first view, and Owen, Wyman, Morse, and Coues holding the second view." I have always maintained the view expressed by the latter gentlemen mentioned; the fact, however, that the first phalanx of manus in *Aves* is the homologue of pollex of the pentadactyle limb seems to be gaining ground.

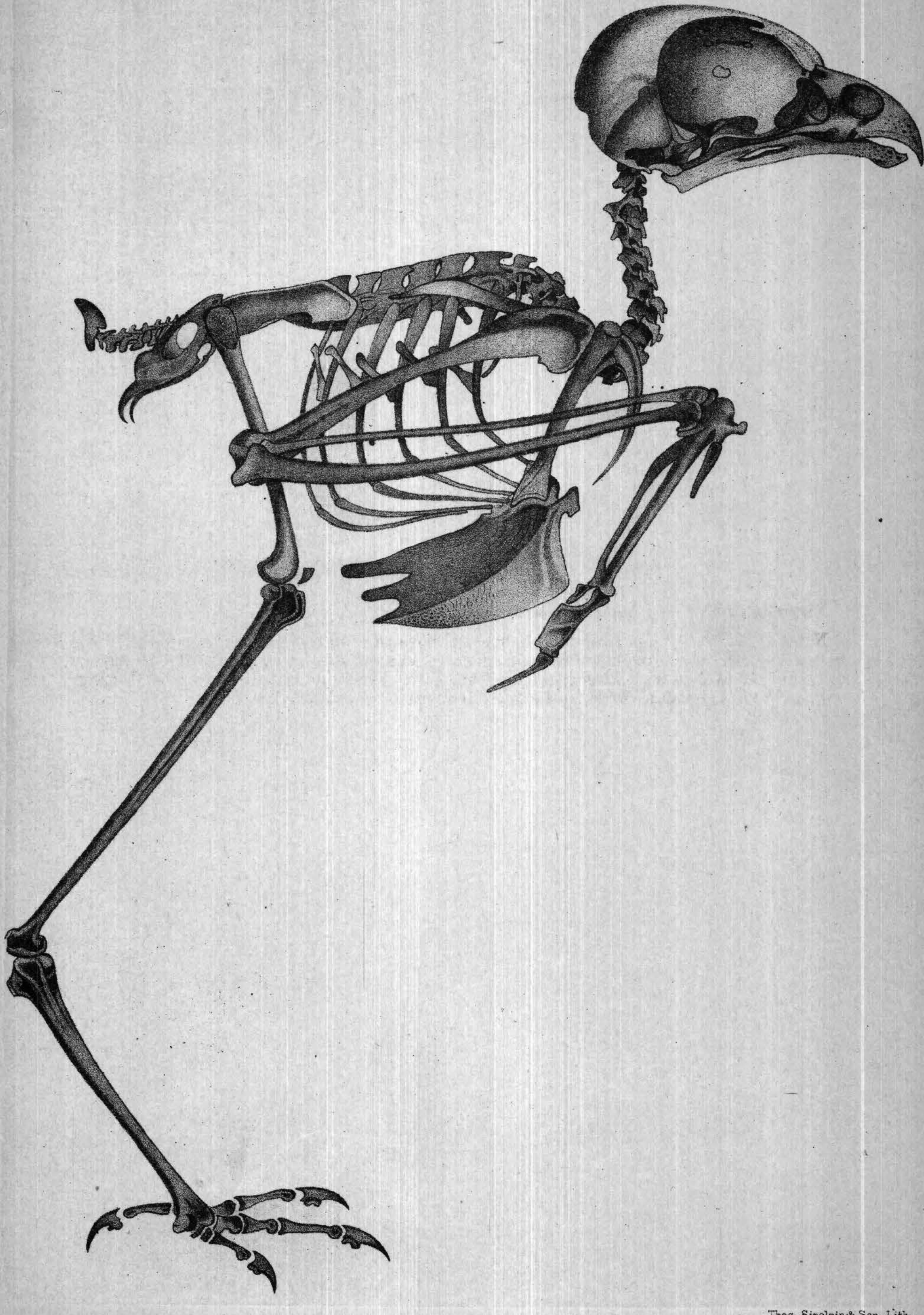
With the head it constitutes the articular surface for the pelvis—it being opposed to the antitrochanterian facet of the ilium, while the caput femoris plays in the cotyloid ring. The excavation for the ligamentum teres on the latter is conical and deep, consuming a good part of the bone; it is situated on its upper and inner aspect. In looking into the relation existing among head, neck, and shaft of the femur of this bird, we must observe that if the straight line lying in the middle of the surface of the internal aspect of the shaft were produced upwards, it would pass through the centre of the facet at the summit—if anything, nearer the trochanterian ridge than it does to the head. This facet also is notably narrower just before arriving at the head than at any other point. Again, the plane passing through the external and circular boundary of the head makes an angle of a good 45° with this line, so that with these facts in view we can hardly assert in the case of the species before us, as do some authors on comparative anatomy in describing this bone *in general*, that the head of the femur is either nearly at right angles with or is sessile with the shaft. It would appear, though, that it has quite as much of a neck to boast of as the anatomical neck of humerus or the neck of the scapula in works on human anatomy. The shaft throughout its length, until it begins to approach the distal condyles, where it is subcompressed and expanded antero-posteriorly, is nearly cylindrical, bent slightly backwards at its lower end, and offers for examination merely the intermuscular ridges, with the linea aspera, feebly marked, and the nutrient foramen, all of which maintain their usual positions on the bone. At the distal extremity the rotular canal, the intercondyloid notch, and the popliteal fossa are all strongly produced, giving due prominence to the condyles, internal and external, between which they form the dividing tract. The external and lower condyle is divided in two by a vertical excavation, deepest above. Of the two facets thus formed, the inner articulates with the tibia, the outer with the head of the fibula. The external surface of this condyle is flat and continuous with the shaft. The inner condyle, broad posteriorly, has a slight depression in the surface that bounds it on the tibial side, and as a rule the usual sites for ligamentous attachments about this extremity are at best but feebly represented. The *patella*, encased in the tendon of the quadriceps femoris, is situated about 3 millimetres above the rotular crest of the tibia, anteriorly, having the form of an oblate hemispheroid with its base directed upwards, the long diameter of which measures 3.5 millimetres. The *tibia* is the longest bone in this bird's skeleton, and at the same time, taking this length into consideration, the least curved or bent along the shaft; it has, however, a slight and just appreciable gradual curvature forwards that is most apparent about the junction of middle and upper thirds. Its average length, measured on the inside, is 6.7 centimetres; its extremities being expanded for articulation, above with the femur, below with the tarsometatarsus. These expansions are of about equal dimensions, though differing vastly in form, in this respect being unlike some of the diurnal *Raptores*, in which the distal condyles constitute the smaller end of the bone.

Among the most important points presented for examination about the head is the articular surface that crowns it above for the condyles of the femur. This is subquadrate in form, uneven, highest at the inner and anterior angle, sloping gradually to the opposite one, bounded almost entirely around by a raised margin, that is most feebly developed posteriorly, and at a point anterior to the head of the fibula, where it is absent. In front this border may be nominated the rotular or epicnemial ridge, though it is no more prominent there than at any other point, but in many birds it is so produced as to form a process of some size, to which these terms are applied. Externally and posteriorly the margin is roughened for the attachment of ligaments that bind the head of the diminutive fibula to this bone. In the middle of this articular surface is to be seen a tuberosity, on either side of which are the depressions for the femoral condyles. Produced downwards, anteriorly from the rotular ridge are the cnemial ridges; these have their crests bent slightly outwards, and they merge into the shaft below, abreast the superior point of the fibular ridge. Of the two, the outer or ecto-cnemial is the shorter; that is, it does not extend so far down the shaft as the inner or pro-cnemial. They have between them an ovate concavity, with the larger end above, the lower end subsiding upon the shaft with the ridges themselves. The vertical elevation on the external aspect of the shaft for articulation with the fibula runs down the side but a short distance; a little below its abrupt termination may be observed in a line with it, the nutrient foramen, entering very obliquely from above downwards. After leaving the fibular ridge as far as the point where the bone begins to expand transversely at the distal extremity, the shaft is remarkably smooth and nearly cylindrical. This transverse and distal expansion is checked, both anteriorly and posteriorly, by abruptly meeting the distal condyles, the point of meeting perhaps being rather the higher behind. The condyles, differing but little in size, are singularly uniform as to shape, with their curved surfaces downwards, being flat on their outer aspects, with a raised rim bounding them in each case. They stand out prominent and apart. Anteriorly their convex surfaces are the widest, behind they slightly approach each other, and the articular convex surface is narrowest on the outer condyle. The intercondyloid notch is deep, and appears equally well marked throughout its extent. Immediately above it, anteriorly, there is a deep triangular depression; another, and more shallow one, is found behind in the corresponding locality. Up the shaft a short distance on the inner side, anteriorly, is a little tubercle, to which is attached the ligament that binds down some of the strong tendons of the extensors. This ligament crosses the anterior triangular depression mentioned above, obliquely, to be inserted near the external condyle superiorly. This is the arrangement also in *Bubo virginianus*, but in some of the Hawks this ligamentous bridge has become thoroughly ossified, forming a strong bony band across the concavity in question. It is interesting to remark here, however general the rule may be as applying to the diurnal and nocturnal *Raptores*, that whereas this band is ligamentous in the tibia in some of the Owls, a bony one fulfilling the same function is found in them just below the head of the tarso metatarsus; these conditions are just reversed among some of the Hawks. In fact, we know of no exception to the arrangement just mentioned for the Owls; even *Surnia funerea* has this bony bridge on the tarso-metatarsus very prominent, and on the inner side of the upper third it being much in the same position as we find it in the well-known exception to the Hawks, that is, in *Pandion*. In short, among the *Raptores* it seems to be found among those birds that possess the reversible toe. Usually, in old birds of this species, the *fibula* is firmly anchylosed to the entire length of the fibular ridge of the tibia; arching outwards, its head, surmounted by an antero-posteriorly elongated facet, rises a little above that bone at the point where it is attached to it by ligament. This is the larger part of the shaft in regard to size. Below the ridge this bone becomes simply a delicate little spine, that emerges into the shaft of the tibia at about the junction of middle and distal thirds, though it may be traced after this as far as the middle of the outer condyle, where it terminates by a minute tubercle. The head is notched externally, near the centre, and has lodged at that point a small sesamoid that is in the lateral ligament of the knee-joint. Posteriorly on the shaft, about midway down the superior tibio-fibular anchylosis, we observe a small tubercle for the insertion of the tendon of the biceps. The long segment that exists between the tibia and the phalanges of the pelvic limb is the bone *tarso-metatarsus*, or the confluent metatarsals of the second, third, and fourth toes with certain tarsal bones at its proximal extremity. It measures down the anterior aspect, mesially, 4.6 centimetres, and has its extremities enlarged for articular purposes, in common with other long bones of the skeleton. At its proximal end the bone presents superiorly two concave articular surfaces for the condyles of the tibia. They appear nearly on a level with each other, the bone being held vertically. The inner and larger of the two is elliptical in outline, antero-posteriorly; the outer and smaller is fashioned off behind by a tuberous process, directed upwards and outwards. Between these two surfaces arises a prominent tuberosity, that in the articulated limb enters the intercondyloid notch of the tibia quite accurately, and is intended for a ligamentous attachment. Anteriorly and internally a groove exists that runs down the shaft, to disappear a little above its middle. This canal is deepest immediately below the articular expansion, and is here bridged over by a little arch of bone, a millimetre in width, that serves to bind down and hold in its proper place the tendon of the long extensor of the toes. Posteriorly there is a much deeper and longer tendinal canal, that extends the entire length of the shaft, being shallowest at the middle and most capacious at the proximal extremity; this is bounded above and internally for a short distance below the head of the bone by the calcaneal process, a thin lamina of bone that has a foramen near its base; this process is surmounted by an elliptical and compressed tuberosity, placed vertically. The opposite wall, above, of this groove is also thin, and extends, in common with the calcaneal process, directly backwards. There are two other foramina seen at this end of the tarso-matatarsus; one just at the external termination of the bony bridge mentioned above, and the other outside and a little above it. Their posterior openings are immediately behind the anterior ones, or, in other words, they do not pierce the shaft in any way obliquely. The shaft of this bone is nearly square on section for the major part of its extent, being encroached upon, however, both before and behind, by the aforesaid tendinal grooves. The tendons, especially those that occupy the posterior canal, are very prone to ossification, forming quite sizable bones in the adult, the largest of these being equal to the fibula in bulk, exclusive of course of the head of that bone, and not being as long. Returning to the tarso-metatarsus, we find at its distal extremity, for examination, the trochleæ that articulate with the rear segment of all the toes except hallux. Viewing this end with the bases of these trochleæ towards one, we find the general outline made by them to be crescentic, with the horns having a tendency to approach each other behind. The outer trochlea is the highest and longest from before backwards; the other two are about on the same level, the inner one having a posterior and internal process, while the middle one is possessed of a median cleft traversing its face antero-posteriorly. They are sharply divided from each other by narrow slits, that extend up as far as the articulating part, and are continued on the anterior aspect of the shaft for a short way as delicate groovelets. A foramen is situated in the outer of these, that gives passage to the anterior tibial artery, and is comparatively larger than usually seen in the Owls. Behind, the tendinal groove expands, and is bounded distally by the concave border formed by the trochleæ. Upon its internal margin, just above the extremity of the bone, it shows an elongated but feebly marked depression of about 3 millimetres in length. This facet articulates with the *os metatarsale accessorium*, which is joined to the bone by ligament. This little bone in this bird has an average length of 4 millimetres. It is twisted upon itself, and bears upon one border a convex, smooth surface for the tarso-metatarsus, while distally it has an articulating surface, resembling more the mid-trochlea than any other, for the proximal segment of the hallux. Above it is sharply grooved for the tendon that goes to that toe. The *toes* are four in number, and their bony segments follow the rule that governs the greater part of the Class *Aves;* that is, first, second, third, and fourth toes have 2, 3, 4, and 5 phalanges allotted to them, respectively. The first phalanx of the hind toe is more compressed from side to side than in the other toes, possessing more of the characteristics of the second joints. Its posterior facet, that articulates with the accessory metatarsal, fits accurately into the cleft surface seen on that little bone. Anteriorly the facet has a median groove, forming two vertical convexities for the double concave facet on the claw, with its dividing ridge. The claws are all a good deal alike, varying in size, the rear one being the most compressed laterally. They are pointed, arched, and nearly conical, the horny thecæ that cover them during life only being grooved on the under side. Their proximal ends have an articulating facet for the next phalanx behind them; this is so arranged that they can be more smartly flexed than any of the other joints of the foot, due to the convex articulating surface extending well beneath on the phalanx they meet. On the under sides of their proximal extremities is a tuberosity for the attachment of the flexor tendons; it has on either side, below, an oval foramen to allow vessels and a nervelet to pass to the extremities of these ungual phalanges. The first joint of the second toe, and the first and second of the third, are thickest and short, articulating internally with the tarso-metatarsus, and having their facets so arranged as to allow of motion only in the one plane. These bones may almost be said to interlock with each other, with their superior projecting processes behind fitting closely into the deep groove intended to receive them on the anterior faces of the joints to their immediate rear. The other underscribed phalanges of these two toes resemble the proximal segment of hallux. The fourth or outside toe possesses five phalanges, but the three innermost segments are very short, and are really nothing more than one of the middle type of phalangeal bones, such as the third on the mid-toe, divided into three nearly equal parts, the proximal and distal pieces retaining all the characteristics of that bone, while the middle segment is simply a mid-section of the shaft. This arrangement, however, together with the manner in which the proximal phalanx, if it may be termed so in this bird, articulates with the long and elevated trochlea on the tarso-metatarsus, gives this toe a versatility and a power to be thrown outward and, to a limited extent, to the rear, not enjoyed by any of the other toes, constituting one of the most interesting anatomical features that we find in the family *Strigidæ*.

PLATE I.

The skeleton of *Speotyto cunicularia hypogæa.*

NOTE.—The drawings from which the lithographic plates and the woodcuts of the bones in these monographs were made were executed by the author; all the cuts of external characters and illustrations of the birds are from Baird, Brewer and Ridgway's North American Birds, and kindly lent me by Professor Baird.



Thos. Sinclair & Son, Lith

SKELETON OF SPEOTYTO CUNICULARIA VAR. HYPOGÆA.

PLATE II.

The skull, sternum, pelvis, etc., natural size.

FIG. 1. The skull from above.

FIG. 2. The skull from below.

FIG. 3. The mandible from above.

FIG. 4. The pelvis from below.

FIG. 5. Anterior view of sternum and first dorsal vertebra, with its corresponding vertebral and sternal ribs.

FIG. 6. The sternum from below.

Fig. 1.

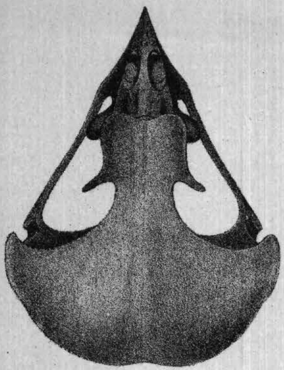


Fig. 2.

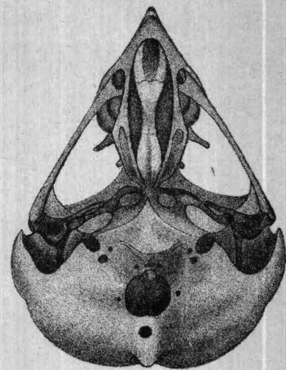


Fig. 3.

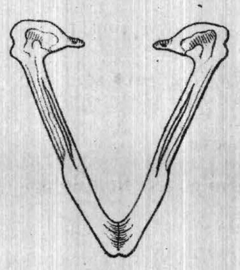


Fig. 4.

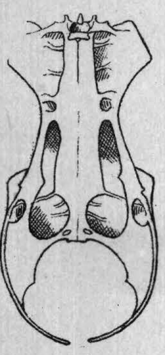


Fig. 5.

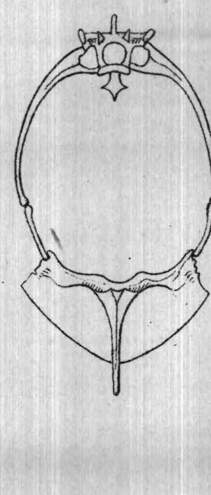
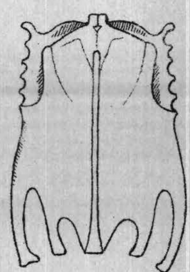


Fig. 6.



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OSTEOLOGY OF SPEOTYTO CUNICULARIA VAR. HYPOGÆA.

PLATE III.

Various bones of the skeleton.

FIG. 7. Anterior view of skull, the lower mandible having been removed.

FIG. 8. ***H*, humerus; *i*, ulnar tubercle; *i′*, oblique tubercle for radius and ulna; *h*, radial crest; *S A* and *S′ A′*, scapular arch; *S* and *S′*, scapula; *C* and *C′*, clavicle; *Cr* and *Cr′*, coracoid; *f*, perforating foramen.**

FIG. 9. *H′*, humerus; *h″*, radial crest; *p f*, pneumatic foramina; *S A″* and *S A‴*, scapular arch; *S″* and *S‴*, scapula; *C″* and *C‴*, clavicle; *Cr″* and *Cr‴*, coracoid; *f′*, perforating foramen.

FIG. 10. *H A*, hyoid arch; *a*, superior view of atlas; *a′*, the same viewed laterally; *b*, the axis; *o*, its odontoid process.

FIG. 11. Right carpus of *Bubo virginianus*, outer aspect, with the bones composing it moved partly from their normal positions to show articulating surfaces; *rd*, radius; *ul*, ulna; *s*, scaphoid; *c*, cuneiform; *m*, metacarpus; *d*, index digit.

FIG. 12. Right radius and ulna, *Speotyto*, inner aspect; *u*, ulna; *r*, radius; *y*, articular facet for oblique tubercle of humerus; *y′* for ulnar tubercle of humerus.

FIG. 13. The same bones, inferior surface, when in position and the wing closed; *r′*, radius; *u′*, ulna.

FIG. 14. Posterior surface, right metacarpus. The differences in form and position of such portion of the articular surface in the metacarpus as is shown by *z* and *z′*, in Figs 11 and 14, between *Bubo* and *Speotyto*, are here seen; flat and rounded below in the first, prominent and pointed in the second.

FIG. 15. Anterior surfaces, right tibia and fibula; *F*, fibula; *T*, tibia.

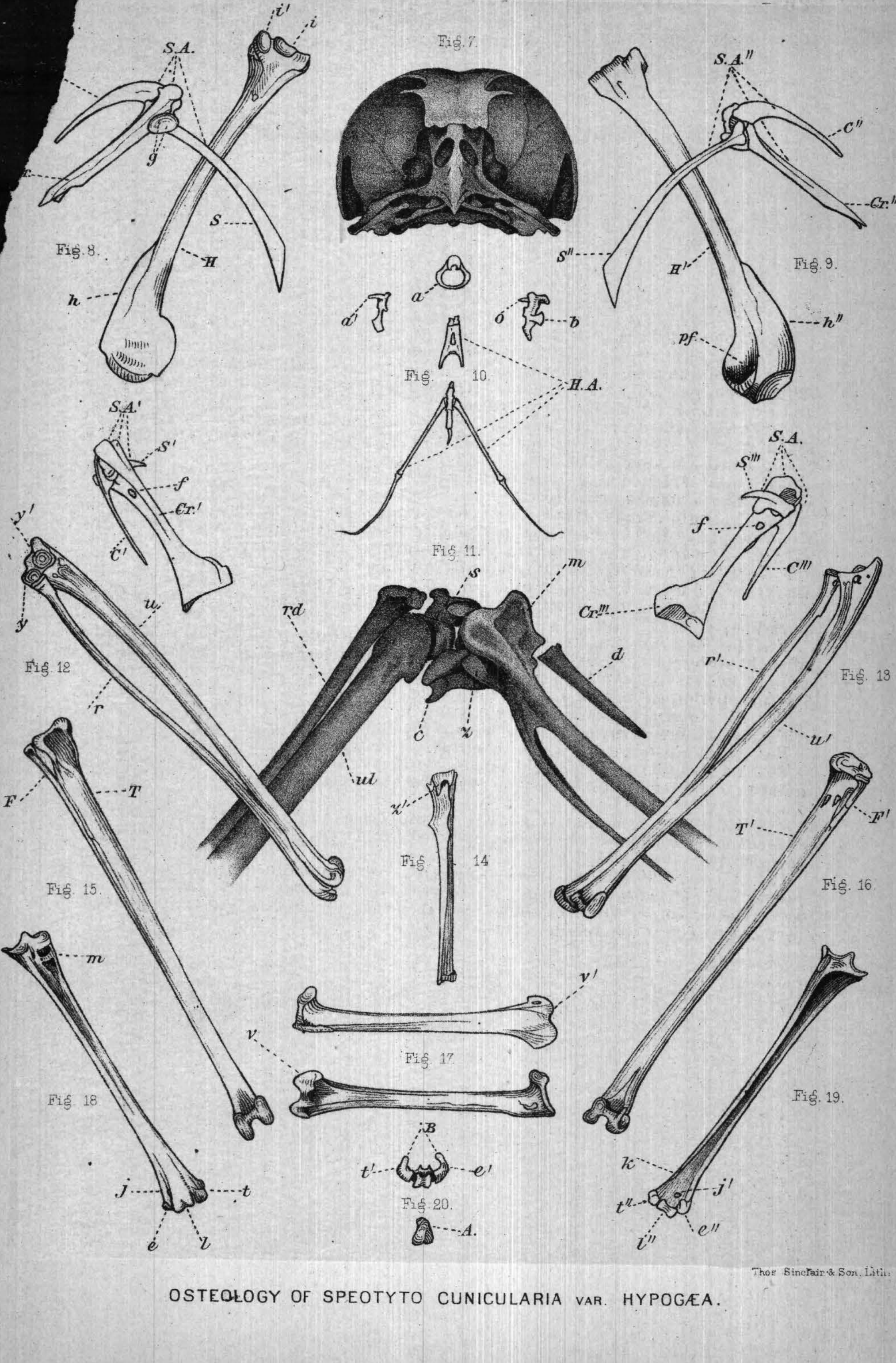
FIG. 16. Posterior surfaces, same bones; *F′*, fibula; *T′*, tibia.

FIG. 17. Right femur; *v*, posterior surface; *v′*, anterior surface.

FIG. 18. Anterior surface, right tarso-metatarsus; *m*, bony bridge over tendons; *j*, foramen for anterior tibial artery; *e*, facet for outer toe, *l*, for middle, and *t* for inner toe.

FIG. 19. Posterior surface same bone: *j′*, the foramen for the anterior tibial artery; *e″* facet for outer toe, *l″* for middle, and *t″* for inner toe; *k*, facet for os metatarsale accessorium.

FIG. 20. *A*, right os metatarsale accessorium, superior surface; *B*, base or inferior surface of right tarso-metatarsus; *e′*, facet for outer toe,*i*, for middle, and *t′* for inner toe. The section of the shaft shows just above the middle facet, on the posterior aspect, ranging near the middle third of the bone.



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OSTEOLOGY OF SPEOTYTO CUNICULARIA VAR. HYPOGÆA.

OSTEOLOGY OF EREMOPHILA ALPESTRIS.

By R. W. Shufeldt, M. D.

Captain, Medical Department, United States Army.

The 11th of March, 1880, was a particularly severe day at Fort Fetterman[1] A violent wind and snow storm prevailed during the entire twenty-four hours. In the creek bottom, below the fort, where the wind had exposed the ground of some land that had been used for gardening purposes the year before, thousands of Horned Larks congregated. They seemed disinclined to vacate their partially sheltered position, preferring to face the few death-dealing fires I delivered them rather than be tossed over the prairie by the freezing storm. At each shot, the flocks arose, skimmed low over the ground, soon to alight again. These simple manœuvres afforded me abundant opportunity to secure many specimens, and several hundred were taken. As they afterwards lay upon the table in my study, one would almost have said, before submitting them to careful scrutiny and examination, that not only was true *alpestris* represented, but both the varieties, *leucolæma* and *chrysolæma*, described by modern writers. Certainly it was that there were many shades of their normal coloring among them, accompanied by differences in size that were not due to sex. I have never seen the black pectoral crescent of this bird in the low position in which Audubon represents it in his work (B. Am., Vol. VIII, pl. 497), where he figures his *Alauda rufa*, the Western Shore Lark.

Before proceeding to the study of the skeleton of this interesting species, we will remind the reader that of all the genera that go to make up the family *Alaudidæ*, or Larks, but few species have fallen to the lot of our North American avi-fauna. We have the Sky Lark, *Alauda arvensis*,[2] and the subject of the present monograph, with its two varieties, *E. alpestris leucolæma* and *chrysolæma*, mentioned above.

The Skull— (Pl. IV, Figs. 22, 25, and 26).—It is a striking characteristic in the skulls of nearly all adult birds that certain bones become firmly united, their sutures entirely disappearing; perhaps in no species of the highly organized suborder *Oscines* has this almost universal avian feature been so thoroughly carried out as in our present subject, the Horned Lark. Occasionally we do find, however, a trace to guide us in locating the original boundaries of the primitive elements, even among the *Oscines*, as the sutures, amidst the parietals and frontals in the cranium of *Lanius*, when maceration is carried to a high degree, but in *Eremophila*,

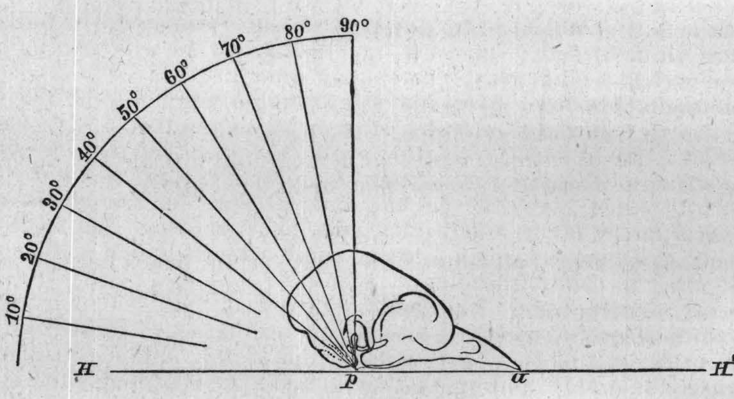
[1] Wyoming Territory, United States, lat. 42° 23′ 35″ N., long. 105° 21′ 4″ W.

[2] *Alauda arvensis*, Linn.—*Cf.* Dresser & Sharpe, Birds Eur., pt.—, and B. B. & R. Hist. N. Am. B., ii. 1874, 136 (Greenland and Bermuda), and Bull. U. S. Nat. Mus., No. 21, p. 293, and Coues' Check-list of N. A. B., 2nd ed., 1882, p. 33, No. 85.

as already stated, there is a total absence of any such indication. If we remove the lower mandible from the skull in any of the Class *Aves*, and place the remainder on the horizontal plane, with the basi-cranii downwards, we observe that in different skulls there exists in this position differences in equilibrium, and differences in, what we will call, the *anterior* and *posterior bearing points*, or the points upon which this part of the skull rests upon the horizontal plane. To illustrate this in the skull we are studying, we find, when placed as directed above, that its equilibrium is quite stable, and that it rests posteriorly upon the tympanics, anteriorly upon the tip of the superior mandible, which constitute, respectively, its posterior and anterior bearing points. In this case there is but one anterior bearing point, with two posterior ones. This is a very common result, but there are at the same time many exceptions to it, as in *Numenius*, and many species of the family *Anatidæ*.

Again, if we erect a perpendicular from one of the posterior bearing points, or the posterior bearing point, for sometimes it is the condyle, we find that the planes passing through the circumference of the foramen magnum and the occipital vertebra, and the point where the foot of this perpendicular and the posterior bearing points coincide, make certain angles with the horizontal plane (the ordinary horn protractor is the best instrument to take these angles with), which we will call, respectively, the *angle of the foramen* and the *angle of the base*. These two angles, in many instances, practically coincide, as in our Lark, where they make an angle of 40° with the horizontal plane. In the cut, H H′ is the horizontal plane; *a* the anterior and *p* the posterior bearing points.

These angles also differ in many birds; *e. g.*, the anterior bearing point in *Ardea herodias* is the tip of the upper mandible, the posterior ones being the inner of the three facets on each tympanic; the angles of the planes of the base and foramen about coincide, and is 50°. In many of the Owls and diurnal birds of prey, the bearing points being the same as in the last example (it being, however, the inner facet of two on the tympanics, as a rule), the combined angles, or either of them separately, is very small, or the base and foramen may be found to lie nearly in a plane parallel to the plane upon which the skull rests, or the



angles are 0°. We see then that in the present case, the bearing points being given, the angle of the combined planes is 40°, which fact, even without actually taking the angles in question, conveys to our minds about the "pitch" or relation of the basi cranii to the other salient features of the skull. Taken accurately, these angles, it is obvious, would have a certain value when we come to compare the various skulls of the Class.

The primary elements of the occipital, or first cranial vertebra, have become completely fused together, and with such other bony elements of the vertebra beyond, of the mesencephalic arch, with which they usually articulate. The well-marked superior curved line that limits muscular attachment above would seem to be, and in all probability is, about the position of the lambdoid suture, and the superior boundary of the bone we are describing. This curved line descends and is gradually lost along the boundaries of the mastoids and occipitals on either side. Externally and inferiorly we find the occipital pierced by the usual foramina of the basi-cranii. The group for the exit of the eighth pair of nerves, being the most anterior of all, are situated on either side, in well-marked depressions or pits, some 7 millimetres apart. Back of these and nearer together are the minute precondyloids, looking forwards and outwards for the passage of the hypoglossal nerves. These last foramina are just anterior to the border of foramen magnum; this latter aperture is of good size, comparatively, having antero-posterior and transverse diameters of 3 millimetres each, with an additional millimetre for the oblique diameters, making the latter 4 millimetres each. It is subcircular in outline, its anterior rim passing around a depression that lies just in front of the condyle, giving the latter the appearance of jutting out into the foraminal space. The condyle is nearly sessile, having the merest trace of a neck, hemispheroidal in form, with an horizontal and average diameter of .5 of a millimetre. Above and midway, laterally, the borders of the foramen are encroached upon by the petrosal on either side, giving it rather a constricted appearance; from these points, as we follow the posterior moiety of the foraminal periphery, we find it to be grooved, each groove ending posteriorly within a millimetre of each other, in a minute foramen that traverses the internal table of the cranium upwards, outwards, and forwards for a short distance, thence to arch around, as a sinus, the epencephalic fossa, to meet in the longitudinal sinus coming from above. This arrangement obtains in the *Corvidæ*, and some other families, where it is more strongly marked. The diapophyses of the occipital vertebra are in a plane but a little lower than the basi-sphenoid; they form, as is quite common, the horizontal floor of the cavity of the otocrane, and blend with the surrounding bones. A moderately well-marked "cerebellar prominence" occupies its usual site in the middle line; no openings or foramina are ever to be discovered either at its summit or laterally, as seen in some other birds (*Anatidæ*, *Strigidæ*). It divides the shallow temporal fossæ that slope away from it on either side, and varies somewhat in size in different individuals. From the upper region of the ear and the superior boundaries of the temporal fossæ to the line of that psuedo-articulation, the fronto-mandibular, this bird's cranium is remarkably smooth, and of a clear white, and, owing to the extraordinary amount of diplöic tissue, possessing a peculiar translucency. The median furrow is only well marked as it passes between the orbits; the superior peripheries of these cavities, as constituting one of the boundaries of the surface under consideration, are sharp at first, rounding as they include the lacrymals, and entirely devoid of any notches or indentations. As is usual, all sutural traces are absent (Pl. IV, Fig. 25). The transverse line of the fronto-mandibular juncture is slightly concave backwards along its middle third, the extremities sloping a little downwards and backwards. The joint motion is only moderately free. No well-marked suture defines its exact locality, as in *Harporhynchus* and others. The bones that go to form the superior mandible, both above and below, are mutually confluent at all their usual points of contact and articulations, with complete obliteration of their original borders. The nearly perpendicular nasals on either side form the anterior boundary of a triangular opening, of which the lacrymals and maxillaries form, respectively, the posterior boundary and base. These triangles are not complete, insomuch as the lacrymals do not meet the infraorbital bars at the inferior and inner angles. They lead into the rhinal vacuity on either side. It must be borne well in mind by the reader that in describing the upper mandible in the skulls of all birds, it invariably presupposes the removal of its horny integumental sheath that it wears during life, and gives to this portion of the cranium a vastly different shape. Either tomial edge is curved and quite sharp; their anterior mergence, or point of the beak, is decidedly rounded, and fully a millimetre in width.

The superior mandible is rather broad at its base; the culmen, originating in a flattened space just anterior to the fronto-mandibular articulation, is rounded throughout its extent and gently curved downwards, while below, the line joining the middle points of the bases of the triangles above mentioned, averages 7 millimetres in length. The sides of the inter-maxillary are smooth, presenting only occasionally a row of very minute foramina for examination; sometimes a faint suture shows itself on either side, extending almost down to the nostril, between this bone and each nasal. Beneath, the palatine fissure is broad and rounded anteriorly, the roof of the mouth beyond being gently concave and grooved mesially for its entire length, and marked by a few foramina. The external apertures of the nostrils are quite large, nearly elliptical in outline, approaching each other within less than .5 of a millimetre above. Their borders, formed by the nasals behind, are sharp; anterior, more rounded. The major axes of these openings average 4 millimetres, the corresponding minor axes 3 millimetres. The planes passed through their peripheries look upward, outward, and forward. The nasals are fan-shaped, both above and below, the expansion being slightly twisted, in order to accommodate themselves to the form of the bill. The broad lacrymals, assisted by the prefrontal, effectually separate the orbital vacuities from the rhinal chambers. The latter are more than usually open, owing to the size in the skull of the various apertures leading into them from without, already described, and devoid of all septa or bony offshoots, although the prefrontal, intermaxillary, and palatines together occasionally develop irregularly formed ethmo-turbinals, that extend into this space from behind and afford the necessary surface for the pituitary membrane. But there is nothing that has the slightest semblance to an osseous septum narium. The anterior olfactory foramina, narrow slits one millimetre long, are found between the lacrymals and prefrontal, close to the vertical septum of the latter; their outer extremities being the superior, they are seen to look downward and forward as they open into the nasal cavities from the bases of the concavities formed by the bones above mentioned.

The orbital cavities are capacious, having rather a forward look; at the same time they look a little downward. Their limiting borders are ovate in outline, with the greater end backward, being incomplete below. Anteriorily the septum that divides them is remarkably entire and of considerable thickness; posteriorly and above there exists quite a deficiency, of a shape shown in Pl. IV, Fig. 22; this is situated just in front of the large quadrilateral rhinencephalic foramen, and allows a good passage from either orbit into the brain-case. The same condition obtains below with the opening for the exit of the optic nerves, only the latter is much smaller and quite circular; to its outer side there are several minute foramina that lead directly into the brain-case. The groove for the first pair is distinct anteriorly on either side, and opens into slits between the prefrontal and lacrymals, similar to those described when speaking of them in connection with the nasal cavities. These, the anterior rhinal foramina, together seem to be the homologue of the "cribriform plate" of anthropotomy. The anterior wall of an orbit is formed by a lacrymal; this bone is larger than usually found in avian crania of this size. It is quadrilateral in form, concave posteriorly, thoroughly confluent with the frontal, nasal, and ethmoid, but not coming in contact either with the palatines or suborbital style. About the middle of its outer border it presents a rounded notch for the lacrymal duct. Its anterior surface, forming the posterior wall for the rhinal vacuity, is undulating, though generally convex.

The superior wall of the orbit is narrow, gently concave, and formed as usual by the frontal. It looks downwards and outwards and merges into the orbito-cranial septum behind, conformably with the shape of the cavity under consideration. The posterior wall of the orbit presents quite a number of interesting points for examination. Internally and above we find the posterior rhinal foramen, and below it the foramen opticus, already described. In addition to other minute openings mentioned above, we have the foramen ovale, occupying a lower plane than any of the others, and situated more external to them, being almost directly behind the orbital process of the tympanic. Above it we observe a thin circular convexity, indicating the locality of the mesencephalic fossa; this sometimes develops at its outer border a sharp, vertical, osseous spine or plate, that points downwards, forwards, and inwards into the orbital cavity. Still beyond this, outwardly, we find another process, or rather two processes combined, with an elliptical foramen between them, placed vertically. The inner portion consists of a square lamina of bone, looking upwards and forwards; the other smaller and outer portion is a trihedral spine that descends, apparently from the frontal, to meet its external margin. The arrangement gives to the entire posterior wall a certain facing, directly forward, forcing upon the cranium of this little bird an aspect peculiar to another family, from which it is far removed—the *Strigidæ*.

The osseous floor of the orbital cavity is always more or less imperfect throughout the class, and is here formed by the customary bones, the tympanic, pterygoid, slightly by the lacrymal, and limited externally by the malo-maxillary squamosal bar.

The palatines nowhere come in contact with each other, and the palatine fissure is very wide, broadly rounded at both ends. The anterior extremity of each of these bones articulates in the usual manner, with the maxilliary and intermaxillary, the joints being immovable ones. Back from this point as far as the under surface of the lacrymals, on either side, they are but very slender, straight, and horizontally flattened little bones, without plate or process; at this latter point they suddenly expand into quadrate posterior ends, each slightly inclined downwards towards the median plane, throwing out a thin, nearly vertical plate for articulation with the fan-like and anterior ends of the pterygoids, while mesially they develop two other slender horizontal plates, the superior one being prolonged forward as a fine spicula of bone to meet the ethmo-turbinal mass, as above described.

They lightly touch the rostrum of the sphenoid, in company with the pterygoids, forming the usual arthrodial joint at this point in avian structure. Above they are smooth, look upwards and outwards, and form a portion of the floor of the orbit on either side. The union among the basi-presphenoidal process and prefrontal plates is complete, all sutural traces having disappeared, and the included bones form the interorbital septum as already described. The zygomatic style, very slender, straight, and throughout its continuity nearly of uniform calibre, descends from before backwards from its maxilliary articulation to the tympanic, about 4 millimetres, the skull being horizontal.

The coalescence among its three original elements is unusually perfect. The anterior horizontal expansion is very slight, being crowded towards the intermaxillary osseous tomium on either side by the widely separated palatines. Its posterior extremity is club-shaped and turned upwards, bearing on its inner aspect a hemispheroidal articular facette for the cotyloid cavity of the tympanic.

In no single articulation found in the skeleton throughout the class does there seem to be more variation in plan, to meet the same end and carry out the same function, than we find in the pterygo-palatine with the rostrum of the basi-sphenoid. In our present subject, as in *Pica* and *Corvus* and many others, this extremity bears a thin expansion that articulates by its anterior edge with the palatine plate and neatly grasps the rounded and inferior side of the rostrum, the two bones not usually coming in contact. The shaft of the pterygoid also slightly expands horizontally just before this articular surface is developed, more particularly in the angle between the two, adding greatly to the strength of the bone, and somewhat to the floor of the cavity of the orbit. The angle of divergence of the pterygoids in the present instance is exactly 45°; the intertympanic chord, 7 millimetres. The shaft of this bone is comparatively slender, prismoidal in form, somewhat twisted, and develops among the older birds sharp projecting edges. The enlarged tympanic extremity bears a subelliptical articulating facette, that glides upon a similarly formed surface surmounting the ptyergoidal process at the base of the orbital process of the corresponding tympanic element. These two little bones are well separated from the basi-sphenoid, and never any evidence of the development of pterapophysial processes is to be observed. As is generally, though by no means universally, the case among birds, the mastoid process of the *tympanic* in this Lark is distinctly bifid, each limb presenting for examination at its extremity an elliptical convex facette for articulation in a cup-shaped cavity intended for its reception in the roof of the aural vacuity. Of the two surfaces, the outer and at the same time the anterior looks outwards, forwards, and upwards, while the inner and posterior one, surmounting the shorter limb or bifurcation, looks backwards and upwards. These two projections of the mastoid process are further separated posteriorly by a deep non-articular depression. The orbital process is well developed, long and slender, terminating in a knobbed extremity, the whole extending well within the orbital space. It has at its base, internally, the facette for the pterygoid already alluded to. This process is subcompressed from before backwards, and has throughout a gentle curvature upwards, having much the form of the thorn of the common rose, without its sharp point.

There are two articular facettes on the inferior side of the mandibular end, divided by rather a deep depression. Of the two, the inner is the larger and more symmetrical in form, being transversely elliptical. The outer one seems to be borne on rather a constricted neck, having on its outer aspect the acetabulum for the hemispheroidal facette on the squamosal. The anterior surface of the body is smooth and triangular in outline; the opposite and inner surface, somewhat similar in appearance, presents for examination, just below the mastoid process, a large, oval, pneumatic foramen; other of these openings may exist in the depression on the posterior surface of the body of the bone already described.

The inferior surface of the *basi-sphenoid* is convex outward, and slopes away gradually into the rostrum, anteriorly. The external orifices of the Eustachian tubes are extremely minute, as are the foramina for the entrance of the branches of the common carotid to the cranium. As already intimated when speaking of the pterygoids, there are no pterapophysial processes.

The external aperture to the cavity of the otocrane is an elliptical slit, 1.5 millimetres wide at its widest part, looking almost directly forwards, its lower end being the innermost or nearest the median plane. The mastoid, however, does not extend so far forwards but that in a direct lateral view we may see, through the opening, the funnel-shaped internal orifice of the Eustachian tube. The stability of the ear cavity is here, as in many birds, highly enhanced by the presence of numerous osseous trabeculæ, acting as struts and braces to its walls.

An examination of the interior of the brain-case shows the fossæ for the several cephalic lobes to be large—indicating a brain of good size for the bird. As already defined, the foramina for the first and second pairs of nerves are in each case single, and as a whole more or less oval. A constriction, however, takes place in their outlines at the middles, formed by the encroaching interorbital septum, so that, looking out of the cavity, the foramen in either case appears double, whereas a view from an orbit reveals the fact of there being but one opening in either case. The olfactory foramen is very large—in the dry cranium—the deficiency being made up by firm membrane in the living Lark. The minute openings for the carotids at the base of the pituitary depression are placed, as usual, side by side transversely. The posterior wall of the sella turcica is deeply notched.

The longitudinal sinus is best seen along the superior and median crest, just before it arrives at the olfactory foramen. The middle fossa for the accommodation of the cerebellum is distinctly marked by long transverse concavities, admitting the rugæ upon the lobe in question when the brain is in situ. With regard to the structure of this bird's cranium, we may say that it is largely cancellated, the intermaxillary and petrosal approaching nearest the compact variety of bone; this fact lends to this part of the skeleton a great lightness, and well-prepared skulls of this Lark are very pretty objects.

The most remarkable feature to be observed, however, is the great amount of separation between the tables of the vault of the brain cavity, being fully a millimetre, and in some localities more, the interspace being filled in by quite an open diplöic tissue. This condition we well know to be a striking feature in the anatomy of the *Strigidæ*, but here is a bird that has the same arrangement as well marked, we believe, for its size, as any Owl in the North American fauna. The outline of the base of the cranium in *Eremophila* approaches the sector of a circle, a figure more or less true in all birds, and here, as in most others, the greatest departure from that figure being a too great convexity of the subtending arc. The length of the radius represented by the middle line is 3.2 centimetres, the intertympanic chord, including the bones, being 1.4 centimetres. We will only mention here, in regard to the free osseous elements of the sense capsules, that the sclerotals retain their usual form and arrangement, numbering in each eye from thirteen to fifteen. The attachment among them is rather firm, remaining as shown in Pl. IV, Fig. 41, after a considerable amount of maceration. The ossicula auditus are also present, but a lens of some power is required to study their form and arrangement.

The hyoid arch—(Pl. IV, Fig. 37, seen from below).—This, the hæmal arch of the parietal vertebra, in no way deviates in this little Lark from the usual ornithic characters possessed by it among living birds, in being freely suspended beneath the cranium and acted upon by certain muscles. The glosso- and cerato-hyals seem to be confluent, and the bone thus formed consists in two narrow little affairs, that for their anterior two-thirds run alongside of each other with a greater or less intimacy, to have their tips slightly diverge anteriorly. Posteriorly the ends have a still greater amount of divergence, and at the junction of the middle and posterior thirds there is a transverse bony bridge, that bears the facette for articulation with the basi-hyal behind. Scarcely any antero-posterior curvature exists. The posterior tips overhang the articulation of the thyro-hyals with the confluent basi- and uro-hyal. As we have never examined the tongue of the young of *Eremophila*, we may be in error in saying that the glosso- and cerato-hyals are confluent, as the bones we have just described may be the cerato-hyals alone, the glosso-hyal being entirely in cartilage. The posterior tips of the cerato-hyals have an expansion to accommodate the articulation referred to, bearing on either side small, elliptical, articular surfaces, looking backwards and outwards for the heads of the hypo-branchial elements of the thyro-hyals.

The bone is subcompressed from above downwards, the uro-hyal being produced behind by cartilage, or rather tipped by that material, while the articulation at the anterior extremity of these confluent bones is hidden from view in the superior aspect of the arch by the glosso- and cerato-hyals; and, as is common, the inferior lip that the basi-hyal lends to this joint is the longer, and protrudes forward.

The hypo- and cerato-branchial elements of the thyro-hyals are very long, slender, up-curved little bones, produced posteriorly, as is the uro-hyal, by cartilaginous tips.

The shaftlets of these delicate elements are slightly flattened from above downwards, as are their articular heads. The free extremities have a tendency to curve inwards a little, or towards the median plane, as well as upwards.

The lower mandible—(Plate IV, Figs. 22 and 29).—*Eremophila* is another example exhibiting the non-approximation of the tomial edges of the mandibles in the dry skull, this feature being more often absent among *Grallatores* and many of the *Natatores*, where these edges come in contact with almost an equal amount of exactness as where the bill is armed with its horny theca.

The lower mandible of the Horned Lark seems to be, in point of structure, composed almost entirely of compact tissue, and, owing in addition to the thorough coalescence of its primary elements, a very firm and strong bone. Sutural traces, the indicators of the boundaries of pristine segments, have entirely disappeared, and no one would ever suspect, in examining it, the presence of nine original parts, were he not familiar with avian osteology or had the opportunity of dissecting the young. The inferior surfaces of the articular ends are on a level with the major part of the under rim of the rami, but they are well below the coronoidal elevations on either side. They present superiorly the usual undulatory surface to meet and articulate with the condyles of the tympanics. Below appears a longitudinal ridge, due to the extension upon that side of the ramal edges. A knob-like process projects behind, and the true articular processes are sharp and rather long. They are directed inwards, upwards, and then forwards, having the usual pneumatic foramen above and near their pointed extremities. The superior margin of the inferior maxilla starts at once from each articular surface, to rise by a moderate angle to the representative coronoids, a distance of 4 millimetres; it then falls gradually to the rounded and anterior termination of the bone. It exhibits about its middle, on each side, a long but very low convexity, the corresponding shallow concavities being between them and the coronoidal elevations. The "coronoids" are marked by deep groovelets with raised borders that extend forwards and downwards as far as the interangular vacuity.

The inferior boundary of the bone, as already stated, rises on each side in the inferior articular surfaces, to ascend first for two-thirds of its extent on each ramus, then to fall at about an equal angle, to sweep round and form the anterior and curved termination in the dentary element. The median line on the dentary segment averages 5 centimetres, this portion of the bone being quite thick and concave above, convex below. The general surface, both inside and out, between the boundaries just defined, is in each case depressed, smooth, and translucent until we arrive at the solid dentary portion, where we find it marked by a row of minute pits. Of some dozen or more lower maxillæ before me, one of the most striking differences existing among them seems to be the variation in size of the interangular vacuity or foramen. This is elliptical in outline with the major axis of the ellipse in the long axis of the bone, and in some specimens squarely meet the raised ramal borders within, while in other individuals, even though the bone be larger, this foramen is markedly smaller. A large concavo-convex sesamoid is found between the tympanic and articular end on each side. The long axes of these bones are placed vertically, and their concave surfaces look forwards. They are attached to the middle of the pointed articular processes behind by a delicate ligament, and above by the same means; by a somewhat broader attachment to the squamosals and tympanics, posteriorly.

Spinal column, cervical portion—(Pl. IV, Figs. 22 and 35).—In making a study of the vertebral column of this Lark, the student will find that he will be materially assisted if he make use of an engraver's eye-lens, or, better still, one of the low-power objectives of a good microscope, as some of the points for examination are rather minute, and are not so easily or satisfactorily demonstrated by the unarmed eye. The cervical portion of the column is composed of thirteen vertebræ; these enjoy, from the atlantal throughout the entire series, a perfectly free movement among each other by their several articular surfaces; and some form of the sigmoidal curve, characteristic of the bird-neck, is invariably preserved during life and action. We find, too, the majority of the salient points pertaining to these segments described by ornithotomists, present, and strongly marked, and the chief functions of this jointed and bony isthmus well carried out—as affording protection for the myelon in its passage from the brain to the body below, and the vessels from their centre to the brain above. The neural canal, beginning in the atlas as a transverse ellipse, rapidly becomes circular, retaining this form throughout the tube, only to resume the elliptical again in the last two or three segments, where in the thirteenth it seems to be of a larger calibre than at the cranial extremity, the ellipse still being placed transversely.

The usual processes of ten of these vertebræ, the third to the twelfth, inclusive, afford protection to the vertebral artery and sympathetic nerve. By an apparent contraction of the parapophyses in the twelfth, the canal is open laterally in this segment. It is confined to the anterior third on each side of the vertebræ enumerated, and is exceedingly small throughout its extent; its largest calibre being at its commencement, its finest in the tenth or eleventh. Among the long vertebræ in the middle of the neck the anterior entrances of the vertebral canal are ellipses placed vertically. They become more circular as we approach the thoracic end of the chain. On the eighth vertebra, mesially, and beneath anteriorly, we find, bounded on either side by the parapophysial processes, the commencement of the interhyapophysial groove or canal for the carotid artery. It extends through the fourth vertebra with about an equal amount of distinctness and depth.

A neural spine is feebly developed upon the axis posteriorly, this process becoming more strongly marked on the summits of the next three succeeding vertebræ, the remainder of the cervical segments being devoid of this feature, though we have occasionally found an evident attempt at its reproduction in the ultimate cervical. The nethermost portion of the pseudo-centrum of the first vertebra has been considered to be the atlantal hypapophysis. Be this as it may, the hypapophysis of the axis certainly has a much greater claim to be termed a *process*, while on the third and fourth segments this spine constitutes one of the most marked features of the vertebra, being a longitudinal and quadrate lamina of bone, equally well developed on the two vertebræ in question, directed immediately forward. In the case of the fifth cervical the hypapophysis has again degenerated to a minute median point, to be entirely obliterated in the sixth. At the ninth it again makes its appearance as a delicate and flattened plate at the anterior margin of the vertebra beneath, at the point at which in the carotid canal it is first seen in the eighth. In the remaining ones it is prominently developed and directed forwards from the median plane in each vertebra as a quadrate lamina. It is usually triplicate in the last, but does not arise from a common stem, as in other birds.

Parapophysial processes appear as lateral spines first on the third cervical; in the middle of the series they are very long and delicate, being parallel with the centrum of the vertebra to which they belong. They become markedly suppressed near the termination of this division of the spinal column.

Anterior and posterior zygapophyses retain throughout the cervical vertebræ their most common ornithic features; in the middle of the neck the postzygapophysial processes are long and bent slightly towards the neural canal, leaving quite an extensive lozenge-shaped space between them in this region where the chord is unprotected by bone; the interarticular facets among the centra likewise retain their most common avian characteristics. The bodies for the most part seem to be slightly compressed from side to side, with a faint inferior median crest. The fourth vertebra has a delicate and outwardly-arched interzygapophysial bar, that includes within it an elliptical foramen on each side of some size. This bony connection in the third vertebra nearly fills in the interzygapophysial space, a very minute vacuity alone remaining.

All the cervical vertebræ appear to be pneumatic, but the foramina in some of them are excessively small and difficult of detection.

The bony cup of the atlas is not usually pierced by the odontoid process of the axis, but one cannot but wonder, this cup being less than half a millimetre across, that the skull, so very large as compared with its tiny occipital condyle, should not be subject to frequent dislocations; this undoubtedly would be the case were not the occipitoatloid articulation so thoroughly re-enforced by the thick muscles that surround it.

A square bony plate projects from below in the atlas, more anterior than any other part of the bone, that covers the atlo-axoid articulation in front.

The arch that connects the neurapophyses is broad and smooth, and assists greatly in the protection of the myelon between the two bones.

The odontoid process on the *axis* is concave in front, flat behind, with a roundish summit. It averages one millimetre in length, and is directed slightly backwards. The articular surface at its base is reniform in outline, the centrum that supports it being contracted below. The postzygapophyses show faint traces of anapophysial tubercles; these are better marked in the latter cervicals. The last or thirteenth vertebra has freely suspended from beneath each diapophysial articular surface a rudimentary pleurapophysis that averages about two millimetres in length. These little bones represent the only true cervical ribs, though we must admit here that in several individuals we found the first pair of dorsal pleurapophyses unconnected with the sternum by the usual hæmapophyses, and ending in pointed extremities. Should such a specimen alone be examined, we would have to recognize fourteen cervical vertebræ, the last two bearing free pleurapophyses, but the common rule must dictate here as elsewhere, and the condition just mentioned be reckoned as the exception.

Dorsal vertebræ, vertebral and sternal ribs, sternum—(Pl. IV, Figs. 22, 24, 27, and 38).—The number of vertebræ devoted to the dorsal portion of the spinal column in *Eremophila* seems to be invariably *five*. They are easily detached one from another, and after ordinary maceration of the skeleton drop apart almost as readily as the cervical vertebræ, so that during life there is at least quite a little amount of free movement among these bones.

The neural canal, as it passes through this series, starts with the transverse ellipse as we left it in the last cervical, in the vicinity of the dorsal expansion of the myelon, to terminate nearly circular, and much diminished in calibre, in the ultimate segment of the sacral extremity.

The neural spines form by their interlocking a continuous ridge above. The thickened crest of this ridge is produced by what we will call the arrow-head joint, a true schindylesial articulation to be found in many of the class. The superior margin of each spine becomes pointed anteriorly, extends forward, and is received into a fissure of the posteriorly produced superior margin of the neural spine of the vertebra next beyond it. This arrangement has the appearance of so many little arrowheads placed in similar juxtaposition, and constitutes one of the elements of stability of the dorsal vertebræ in this bird. The open spaces remaining among the bodies of the spines below, between their produced crests and the several neural arches, are filled up by connecting ligament and membrane.

The diapophyses of the dorsals are a very much horizontally flattened series. They are all slightly tilted upwards, the anterior ones being the broadest and shortest, and the ultimate one, by a gradual departure in this regard from the first, the narrowest and longest. In the middle of the series, moderately well developed and antero-posteriorly produced metapophysial ridges are found limiting the diapophyses externally; they do not reach from one vertebra to another. The pneumatic foramina at the bases of these processes are very minute and scarcely discernible by the naked eye.

The inferior diapophysial facettes for the pleurapophysial tubercula are concave-elliptical surfaces, with their major axes parallel to the median line. The anterior ones are the more circular.

The zygapophysial processes, to assist in the intimate proximity of these vertebra, are short and thick. The anterior ones look upwards and inwards, the reverse being the case with the posterior series, which latter develop pointed spines that overlap above, each in its turn, on either side, the vertebra next behind, at the base of the common neural spine. The longest of these processes are found anteriorly; they gradually disappear as we near the sacrum.

The first dorsal hypapophysis consists of three plates, arising from the centrum of the vertebra separately, and arranged as shown in Fig. 38. On the second dorsal we find only a single quadrate plate in the median plane, directed forwards. It occupies a position at the anterior margin of the vertebra, but is produced posteriorly as a low, thin lamina of bone, along the remainder of the centrum mesial to the raised and posterior margin. The third vertebra takes it up in this form, and it is thus passed along the series, constituting a continuous hypapophysial ridge, intersected by the expanded anterior and posterior borders of the centra.

The articular surfaces among the bodies retain their usual characters. They extend into the ridge just described. The centra of the dorsal vertebra are somewhat compressed in a slightly increasing degree from before backwards; each lateral and anterior margin supplies a nearly circular parapophysis for the pleurapophysial capitula, while at points on the posterior margins in the same plane we find the major share of the notch, which in coaptation of the segments constitutes the subcircular foramina for the exit of the dorsal nerves.

There is a free *pleurapophysis* for each dorsal vertebra, but the first is not always connected with the sternum by a sternal rib, as already defined; it sometimes has all the characteristics of a movable cervical rib; again, when it connects with the sternum, its hæmapophysis articulates rather high on the costal border (Pl. IV, Fig. 22). It may or may not bear an epipleural appendage.

The vertebral ribs of this Lark articulate, as usual, by tubercula and capitula, with the dorsals, meeting par- and di-apophyses in the ordinary manner. The necks of the ribs in the middle of the series are the longest, and often we find among the ultimate ones a slight projection beyond the tubercle, that is received in a corresponding notch at the outer border of the diapophysis it meets. There is but little difference in the width of these flat bones; perhaps the anterior ones have rather the advantage in this respect. Minute apertures, to allow the air to enter their bodies, are observed in the usual localities.

The laterally viewed curve of a dorsal rib is barely sigmoidal; viewed from in front it approaches a portion of the curve of an arc of an ellipse.

A ridge continuous with the neck is carried down the inner aspect of each bone, to gradually disappear near its middle. The lower extremities of these ribs are slightly enlarged, to afford space for articulation with the sternal ribs; the surface is convex.

The epipleural appendages of the dorsal pleurapophyses are confluent with the posterior edges of the bones, and situated below their middles. Occasionally the one in the middle of the series has sufficient length to overlap two ribs; in young birds of this species they are much shorter, and the best-developed ones show an angle on their inferior borders just after leaving the rib, as if they had left that bone with the original intention of proceeding downwards and backwards at a gentle angle, but suddenly changing mind, proceeded directly upwards and backwards at an equal angle; hence the condition alluded to.

When the first dorsal rib articulates with the hæmal spine below by the intervention of a sternal rib, this latter bone is quite small and delicate, averaging about 3 millimetres in length, and but slightly curved. The remaining dorsal hæmapophyses become longer and more curved as we follow them backwards. They are all flattened from side to side, their lower extremities being abruptly twisted at right angles with their shafts, enlarged, and terminating in a flattened articular surface for the costal border of the sternum. These articular surfaces are dumb-bell shaped, *i. e.*, contracted in their middles. The upper ends of these sternal ribs are also enlarged and laterally flattened for articulation with the vertebral ribs. These latter enlarged ends are sometimes larger, sometimes smaller, than the extremity of the pleurapophysis they meet.

If we accept as true the old vertebral theory of Oken, Goethe, and Owen, a theory that holds that the skull of all vertebrates is composed of three, four, or more modified vertebræ, that these vertebræ in evoluting from the very earliest forms in which a bony segmented column appeared, that during this evolution many metamorphoses took place in the skull, such as the restriction of the notochord to the first or occipital vertebra, the mode of development of the elements themselves, whether by cartilage or membrane, and the appropriation by these "cranial vertebræ" of bones that did not originally belong to them, that we cannot positively say what may become of the cranial extremity of the spinal column of *Amphioxus*, or some of the hæmal arches in the hag and others, then we must recognize in the sternum of birds, developed as it may be, the confluent hæmal spines of the dorsal series of ribs; and in it, in its maturity, see one of the most interesting bones to contemplate, it being one of the most diversified in form in the bird skeleton. Owen styled the type of this bone, as found in the Lark now under consideration, "cantorial" (Anat. and Phys. of Vert., Vol. II, p. 20). It is certainly typical of the suborder *Oscines*, as far as American ornithology is concerned; good examples as testifying to this I have now before me, in the hæmal spines of *Turdus migratorius*, *Ampelis garrulus*, *Mimus polyglottus*, *Lanius*, and many others.

In *Eremophila* the sternum is very light and delicate in structure; so thin is it in some individuals that we find deficiencies occurring, usually in the body, as foramina of no mean size (1.8 millimetres). Its outer surface, indeed the entire surface of the bone, has the appearance as if it were venated, the solid bony veins being thicker and more opaque than the general surface of the bone, and branching from the various borders.

The carina is moderately well developed, measuring in the vertical line below the coracoidal groove 9 millimetres. Its inferior border, expanded behind, is rounded and somewhat thickened; this thickening disappears on the anterior border, which is sharper and continuous with a conspicuous crest on the front of the manubrium.

The carinal angle, with an aperture of 70°, is quite prominent and produced anteriorly. Just within the anterior margin of the keel we find a rather prominent *carinal ridge*, its lower extremity branching backwards, and by its ramifications taking part in the superficial venation referred to above. The keel arises abruptly from the inferior and median angles formed by the sides of the body where they meet mesiad.

The xiphoidal prolongation is profoundly notched once on each side. These notches have the outlines of isoceles triangles, with their angles rounded, and apices but a short distance from the costal borders. These deep indentations of the xiphoid give rise on either lateral sternal border to a long, stout process, extending backwards and outwards, with dilated extremity.

The outer surface of the body of the sternum presents for examination well-marked *pectoral ridges*, and, running from the bases of the xiphoidal processes to the outer angles of the coracoidal depression, clearly defined *subcostal ridges*.

The *manubrium* is a prominent, superiorly bifurcated, trihedral process, jutting out from a substantial base in the median plane, forwards and upwards, from the angle formed by the coracoid groove and the front border of the carina. At its base internally there is an extensive oval pneumatic foramen. Its bifurcations are rounded, and give attachment at their extremities to firm ligaments, that pass directly to the coracoidal capitula above.

The *groove for the coracoids* is strongly marked and continuous in front, extending from costal process to costal process; its boundaries form the thickest and stoutest part of the bone we are describing.

The *costal processes*, possessed of broad bases, arise as thin but prominent lamina, upwards, forwards, and outwards, terminated by flattened summits. Their posterior margins bear the costal facets for the articulating ends of the sternal hæmapophyses.

The sides of the body of the sternum on its ventral aspect make an obtuse angle with each other. The line of meeting in the mesial plane is quite evident; its anterior half is the seat of a row of various-sized pneumatic foramina. There are upon each costal border five, sometimes six, transverse facettes for the sternal ribs; the shallow depressions among them are scantily supplied with pneumatic foramina.

The mid-xiphoidal border, in which the keel terminates posteriorly, is thickened; its other boundaries are sharp, with raised ridges below, just within their edges. The greatest length of the sternal body is a little more than two centimetres, and its greatest width a little more than one centimetre, the last measurement taken to the rear of the costal processes.

Sacral vertebra and ribs, pelvis, coccygeal vertebræ—(Pl. IV, Figs. 22, 23, and 28).—The first sacral vertebra has become thoroughly confluent with the ossa innominata on either side and with the vertebra behind it. Its diapophyses seem to have spread out upon the under surface of the ilia, combining with them, for we observe that the first sacral pleurapophyses articulate in the ordinary manner with the transverse processes and the parapophyses, the tubercula being situated just near the outer iliac borders. This rib may become, as a rare event, confluent with the pelvis, but is usually free. Its hæmapophysis is the longest of the series, and the articular facette on its lower extremity meets the last facette upon the sternal costal border. This sacral pleurapophysis may possess an epipleural appendage, though it seems to be the exception.

The second sacral rib is a delicate hair-like bone of uniform thickness, that does not show any decided tubercle, merely, after leaving the vertebra, coming in contact with the under surface of the ilium, on each side, for the entire interspace between the tubercle and head. It, too, may become confluent with the pelvis on its lower surface.

Extending downwards and forwards by a gentle curve, it meets its hæmapophysis through a miniature articulation. This latter style articulates along the posterior border of the sternal rib of the first sacral pleurapophysis, never reaching the costal border, and the second sacral rib never bears an epipleural spine on its posterior border.

The sacral vertebræ are invariably confluent throughout the chain in the *pelvis* of the Horned Lark; indeed, it is only by a process of staining this compound bone, and the aid of a strong light, that they can with any satisfaction be counted. There are eleven of them; exceptionally, twelve.

The neural canal, circular at the outstart, shows the usual *pelvic swell*, chiefly anterior to the acetabula, conformable with the *ventricular dilatation* of the myelon in that locality. The exit of this tube distally is likewise nearly circular. The foramina along the bodies of the centra, in the vicinity of the dilatation referred to, are double and placed one above another, for the separate egress of the roots of the pelvic plexus.

The anterior aspect of the first sacral vertebra presents every element and process requisite for articulation with the ultimate dorsal segment. It is largely overshadowed by the ossa innominata. Opposite the iliac contraction, in the neighborhood of the fourth and fifth sacrals, these vertebræ throw out their par- and di-apophysial processes far enough to meet and brace the iliac bones. We do not meet with such braces again until arriving opposite the acetabula and beyond, where the parapophyses project upwards and unite with the outer margins of the transverse processes, the ilia articulating with the free and united borders.

Foraminal deficiencies not unusually occur among these processes, more particularly between the last two sacrals, where they seem to be constant, though of varying size and shape in different individuals.

The last sacral vertebra is compressed from above downwards, retaining, however, all the elements required in articulation with the first and much-modified coccygeal vertebra.

Viewing the confluent sacral vertebræ, or the "*sacrum*", from above, we find the united neural spines, as a vertical lamina, dividing the anterior interiliac space into two capacious *ilio-neural grooves* at that moiety of the bone.

This common neural spine and the ilio neural grooves proceed backwards until the *gluteal ridge* of the ilium curves outward to the antitrochanter on either side. At this point the spine disappears with the grooves, the sacrum becomes nearly flat and spreads out, to gradually contract again before its ultimate dilatation in the diapophyses of the last vertebra.

It is a well-known fact to the ornithotomist that the pelves of birds differ with respect to the ilio-neural grooves in one of two ways. As seen in this bird they are *grooves*, as the ilia do not meet the united spines of the vertebræ; they are very frequently, however, converted into *canals* in other orders, by meeting of the interested bones above. The condition as defined though, in the previous paragraph, as relating to *Eremophila*, seems to be characteristic of American *Oscines*. The sacrum is slightly convex from before backwards on its upper surface, moderately concave along the confluent centra below.

The *pelvis* of this bird is uncommonly wide and short, and the ischiadic and pubic posterior extremities remarkably flared outwards. The anterior and inner angle of each ilium, apparently assisted by the diapophysis of the first sacral vertebra from beneath, is pointed; the anterior border slopes backwards gradually, for a distance of 3 or 4 millimetres, to the rounded anterior external angle of the ilium. Between this point and the acetabulum the iliac border is strongly concave inwards, as is the surface of the bone above it, the preacetabular being included between this border and a well-defined *gluteal ridge*. The superior postacetabular iliac surface is nearly square in outline, convex, and equal to a little more than one-third of the bone. It is thin and translucent, its outer and posterior borders receiving the greater share of osseous reënforcement, particularly in the vicinity of the antitrochanter.

Posteriorly, the ilium, slightly aided by the ischium, is carried out from an ilio-ischiadic, overhanging crest, as bony processes, with their points turned slightly inwards.

These processes are strongly marked in another of our *Oscines*, *Harporhynchus rufus*, a bird that has a strikingly angular and rather unique pelvis.

The *antitrochanter* is subelliptical in outline, and faces downwards, forwards, and outwards. The articular surface is produced downwards as far as the cotyloid cavity, upwards slightly above the general surface of the ilium, and is bounded posteriorly by the ischiadic notch.

The foramen at the base of the hemispherical cotyloid cavity has so far absorbed the bone that really scarcely anything remains of it beyond a cylindraceous acetabular vacuity, the internal and external apertures being circles of equal diameter, and the femur consequently relying almost exclusively upon its fleshy and ligamentous attachments to retain its head in the ring.

Sutural traces of the margins of the pelvic bones as the components of this osseous ring have entirely disappeared, having been obliterated during the pelvic consolidation.

The *ischium*, for its major part, is like the ilium—very thin, more particularly so at its free posterior borders; joining with the ilium behind, it shuts off a large and elliptical *ischiadic foramen*, the superior arc of which is situated just beneath the ilio-ischiadic crest described above. The major axis of this ellipse is directed downwards and backwards.

The posterior extremity of the ischium has an odd-appearing, foot-like termination, that is bent down to meet the *pubis*.

This latter bone is an extremely slender style, that, immediately after assisting in the formation of the cotyloid ring, closes in a small, in fact the smallest of the group, subcircular *obturator foramen* behind; then running parallel with the ischium, by touching its further end, inclose, another long spindle-shaped vacuity; it is finally produced beyond that bone by a pointed extremity, that curves backwards and inwards.

It only remains now to say of the pelvis, as far as its internal aspect is concerned—after what we have said in regard to its extreme lightness, its translucency, its sacrum, and its borders—that, in general, superior convexities cause or create internal concavities, and *vice versa*. It is capacious, and the various bones that compose it thoroughly anchylosed together.

There are seven *coccygeal* or *caudal vertebræ*, rarely only six, and the *pygostyle*; they are in the skeleton so arranged and articulated that they have, as a whole, a gentle curve upwards, terminated by the quadrate "coccygeal vomer."

These segments are all free, being easily individualized, even before maceration, by simple section of the ligaments that bind them together.

The subcircular neural canal, that passes through them, almost capillary in its dimensions, terminates without passing into the pygostyle.

There is no hæmal canal developed, and indeed hypapophyses are found as stunted tubercles only on the last two or three vertebræ.

A neural spine is developed on each, as a prominent and curved process, pointing forwards; this spine is wanting, however, on the last caudal.

Of the lateral apophyses the transverse processes seem to be the only ones entitled to any consideration; these, as broad, flattened lamina, extend from each vertebra, downwards and outwards, decreasing in width from before backwards; in fact, each vertebra in the coccygeal series becomes more and more rudimentary as we proceed in that direction.

The articular facettes upon the centra start reniform, to terminate almost circular in the last vertebra; and the zygapophysial processes are exceedingly elementary in character.

The *pygostyle* is parallelogramic in outline, articulating with the ultimate coccygeal vertebra by an unperforated cup-shaped depression, at the middle of its long anterior side. The edge of the bone above this point rests on the posterior border of the neural spine of the last caudal; below it is free.

The superior angle is more or less produced, and the posterior corner of the parallelogram is expanded laterally; this expansion is highly developed in many birds, as in *Colaptes mexicanus* and other members of the family *Picidæ*. The caudal vertebræ are non-pneumatic in our present subject, whereas in the pelvis we find these foramina in their usual localities.

The scapular arch—(Pl. IV, Figs. 22, 30, 32, 33, and 34).—This arch is very strong and perfect in this bird, as it is among the *Oscines* generally.

The bones can be easily separated from each other by maceration, though during life they are remarkably well strapped together and to the sternum by their numerous ligaments.

The *scapula* lies along the dorsum in its usual position over the dorsal pleurapophyses, parallel with the vertebræ, with its posterior point touching the fifth one in the vast majority of the specimens.

Certain bones in all skeletons force upon us their resemblance to familiar objects, and we know many of them have received their distinctive appellations through such likeness; more particularly is this the case in the skeleton of man, where the bone we are describing is frequently termed the shoulder-*blade*, but how much more blade-like is the scapula in this Lark and many other birds, as far as shape is concerned. It is truly a miniature bony cimeter in *Eremophila*. This is not true for scapulæ of all birds, however, for no one would ever be struck by such a resemblance while regarding the J-shaped scapula of *Colaptes mexicanus*, or the straight, almost square-cut bone in some of our natatorial birds.

In the Horned Lark the scapula is pointed and obliquely truncate behind for more than a third of its slightly dilated posterior portion, on the side towards the vertebræ.

The outer border is reënforced by a rounded ridge for nearly its entire length, while the inner is quite sharp.

The blade becomes stouter and subcompressed as we near the glenoidal process; this broad tuberosity extends downwards, forwards, and outwards, and is crowned on its entire summit by a curved, subcircular, articular facet, that supplies rather more than one-third of the glenoid cavity for the head of the *os humeri*.

The *acromial process* is bifurcated, and the clavicular head rests in the fork. The larger bifurcation is the lower, and both rest against the coracoid, on the inside and just below the head, creating the usual scapulo-coracoid foramen, which in this case is not very extensive.

The scapula is pneumatic, and the foramina are to be found at the extremity of the larger bifurcation of the acromial process, and in the notch between the two.

The *coracoid* can boast of a very fair subcylindrical shaft between its head and inferior expansion. This flared extremity is quite thin outwardly, stouter within, where it appears to be more of an extension and spreading of the shaft in its course downwards. Below there is a narrow crescentic facet for the sternum, and at the upper edge of the exterior and thin side of the dilated end we find a notch, sometimes a foramen, that appears to be constant.

The upper extremity of the coracoid is an irregular tuberosity, consisting of a lower, inner, and smaller process for articulation with the clavicle, and an upper, superiorly convex head, that curls over mesiad to create a fossa, at the base of which we discover a group of various-sized pneumatic foramina. Anteriorly the head shows rather a well-marked process, into which the ligament coming from the horn of the sternal manubrium, of the same side, is inserted.

To the outer aspect, and below the head, is the reniform and vertical facet that, with the scapula and os humero-scapulare, goes to complete the glenoid cavity.

The *os humero-scapulare* is a free bone, rather larger than the patella, found at the upper and posterior angle of the glenoidal process of the scapula. It is an elliptical disc, with a peg-like process extending from it from behind. The outer surface is concave and articular for the completion of the glenoid cavity. This ossicle is held in position by various fibrous ligaments stretching from its borders to the scapular arch and the humerus.[1]

The *clavicles* are thoroughly fused together, forming one deeply U-shaped bone; their cylindrical and curved lengths support at the union, mesially and below, a long lamina of bone, in the median plane, that is directed upwards and backwards, parallel to the anterior carinal crest, to which it is united by ligament in the living bird. Their upper ends are expanded and placed in the skeleton flat-wise against the acromial process of the scapula and the head and the lower or clavicular process of the coracoid. The acromial process, through its bifurcation, partially grasps the hind border of this expanded end of the furculum, on either side.

This bone seems to be non-pneumatic, while the coracoids are hollow almost throughout their entire extent, having in their composition very little cancellous tissue and a thin though firm, compact layer. The scapulæ are hollow for some little distance into their blades, to be terminated by a cancellous structure, with an external and attenuated outer compact coat.

With the scapula arch *in situ*, we observe that the coracoids do not meet below in the coracoidal groove of the sternum, but approach only, on each side, as far as the periphery of the pneumatic foramen at the base and behind the manubrium.

They are directed upwards, forwards, and outwards, at an angle of about 45° with the horizontal plane, the skeleton being erect; and, as a consequence, we find their upper ends further apart than any other part of the bone.

The aperture between scapula and coracoid is in nearly a right angle, and the straight part of the inner scapular borders are parallel, their obliquely cut ends alone slightly turning outwards.

A scapula is 2.5 centimetres long, a coracoid 3 centimetres, the interclavicular space above being 1 centimetre.

In *Turdus migratorius* we find the scapula *shorter* in proportion when

[1] This little bone should be considered as a sesamoidal auxiliary to the shoulder girdle, as it increases the articular surface of the glenoid cavity, and never be enumerated as one of the bones of the pectoral limb.

compared with the other bones of the arch; the coracoids more depressed, *i. e.*, more in line with the sternum; and the furculum in its direction backwards showing a gentler curve.

The upper extremity—(Pl. IV, Figs. 22, 31, 36, and 43).—The pectoral limb in *Eremophila* maintains the usual ornithic characters of a great number of the class, both in arrangement and number of the bones comprising it. The skeleton arm has *ten* distinct segments; of these, we find one devoted to the brachium, two to the antibrachium, two to the carpus, one to the metacarpus, and four to the phalangeal portion of the manus.

The bone *humerus* in this bird is more remarkable for its lack of curvature than anything else, being short and straight, as in others of the suborder among which our subject is classed and belongs.

The head of the bone is broad and moderately flexed anconad, developing only a very narrow and thin radial crest, which is bent for its entire extent toward the palmar aspect. This crest, answering to the "greater tuberosity" of anthropotomy, and giving attachment to the usual muscles, extends along on a straight line on the upper aspect of the shaft longitudinally for only about half a centimetre.

The ulnar tubercle, or lesser tuberosity, makes up the thickened and proximal border of the confines of the pneumatic foramen; a deep little pit on its palmar side or margin lodges the extremity of a strong ligament coming from the head of the coracoid of the same side, and materially assists in keeping the head of the humerus in its socket.

The elliptical and convex articulating facet of the head curls over anconad, and from its middle a line runs down the bone for a short distance, being one of the angular boundaries of this the trihedral extremity of the bone. Quite a notch exists between the facet just described and the wall of the pneumatic foramen. This latter is on the under side of the head of the bone, snrrounded on its upper, proximal, and lower aspects by a firm bony wall, the lower and proximal parts of which are continuous with the smooth and otherwise unbroken surface of the expanded and palmar side of the head.

The pneumatic fossa thus formed is deep, having at its bottom the foramen alluded to. Quite often the aperture is multiple, and vast differences in size exist, being very large in some individuals, nearly consuming the base of the fossa where it is found. From the lower boundary of the pneumatic enclosure another longitudinal line is seen on the proximal end of the shaft, limiting the anconal face of the trihedral end of the humerus in this direction. The palmar aspect of the head, broad and smooth, arches gradually inwards and towards the articular facet; it is also slightly convex from above downwards, supposing the bone to be *in situ* and in its position of rest, as we do during the course of our description.

The shaft of the humerus is subcompressed from within outwards, smooth, and, viewing it laterally, it is barely convex above, by virtue of the ends being bent slightly down; viewing it from above, we may say that it is almost straight.

It retains its form until close under the expanded distal extremity, which is curved palmad. On the radial side of this end of the bone we find the transverse and convex elliptical trochlea below, for the sigmoid articulating depression of the ulna. This has inferiorly the quadrilateral internal condyle.

The ulnar convexity is separated from the *oblique tubercle* for the radius most effectually by a deep, well-marked, though narrow, notch.

The oblique tubercle maintains its usual position as found on this bone in birds generally.

The trochlea surface does not extend inwards very far; *i. e.*, does not pass over the end of the bone. Above it, and towards the proximal end, appears a distinct and prominent external condyle.

Anconad, this extremity of the humerus presents for examination the upturned internal condyle and a longitudinal tendinal groove, situated opposite the radial convexity, with intervening indentations. This arrangement lends to this aspect of the bone rather an uneven and tuberous look. The nutrient foramen, almost too minute to be observed by the naked eye, is found at the middle and inner aspect of the shaft.

The *radius* is a long, delicate bone, with a bent and compressed shaft. A moderately well-expanded and circular head presents the usual concavity for the oblique tubercle of the humeral trochlea, while below is a feebly marked ulnar facet and bicipital tuberosity; beyond this, again, the shaft develops a sharp, protruding edge, that extends nearly to midshaft and into the interosseous space.

The distal extremity of this bone is spread transversely and curved downwards. It articulates with the upper surface and distal end of the ulna, and is lined above by very minute tendinal grooves. The outer border of this extremity presents a transverse lamina of bone that seems to be superadded to the dilated end.

In articulation, the radius at first curves away from its companion, the ulna, to approach it again towards the carpal end, for about the outer third of the shaft, to remain with it until both arrive at the wrist. The distal border of the radius is transversely convex for an articular facette on the scapho-lunar. The *ulna* is the main bony support of the forearm, and, indeed, its shaft is nearly equal in size and strength to that of the humerus itself, having the appearance of being the true continuation of the pectoral limb, so diminutive and slender is the accompanying radius.

Its proximal extremity is the larger, and is gently curved anconad, to meet the corresponding flexure of the brachium to form the elbow-joint, the articular surface engaged being quite extensive and vertically expanded. The lower, circular, and concave trochlea is the greater sigmoid cavity, and is intended for the ulnar tubercle of the humerus. Its proximal margin is so produced as to form a strongly defined "olecranon process", the lower lip of the cavity being the homologue of the "coronoid process", and is so feebly developed as to scarcely deserve the distinction. In close proximity to the greater sigmoid cavity, above, there is another articular surface, quadrilateral in outline, decidedly concave from above downwards, much more shallow in the opposite direction, for the oblique tubercle. Immediately beyond its distal margin is a weak and shallow facette for the side of the head of the radius, so that the oblique tubercle articulates in a cavity furnished by the cupped head of the radius and the larger quadrilateral trochlea of the cubitus, the two being almost continuous.

The outer aspect of this extremity presents simply certain feeble elevations and depressions for muscles and the ligaments surrounding the joint.

From the proximal extremity, the nearly cylindrical shaft curves gently palmad from its inner third only; after that it takes a comparatively straight course for the wrist. The anconal aspect of the shaft presents at the junction of the inner and middle thirds an eliptical nutrient foramen, that enters the bone almost perpendicularly to its long axis. The tubercles for the insertion of the bases of the quills of the secondaries, so prominent on this bone in some birds, as in *Colaptes*, seem to be entirely absent. We find them barely present in *Harporhynchus*, quite strongly marked in *Lanius*. The carpal extremity of the ulna is likewise articular, being vertically cleft and curved downwards. Anconad it develops a rough eminence, and above a depression for the fan-like expansion of the radius. This end, as in the majority of the class, articulates with the three carpal bones and the radius above.

The humerus measures 2.4 centimetres, the ulna 3 centimetres, and the radius 2.7 centimetres; so that when the bones are placed *in situ* and the wing closed, the anti-brachium projects beyond the brachium about 5 millimetres. The bones of the forearm, though hollow, are apparently non-pneumatic, as is the case with the carpals and long bones of the manus.

As in the great majority of the class, the bird-wrist is composed of the two free carpals and the os magnum, which is confluent with the proximal extremity of the second metacarpal.

The superior and smaller carpal is the *scaphoid*, here an irregularly shaped bonelet, introduced among the cubitus, the radius, and the confluent os magnum, with a distal articular face for the latter and two proximal ones for the trochleæ of the anti-brachium. Between the scaphoid and the cuneiform, the other free and inferior carpal, there exists an interspace, where the ulna meets the *os magnum*.

The *cuneiform* has an elongated facet on its outer aspect for the ulna, and two articular processes that grasp the metacarpal below—an arrangement that admirably meets the action required of the avian wrist.

The last carpal merely constitutes the trochlear head of the confluent metacarpals; by a gentle and backward sweep its general surface is directed inwards.

The composition of the *metacarpal* bone of this bird does not deviate from the general rule, as applied to the class, in any important particular. The three long bones comprising it are firmly anchylosed together and bear the fingers. The shortest and first metacarpal, obliquely fused with the anterior and upper end of the second, supports a free and pointed index digit. The second, or medius, supports, first in order below, a phalanx peculiar to birds, that is at once recognized by its expanded posterior border. It is here deeply concave on its inner surface, which concavity is partially divided by a feeble transverse line.

The blade of this bone is quite thin in some birds, even the general surface is sometimes absorbed, leaving nothing but the rounded and limital borders, as in *Larus delawarensis* and others.

The neck of this bone is but moderately constricted between the blade and articular facet for the metacarpal to which it belongs. It bears below another, and the smallest, phalanx of the hand, a little, free, sharp-pointed and compressed finger, that completes the skeletal bird-arm distally, being the ultimate segment.

The third metacarpal, termed *annularis*, a slender, ribbon-like bone, fast above and below to medius, and extending slightly beyond it, also articulates distally with another free phalanx, of the general character as the index digit and the ultimate joint of the mid-metacarpal, although it is longer than either of them. Measuring along the anterior aspect, from the summit of mid-metacarpal to the point of the last phalanx, we find the manus in *Eremophila* to average 2.6 centimetres.

This, the pectoral limb, as we have endeavored to picture it in this Lark, with its brachium, anti-brachium, and pinion in proportionate equipoise as to length of segments, with its various bones smooth, straight, and devoid of those evidences of being acted upon by powerful muscles, would require but a glance from the student of avian skeletology to pronounce it as belonging to a bird possessed of a flight barely mediocral in rapidity and power.

Of the pelvic limb—(Pl. IV, Figs. 22, 39, 40, 42, 44, and 46).—The inner aspect of the upper extremity of the *femur* presents the usual globular head for articulation with the cotyloid ring of the pelvis. It is nearly sessile with the shaft, the neck amounting to almost *nil*. A shallow and inconspicuous excavation occurs on the head for the insertion of the ligamentum teres. The articular surface that originates with this hemispherical protuberance extends outwards over the summit of the bone, constantly spreading, until limited by the trochanterian ridge, in a plane with the outer aspect of the shaft; it occupies a slightly higher level than the head, and it is opposed to the anti-trochanter in the articulated skeleton.

Anteriorly the trochanterian ridge and line are quite prominent, extending a short distance down the shaft, to be lost on the general surface; posteriorly it projects outwards horizontally from the articular surface, over a shallow concavity that is found immediately below, that presents at its base a circular foramen that leads to the hollow shaft, and is probably the pneumatic foramen, though the femur of this bird does not have the appearance of a bone possessed of pneumaticity; the orifice, if nutrient, is certainly situated in an unusual place, though we must confess that a careful search over the entire shaft with a powerful lens has failed to reveal any other opening. The trochanter minor is not represented.

The shaft, for the greater part of its extent, is cylindrical, and decidedly convex forwards, with a clean superficies, undivided by any intermuscular ridges or lines, or if so, they are very faintly marked.

The distal extremity of the femur enters largely into the knee-joint, and is more bulky than the proximal extremity of the bone. It is directed backwards, and, as usual, is divided by an antero-posterior shallow intercondyloid notch, which is continued up the shaft anteriorly, as the "rotular channel," soon to disappear into internal and external condyles. The larger and lower external condyle is longitudinally cleft posteriorly, so as to afford an additional and outer condyloid surface for the head of the fibula, with which it articulates.

A tuberosity is found behind, just above this cleft, and a few others, less prominent and situated more internally, are seen on this aspect of the bone, in the popliteal fossa.

The limiting margin of the internal condyle is sharp and distinct. The ordinary features, as tuberosities and muscular lines and markings, usually sought for at this end of the bone in nearly all birds, are very feebly reproduced in our present subject.

The proximal extremity of the *tibia* has a very interesting form, due to the prominence of the cnemial ridges. These are attached to the head of the bone, well above the horizontal articular surface for the condyles of the femur. Their superior border is continuous and convex upwards; their inferior borders meet the shaft abruptly, and there terminate. Both of these wing-like processes are turned towards the fibular side of the bone, the procnemial process being the larger in every respect; and the ectocnemial sometimes is produced downwards into a very sharp and needle-like spine, a characteristic of other *Oscines*. They include between them a triangular concave and rather deep recess. The expansion supporting the superior articular surface projects over the shaft of the bone in all directions, being quadrilateral in outline, and having an articular facet for the fibula on the outer side, while in the middle of the surface above a tuberous spine of the tibia exists, with concavities on either side for the condyles of the thigh-bone.

The shaft is remarkably straight, light, and hollow, though apparently non-pneumatic, no apertures having been discovered to allow the air access to the interior.

A fibular ridge, 4 millimetres long and 1 millimetre deep, is developed in the upper third of the shaft, perpendicular to its outer aspect, for the lower articulation of that bone.

Huxley and Gegenbaur maintain that the distal extremity of the tibia represents the astragalus among the Class *Aves*, and there certainly seems to be some foundation for this assertion, for if we examine this bone in the young of any of the *Gallinæ*, as in *Centrocercus*, we find the segment that eventually ossifies with this end of the tibia to be rather too extensive for a mere epiphysis, and may represent that tarsal bone. This joint is more thoroughly discussed in the osteology of the *Tetraonidæ*, further on. Without further remark, then, upon this important and still unsettled question here, we will observe that in *Eremophila*, and in all birds, the leg-bone terminates distally by two anteriorly placed condyles, separated by a well-defined intercondyloid notch. These condyles, approaching each other behind, diverging in front, are reniform in outline and shape, with their convex surfaces downwards. They are higher on the shaft anteriorly, and the articular portion is more extensive. Likewise, anteriorly the shaft is grooved below, to be bridged over just above the notch by a narrow bony span, arched outwardly, that holds the tendons of the deep extensors in position.

The inner end of this arch is the higher on the bone, and just above it, on the shaft, we find a minute tubercle, that gives attachment to a ligament that is extended to another tubercle lower down on the shaft, and on the opposite side.

The *fibula* is the merest apology for a bone, represented only by a slender spine on the outer side of the tibia. It has a superior and knob-like head, that articulates with the horizontally expanded head of its sizable companion; lower down it meets the fibular ridge, and is firmly attached to it by a strong, fibrous, and close-fitting connection.

Below the ridge the fibula is continued, hair-like in dimensions, to meet the tibia below the middle of the shaft, to become thoroughly and indistinguishably confluent with it.

The *patella* (Pl. IV, Fig. 22) is a free bone, and is found in the tendon of the quadriceps extensor. It is compressed antero-posteriorly, with an elliptical base above. From the points representing the vertices of the major axis of this ellipse, bounding lines pass, to meet broadly concave below. The anterior surface, limited by these boundaries, is convex outwards; the posterior surface, slightly concave, is divided by a vertical ridge into two unequal parts, the outer of which is the greater.

The femur averages 2 centimetres in length, the tibia 3.2 centimetres, and the bone now to be described as the tarso-metatarsus nearly 2.3 centimetres.

The metatarsals of the second, third, and fourth toes, and certain tarsals at the upper extremity of the bone, coalescing, form the segment, *tarso-metatarsus*, next in order below the tibia, with which it articulates.

The articular surface of its summit is so arranged as to accommodate itself to the condyles of the tibia, consisting essentially of an inner and outer antero-posterior facet, and a prominent spine on the anterior margin, that accurately fits in the intercondyloid notch of the bone above.

On the posterior aspect of the bone above we find the "calcâneal" process, here approaching a right parallelopiped in form, being vertically pierced by four minute cylindrical canals, two next the shaft and two parallel with them and above. They are for flexor tendons, which pass through them. The shaft is straight, subcylindrical, and hollow, expanding below for the trochleæ for the phalanges. For its upper half and posteriorly, ranging below the calcaneal process, it develops a sharp vertical crest, that gradually subsides below.

The anterior aspect of the shaft is faintly grooved longitudinally, and where it dies out below, just above the notch between the third and fourth terminal trochleæ, we observe a minute perforating foramen for the anterior tibial artery. Upon the inner margin of the shaft below there is the well-marked though shallow facet for the *os metatarsale accessorium*. This diminutive bone is, as usual, slung to the tarso-metatarsus by a ligament, articulating beyond with the hallux. It represents the first metatarsal, and has all the appearances of one of the larger-sized phalangeal segments, divided obliquely through the shaft, with the cut surface closed in and forming the articular surface for the tarso-metatarsus. Its position, *in situ*, is figured in Pl. IV, Fig. 44. The lower and expanded end of the tarso-metatarsus, bearing the trochleæ of the remaining phalanges, is further conspicuous for the marked manner in which the bone is compressed antero-posteriorly, causing the trochlear ends to be placed side by side, transversely. The middle one is the largest and grooved entirely round, the one for the second toe being slightly the higher and bent a little outwards; finally, the fourth is the smallest. Slit-like spaces among these "processes" completely divide them.

The joints of the toes are arranged upon the most common plan, and, we believe, upon the general rule for all *Oscines; i. e.*, the hallux possesses two phalanges, second toe three, third toe four, and the outer and last toe five.

These joints are not impressed with anything particularly remarkable, beyond what is found in them among the class generally. Their vertically cleft and anterior extremities articulate with the joint beyond, which is diminished in size and articulates in like manner with the next anterior segment.

The claws are grooved laterally, and show a process at their proximal and lower aspects.

A glance at Pl. IV, Fig. 22, will be sufficient to satisfy ourselves that the great length of the claw of the hind toe sometimes seen in *Eremophila*, and always characteristic, is due almost entirely to the growth of the horny theca that encases it, and not to the length of the osseous claw.

In the figure just referred to, the hallux, with the first metatarsal, has been drawn backwards in the skeleton, not only to show the os metatarsale accessorium, but also a sesamoid, of no mean size, that is found on its outer side, an ossicle that betrays its possessor and declares the habit he has of spending a good share of his time upon the ground.

PLATE IV.*

FIG. 22. Skeleton of *Eremophila alpestris*.
FIG. 23. Sacrum and pelvis from above.
FIG. 24. The sternum from below.
FIG. 25. The skull from above.
FIG. 26. The skull from below.
FIG. 27. The sternum from above.
FIG. 28. Sacrum and pelvis from below.
FIG. 29. Lower mandible from above.
FIG. 30. The clavicular furculum from in front.
FIG. 31. Left humerus, anconal aspect.
FIG. 32. Left scapula and coracoid, internal aspect.
FIG. 33. Scapular extremity of clavicle.
FIG. 34. Left scapula and coracoid, external aspect, showing extent of glenoid cavity.
FIG. 35. The thirteenth cervical vetebra, showing first pair of free pleurapophyses.
FIG. 36. Left humerus, palmar aspect.
FIG. 37. Hyoid arch from below.
FIG. 38. Anterior view of sternum, first dorsal vertebra, with its movable pleurapophyses and hæmapophyses, *in situ*.
FIG. 39. Right tarso-metatarsus, anterior aspect.
FIG. 40. Right femur, anterior aspect.
FIG. 41. Sclerotals, right eye.
FIG. 42. Right tibia and fibula, anterior aspect.
FIG. 43. Right ulna, anconal aspect.
FIG. 44. Right foot, with a portion of the podotheca removed to show the os metatarsale accessorium, *in situ*.
FIG. 46. Right femur, posterior aspect.

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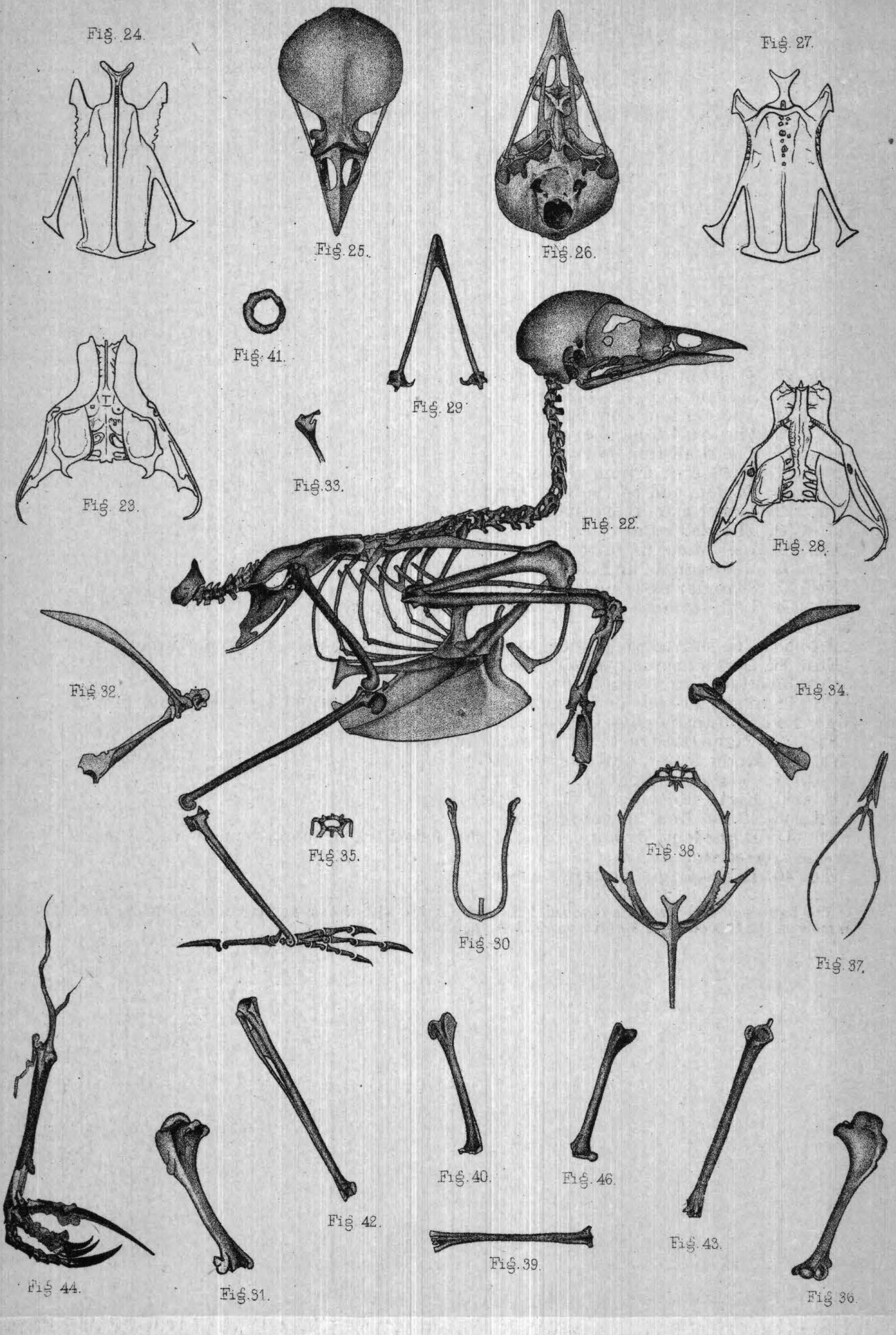
* The figures on this plate are numbered in continuation with the author's plates and figures to his Memoir on the Osteology of *Speotyto cunicularia hypogœa*.



OSTEOLOGY OF EREMOPHILA ALPESTRIS.

OSTEOLOGY OF THE NORTH AMERICAN TETRAONIDÆ.

By R. W. Shufeldt, M. D.,
Captain, Medical Department, United States Army.

The representatives of the Gallinaceous order of birds in the North American fauna are referred to four families, the *Cracidæ*, the *Meleagridæ*, the *Tetraonidæ*, and the *Perdicidæ*. Members of the family *Cracidæ* or the Curassows, are all American birds, being distributed over the continent from the Rio Grande southward.

The latter group has been divided by Messrs. Sclater and Salvin into three subfamilies, the *Cracinæ*, the *Penelopinæ*, and the *Oreophasinæ*. Of the fifty or more species making up these subfamilies, at the present writing, but one form has been taken within the limits of the United States, this being the *Ortalis vetula maccalli*, the Chachalaca of the Texans and Mexicans. The subfamily *Penelopinæ*, referred to above, has been divided into seven genera, of which *Ortalis* is the last, and the one to which our only North American species belongs. Every attempt of the author to secure the skeleton of this interesting bird has thus far failed, and as he has had no personal experience with *Ortalis* in its native haunts, the reader is referred to the standard works upon ornithology for descriptions of this species. In *Meleagridæ*, the second family enumerated above, we have but one genus, *Meleagris*, containing the Turkeys, well-known fowls peculiar to North America, and of which there are two species, or rather a species, the western form, *Meleagris gallopavo*, and the eastern variety, or subspecies, *Meleagris gallopavo americana.*[1]

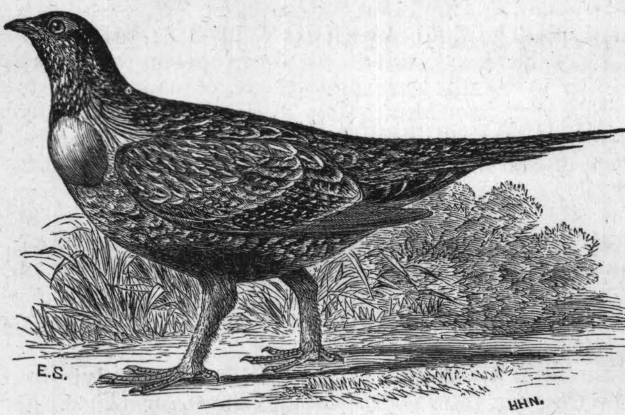
Although the writer has had the opportunity of comparing several skeletons and parts of skeletons of both of these forms with the *Tetraonidæ*, it must be understood that in recording his observations it has only been with the view of calling the reader's attention to the osteological similarities and differences, *en passant*. Professor Huxley, in his studies of this group, has left but little to be desired in the way of osteological descriptions, clearly pointing out differential characteristics existing between the Turkeys and the *Numididæ*, or the Guinea Hens. It is the third family, the *Tetraonidæ*, in our enumeration that has claimed the greatest share of our labor, and to which the title of this paper has been awarded in consequence. We have before us a complete collection of the skeletons of the members of this group, which is unfortunately more than we can say for the partridges, although of the latter family we have, we believe, a sufficient number to observe their general characteristics.

The family *Tetraonidæ* includes the Grouse, of which there are six genera in North America, containing sixteen species, embracing ten varieties. Of these we shall give a synopsis further on, showing their principal external characters, as set forth by American ornithologists,

[1] A second species, *M. ocellata*, is found in portions of Yucatan, Honduras, and Guatemala.

and also from the author's observations, both in the field and from specimens in his own collection.

Among gallinaceous fowls the Grouse are known by certain characters, such as the narrow and naked supra-palpetral processes; by the feathers filling the external nasal fossæ; by the cervical and inflatable air-sacs of *Cupidonia* and others; and finally by the feathered tarsi, the naked toes, with the peculiar horny processes, fringing their edges In *Lagopus* the feathers of the tarsi are dense, and carried to the very claws, this genus thus forming an exception to the last observation.



Centrocercus urophasianus.

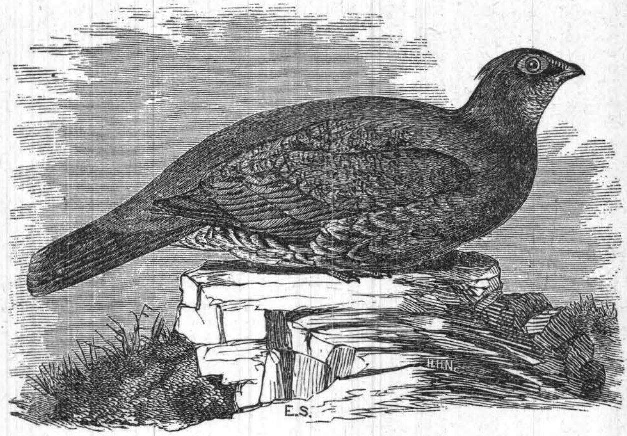
In the arrangement of the genera we adopt the high authority of the authors of the History of North American Birds (A Hist. N. A. Birds, Boston, 1874, Baird, Brewer, and Ridgway). In this work we find the following divisions given us, with some few modifications, which the reader will readily recognize:

Family	Genus	Subgenus	Species
Family Tetraonidæ. (*Grouse.*)	1. Genus Canace. (*American Wood Grouse.*)	Subgenus Canace.	Species: 1. Canace canadensis. (*Spruce Grouse.*) 2. Canace canadensis franklini. (*Franklin's Grouse.*)
		Subgenus Dendragapus.	1. Canace obscura. (*Dusky Grouse.*) 2. Canace obscura fuliginosa. (*Oregon Dusky Grouse.*) 3. Canace obscura richardsoni. (*Richardson's Dusky Grouse.*)
	2. Genus Bonasa. (*Ruffed Grouse.*)		Species: 1. Bonasa umbella. (*Ruffed Grouse.*) 2. Bonasa umbella umbelloides. (*Gray Ruffed Grouse.*) 3. Bonasa umbella sabinii. (*Oregon Ruffed Grouse.*)
	3. Genus Lagopus. (*The Ptarmigans.*)		Species: 1. Lagopus albus. (*The Willow Ptarmigan.*) 2. Lagopus rupestris. (*Rock Ptarmigan.*) 3. Lagopus leucurus. (*White-tailed Ptarmigan.*)
	4. Genus Cupidonia. (*Pinnated Grouse.*)		Species: 1. Cupidonia cupido. (*Prairie Chicken.*) 2. Cupidonia cupido pallidi cincta. (*Lesser Prairie Chicken.*)
	5. Genus Pediœcetes. (*Sharp-tailed Grouse.*)		Species: 1. Pediœcetes phasianellus. (*Northern Sharp-tailed Grouse.*) 2. Pediœcetes phasianellus columbianus. (*Common Sharp-tailed Grouse.*)
	6. Genus Centrocercus. (*Sage Cock; Cock of the Plains.*)		Species: 1. Centrocercus urophasianus. (*Sage Cock.*)

For the two subgenera of *Canace*, the principal differences seem to be, that the first, *Canace*, differs from the second, *Dendragapus*, in that it is of smaller size; has sixteen tail-feathers to twenty of the latter, and also *Canace* has no inflatable air-sac at the side of the neck, which the subgenus *Dendragapus* has. Otherwise the varieties of each subgenus seem to have arisen mainly, as so many varieties doubtless have, from climatic influences, due to their inhabiting various geographical areas.

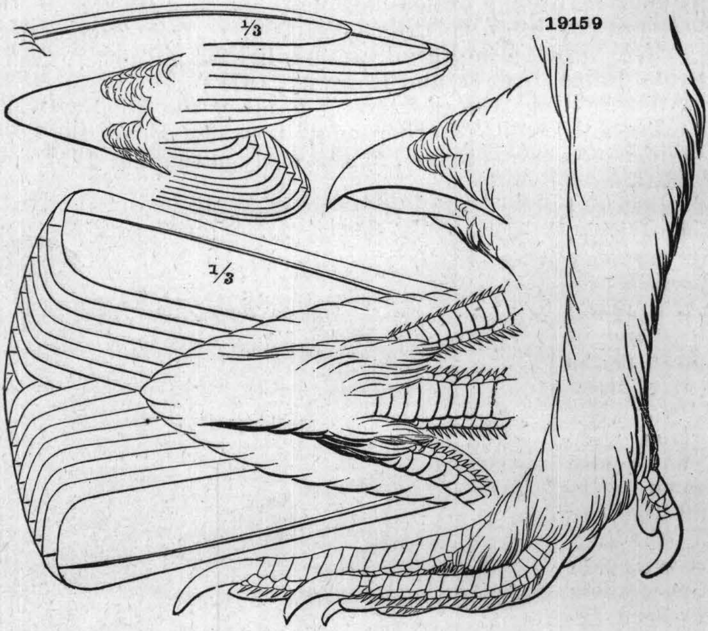
Canace canadensis is found ranging from northern United States to the Arctic seas; west nearly to the Rocky Mountains. *C. canadensis franklini* from northern Rocky Mountains, near United States boundary, and west to the Coast Range. *Canace obscura* ranges in the Rocky Mountains to the south of South Pass and Sierra Nevada, north to Oregon and south to San Francisco Mountains, New Mexico, and finally *Canace obscura fuliginosa*, northwest coast region, from Oregon to Sitka. The latter two varieties intergrade at their limits. (Habitat. from Hist. N. A. Birds, Baird, Brewer, and Ridgway, 1874.)

The writer has had the pleasure of hunting the Dusky Grouse at various times and localities in the mountainous districts of the Territory of Wyoming. On one occasion, in the early autumn of 1877, I found myself heading a file of several Sioux Indians, winding my way over a well-beaten game-path, along the side of one of the highest peaks of the Big Horn Mountains. My companions were armed with the well-known carbine, and I had my double fowling-piece, a weapon that none of them had ever seen before and were evidently quite curious to see the use and effect of. Suddenly we emerged into one of those delightful little open spaces that we occasionally find occurring even on the sides of the most rugged ascents. It was devoid of trees and carpeted with the greenest of verdure. Hardly had we entered this area when away went a magnificent "Blue Grouse" from his hiding place and cover. It was the first bird of the kind that I had ever seen alive, and the effect could hardly have been less demoralizing than the impression produced upon the renowned Wallace, when the first Bird of Paradise dazzled his vision in the jungles of New Guinea. Suffice it to say, that, in a twinkling, this vigorous old Grouse was entirely out of my reach, and was whirling up the mountain-side through the darkpine woods that covered it.



Canace obscura.

But my game was not alone in a spot so inviting, for a step or two more started two other fine old males of the same bevy. By this time self-possession had been entirely recovered, and before this pair could reach the confines of the open space in which we were, each had been overtaken by the contents of one of the barrels of my breech-loader with fatal effect. Before the echoes of the double report had died away among the rocky cañons, my Indians had these beautiful birds in their hands and were closely examining them, apparently looking for some immense wound that the bore of my gun certainly seemed capable of inflicting. The Indian has, we know, an aggravating way of not showing his wonderment even on the most startling occasions, and it has always been a source of intense gratification to me if I could by any means whatever so surprise one of these stolid sons of the forest as to induce him to elevate his eyebrows, be it ever so little. On this particular occasion the position was mine. I simply shrugged my shoulders, giving them to understand that it was an extremely simple matter, and left them to make what they could out of it.



Canace obscura.

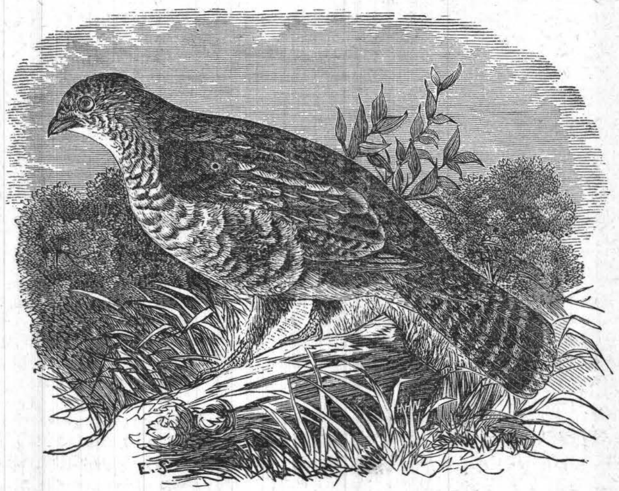
All of the birds of this species taken in the Big Horn Mountains were, to the best of my recollection, the form recognized as *C. obscura richardsoni* I do not remember an exception. This is not the case, however, when we come to the Laramie foot-hills about the country and less elevated peaks lying to the southward and westward of Fort Fetterman. It was in this vicinity and near the top of one of the highest hills to the eastward of Casper Mountain that the writer, in the depth of winter, with the thermometer many degrees below zero and the snow knee-deep, found small bevies of the type bird *C. obscura*, and succeeded in taking several specimens. They seemed to occur more frequently in those hills where the immense herds of elk resorted, and perhaps this was due to the fact that these animals bared the ground of snow in many places, and thus exposed winter berries and other foods that might not otherwise have been added to the bill of fare of these Grouse. *Centrocercus urophasianus* occurs throughout the Northwest, frequenting, almost with out exception, the arid plains wherever the sage-brush thrives, the buds and leaves of which form its principal food.

Thus far this genus has contained but the one species just alluded to, and although this Grouse occurs over an immense area of country, there is not an ornithologist that we are aware of, that has ever detected sufficient differences in specimens taken in widely-separated districts that would guarantee the establishment of varieties. The author for several seasons had the opportunity to study these birds in the very heart of their native haunts; observed them under all manner of circumstances, both young and old; but the bird and its habits are so well known at the present writing that personal experiences will be almost superfluous here.

For the species and varieties of *Bonasa*, we find that the type, *B. umbella*, is found throughout the eastern districts, it being the Partridge of New England and the Pheasant of the South. This form intergrades with the first variety that we find as we proceed westward; that is, *B. umbella umbelloides*, a geographical race found in the Rocky Mountains and British America. The last variety, *B. umbella sabinii*, the Oregon Grouse, is the Pacific coast form. The best authorities allow that the varieties of the type of this Grouse owe their differences in coloration to geographical modifications.

The extent of this intergradation is well described in the History of North American Birds, already cited. After presenting a synopsis of the varieties, it reads as follows:

The above synopsis is intended to present in the simplest form the characteristic features of the three definite races of this exceedingly variable species, as exhibited in a light-rusty rufous-tailed form of the Atlantic States, a pale, gray, ashy-tailed form of the Rocky Mountains of the United States and British America, and a dark-rusty rufous-tailed form of the Northwest coast region. These three, when based on specimens from the regions where their characters are most exaggerated and uniform, appear sufficiently distinct; but when we find that specimens from the New England States have the rufous bodies of *umbellus*, and gray tails of *umbelloides*, and continue to see that the transition between any two of the three forms is gradual with the locality, we are unavoidably led to the conclusion that they are merely geographical modifications of one species.



Bonasa umbella.

Pediœcetes presents us with two forms, already given in our enumeration of species and varieties; the first, *P. phasianellus* is found pretty generally throughout British America and to the northward of our boundary. It also occurs in Alaska. *P. phasianellus columbianus* supplants this species, being a variety of it, and is found in the prairie regions west of the Mississippi River, and has even been taken as far east as Chicago.

In Wyoming, I found them during the spring and winter months in large numbers along the banks of the Platte River and the streams and creeks that empty into it. During the summer months, however, they desert these localities and resort to the hills and mountains, where many of them breed.

As in the genus just alluded to, *Cupidonia* has its type and a variety.

Cupidonia cupido being found in the more central portions of the United States, and at one time, we are well aware, was plentiful all along the Atlantic Coast, particularly to the northward. *C. cupido pallidicincta* is a variety occurring from Texas to Nebraska, generally lighter in color, and decidedly smaller. This is one of the most interesting members of the family *Tetraonidæ*, and descriptive ornithologists have delighted in repsenting us in their works with the engaging history of the famed prairie hen.

There are three species of ptarmigan found in North America, as already shown in our table given above. *Lagopus albus* is confined to sub-Arctic and Arctic America, occurring more or less abundantly across the continent. *L. rupestris* is also an Arctic bird, while our last species, *L. leucurus*, is not only found in these sub-polar regions but inhabits the mountainous districts of the West as far south as New Mexico.

I have not had the pleasure of hunting this beautiful Grouse, never having been in sections where it was found, so that in the following partial synopsis of external characters and appearances of the *Tetraonidæ*, I am, as far as this species is concerned, indebted entirely to the authors of A History of North American Birds, from which valuable work I have borrowed the necessary data differentiating this genus from others of the group.

GENERA OF THE TETRAONIDÆ.

CANACE.—Nasal fossæ occupying barely half the culmen. An extensible bare space on either side of neck. No cervical ruffs. Tail broad and rounded at outer angles. Toes without feathers, which occur on the basal membranes between them and the entire tarsi. The varieties *C. canadensis* and *C. franklini* are distinguishable in that the former has a rounded tail that terminates with a lightish brown band, and the upper tail coverts have light ash emarginations, whereas the latter bird has nearly a square tail, entirely black, only occasionally showing a light colored tipping, and the superior tail-coverts have extensive white margins.

BONASA.—Crested, cervical ruffs of black and particularly soft and glossy feathers. Tail broad and nearly square. Tarsi bare below. Anterior scutellæ arranged in two rows, approaching the Partridges in this as in many osteological characters.

B. umbella umbelloides.—Pale; slaty-gray the prevailing shade. *(Coues.)*

B. umbella sabinii.—Dark; chestnut-brown the prevailing shade. *(Coues.)*

LAGOPUS.—No cervical ruffs. Tail but slightly rounded. Tarsi and toes thickly feathered to the very claws. Species become white during winter season.

L. albus.—Bill very stout. "Bill as high as the distance from the nasal groove to its tip. Tail always black, narrowly tipped with white; wing (except upper coverts) pure white."

L. rupestris.—"Bill slender; distance from the nasal grove to tip (.35) greater than height at base (.27). In summer the feathers of back black, banded distinctly with yellowish-brown and tipped with white. In winter white, the tail black; the male with a black bar from bill through the eye. Size considerably less than that of *L. albus*."

L. leucurus.—"Entirely pure white, including the tail."

CUPIDONIA.—Nasal fossæ less than one-third the length of the culmen. Sides of neck ornamented with long and sharp outstanding tufts, composed of thick black feathers. Tail shorter in comparison than any other Grouse. Feathers extend to lower end of tarsi. Head slightly crested. Inflatable air-sacs below cervical tufts. Osteologically *Cupidonia* and *Pediœcetes* are nearly related and opposed to all the other forms or genera of the *Tetraonidæ*. As in the following genus, *Cupidonia* has one well-defined variety, *C. cupido pallidicincta;* this form is alluded to in the History of North American Birds, above cited, in these words: "In its relations with the *C. cupido* this race bears a direct analogy to *Pediœcetes columbianus*, as compared with *P. phasianellus*, and to *Ortyx texana*, as distinguished from *O. virginiana*. Thus in a much less development of the tarsal feathers it agrees with the southern *Pediœcetes*, while in paler, grayer colors, and smaller size, it is like the southwestern *Ortyx*."

PEDIŒCETES.—Nasal fossæ less than half the length of the culmen. Cannot be said to be crested, but has the habit of raising the feathers of the crown under the same circumstances that the crested forms elevate their crests. Have seen specimens that certainly seemed to possess rudimentary cervical tufts. The mid-pair of tail-feathers produced beyond the short and graduated tail proper, their ends being truncate. Tarsi feathered to the toes. In *P. phasianellus* the toes are hidden by the feathers and the coloration of the two forms differs materially.

Centrocercus urophasianus.—Nasal fossæ nearly two-thirds the culmen. Large, inflatable air-sacs. Not crested. Feathers of throat with spiny shafts, and those of the body with *large after shafts*. Tail long, graduated, and of twenty acuminate feathers. Tarsi covered with feathers, which extend over the basal webs.

As we do not enter especially into the subject of the osteology of the family *Perdicidæ*, we will merely present the reader here with a synopsis of the North American forms and their habitats.

		GENUS.	SPECIES.	HABITAT.
FAMILY *Perdicidæ*. (The Partridges.)	SUBFAMILY *Ortyginæ*.	*Ortyx*	1. *Ortyx virginiana.* (American Partridge.)	Eastern United States and to the plains west.
			2. *O. virginiana floridana.* (Florida Partridge.)	Florida.
			3. *O. virginiana texana.* (Texan Partridge.)	Texas and certain localities to the northward.
		Orortyx	*Orortyx picta.* (Plumed Partridge.)	Northern coast region of California, Washington Territory, and Oregon.
			Orortyx picta plumifera. (Plumed Quail.)	Southern California. A race that simply differs slightly in coloration.
		Lophortyx	*Lophortyx californica.* (California Quail.)	Valleys to the foot-hills of the Pacific region.
			Lophortyx gambeli. (Gambel's Quail.)	Colorado Valley of the United States, north to Southern Utah, and east to Western Texas. (Hist. of N. A. Birds.)
		Callipepla	*Callipepla squamata.* (Scaled or Blue Partridge.)	Texas, New Mexico, and Arizona.
		Cyrtortyx	*Cyrtonyx massena.* (Massena Partridge.)	New Mexico, Arizona, and Texas, and to the southward.

To this list, my friend Dr. Coues has added *Coturnix dactylisonans*, the common Migratory Quail of Europe, a bird that at different times has been imported and set at liberty in various parts of the Union—in New England for one locality—and it is at present supposed that this Quail will become a bird of the country, as *Passer domesticus* has.

I learn also from Mr. Lucien M. Turner, lately returned from Alaska, that he has been so fortunate as to find a new race of *Lagopus* that will be duly described in his report.

The anatomical peculiarities of the order *Gallinæ* has been the favorite theme of many an able writer, and we find Huxley, Owen, Gegenbaur, Parker, Coues, and others, in their several works, dwelling largely upon the osteology of these birds, ably exposing the observed characteristics of structure both by pen and pencil; but, as far as our knowledge extends, no one has as yet devoted himself to the production of a paper devoted exclusively to the osteology of the North American Grouse, such as the writer here proposes to undertake with every hope of success, aided as he has been by the kind assistance of many friends in different parts of the Union, in sending him valuable material in the way of representatives of the Family.

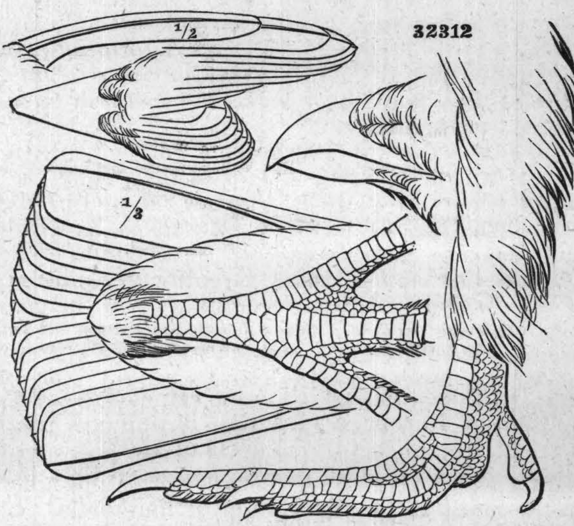
In this monograph we will omit, as we have in former ones now published, any detailed description of the osseous elements of the ear, or the respiratory tube, small sesamoids, or such tendons as may ossify in the extremities. The hyoid as an arch of one of the cranial vertebræ evidently is not included in this category, and will in consequence receive the attention it undoubtedly deserves in its proper place.

The study of the bones entering into the cranial vertebræ has been initiated at a stage in the chick's life a few days after birth, and their relation to each other and their development carried up to the adult bird. It will be observed after a glance at the writer's drawings in Plate V that he has chosen the young of that grand old prairie-loving Grouse, *Centrocercus urophasianus*, as an example of the growth of the skull from the time above referred to in the *Tetraoninæ*.

In this plate the first three figures show respectively the skull of the young of the Sage Cock a few days after the parent has led it from the nest: 47 from above, 48 lateral view, with mandible, and 49 from below, the mandible removed.

Fig. 50 shows the bird in August of the same year, and Fig. 51 the disarticulated skull of the same, whereas in the next plate we observe the skull of an old cock of the same species, that has, no doubt, trod the prairie for many a season. (Fig. 52.)

In these birds the greatest amount of difference exists in point of size among the sexes and in individuals of various ages of the same sex; so we naturally find a corresponding amount of difference in the sizes of their crania.



Bonasa umbella.

Fig. 52 is the skull of an exceptionally large adult, ♂, chosen from a bevy of several hundred others, with a view of affording the reader the opportunity of seeing the proportions this Grouse may attain, as far as this part of its skeleton is concerned. This peculiarity seems to be confined to *Centrocercus*, and does not obtain with the other varieties, they seemingly arriving at maturity of growth at a much earlier period of their existence. *Canace obscura* may form an exception to these remarks, but it is certain that it is not by any means so striking a characteristic in this bird. Another interesting point to be observed here, that no doubt has forced itself upon the reader since his inspection of the plates already introduced, is the unusual length of time that the original bony segments of this Grouse's head retain their individuality over others of the class. This is indeed so, and in birds of one or two years of age, if we exclude the epencephalic arch of the occipital vertebra, it is not an unusual occurrence to be able to distinguish all the sutural boundaries among the remaining elements, and these appear to be persistent when applied to the nasals and the premaxillary bone of very old birds. We are all well aware that this rule holds good in the common barn-yard fowl.

Students of the works of that eminent anatomist and observer, Owen, will remember that in his Comparative Anatomy and Physiology of Vertebrates he seems to accuse the *Struthionidæ* alone of this singular feature, or at least "those birds in which the power of flight is abrogated." Now, such of my readers as have had the opportunity of observing the flight of the "Cock of the Plains," after he has once been induced to take wing, will agree that there is anything save an abrogation of that avian privilege.

Crania of the North American *Tetraoninæ* being placed on the horizontal plane, as described in my monograph on the osteology of *Eremophila alpestris* (Bull. U. S. Geol. and Geogr. Surv. of the Ters., vol. vi., No. 1), we observe that their equilibrium is moderately stable, the anterior bearing point being the tip of the superior mandible, and the two posterior bearing points being the external facets upon the tympanics. The angles of the foramina magna average 70° while the centrum of the parietal vertebra is the chief bone of what here must be the basicranii, and is found to be nearly in the horizontal plane; the neural arch of the occipital vertebra being, as a whole, gently convex outwards and lying in nearly the same plane with the foramina magna.

The Skull.[1]—So distinct do we find the hæmal arch of the first cranial or occipital vertebra, and fulfilling such a diverse end, with its appendage the pectoral limb, in birds generally, that its description will be undertaken further on under the subject of the "scapular arch," and our attention be engaged at this point only with the neural or epencephalic arch of this segment of the cranium.

The primoidal elements of this, the superior arch of the vertebra in question are seen to a greater or less extent *in situ* in the young and "bird of the year" of *Centrocercus* in Plate V, Figs. 47–50, and in the disarticulated skull of the same, Fig. 51, as *so*, *eo*, *bo*, and *po*, lettering respectively the essential elements "superoccipital," "exoccipital" (the parial bone and counterpart of this segment being intentionally omitted, as are the duplicates of other segments), "basioccipital,"[2] and the connately developed process, "paroccipital" of the neurapophyses.

In Sage Cocks the size of those figured in Plate V, Figs. 50 and 51, we find the neutral spine of the first vertebra, *so*, to be a light, spongy bone, one and a half centimeters wide by about one-half of a centimeter deep—covered with a thin layer of compact substance. Its upper border displays in the median line a demi-lozenged shaped notch that when the bone meets the parietals, which latter have their posterior and inner corners deficient, forms in many birds of this age a fontanelle. In younger individuals this diamond-shaped vacuity is always present, the

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[1]The author's plates and figures illustrating this paper are numbéred in continuation with others of his published monographs.

The reader is kindly referred to the foot-note under "Skull" on page 594 of this volume, in my monograph upon the osteology of *Speotyto cunicularia hypogæa*, where he will find the author's remarks upon the theory of the four cranial vertebræ, and the reasons why they were adopted in certain of his papers. These remarks apply with equal force to the present article.

[2]The terms here used for the elements superoccipital, exoccipital, and basioccipital, seem to be more or less universally adopted and applied by anatomical writers. Professor Parker and Gegenbaur term the first-mentioned element the supraoccipital rather than the superoccipial, as here given. The former of these comparative anatomists says, in his Morphology of the Skull (Lond., 1877, p. 241) in regard to these segments as they are found in the chick of the common fowl the second day after hatching: "The extensive occipital plane, swelling backwards above, is largely ossified, although there are considerable chondrous tracts remaining. The basioccipital extends into the occipital condyle, and it is considerably underfloored by the basitemporal plate in front. (Fig. 63.) The exoccipitals ossify the lower half of the sides of the foramen magnum. They are very irregular in shape, extending considerably into the ear-cartilage. They are perforated by the vagus and hypoglossal nerves. The supraoccipital centers have coalesced almost completely to form a large bone bounding the upper half of the foramen magnum, which is pointed above. Superiorly, the margin of the bone is curved like a fan, and abuts on the parietals." The supraoccipital centers, according to Professor Parker, are two in number, developing side by side. (*Op. cit.*, page 235.)

anterior fontanelle being formed in them in a similar manner, though narrower and longer, between the frontals and parietals. The lower border of the superoccipital presents a smooth, angular depression, that in the articulated vertebra goes to complete the superior third of the foramen magnum.

The lateral bodies of this bone are cellular masses with several apertures opening forwards and outwards, the mastoids closing them in, in the completed cranium. On its outer surface near the inferior angles we observe two, one on either side, grooved foramina, leading upwards and inwards, to open into the lateral sinuses on the inner surface of the segment, nearer together. As age advances these canals contract, but still exist throughout life.

The basioccipital segment, *bo*, also is largely cancellous in structure, wedge-shaped, having at its apex a long, rounded tubercle curving outwards and backwards, overhanging a slight depression beneath it. This tubercle in the complete vertebra forms the middle two-thirds of the occipital condyle, which, in the adult, is found below the foramen magnum, sessile, uniform in outline, with the rounded border below, and all indications of its original division into three parts obliterated.

The neurapophyses of this vertebra, termed the "exoccipitals" (Plate V, Fig. 51, *eo*), are each nearly as large as the neural spine; on their inner borders they present for examination the deeply-rounded margins to complete the foramen magnum, and immediately beneath, the minute tubercle jutting out that lends its assistance on either side to form the condyle of the occiput.

The outer angles, quadrate in outline, deflected slightly downwards, are the transverse processes of the vertebra, the "paroccipitals." The precondyloid foramina are also to be observed here, with one still more external, belonging to the group from which the eighth nerve makes its way from the cranium. The internal aspect of an exoccipital is a mass of open, irregular cells, that are closed in when this segment is approximated with the mastoid, superoccipital, and the "petrosal",[1] (Fig. 51,1), that odd-shaped and spongy bonelet which constitutes the capsule of the organ of hearing—and which has a foramen on its inner and smooth surface for the passage of the auditory nerve—forming, also, by a bending forwards of a part of this surface, and aided by the basi-sphenoid, the floor of the mesencephalic fossa on either side, while externally it shares in forming the entrance from without to the otocrane.

With the exception of the petrosal, the elements thus far described, when duly articulated, form the neural arch of the occipital vertebra, as already intimated above. The basioccipital, the centrum of this vertebra, by its larger extremity and the exoccipitals with the connate diapophyses articulate with the basi-sphenoid in the basi cranii below; the latter, with the superoccipital, meet the parietals and mastoids above and laterally. In old birds every trace, both sutural and otherwise, becomes completely obliterated as the osseous amalgamation progresses, though throughout the group a well-defined "superior line" limiting muscular attachment, indicates very nearly the terminating borders above, and sometimes, as in *Centrocercus*, a fainter indication exists in the vicinity of the union among the interested bones below. On either side of the condyle to its outer aspect we observe in a slight depression a group of usually four foramina—two external opening into

[1] Quite recently Dr. Coues has, in an admirable paper, presented us with a review of the literature bearing upon the so-called "temporal bone" of human anatomy, and as in this paper the true relations and composition of the "petrossal" are so clearly set forth, and they express the views now generally accepted, that it gives me pleasure

the otocrane, one into the cranial cavity, and one leading through the basi-sphenoid to the base of the "sella turcica" at the carotid opening; they transmit principally the eighth nerve and the internal jugular and branches.

In some of the very old individuals of the *Tetraoninæ* quite a striking characteristic presents itself in the capaciousness of the opening to the otocrane, produced by a thin, wing-like expansion, recurved forwards, formed by the outgrowing and union of the centrum of the second vertebra and the diapophysis of the first. This feature is not particularly noticeable in the *Ortyginæ*, nor in *Lagopus*, *Cupidonia*, and *Bonasa*, still less so in the Sharp-tailed Grouse, among the *Tetraoninæ*, but quite marked in old males, especially in *Canace* and *Centrocercus* (Figs. 52, 74, 88, and 89). No very decided differences exist among the Grouse with regard to the foramen magnum and the occipital condyle; the former is universally of good size for its owner, subcircular, and without any encroachments upon its margins beyond the condyle. This latter, always sessile, reniform in contour, occupies its usual position below the foramen, with its long axis placed horizontally. In all the Grouse, save *Canace* and *Centrocercus*, it slightly invades the marginal periphery of the great foramen of the occiput, and in all the excepted genera is more or less shortened transversely.

The second cranial segment constitutes the parietal vertebra, and its elements are shown in the same plate, Fig. 51, where indicators pass through its neural and hæmal arches, P. V. and P. V′: P. V is the mesencephalic arch, constituted in the complete cranium by the bones P, the parietal or neural spine, when linked with its fellow; *a. s.*, the alisphenoids, the neurapophyses; *m. s.*, the mastoids, the diapophyses; and

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to quote the following from him. In summing up the various parts of the temporal bone, he says:

The following is a list of these morphological elements:

1. Squamosal. A membrane bone with which in mammals the maxilla is connected by the malar and the mandible is directly articulated. The "squamous portion" of the temporal.
2. Tympanic. Accessory to the organ of hearing, forming the meatus auditorius externus. The "auditory process."

3. Pro-otic. 4. Epi-otic. 5. Opisth-otic	Primitive otic elements together forming the periotic or petro-mastoid; the otocrane or bony capsule of the organ of hearing, inclosing the bony labyrinth, developing the mastoid cells, and practically constituting the "petrous" and "mastoid" parts of the temporal,	
6. Mallens. 7. Incas. 8. Stapes.	Ossicula aditus or phonophori in man devoted to audition, but	6. *Malleus*, the proximal end of the mandibular arch 7. *Incas*, the proximal end of the hyoidean arch. 8. *Stapes*, connecting fenestra ovalis with the hyoidean arch.
9. Tympano-hyal. 10. Stylo-hyal.	Elements of the hyoidean arch.	Tympano-hyal not recognized in human anatomy. Stylo-hyal, the "styloid process."

This does not include the *os orbiculare*, a minute ossification occurring at the junction of the incus with the stapes, and in man for a short time separate.

Still further on this author states: "The periotic develops from a mass of cartilage situated in the basis cranii between the occipital and sphenoid from three centers of ossification, which, however speedily and completely they may coalesce, as they do in man before birth, represent as many distinct bones, one or more of which may remain separate in many animals. These are the *proötic*, the *epiotic*, and the *opisthotic*. The first of these is anterior and in special relation with the corresponding vertical semi-circular canal. The second is superior and external. The third is posterior and inferior in relation with the posterior vertical semi-circular canal. Their confluence completes a bony periotic capsule, inclosing the labyrinth or cavity of the inner ear. This is the triune *periotic bone;* with its mastoid developments the still only triune *petro-mastoid bone;* with its tympanic annex the *otocrane*, or skull of the ear, containing the essential parts of the organ of hearing. The periotic proper corresponds closely enough with the "petrous portion of the temporal" of human anatomy—the "petrosal bone," as it is sometimes called. (The Nature of the Human Temporal Bone, Am. Jour. Otology, vol. iv, Jan., 1882, pp. 25–29.)

b. s., the basi-sphenoid, the centrum of the vertebra. The hæmal arch we see in the "hyoid," which here shares the same fate of its neighbor in the occipital vertebra, insomuch as it is ununited to the superior arch by either osseous connection or by articulation, for in all living birds the hyoid, the well-known bony support of the tongue, depends entirely upon its muscular and ligamentous connections to retain its relations with the cranium. The manner in which the disjoined neural spine of the parietal vertebra goes to form the posterior fontanelle in the half-grown bird has already been sufficiently dwelt upon. The bone P, as detached in an individual of this age, is quadrilateral in outline, excessively spongy and light, owing to the paucity of compact substance over quite a large share of diploic tissue, which is chiefly deposited in a protuberance on its inner table, which protuberance, in union with the fellow of the opposite side of the complete cranial vault, forms two concave surfaces out of the remainder of the superficies, essential portions of the ep- and prosencephalic fossæ.

Superficially, these elements are smooth and convex, and in the adult, after consolidation, exhibit some faint evidence of a parietal eminence on either side—more marked elevations, however, occurring in the spine of the vertebra beyond, immediately anterior to the suture termed in Anthropotomy the "coronal." With the exceptions of the tympano-mastoidal articulation and the connections between the mastoids and petrosals, the majority of the articulations of this vertebra in the mid-aged bird may be classed among the variety known and described in works upon human anatomy as the "squamosal"—the parietals being beveled above to accommodate themselves to the frontals.

The alisphenoids are separated from each other mesially by nearly half a centimeter; above they meet the frontals, below the basi-sphenoid, and laterally the mastoids—the lower and outer angles almost reaching the cup-shaped articulation for the tympanics. This segment seems to ossify from its borders towards the center, leaving a foramen that is eventually closed in. Touching this point, Professor Parker says, when treating of the development of the skull of the Common Fowl, "From the hinder half of the basisphenoidal region a considerable elongated *alisphenoidal* lamina arises (*a. s.* Fig. 59), passing outwards and backwards on either side in the cranial floor, and ascending a little into the side wall; coalescing at its extremity with the periotic mass, but leaving an elongated space unfilled by cartilage between the two tracts. The cranial surface of the alisphenoid conforms closely with the concave curvature of the hinder part of the cranium (see Fig. 62)." (Morphology of the Skull, Lond. 1877, p. 230). And further on, "A membranous fontanelle (*a. s. f.*) arises in its center; and both in front and behind this distinct ossific centers appear in the cartilage; these afterwards unite to form one *alisphenoid* bone." (*Ibid* p. 236).

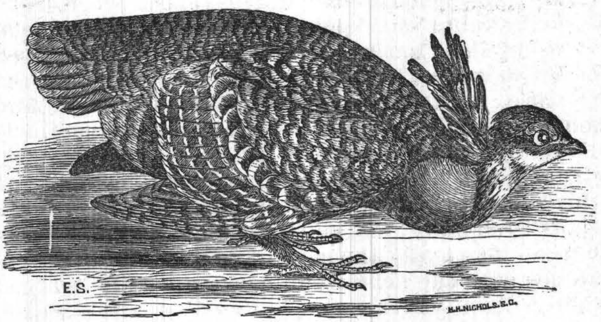
Professor Huxley, in treating of the development of the cranium, says of this bone—

"In front of the auditory capsules and of the exit of the third division of the fifth nerve, a center of ossification may appear on each side and give rise to the *alisphenoid*, which normally becomes united below with the basisphenoid." (The Anat. of Vert. Animals, p. 24.)

This bone, on its mid and lower border, presents for examination the half of the "foramen ovale," which is completed by meeting the centrum of the vertebra. It is for the transmission of the trigeminal nerve into the orbital cavity. Laterally there is developed a quadrate apophysis (the parapophysis of the vertebra?), which joins with a similar, subsequently scale-like process coming from the mastoid, resulting in a foramen, cordate in outline above, elliptical below, between them, giving passage to the fibres of the temporal muscle that is markedly characteristic of the *Tetraonidæ*. Below the point of union this sphenotic process, as this latter apophysis has been termed by authors, is triangular, with its apex pointing forwards and downwards, flat, with its inner surface looking forwards, upwards, and inwards. Internally, the alisphenoid is deeply concave. (Plate VI, Fig. 52, and other skulls illustrating this paper.)

The external appearance of the *mastoid*[1] is well shown in Plate V, Fig. 50, and as *m. s.*, Fig. 51. Internally the half-cells observed close in by the aid of similar excavations in the segments of the occipital vertebra, the acoustic capsule; and a double-concave surface assists in forming cranial fossæ.

We now come to examine the ornithic characters of one of the most interesting segments of the bird-skull, the centrum of the parietal vertebra, well termed by most ornithotomists and general anatomists as the basi-sphenoid. At an early date in the life of the chick (*Centrocercus* and others) this bone becomes confluent with the centrum of the frontal vertebra beyond; this confluence takes place, if we may be allowed to differ with such high authority as Owen, who makes the rather sweeping assertion "that the pit for the pituitary body marks the boundary" (Comp. Anat. and Phys. of the Vert., vol. ii. p. 45) in the following manner, and the sutural trace is yet discernible in young birds of the Family under discussion (Plate V, Fig. 51). The *pre-sphenoid* lies beneath a tuberous process projecting anteriorly from the latter bone, reaching *nearly* as far back as the carotid foramina. The combined bones, the centra of the two mid-cranial vertebræ, thus constitute the compound bone *basi-pre-sphenoid* of comparative anatomists.



Cupidonia cupido.

Viewed from above, we discover, proceeding from before backwards, in the median line, 1. The upper aspect of the apophysis just mentioned, and immediately to its rear the deep "sella turcica" with the osseous canals of the carotids opening into one foramen at its base; 2. Two smooth surfaces, one on either side and a little laterally, for the optic chiasma to rest upon; 3. Another surface still more posteriorly for the mesencephalic fossa, being perforated by diminutive parial foramina; 4. A roughened open space for the articulation, with the head of the wedge-like basi-occipital. Anteriorly, and at the same time laterally, broad and uneven borders for the alisphenoids, with their smooth groovelets of the foramen ovale, while back of these again, on either posterior angle, a concave wing-like expansion, the terminations of the Eustachian

[1] The bone here called *mastoid* is the *squamosal* of the majority of authors, as Huxley, Parker, and others. It corresponds with the bone that bears the same name in the works of Professor Owen. The bone *squamosal* of this latter author, and used in the same connection by myself in this monograph, is the *quadrato-jugal* of Huxley and others.

tubes, that add to the parietes of the entrance of the otocrane. Below and superiorly, at the base of the junction of the two bones, we find the carotid foramina, with a depression between them mesially, and still lower down, slightly protected by an attenuated offshoot from beneath, the separate apertures of the anterior and buccal entrances of the Eustachian tubes.

The remaining surface, unbroken in character, extending posteriorly, goes to complete the basi cranii. The coaptation of the elements forming the neural arch of the parietal vertebra is shown in Plate V, Figs. 47–50, their amalgamation in the adult in Plate VI, Fig. 52.

The chief importance of the hæmal arch of this vertebra depends upon the bony support it affords the tongue. In a fine specimen of an adult *Lagopus leucurus*, kindly presented me by Mr. Robert B. McLeod, then residing in Leadville, Colo., we find the following characteristics presented to us for examination, and they extend with little deviation to all the members of the family. The hyoid arch[1] consists of, in the specimen under consideration, seven bones. The confluent ceratohyals and glossohyal, which latter is largely completed anteriorly by cartilage, form one segment; the ceratohyals diverge from each other smartly behind, and at their point of meeting afford the facette for the transverse trochlea surface on the basi-hyal. This last bone, the second in order, measures half a centimeter in length, being enlarged at both extremities, flattened from above downwards, the anterior end being fashioned to fulfill the purpose already mentioned, while the posterior and larger extremity presents two facettes, looking backwards and outwards, to articulate with the hypobranchial elements of the thyro-hyals. The third segment also meets this compound articulation at this point, a short urohyal, it, too, being completed at its posterior extremity by cartilage. The hypo- and cerato-branchial elements of the thyro-hyals make angles with each other and curve upwards in conformity with the basi-cranii.

The sub-cylindrical hypo-branchials are one and a half centimeters long, and connected with the posterior elements by quite along and intervening piece of cartilage of the same caliber; the smaller cerato-branchials also taper off behind with the same material.

This arch in the *Tetraonidæ* long remains almost entirely cartilaginous, the hypo-branchial elements alone being composed of bone, and a bird must be of quite an advanced age before he can boast of a complete osseous framework as forming a component part of his lingual apparatus.

The neural arch of the third cranial vertebra now to be defined is the prosencephalic—its hæmal arch the "mandibular," as its hæmapophysis constitutes the lower jaw, termed "mandible," in avian skeletology.

The fusing of the centrum of this segment with the basi-sphenoid has already been elucidated; the rostrum thus formed is gently inclined upwards and forwards, grooved along its entire superior aspect, tapering to a sharp point anteriorly to receive the connate prefrontals in the bony gutter at its distal third. Beneath it displays towards its base the

[1] In speaking of this compound bone, Professor Gegenbaur tells us: "Two pairs of arches can be made out in birds. The rudimentary first arch fuses to form the so-called entoglossal bone (Fig. 259, 2), posteriorly to which lies the true body of the hyoid. The second arch, however, is well developed, and gives rise to the cornua (4, 5), which are formed of two large pieces, which generally curve backwards behind the skull, without being directly connected with it. Behind the copula there is the remnant of a second one, which forms the hyoid process (3)." (Elements of Comp. Anat., Lond., 1878, p. 472.) In the description of the hyoid in this paper the ceratohyals correspond to the entoglossal bone, as referred to in the above quotation from Gegenbaur, and the copula of that author to the basi-hyal, his hyoid process being the urohyal.

parial facets for the pterygoids and beyond the rounded surface for the palatine articulation.

It will be remembered that in the first edition of this monograph the writer announced the fact that he had failed to discover the *orbito-sphenoids* (considered as the neurapophyses of the arch) *i. e.*, they were not found as bones that were produced from separate points of ossification. Since that time, more than a year ago, I have not had the opportunity to look more thoroughly into the mattter, but the series of my skulls of the common fowl and those of *Centrocercus* show the spaces these bones occupy in the mature birds to be completely filled in, the posterior orbital walls being more or less complete, a fact familiar to all of us, but in birds of the year and still younger specimens large vacuities exist where these bones should be; moreover, I have in my possession a skull of the common fowl in which the basi-sphenoid sends up on either side two delicate bony sprouts that subsequently complete the periphery of the circular foramen for the oculomotorial nerve and the optic. Professor Owen seems to think that these are the centres of ossification for the orbito-sphenoids, for this anatomist tells us that "the bones, 10 (orbito-sphenoids), of the third neural arch coalesce with each other, and the centrum below, protect a smaller proportion of the prosencephalon than in the Crocodile, but maintain their neurapophysial relation to it and to the optic nerves, below the exit of which they begin to ossify." (Anat. of Verts. Vol. II, p. 46.) Huxley, in his Anatomy of Vertebrated Animals, page 22, says, "In front of, or above, the exits of the optic nerves the *orbitosphenoidal* ossifications may appear and unite below with the pre-sphenoid." Professor Parker is even more decided, for this writer informs us that "Above the optic foramen, wedged in between the alisphenoid and the interorbital septum, a four-sided bone has arisen in membrane on each side, and there is a smaller pair in front of and above the larger, helping to fill in the fenestræ left unoccupied by the orbital plates of the frontals. These are the anterior and posterior *orbitosphenoids* (*o. s.* Fig. 66.) The anterior half of the interorbital septum is ossified, the mesethmoid encroaching on the anterior margin of the interorbital fenestra." (Morph. of the Skull, young fowls up to nine months old, page 249.)

This is very clear, and as Professor Parker is a very careful observer and devoted himself particularly to the subject in question, no doubt his observation is correct, and some more fortunate observer than myself will some day detect these ossifications for the orbito-sphenoids in our *Tetraonidæ;* for since they occur in the common fowl, it seems only natural that we should look for them in the *Gallinæ* generally. This accounts for the fact that in my drawing in Plate V., Fig. 51, the position of an *orbito-sphenoid* was simply shown by dotted lines, and marked *os.;* in this same figure Fr. is the "frontal," *ps.* the prefrontal or centrum of the vertebra, and *x* the usual site for the postfrontal—this exogenous element, the diapophysis of the vertebra is not here found, its position being occupied by a depressed roughened surface for the squamous articulation of the mastoid. We have never personally examined any bird in our avi-fauna where this bone is seen independent. Descriptive ornithotomists, in their studies upon the skulls of *Rheidæ* and *Struthionidæ*, give the presence of this process as occurring free.

The neural spine of the frontal vertebra follows the example of the parietal in being completely bifidated in the younger specimens. As a whole it is perhaps the largest segment in the bird-skull—certainly as far as our Grouse and Partridges are concerned. Either half of its spine presents, projecting anteriorly from the middle, a flattened process, directed gently forwards, downwards, and outwards; that at its extremity is marked above by quite an extensive surface for one of the nasals, and below by another, against which the head of the ethmoid abuts. The concave surface below this process and the remaining hinder moiety form the vault of the orbit. Another scale-like projection is thrown out posteriorly, deeply concave within, correspondingly convex without, to shield the prosencephalic lobes—the bones being joined. Huxley terms the pleurapophysis of the hæmal arch of this segment the "quadrate"—the "os quadratum" of the older anatomists. Owen defined it as the *tympanic*,[1] it being the homologue of a bone of the vertebral skull generally—it was the os carré, in birds, in the writings of the eminent Cuvier. The tympanic bones here, as in all sauropsida, are free ossicles, connecting the articular ends of the lower jaw with the skull. They are in the *Tetraonidæ*, symmetrical and well proportioned, not exhibiting any marked peculiarities or deviations from a common type. The mastoidal and orbital arms are about of a length and calibre, the first being rather the larger, and is surmounted by a hemispherical articulating head for the cup on the lower border of the mastoid. The neck below the processes is moderately constricted before it expands to become the "mandibular" end, that has beneath its tranverse elliptical facet outwardly the intervening notch, and then the inner and smaller one, all for articulation with the mandible. The bone has likewise a surface to articulate with the pterygoid below the orbital process, and is always pneumatic. From the outer aspect of the mandibular extremity it supports its two appendages, the bony styles, termed "squamosal" and malar—the first by a diminutive ball-and-socket joint articulated in the usual manner. The malar, as we know, is the mid-style of the infraorbital bar—the maxillary completing the connection anteriorly, and although upon superficial inspection of this striking ornithic feature of the lateral aspect of the skull, it seems to be firmly united in its schindylesial articulation, it simply requires ordinary maceration in the adult of any of the Grouse or Quails to have the three styles separate from each other and from their tympanic and intermaxillary connections.

The lower jaws of the *Tetraoninæ* are singularly alike in all their characteristics throughout the sub-family. The single bone is developed in the usual way by confluency of the "articular," "surangular," "angular," and "splenial" elements posteriorly, and the outer moiety by the "dentary" element, the hæmal spine. (Plate V. See explanation of plates for the above-described bones.)

The mandible in the adult has a gentle and increasing curvature downwards from the interangular vacuity forwards. The curvatures

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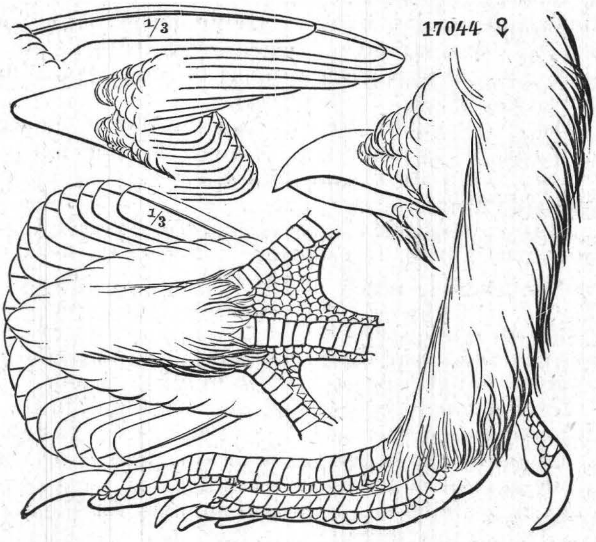
[1] There can scarcely be a reasonable doubt left in the minds of comparative anatomists that the question is now settled and the fact generally accepted that the bone termed *tympanic* and so used by Professor Owen in his writings, is the representative of the malleus of the mammalia. It is the "quadrate bone" of all modern writers, I believe without exception, and articulates with the skull, the quadrato-jugal and the pterygoid and the lower jaw on either side. Professor Huxley alludes to its development in the following words: "In the sauropsidan embryo a rod of cartilage occupies the first viseral arch on each side and meets its fellow in the middle line. The rod becomes jointed, and the part on the distal side of the joint is converted into Meckel's cartilage, while that on the proximal side of the joint is modeled into the rudiment of the quadrate bone, which is invariably in its earliest state cartilaginous. Soon, however, the quadrate cartilage ossifies, and a centre of ossification appears in that part of Meckel's cartilage which articulates with the quadratum. This gives rise to the articular element of the mandible. All the other constituents of the lower jaw are developed in the fibrous tissue which surrounds the rest of Meckel's cartilage, which structure either persists throughout life or disappears." (On the Representatives of the Malleus and the Incus of the Mammalian and other Vertebrata, Proc. Zool. Soc. Lond., 1869, page 401.)

at the extremities of the symphysisial suture are both parabolic, the inner being the more open of the two. The interangular fenestra is a flattened ellipse, which has distinct sutural traces leading from it, indicating the borders of some of the original bits of bone of which it is composed.

The "coranoids" are but feebly developed and the articular ends not far below them; these latter have the usual pneumatic foramen at the ends of their inpointed and blunt extremities, and sharp recurved processes behind, in a line with the rami of the jaw, which apophyses long remain in cartilage in immature birds. (Plate X, Fig. 71.)



Cupidonia cupido.

On the lateral aspect of the bone, two muscular lines lead away from the coronoidal elevations. These last two mentioned features are universally characteristic of the *Tetraonidæ;* they are strongly marked in *Lagopus*. (Plate XIII, Fig. 88.) Minute foramina are found above and below near the dentary margins, and two quite prominent, one beyond the ramal fenestra on the inner surface of the jaw; still another just anterior to a small tubercle below the coronoids on the same aspect. The inferior ramal borders are smooth and rounded, as are the under surfaces of the articular ends where they originate in nearly the same plane.

The divergence of the ramal limbs of the mandible in *Ortyginæ* is greater, owing to the greater width of the skull when compared with its length.

In some fine specimens of *Lophortyx californica*, generously furnished us by Mr. Charles A. Allen, of Nicasio, Marin County, California, we note the striking departure from the mandible in the Grouse in the absence of the interangular vacuity—this feature obtains, however, in the common Virginia Partridge and others. The deflection of the rami anteriorly is greater in these birds also, or at least more sudden, and so prominent are these ramal borders that the inner sides, towards the posterior ends, are converted into true fossæ.

Those interesting osseous and diminutive oblong plates, the *sclerotals*, present in all of the class, we believe without exception, are found here occupying their usual position. (Plate V, Fig. 51, 2, and Plate X, Fig. 75, in *Cupidonia.*) They number from thirteen to eighteen or twenty, and their function is so well known that it will not be dwelt upon here. They differ principally in the amount of tenacity with which they retain their normal relation after prolonged maceration. *Cupidonia* holds a high place here, and the fact seems to be due to the greater overlapping of the edges of these little affairs and the toughness, or perchance the thickness, of the internal and external sclerotic coats that cover them. Lately we saw in the case of *Sayornis nigricans* where these platelets were apparently confluent; no such condition ever occurs in the Grouse or Partridges.

The "lacrymal" (Plate V, Fig. 51, 3 and other figured skulls), is found on the anterior margin of the frontal, enjoying a free harmonial articulation that encroaches slightly on the nasal border. Each is a squamous, cordate lamella, with its larger end nearer the orbital cavity; this completes the bone in young birds, but in mature individuals it sends down a curved and delicate style with its point directed outwards, that encircles and gives support to the lacrymal duct on its passage to the rhinal cavity (*Centrocercus*).

We now come to examine into the last of the cranial vertebræ, and, in the family under consideration, the one most modified. It is the "nasal," and its neural arch the "rhinencephalic," the hæmal, the "maxillary."

In the *Tetraonidæ* its centrum, the "vomer." is missing.[1] Whether this be due to the foreshortened skull of the Grouse, with its long sphenoidal rostrum rendering any further extension superfluous, we cannot say. In the lengthened skull of any of the *Anatidæ*, where such a bone is imperatively called for, as a sub-interspinal partition, it is invariably present and unusually prominent (Plate V, Fig. 51, *vr.* vomer, is merely outlined to indicate its position in other birds).

The neurapophyses of the arch are found in the connate *prefrontals*, the bone called "ethmoid" in androtomy. It here, in the young bird, is lodged in the outer third of the groove on the pre-sphenoid, rises columnar, sub-compressed laterally, leaning forwards at a gentle angle to expand above in a trihedral summit for the support of the frontals, nasals, and intermaxillary, a short process being projected backwards for the former. The posterior aspect of the column develops as the bird grows, the interorbital septum, reaching to, and perhaps aiding in, the formation of the exogenous orbito-sphenoids.

The *nasals*, or the divided neural spine of the arch, are squamous

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[1] Since making the above statement I have been able to examine a large mass of material from all imaginable sources, and have come to the final conclusion that the vomer occurs in the entire group of gallinaceous birds of America. Many things may have led me to believe at the time that this bone was missing, as stated in the text: In the first place, it is an extremely delicate and freely articulated one in the *Tetraonidæ*, and in the second place the doubt still harasses my mind as to whether there may not be instances where this vomer does not ossify until very late in the life of the bird, and all of the *fresh* specimens I examined may have been of this character. The foundation for this assertion lies in the fact, that quite recently I examined, with great care, numbers of market specimens of *Bonasa* and *Cupidonia*, in which I failed to discover this bonelet, while in others it was easily found. The specimens examined were all apparently birds that had attained maturity, and displayed no external characters by which they could be separated from each other.

The plates accompanying this edition were not submitted to me in time to add this bone to such figures in which it would show, so that the vomer does not appear in any of them. In Plate V, fig. 51, where it is shown in dotted outline as *vr.*, it should be beyond the ethmoid, Pf. and shaded like the other bones indicating its presence. A good figure, giving its proper position, is presented to us by Huxley in his Anatomy of the Vertebrated Animals, page 283 (figure 82 of the common fowl). This writer tells us "the vomers vary more than almost any other bones of the skull. They underlie and embrace the inferior edge of the ethmo-presphenoidal region of the basis cranii, and, in all birds in which they are distinctly developed, except the Ostrich, they are connected behind with the palatine bones. In most birds they early unite into a single bone; but they long remain distinct in some *Coracomorphæ*, and seem to be always separate in the Woodpeckers."

I have found it in numerous adult specimens of the common fowl, but it is a rare coincidence to ever find it in the crania of museum collections. I have in my section at the United States National Museum, the "Darwin types" of the skulls of the wild lamella, twisted upon themselves in a manner to conform with the superior base of the beak, overlap the frontals, as already defined, are separated from each other by the intermaxillary, throwing out below to meet this bone a sharp process, thus forming a broad elliptical boundary limiting the capacious osseous nares. In all adults of this family they are easily detached by maceration. These bones are well shown in Plate X, Figs. 71 and 73, in the cranium of *Cupidonia*, from an unusually fine bird sent with a number of others, for which our thanks are graciously tendered to Captain Richards Barnett, Medical Department, United States Army. It will be observed that the bone becomes so attenuated in some specimens as to give rise to a foramen, as seen in the latter figure. The hæmal arch of this vertebra is called the maxillary as its lower rib and spine constitute the major share of the superior mandible or *maxilla*. The pleurapophyses seen in the *palatines* are long, riblike bones with their anterior ends much flattened from above downwards, to fit into a fissure on either side made for them in the intermaxillary below the maxillaries. Near their middles they curve moderately outwards to develop compressed heads at their posterior extremities, fitting into a notch in either pterygoid, and concave mesially for the rostrum of the basi-sphenoid.

At their inner thirds they send off thin sheets of bone that curve upwards, barely to touch the ramphosial process of the sphenoid, accompanying it as far as it extends distad, then sloping away on the ribs of the bones themselves. The hæmapophysial maxillaries are elements that seldom change their ornithic characters, and in the *Tetraonidæ* seem to be reduced to their simple typical form—in completing the delicate infraorbital bar on the one hand—and just previous to becoming wedged into the premaxillary above the palatines, dispatching a bony offshoot on either side nearly to meet each other in the palatine fissure on the other.

The remaining pair of bones found at the interior aspect of the bird's skull are the *pterygoids*. In the Grouse they are stumpy, subcompressed concerns, with half-twisted shafts, having broad concave surfaces for the facets on the rostrum, which are notched distally for the reception of the palatines. The articulation with the tympanics is equally extensive, monopolizing long, narrow facets beneath the orbital processes on those bones.

We have arrived finally at the point in our descriptive skeletology of the avian skull, where we have to deal with the anterior and ultimate

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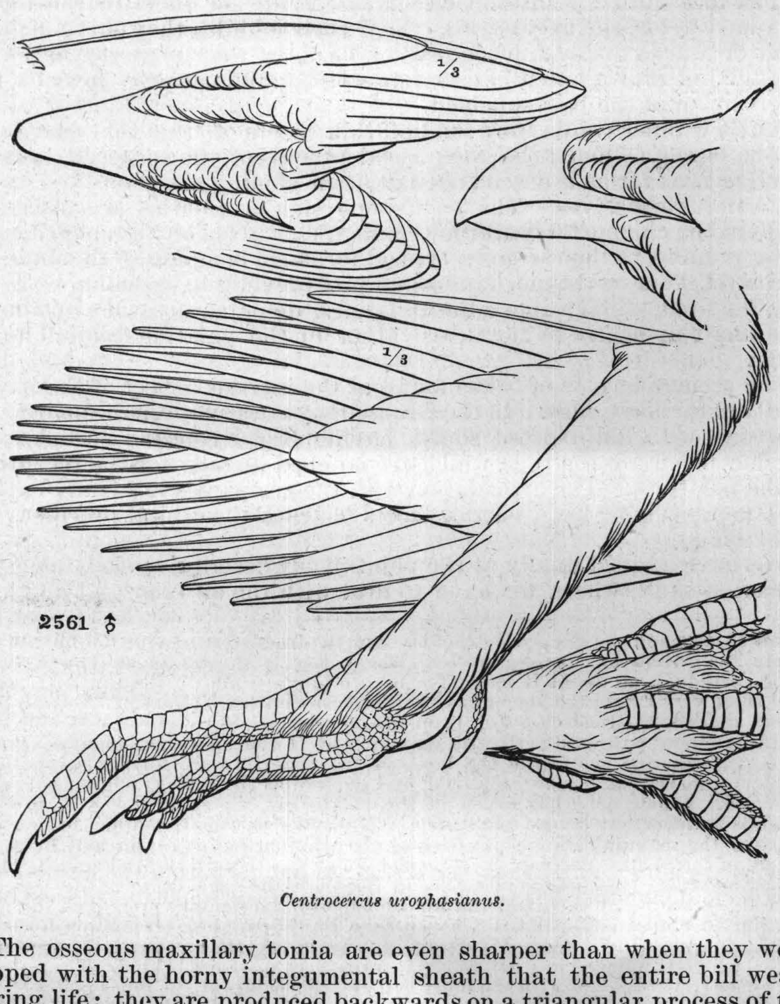
Gallas baukiva and the Horned Fowl of the Azores. They were presented to the Smithsonian Institution by Mr. Tegetmeier. The vomer is present in neither of these crania, although no doubt it may have been originally, and in the drawings made from these very crania the vomer has likewise been omitted. (Darwin's Animals and Plants under Domestication. Vol. 1, pp. 275, 279, figs. 34, 36.)

Other eminent writers describe its development in the following language: "The pre-maxillaries and the rest of the bones of the upper jaw are further advanced in development, becoming more solidified, and perfecting the various relations already described. A new bone has arisen in the palate, viz, the *vomer* (*v.* fig. 65, p. 246), which is however but a very small style, lying under the nasal septum, behind the points of the maxillo-palatine processes of the maxillaries." (Parker and Bettany, Morph. of the Skull. Section 549. Common Fowl, fourth stage.) And again: "The slender maxillary (figs. 64, 65) now rises in front into the angle between the descending crus of the nasal bone and the hinder edge of the dentary process of the premaxillary. The maxillo-palatine plates (*Mx. p.* Fig. 65) are broader and reach nearly to the mid-line, being separated partly by the nasal septum and partly by the small vomer, which is rounded in front and split for a short distance behind. The forks of the vomer (*v.*) articulate with the inner and anterior points of the inner plates of the palatine bones, which lie side by side mesially, nearly concealing the rostrum." (*Ibid.* sect. 563. Fifth stage. The chick second day after hatching.)

hæmal spine, here fulfilling most important functions as the superior mandible, as it does throughout the class at large. In the *Tetraonidæ*, as in the vast majority of birds, the *intermaxillary* or the "premaxillary" of some authors is of much stouter material than most other bones of the head, its use being a very obvious reason for this. (Plate V, Fig. 51, N. *Pf. mx*, *i. mx.*)

From the moderately free fronto-maxillary and pseudo hinge-joint, between the out-turned frontals, the culmen of this bone slopes by a gently increasing arc to the tip of the beak. This surface is rounded and split in two from the enlarged inner extremity to a point over the distal border of the nostril; this division lasts during life. The external nasal orifices are unusually large and sub-elliptical in outline. The head of the ethmoid shows in very young chicks, but is eventually covered by this bone, which also fills in snugly the internasal space (Plate X, Fig. 73).



Centrocercus urophasianus.

The osseous maxillary tomia are even sharper than when they were capped with the horny integumental sheath that the entire bill wears during life; they are produced backwards on a triangular process of the bone below the shaft of the maxillaries, touching them in the Quails.

A row of minute foramina encircle the beak anteriorly, where it is the thickest, though the segment is non-pneumatic. The general surface beneath is depressed below the tomial margins, though it is not very extensive, as the wide palatine fissure occupies a good part of the space, that terminates anteriorly in a U-shaped curve, opposite the outer nasal border. In the *Ortigynæ* the curve of the culmen is more abrupt, and the frontals rise above, in some cases even jut over, the premaxillary. The nasal apertures are also very large and of a shorter elliptical outline; the palatine fissure is likewise narrower in comparison, a few of which differences are such as one would naturally look for in a bird of so near kin, and whose beak has been more than proportionately curtailed.

On removing the vault of the cranium in an adult female of *Centrocercus*, so as to obtain a free view of the brain-case, we discover the usual nervous and vascular foramina present at their most common sites, but beyond this we are more struck with the feebleness with which many of the salient points are developed, as compared with some of the other avian groups; we might sum it up by describing it as a lack of angularity and depth. It is true the various fossæ are well, though not strongly divided, the superior median crest is present, but not very prominently developed, and the rhinencephalic fossa is barely conical. The section shows the greatest amount of deplöic tissue to be in the basi-sphenoid, and bones of the occiput, where for potent reasons such material is most urgently in demand.

In the study of the crania of the adult *Tetraonidæ* as an entirety we find among the most conspicuous features enlisting our interest the unusual number of bones that remain free in them. The skull can be so stripped of its outstanding segments that nothing remains save the cephalic casket with the interorbital septum. The rhinal chamber is strikingly open, due to the great external nasal passages, and all its internal structures, as the ethmo-turbinals, internasal septum, and floor being formed only in cartilage. A pocket existing in the extremity of the premaxillary, that fills in with a spongy osseous tissue during life, is observed in *Centrocercus*, which is solid in the *Ortyginæ* and *Lagopus*—parial, subcircular pits placed side by side in like locality in *Canace obscura.*

The orbits are more fortunate in the completeness of their bony inclosures—the heavy plate generously extended by the ethmoid to divide these cavities very rarely shows any deficiencies. Of all the crania before us *Canace obscura* is the only delinquent in this respect, though no doubt this may occur in others. In it quite a vacuity exists near the middle of the septum. Anteriorly the prefrontal and frontal throw out laterally squamous septa of greater or less completeness, that divide these cavities from the common rhinal space. These plates may coalesce with the processes of the lacrymal, as a rare coincidence, and perchance meet the infraorbital style. The foramina for the passage of the optic nerves and the first pair are, as a rule, singularly circular and distinct, the minor apertures about them enjoying a like individuality. They are noted for their greater size among the Partridges.

A separate canal is devoted to each olfactory nerve immediately below the orbital vaults, that usually at its outstart from the cranial end has a small opening between it and the one of the opposite side. About the entrance to the otocrane we notice principally a rounded, squamous plate thrown down from above by the mastoid, that is present in all the Grouse. Just below and within, this segment also develops a sharp spicula of bone, posterior to the tympanic articulation, that evidently serves the purpose of keeping this free ossicle in its socket in certain movements of the jaw.

Peculiarities of the floor of this cavity have already been described above; in specimens of *Canace canadensis*, carefully selected for me by Mr. William Brewster, of Cambridge, Mass., and forwarded to me by Prof. J. A. Allen, of the Museum of Comparative Zoology, also of Cambridge, to whom my grateful acknowledgments are due for so many like favors, we find, upon viewing the skull from below, the elevations or convexities due to these ellipsoidal and wing-like formations, reminding one of their marked resemblance to the acoustic bullæ of the tympanic found among the crania of *Felidæ*.

The author in his various plates and figures believes he has given sufficient life size, as they all are, views of basal and superior aspects of the skulls of these birds, will not enter here into any needless details of measurements. The variation in size in this respect in *Centrocercus* has already been dwelt upon; it is not nearly so marked in other genera. The surfaces of the skulls above have a rough look caused by many minute depressions and groovelets, these running out to the margins of the orbits cause them in some to be finely serrated.

The sharp-tailed Grouse is a unique exception to this, it being a bird of rather a delicate skull with smooth cranial superficies. All save *Centrocercus* possess rather depressed foreheads, apparently due more to a slight tilting upwards of the superior orbital peripheries. The lateral temporal fossæ are shallow and scarcely noticeable, the muscles they afford lodgment not being remarkable either for their size or strength.

Did the writer feel that he had sufficient material before him he would gladly devote a few of these pages to the description of some of the exceedingly interesting osteological differences existing between the domestic and the wild Turkey; but as such facts can only be considered reliable, and such differences constant, after the examination of a large series of each, such as we have not at present at our hand, we will simply speak of a few of the cranial peculiarities as seen in a set of skulls of *Meleagris gallopavo* and *M. gallopavo americana* from the collection of the Army Medical Museum of Washington. As we might expect, the skull of *Meleagris* has in it all of the leading points that we have attributed to the *Tetraonidæ* generally. The occiput and the foramen magnum are found to be nearly or quite in the vertical plane, the skull resting on its bearing points in the horizontal plane; the surface above is more or less rough and venated, as in *Cupidonia*. The parietals rise above the general surface as rounded domes, constituting quite a prominent feature in the skull of this bird. A depression occurs in the frontal region between the margins of the orbit and posterior to the nasals; this is more decided in my specimens of *Pavo cristatus*, a bird that possesses a cranium not at all unlike the Turkey. In *Meleagris* we find the lacrymals to be strong and pointed bones directed backwards, articulating principally with the nasals, though the frontals usually extend down to meet their posterior borders; below, their descending processes are flattened and turned towards the median plane. Taken as a whole the lacrymals of the Wild Turkey are quite different bones as compared with the same bones as we found them in the Grouse and Quails. A very interesting change is seen to take place in these bones in *Numida meleagris*, as this bird attains maturity. We have just said that the frontals in the Turkey extended down so as to meet and articulate with the posterior borders of these bones on either side; now, the older the bird the more extensive is the meeting of these bones; this is carried to its maximum condition in *Numida*, for in the young of this fowl the lacrymals are found to be freely articulated to the outer borders of the nasals, the frontals barely making any encroachment upon them, but in a very old bird we find the lacrymals actually wedged in between the frontals and nasals on either side, and the superior periphery of each orbit formed by the continuous outer margins of a frontal and a lacrymal. The prominent bony crest seen in the median line of the skull of the Guinea Hen is formed entirely by an uprising of the frontals and increases as this fowl becomes older.

In the Wild Turkey, the external nasal apertures are large and elliptical, and the various sutures among the bones of the superior mandible, long remain clear and distinct as we found it to be the case in the Grouse. On a lateral view of the skull we find the arrangement of the sphenotic process the same as in all of the *Tetraonidæ;* it differs in *Numida* by being single and very stout; there seems to be no rule governing the condition of the orbital septum, for in skulls of Wild Turkeys of apparently the same age—in one, large deficiencies will be found in this plate while in the other the partition will be entire and quite thick.

The pterygoids are large and stumpy bones, articulated in precisely the same manner as we described them for the Grouse. The vomer is short and the spinal chamber in the dry skull capacious and undivided by an osseous septum narium.

The lower jaw is stout and may or may not have the fenestra present in its side; behind it has the sharp, upturned processes so characteristic of Gallinaceous birds. The ramal apertures is absent in all of my specimens of *Pavo* and *Numida*, otherwise the birds have inferior maxillæ typical of the family to which they belong.

We have examined skulls of all of the forms of *Lagopus* occurring in America, and discover but trifling differences existing; in a specimen of *L. albus* the orbital septum is complete and the cranium of the bird is broad across the fronto-maxillary region; a deep median pit exists in this region among many of the Quails, less marked in *Ortyx*, but very decided in *Cyrtonyx massena*, still more in *Orortyx picta*, the beautiful plumed Partridge of the Pacific States. In this latter bird we find a deep and longitudinal cleft occurring in the median line on the superior aspect of the skull, between the orbital margins, that is characteristic and not found among the other American Quails.

The skull of the young of *Pediœcetes*, a few days after it has left the nest, differs in no great degree from the skull of the young of *Centrocercus—i. e.*, in points of ossification and the relation of the bones.

Of the Vertebral Column.—In discussing the development and peculiarities of the vertebral column, we will still continue to adhere to *Centrocercus* as our model, explicitly stating names of other species when occasion requires a departure therefrom.

In examining the atlas and axis as they occur together in the chick a few days old, we find that the neurapophyses of the first have as yet failed to fairly meet above in the median line; though they may in some instances, as they undoubtedly do, soon touch each other. No ossific centre exists for an atlantal neural spine, as that process is not found upon this bone in any of the *Tetraonidæ*. Below the arch the interesting procedure is progressing in the appropriation of the centrum of this segment by the axis. The inferior extremeties of the atlantal neurapophyses have inserted between them a circular ossicle whose plane is in the horizontal plane and on a level with the floor of the neural canal of the axis. This bonelet eventually becomes the "odontoid process" of the second vertebra. At this stage it is a little less than a millimeter in diameter, and in the adult occupying the same position remains a subsessile, and in comparison with the bulk of the bone it is attached to, an insignificant tubercle, though unquestionably fulfilling all the important functions required of it. In less than six weeks the odontoidal larceny is complete, and no trace remains to lead one to suspect how matters stood at the earlier date.

Immediately beneath and a little posterior to the primoidal and distinct centrum of the atlas, there is another, and still larger, free ossific centre, uniform in outline, concave above, surrounding the primitive odontoid apophysis with its long axis lying transversely; behind, and in contact with it, are two more very minute and elliptical ones placed side by side. The first of these unite with the atlas and latterly form the bony ring for the occipital condyle to revolve in, and the surface for the odontoid to move upon, and a notched lip of bone that projects from it behind, that subsequently develops; the remaining two, behind the first ossicle mentioned, form the anterior part of the body of the axis that bears the articulating surface for the first vertebra. In the full-grown bird the postzygapophyses of the first vertebra projecting well to the rear look almost directly inward. They meet the prezygapophyses of the axis that face in a contrary direction and a little backwards. The articulating facet for the centrum of the axis is subelliptical, convex, of some size, and has in the segmented column the inferior and convex surface of the odontoid playing just above it, the superior and flat surface of the latter being confined by intervening and delicate ligament forming a part of the floor of the neural canal of this bone. In the axis of the adult the anterior part of the bone with the odontoid process, that was separately added, projects conspicuously forwards beyond the neural arch, and in birds of several months of age it can be distinctly discerned where the union was established between neurapophyses and centrum.

In the mature vertebra the neural canal is nearly circular. In the center of the bone, above, a knob-like tubercle acts as the neural spine, which has mesially and behind a deep pitlet for the insertion of the interspinous ligament. Anapophysial tubercles are found above the postzygapophyses, which latter are of considerable size, concave, and faced downwards. The centrum of the axis is subcompressed from side to side and supports mesially, just anterior to the second vertebral articulation, the first hypapophysis of the series. The first two segments of the vertebral column are non-pneumatic.

Vertebræ throughout the chain in the young chick invariably show the line of union between the centra and neurapophyses, but it is lost as soon as the birds come to be two or three months old. At this age, however, still very interesting points of development are strikingly visible in the third vertebra, which otherwise varies but slightly from the same bone in appearance as seen in the column of an old male, such as we have before us.

The neural spine, more compressed than in the axis, is nearer the middle of the vertebra, still deeply pitted for the interspinous ligament behind, and slightly so on its anterior margin. This characteristic becomes very faint among the long vertebræ in the middle of the neck, to be more strongly reproduced as we approach the dorsals, the posterior depression always being by far the best defined. We find anapophysial tubercles still present in the third vertebra. These also exist throughout the cervical series, with more or less clearness; they form ridge-like lines upon the elongated segments of the mid-neck. The zygapophysial processes in general look upwards and inwards anteriorly, and *vice versa* behind—the fourth vertebra having in common with the one we are now describing an interzygapophysial bar, lending to these two segments that broad and solid appearance well known to ornithotomists, not possessed by any other of the cervicals. The neural canal in the third vertebra is nearly circular, which is also its form in the adult, becoming only moderately compressed from above downwards in the last three or four cervicals. Regarding the third vertebra from below, we observe that the articulating surface of the centrum for the axis to be quite concave and turned a little downwards. The processes that fall beneath the prezygapophyses form what would be a canal with its lateral margins; this groove, however, in the "bird of the year" is converted into the vertebral canal by an independent ossicle being placed over it on either side, and, being below the rest, it causes a broad shallow concavity to appear mesially and anteriorly.

These small bones have at the very outstart stumpy apophyses projecting backwards, which are the parapophyses of the vertebra—the projections they meet from above being the pleurapophyses, the groove they form mesially being the broad termination of the carotid canal.

The fourth vertebra has the same general appearance of the third, that we have just been describing; it is a little longer, however, and in both large pneumatic foramina are found laterally and beneath the diapophyses. These apertures are found in the vertebral canal in the remainder of the cervicals. Again, in both, the bodies are rather compressed from side to side, and it is not until the bird has arrived at maturity that the hypapophyses are well seen in these two segments.

Now, taking up the cervicals from the fifth vertebra, we find certain characteristics holding good throughout the series, with certain gradual modifications. In the adult the neural spine in the fifth is prominent and placed anteriorly; it slowly subsides to the tenth, where it is more tuberous, nearer the middle of the bone, and bears evidence of having a posterior projection overhanging the depression for the interspinous ligament. This is the type to include the thirteenth, the projection being more and more prominent and slightly cleft behind; in the fourteenth and fifteenth it suddenly assumes the broad quadrate spine of the dorsal type. Returning to the fifth vertebra, we note another change in the lengthening of the postzygapophyses; the acme of this modification is seen to be in the sixth and seventh vertebræ. From these they gradually shorten again, while the anterior ones spread out with the diapophyses to assume the form of the consolidated ones in mid-dorsal column. This arrangement allows lozenge-shaped apertures to exist between the segments above, and subelliptical ones laterally, that become smaller and more circular above as the postzygapophyses shorten, and quite large laterally as they approach the point opposite where the brachial plexus is thrown off from the myelon.

In the adult Cock of the Plains we detect beneath, in the fifth vertebra, well anteriorly, a strongly-developed quadrate hypapophysis. This process entirely disappears in the sixth, for in this segment the centrum of the bone, anteriorly on either side, just where the parapophyses meet the body mesiad, a tubercle commences to make its appearance, the apices slightly inclined towards each other. From the sixth to the tenth inclusive these apophyses become longer, approach each other below, but never meet so long as they have the "carotid canal," which they form between them. In the eleventh they seem to have met throughout their extent to form a hypapophysis on the exact site they occupy in the tenth, the tenth vertebra being the last cervical where there is any evidence of the carotid canal; hence from this method of formation Professor Owen is made to say (Comp. Anat. and Phys. of Vertebrates, vol. 11, p. 190), "In the common Fowl each carotid * * * enters (ing) the canal formed by the hypapophyses."

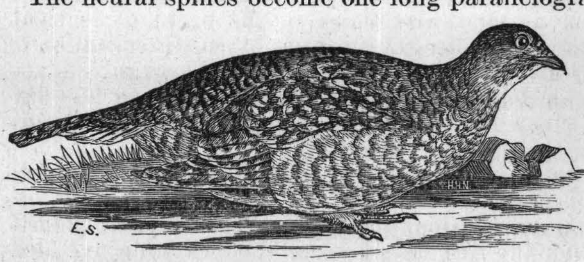
In the completed twelfth vertebra of mature birds we find this hypapophysis very large, with expanded extremity, and the parapophysis, on either side, sending down long subsquamous processes. In the thirteenth segment of the "bird of the year" the parapophyses begin to take on a change. This change develops in the adult still a perfect hypapophysis, but in the younger individual the parapophysial element begins to be notched anteriorly, a part favoring the pleurapophysis, a part the centrum, so that in the fourteenth vertebra of the adult the hypapophysis is still present anteriorly with a tubercle developing on either side of it, with the parietes of the vertebral canal very much slenderer. In examining this segment in the younger bird we ascertain that the original ossicle is now a descending pleurapophysis meeting the parapophysis, a delicate and independent process, which, in the fifteenth and last cervical vertebra, constitutes a free rib, while the hypapophysis consists of a mid-process and a smaller nodule on either side. This beautiful metamorphosis can be thoroughly studied and easily comprehended in the cervical portion of the vertebral column in our *Cathartes aura*.

So that, as a partial recapitulation of the first fifteen segments, we find that they make up the "cervical portion" of the column. Their centra are universally subcompressed at their middles, they develop in the young bird parapophysial projections that eventually produce free ribs by the aid of the descending pleurapophyses, and their interarticulations, as far as their bodies are concerned, bear out the general ornithic law of being apparently procœlous on vertical section and opisthocœlous on horizontal section.

Backwards from the fifteenth the vertebral segments or the links of the chain take on a metamorphosis that is characteristic of the *Tetraonidæ*. It consists in, in all the adults of the genera, a consolidation ot the ensuing four vertebræ. The confluent bone thus formed constitutes the major part of the *dorsal* division of the spinal column and invariably supports free pleurapophyses (Plate VI, Fig. 55, *Centrocercus*, ad. ♂).

In *Centrocercus* these four vertebræ can easily be distinguished from each other until the bird is over a year old, but very soon after this all sutural traces are entirely obliterated and we have the segment as represented in the plate.

The neural spines become one long parallelogrammic plate, occasionally exhibiting a foramen or so at the site of the original interspinous spaces.



Pediœcetes phasianellus.

Its crest is rounded, but has no independent rim. Muscular fascia attached to it posteriorly often ossifies, leaving in the prepared skeleton flattened spiculæ, on either side, directed backwards. The anterior aspect of this bone has all the necessary elements to meet the last free vertebra beyond it. The first pair of diapophyses are the shortest, the last pair the longest and most raised; these processes are more or less bound together by metapophysial offshoots of variously defined serrate margins, that allow interdiapophysial vacuities to exist. Below, and just anterior to the bases of the diapophyses, are the four subelliptical and concave facets of the capitula of the dorsal pleurapophyses. From their upper and posterior points sharp crests run beneath the transverse processes to meet the out-turned and cordate facets at their extremities for the tubercula of the ribs. At regular intervals, and nearly in a right line among the diapophyses, are the elliptical orifices for the transmission of the dorsal nerves.

Pneumatic foramina are found about the bases of the transverse processes, the most anterior one being of some size.

The centra of these amalgamated vertebræ are very much compressed from side to side. This compression has its due influence upon the form of the neural tube within, while the bone below is produced downwards into an excessively thin and sharp crest, which is still further extended into four inverted T-shaped hypapophyses of large size. They join each other beneath to a greater or less degree in many of the genera. This union more frequently takes place between the first and second, and the first is always upturned and flanged out laterally, a feature prominently reproduced in *Lagopus* and *Bonasa*. These winglike side extensions of the lower margins of the hypapophyses not infrequently are continued on two or three consecutive ones, and are sometimes the widest on the second.—*Canace*.

Both in the Grouse and Partridges we find a free vertebra inserted between the compound bone we have just been discussing and the first sacral vertebra. This segment we must consider as belonging to the dorsal series, although in *Cupidonia* and *Pediœcetes* the upper and distal aspects of its diapophyses are more or less moulded to conform with the ilia. This bone is also figured in Plate VI, Fig. 55, in conjunction with the other dorsals, with which it has all its characteristics in common, and such ones superadded as we might expect to find in a vertebra naturally disjointed in the middle of the column. It has the longest diapophyses of any of the series to which it belongs; facets for the tubercula and capitula of its own free pleurapophyses; a hypapophysis of no mean length that may or may not be expanded below.

Metapophysial spiculæ on its transverse processes sometimes are so far produced as to reach vertebræ before and behind it.

This segment is likewise pneumatic.

There is a wonderful vein of regularity running through the dorsal pleurapophyses, hæmapophyses, and hæmal spine or sternum. As to the first pleurapophysis, or rather the first pair of these bones, we have already described them as they are found in the ultimate cervical. There we are aware it never reaches the sternum by the intervention of a sternal rib; that they are usually found to possess thoroughly developed heads and tubercles for the vertebra, their shafts being less flattened than the dorsal ribs, and only in *Lagopus* did we discover any epipleural appendages.

As far as our observations extend, the consolidated portion of the column of the dorsum has always consisted of four vertebræ, and consequently we find in this portion four pairs of movable dorsal pleurapophyses and one pair for the free dorsal vertebra, reckoning five altogether for this region. The first pair of dorsal vertebral ribs terminate in free extremities, which are usually in line with the inter-hæma-pleurapophysial articulations in old specimens, and as a rule support epipleural appendages, characteristic of the species to which the rib belongs.

In the *Tetraonidæ*, following the general aphorism of the class, we observe a gradual dilatation of the skeleton from the inter-coracoidal aperture towards the pelvic extremity of the body. To compensate, or rather what really gives rise to to this, as far as the bird's osseous structure is concerned, among other things, is a lengthening of the diapophyses as we proceed in that direction. The ribs also become longer; the xiphoidal forks of the sternum flange outwards. So, too, we find a corresponding shrinking of the tubercula on the dorso-vertebral pleurapophyses, and a stretching of the correlative necks, so that the capitula may reach the facet intended for them on the vertebræ.

The vertebral ribs as seen in the Grouse are pneumatic, the foramina being found on the posterior aspect of these bones immediately below the tubercles, sheltered by the flattened bodies as they dilate in that region.

As in nearly all birds, these ribs are compressed from within outwards, and in *Centrocercus* are wider below the uncinate processes, contracting as they meet their sternal ribs. In these birds, too, the epi-pleural appendages are firmly knit to the body of the rib—though in *Bonasa*, *Lagopus*, and *Canace* they may be easily detached, leaving behind them in each case a shallow concave facet. In the last dorsal rib this appendage is the smallest, and is directed upwards nearly parallel with the body of the rib, and sometimes (*Centrocercus*) the edge of its rib swells out to meet its apex above; and this may have been the method by which the unique and remarkably striking uncinate appendages were formed in *Cupidonia*, a bird that constitutes itself an exception among the North American Grouse in this respect (Pl. XI, Figs. 79, 80), where not only the vertebral ribs are unusually broad, but their processes much more so, being great, odd, quadrate and compressed plates confluent with the body of the rib, and only rarely condescending to be weakened by the merest apology for a foramen to exist in them, as in Fig. 80. The Sharp-tailed Grouse appears to come next in approaching this state of affairs; it, too, invariably developing more or less expanded ribs. The only sacral pair of pleurapophyses conform to the general shape of the series to which they belong, and never support epi-pleural processes.

These bony protectors of the thoracic parietes were found to be exceedingly delicate in specimens of *Bonasa* kindly sent me by Leslie A. Lee, Esq., of Brunswick, Me.

Four hæmal ribs ascend from the costal borders of the sternum to meet the dorsal pleurapophyses in arthrodial articulations above the mid-horizontal plane of the bird's body. As is usual, their sternal ends are twisted so that the facets are situated transversely, while the upper extremities are broad and flat, particularly in *Cupidonia* and *Pediœcetes*.

The first pair are generally in advance of the others, and insert themselves higher up on the costal processes: The pneumatic foramina for these bones are to be found just above their transverse facets anteriorly. The extremities of the hæmapophyses of the sacral ribs meet the posterior borders of the hæmal ribs of the last dorsal pair usually about the junction of their middle and lower thirds of the bodies of these bones.

The distal or upper extremities of these, the last pair of hæmapophyses, are sometimes very much expanded, and in a specimen of *Centrocercus*, ♀, a small bit of bone has been superadded, simulating an additional hæmal spine on either side, as if anticipating the descent of another pair of sacral ribs to protect this otherwise feebly guarded region of its owner's anatomy.

The short pair of xiphoidal processes overlap the ultimate sternal ribs of all the Grouse and Quails, on either side, as do the ilia the sacral pleurapophyses above.

The *Sternum*, in the North American *Tertraonidæ*, is developed from *five* points of ossification, and to these it seems to have added, later in life, or before the bone becomes one entire piece, an ossific centre at the extremity of each of the four lateral xiphoidal prolongations from which their subsequently dilated ends are produced. These later are easily to be demonstrated in the hæmal spine of *Centrocercus*, in the "bird of the year" (Plate VI, Figs. 53 and 56).

Fig. 53 represents the young of this last-named Grouse a day or so old, at which time all five of the primoidal points of development are eminently distinct. The "body" of the bone is nearly circular. The "keel," of which only the anterior part has as yet ossified, dips well down between the tender pectorals; the manubrium, now only in cartilage, has at this date no evidence of the foramen that later joins the coracoidal grooves. As to the rest, bands of delicate membranous tissue bind them loosely together. The sternum in a bird of several months' growth is shown in Fig. 56. Here the bone is rapidly assuming the shape it is destined to retain during life. The body and with it the keel is extending by generous deposition of bone tissue at its margins, principally at the mid-xiphoidal prolongation. The manubrium, still in cartilage, we find pierced at its base by the foramen just alluded to, and a rim of the same material runs about the anterior border of the *lophosteon*, Fig. 56, 4, while a rapidly diminishing band also connects the elements known at this stage as the *pleurosteon*, *ib.*, 6, and the *metosteon*, *ib.*, 5. In cases where severe maceration is resorted to with this bone, in still older specimens, in which the sutures are not suspected, these parts will still separate about the original points of ultimate union.

On the reverse side of the bone shown in Fig. 56 we find that even at this stage it is deeply perforated by the pneumatic foramen at a point immediately over the carinal ridge.

In the adult the sternum is highly pneumatic, air having access to it through such apertures not only at this point but also in the costal borders between the sternal ribs, and by a single foramen in the groove, posterior to the manubrial process mesiad.

In Plate VI, Figs. 52, 54, and 55 are all parts of the skeleton of the same bird—an old adult Sage Cock, *Centrocercus*—of which Fig. 54 is a view from below of the sternum.

It will be seen that it has a length of 14 centimetres, and other measurements can be easily obtained from it. We have never seen this bone any larger, and, as it is, it represents the maximum size the hæmal spine attains among North American Grouse. The bone is shown in other plates also, and their owners can be ascertained if the reader will kindly refer to the description given opposite each plate.

The unique outline of the sternum of the *Gallinæ* has long been known, many authors having both figured and described it, and we will say here that in the *Tetraonidæ* of our country no marked deviations are to be noted from the more common type.

Anteriorly the manubrium juts out as a quadrate process with rounded angles; its inferior margin is continuous with a line that runs down between the slightly prominent carinal ridges, to become continuous below with the anterior carinal margin.

Above, the general surface of the sternal body extends over it. A subcircular foramen, connecting the coracoidal grooves, pierces it at its base. The coracoidal furrow, thus becoming one groove, is biconvex, being depressed mesiad behind the manubrium, in which depression another pneumatic foramen usually occurs. Their upper and lower margins are produced slightly outwards, the inferior being the sharper of the two.

The "costal processes" are exceedingly prominent, being bent over anteriorly at their apices, which are rounded. Behind them are observed the limited "costal borders," exhibiting the four transverse facets for the sternal ribs, and pneumatic foramina. The "carina" or keel affords the greatest amount of osseous surface of the entire bone, greatly exceeding the body. Its lower margin is a long convex curve outwards, and the "carinal angle" protrudes forwards nearly as far as the manubrium, causing the anterior margin of the keel to be decidedly concave.

The "carinal ridge" is thickened and heavy superiorly, where it limits or rather constitutes the boundary of the bone in that direction. Below it spreads out and is gradually lost, *within* the boundary of the carinal border proper.

"Subcostal" and "pectoral ridges" are nearly always well defined.

The *superior* and *inferior* xiphoidal processes are very characteristic of the *Tetraonidæ*. They terminate by dilated extremities of nearly similar shapes, *Cupidonia* being an exception; the ends of the apophyses of the superior pair in this bird being rounded posteriorly (Plate XI, Fig. 82; see Plate XIII, Fig. 91, *Lagopus*, for the common pattern.) These processes arise from a common stem, and their shafts are flat internally, with a raised ridge extending the entire length externally. The "body" of the sternum is, as a rule, very narrow, and notably concave anteriorly, becoming nearly flat behind, where it is produced beyond the keel for a greater or less distance.

The manner in which this part terminates varies in the different Grouse.

In *Centrocercus* it is nearly square across; in *Lagopus* roundly notched in the middle line, as it is in *Bonasa;* in *Tetrao canadensis* it is broadly cordate; while in *Canace obscura*, *Cupidonia*, and *Pediœcetes* it is distinctly cuneiform. The body is very narrow in *Bonasa*, approaching the *Ortyginæ*, where it seems really to be nothing more than a good ribbon-like finish to the *superior* border of the keel. In these birds, too, we are struck with the double carinal margins anteriorly formed by the projecting ridges, and the long spicula-form costal processes that extend nearly half-way up the shafts of the coracoids.

So much do the sterna of the Grouse resemble one another in species of average size that it would puzzle one not a little to tell them apart if they were separated from the skeleton, and we were not allowed to examine them in connection with other diagnostic features of the osseous parts of the species to which they might belong.

In the *Ortyginæ* dilatations at the outer extremities of the xiphoidal prolongations are sometimes but moderately developed, as in our specimen of *Cyrtonyx massena*, and the Plumed Partridge. The dilatations of the anterior or shorter pair of these processes are very broad in *Meleagris*, as are the stems that support them; the expanded part may have a foramen in it, or it may become bifurcated and the same specimen may show both varieties of termination. The longer or posterior pair in this species become very narrow behind, but stouter, and scarcely support any terminal expansions at all. The anterior half of the keel of the sternum of the Wild Turkey is very thick and strong, and all its anterior parts are prolonged upwards and forwards, being massive and lofty in very old birds. In other respects the sternum is stamped with the leading features of the bone as found among gallinaceous fowls generally, and this remark applies also to the sterna of *Pavo cristatus* and *Numida*.

Cupidonia and *Pediœcetes* are particularly alike, but the former could be recognized by its superior xiphoidal processes, *Bonasa* by the narrow body, *Centrocercus* by its size in the larger specimens, and so on.

We will still continue to consider such of the vertebral column as is confluent in the old bird, or rather such vertebræ as become confluent and are more or less embraced by the ossa innominata, as the sacrum, and composed of sacral vertebræ, attempting to make no such divisions as Professor Huxley did, in his Anatomy of Vertebrated Animals, of this compound bone, though we must believe that this author is eminently correct in the view that he takes of this bone.

There are sixteen of these segments that are to be so reckoned in *Centrocercus*, but it is only in the "bird of the year" that they can be counted with anything like accuracy, and even then great care must be exercised, and various pelves examined and compared with the younger birds at different stages and ages.

The first sacral vertebra possesses free pleurapophyses, whose hæmapophyses do not reach the costal borders of the sternum, but articulate in a manner to be described further on. Regarding the pelvis from below in *Centrocercus*, we note that the anterior four sacral vertebræ have their combined par- and diapophysial processes thrown out as braces against the expanded anterior iliac wings. After this the ilia change their form to accommodate themselves to the basin of the pelvis, which they assist in inclosing, and with this change the succeeding vertebræ have their diapophyses much elevated to meet the internal iliac margins.

This section consumes four additional vertebræ, the centra of which go to make up the latter moiety of the cavity for the "ventricular dilatation" of the myelon, and they show the double foramina on either side, one above another, for the separate exit of the motor and sensory roots of the sacral plexus.

A double row, *i. e.*, one on either side of subcircular vacuities, exists here also among the transverse processes (Plate XIII, Fig. 90, *Canace canadensis*, ♂). It is through this portion of the sacrum that we observe in the chick the greatest amount of tardiness in sealing up of the neural tube above by the superior union of the engaged neurapophyses.

The remaining eight vertebræ become much compressed with expanded processes that rarely allow apertures to remain among them, forming an excellent mid-section to the broad and capacious pelvic cavity, with nearly all signs of its original formation obliterated on the outer and superior aspect.

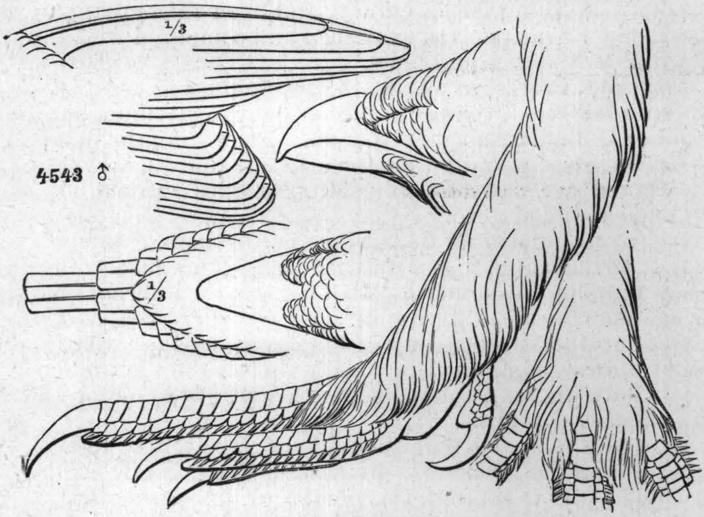
The neural canal is distinctly circular as it enters the sacrum anteriorly, becoming only slightly flattened as it nears the coccyx. Above we find the neural spine confluent with the ilia anteriorly along its summit, and some additional bone deposited posteriorly in the way of their lateral plates, to bridge over the ample "ilio-neural" canals. Opposite the "gluteal ridges" the bones are yet firmly knit, but for the remaining part of the sacro-iliac suture the interested bones can be said only to snugly meet each other. *Cupidonia* alone has quite an interspace present (Plate XII, Figs. 83 and 84).

The sacral wedge is quite thoroughly permeated by air, which enters through foramina in the vertebræ in localities similarly situated to those described in speaking of the anterior part of the column.

In *Centrocercus* sometimes the first sacral vertebra bears a well-developed hypapophysis, and there may even be some evidence of this process on the second segment. The expanded extremities of these median processes are connected along their inferior margins by a delicate ligament of a firmer consistence than that membrane, which fills in the vacuities between the processes to which it is a limiting border.

Now, it depends how far this ligament is conducted backwards as to how many of the anterior sacral vertebræ bear hypapophyses, as from its attachment to the hypapophysis (we have never seen it commence on the cervicals, though the directions assumed by their processes bear it out) of the first dorsal it completes a long shallow arc of an ellipse, in which the lower margins of the hypapophyses are found and assist to complete. This semi-osseous, semi-membranous, attenuated median plate dips down into the thoracic cavity in the living bird for some little distance, as an interpneumonic septum.

The number of free caudal vertebræ in the adult Sage Cock is five,



Pediœcetes phasianellus.

and to these is to be added the *pygostyle*. They all have pretty much the same general appearance, differing principally in the length of their outstanding transverse processes. In this respect the first and second are about equal; in the third and fourth two or three millimetres are added on either side, with a roughened tuberosity above; while the fifth and last is in appearance and size very much like the first. These diapophyses are rounded at their extremities, and all slightly deflected. The centra are transversely elliptical and of good size. The neurapophyses arise from them to inclose a subcircular neural canal, which is roofed over by the bifid and clubbed terminations of the elements, that hook or lean forward (Plate IX, Fig. 66; Plate XIII, Fig. 91). We have never observed an hypapophsis upon any of them; and all the elements and processes, as always occurs in the cocygeal series, are more or less imperfectly developed.

The *pygostyle* is an acute subcompressed triangle with tuberous base. Anteriorly and above it exhibts a bifurcated process that simulates the crests of the series; below this a shallow facet, for articulation with the last caudal, and a feeble subconical depression to protect the termination of the myelon between the two. Behind it has, at its lower angle, a deep groove, with a heavy bony rim or margin that shows a constriction near its middle (Plate IX, Fig. 65). This formation is easily explained when we come to examine the development of this compound appendage in the chick of a day or so old. This will reveal the fact that the pygostyle is composed of *three* vertebræ, which are fused together, distorted and modified as the bird grows, so as to eventually result in the bone we have before us.

We will now offer a few remarks upon the vertebral column, as applied to others of the *North American Tetraonidæ.*

Of all the specimens examined, representing all the genera, the number of distinctly free vertebræ between the skull and the anchylosed dorsals has been found to be invariably fifteen, the last one supporting movably-articulated pleurapophyses, that in *Lagopus*, at least, possess small epi-pleural appendages. This portion of the spinal column, then, will constitute the cervical division, and in it we note that the third and fourth segments have interzygopophysial bars present, becoming so broad in the quails that the foramina they give rise to are sometimes very minute.

The pleurapophyses become long and sharp in some and more conspicuous than in others; this applies particularly to *Cupidonia* and *Pediœcetes.* The last cervical in the former has osseous spiculæ leading backwards from its neural spine and postzygapophyses, as in the anterior dorsals. In the same vertebræ the hypapophyses become confluent to form one broad process placed traversely with a mesial keel in front as the only indication of its original device.

The normal number of cervical vertebræ in any of the species of Wild Turkey of this country is likewise fifteen, and this number holds good also, in the Guinea Hen and the Peacock.

The carotid canal seems to commence and terminate in the same vertebræ both in *Tetraonidæ* and *Ortyginæ.*

Of the eminently characteristic dorsal bone little has to be said in addition to what has already been noted above. The number of vertebræ included in the anchylosis is never more nor less than four, and the first vertebral ribs have no hæmapophyses; so they never connect with the sternum, though they invariably bear uncinate processes, and in many species contribute a good share toward the stability of the thoracic parietes. The metapophysial processes vary principally in their extent: in *Bonasa*, *Cupidonia*, and *Pediœcetes.* In several specimens they nearly cover the tops of the diapophysial arms. In *Lagopus* a narrow bar defines them, connecting the extremities of the transverse processes with comparatively few offshoots. In *Canace canadensis* the bone is very long and delicate. In *C. obscura* it has the same general appearance as in *Centrocercus.* The hypapophyses develop after the common type, but often irregularly; they are found to be missing on the ultimate segment or rather the pelvic end of the bone in the Quails.

The free and last dorsal may or may not have a hypapophysis; we believe it never does in the *Ortyginæ.* It is overlapped by the ilia in *Cupidonia* and the Sharp-tailed Grouse. We find this to be a very marked feature in the last, and well marked among some of these birds sent me by Capt. James C. Merrill, Medical Department United States Army, from Fort Custer, Mont., at a time they were particularly acceptable, and when this erratic fowl became suddenly and unusually rare in many localities, so that the gift was reckoned at the time as more than valuable desiderata. As far as the sacral vertebræ are concerned, the same general plan seems to be carried out: sixteen seems to be the allotted number among the Grouse and, as a rule, among the Partridges. In these birds the sacrum, *i. e.*, the anchylosed sacral vertebræ, is much narrower, as is the entire pelvis, and much fewer perforations are to be seen among the dilated processes that go to meet the ossa innominata.

In *Cupidonia* and *Pediœcetes* the sacrum is very broad, conforming to a pelvis in these birds that will be described further on. We find in a specimen of *Canace canadensis*, for which we are greatly indebted to Mr. Manly Hardy, of Brewer, Me., where the sacro-iliac anchylosis is so perfect, and original land-marks so obscure, that one might easily imagine the pelvis in this individual as being developed from a very much fewer number of ossific centres. The caudal vertebræ number five in all the Grouse except *Cupidonia* and *Pediœcetes*, these birds each having distinctly six apiece. We would especially call the reader's attention to this fact, because when we come to discuss the pelves of these two birds, and recapitulate general skeletal data, it will be found that, as far as osteological similarities are concerned, they come *very* near to each other. The coccygeal vertebræ, otherwise, in common with the pygostyle, show very few differences worthy of record.[1] In *Ortyx* and *Lophortyx* there are but four caudal vertebræ and the pygostyle is markedly acute and long. Occasionally the last segment is but feebly developed, as in *Lagopus*, where it may be a mere nodule; and in *Bonasa*, too, sometimes a sixth vertebra can be be found, but usually requires force to detach it from the pygostyle, and in our specimens seems to be one of those that originally formed that bone—though we do not deny in the face of such evidence that specimens of the Ruffed Grouse may be found that possess six of these vertebræ.

Of the Scapular Arch and the pectoral limb.—This arch, with its concomitant, could have, with all propriety, been described in connection with its vertebra, but so distinct has it become, and so far removed in order to assist in carrying out such a notorious function as the bird's flight, that the author prefers to follow the general ruling of others by discussing it separately. Nothing could be more entertaining in the whole range of osteological research and study than the contemplation of the various avian shoulder girdles, with their attached wing bones, particularly the former, as exemplifying the law of equilibrium between a bird's habits, the never-varying part it is to play in nature, and its skeleton or the framework that has been given it to carry that part out. This thought invariably enforces itself upon me in every instance after an examination of a collection of clavicles of different species of birds. It seems that there could not be an equipoise established anywhere in living nature more thoroughly compensatory than that 'twixt a bird's power and mode of flight, and its scapular arch and other bones about the chest—to meet it, more essentially the clavicles. See the broad, excessively pneumatic, yet robust, clavicular arch in any of the genus *Cathartes*, birds that sail aloft for hours apparently without fatigue, or the very similarly shaped arch in the Canada Goose, but in the latter for a very opposite style of sustained flight is non-pneumatic; the feeble and often ununited arch in *Speotyto*, a bird with scarcely any pretensions to being a good flyer at all; in short one would, having a thorough knowledge of a bird's habits, be, in the vast majority of instances, able to guess very near as to the pattern of the furculum he would expect to find.

Now we have seen, in reviewing the skeletons of the Grouse, that in many points some of the species, if we disregard size, similate each other very closely, as for instance in the various sterna and vertebræ. The clavicles of these birds form no exception to this rule, as far as

[1] The number of caudal vertebræ present or absent in any species must not be overrated as a character, as the segments are liable to vary. I once heard it said that the number of true caudal vertebræ, including those that went to form the pygostyle, ought to equal the number of pairs of feathers in the bird's tail, judging from the arrangement as found in *Archeopteryx*.

general appearance goes. The common model is seen in Plate XII, Fig. 87, *Cupidonia*; but observe even here in these closely-related fowls how habit still tells upon skeletal characteristics. The broad, and not deep, pneumatic **U**-arch of *Cathartes* becomes the long non-pneumatic, almost acute, **V**-arch of the birds we are describing; so, in view of being familiar with the habits of the Sharp-tailed Grouse and Sage Cock, need one be surprised to find in the fourchette of the first a depth of 4 centimeters (omitting the inferior clavicular expansion), with an interspace of 2.5 centimeters separating the superior articulating extremities, as compared with the bone in the second, where the depth is 6.2 centimeters, and the interspace above only 1.7 centimetres.

The bones of this arch are easily taken apart by maceration, and as has already been hinted they resemble each other very closely among the genera. The posterior angle between *scapula* and *coracoid* averages for the species about 60°, and among the Grouse the distal end of the shoulder-blade is usually found to overhang the fourth dorsal pleurapophysis on either side; but in the California Quail these bones actually extend so far back as to overshadow the ilia for nearly a centimetre, they being proportionately narrow for their unusual length. This bone with the Grouse is only semi-pneumatic, its pneumaticity being confined to its coracoidal extremity, where the foramen is found in its usual site.

The blade is thin behind, becoming stouter as it nears the glenoid cavity, sharp along its inner border, rounded without, clubbed at its pelvic end, and turned gently outwards along its entire length. Anteriorly it contributes about one-third of the surface for the humeral joint, the coracoid the remaining two-thirds, while the acromial process within reaches forward barely to touch the clavicle, forming, as it does so, the usual interscapulo-coracoidal canal

These bones are narrow in *Bonasa* and in *C. canadensis*, more curved in *Lagopus*, and very stout in *Centrocercus*, a good medium being seen in the Pinnated Grouse (Plate XII, Fig. 85).

In *Meleagris*, they have their distal extremities cut square across, and reach back slightly beyond the pelvis. These bones in this species are also very stout and strong, and present the interesting variation in having a long pneumatic foramen on the superior aspect of each just beyond their glenoidal ends; this feature is not present in *Pavo*. They are exceedingly narrow and long in the Massena Partridge.

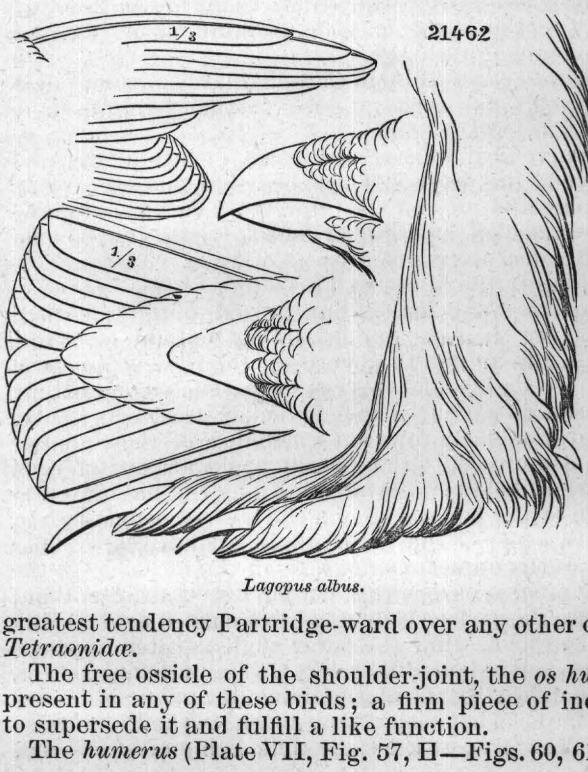
The *Coracoids* are quite stout bones, but devoid of any marked peculiarities; after leaving their sternal beds they extend upwards, forwards, and outwards, the furculum governing their distance apart at their upper ends. The glenoidal procss is extensive, and rises nearly as high as the head of the bone; the clavicular process is faintly bifurcated, and curls over slightly towards the fellow of the opposite side. The shafts are compressed from before backwards, and soon dilate into broad expansions below; anteriorly one longitudinal muscular ridge marks the surface of the bone, while on the sternal aspect two or three very distinct ones occur. The inner angle of the dilated base nearly meets its fellow of the opposite side through the foramen, at the root of the manubrial process; from this corner outwards, for about two-thirds of the distance the surface is devoted to a curved articulating facet for the coracoidal groove, while the outer angle is tilted upwards and finished off by a distinctive little tubercle. On its posterior aspect, about the middle of the dilated part, a large, irregular pneumatic foramen is found in all the Grouse, but seems to be absent in the Partridges. They are very large in *Meleagris*, at the same time being elliptical and so open as to give a pretty fair view of the interior of the bone in some cases.

The position of the united clavicles, or the free acromial extensions of the scapulæ, is shown for *Lagopus* in my drawing in Fig. 91. Something has been said about this bone already; we will add, however, that the superior ends always terminate by rather tuberous enlargements, smooth internally, but even as applied to the clavicular processes of the coracoids. The shafts are gently curved, of even calibre, and fall nearly directly downwards in some species, to be slightly expanded beneath in order to give better support for the large median dilatation below; this is triangular in outline, thickened in front, sharpened behind. In *Ortyx* this process is sometimes produced backwards, so as to nearly touch the sternum; this feature obtains, also, among some of the other Quails.

The furculum of *Meleagris* is very different from that bone, as just described in general terms for the Grouse. It is V-shaped, to be sure, but for the size of the bird is extremely slender, the medium plate is smaller than we find it in many of the Quails; the superior halves of the limbs are dilated and exhibit excavations on their inner aspects, at the bases of which we find irregular groups of pneumatic foramen; these limbs terminated above in truncate and thickened ends for articulation with the remaining bones of the shoulder girdle.

The furcula of *Pavo* and *Numida* are much more like the general type of the bone as found in the *Tetraonidæ* than the same bone in the Wild Turkey is.

The bones of the shoulder girdle are all well advanced in ossification in the young chick, but do not develop their distinctive markings until a bird is pretty well along in age; this applies more particularly to muscular lines on the shafts, the base of the coracoids, and the clubbed extremities of the scapulæ. In *Bonasa*, where we noticed how the body of the sternum was narrow like the Quails, we find also the median process of the united clavicles produced backwards towards that bone. This Grouse's skeleton, in fact, seems to have the greatest tendency Partridge-ward over any other of the North American *Tetraonidæ*.



Lagopus albus.

The free ossicle of the shoulder-joint, the *os humero scapulare*, is not present in any of these birds; a firm piece of inelastic cartilage seems to supersede it and fulfill a like function.

The *humerus* (Plate VII, Fig. 57, H—Figs. 60, 61; also Plate X, Figs.

76, 77 *of Cupidonia*) of *Centrocercus* is so exceedingly regular that it could be well chosen as the type of that bone in all birds in which it is pneumatic. It is due proportion for the size of the bird to which it belongs, possessing the usual sigmoidal curves from lateral and superior aspects (we describe the bone *in situ* in the closed wing) in graceful, though not decided prominence. The head or proximal extremity, slightly bent anconad, displays the most usual points for examination about it; an extensive convex, smooth surface is seen for the glenoidal cavity, below it a deep notch, then the well-defined "ulnar crest" or lesser tuberosity curling over a large sub-elliptical pneumatic foramen, that is so patulous that the osseous trabeculæ and net-work are plainly seen at its base. The radial crest encroaches but very little upon the shaft, is quite stout, and only at its summit shows any disposition to curve over palmad.

The shaft is smooth, elliptical on section throughout its extent, and almost entirely devoid of any muscular markings or lines; it swells gently in the vertical plane as it approaches the distal end of the bone, upon which is placed the ordinary tubercles for articulation with radius and ulna. The inferior condyle, the internal of human anatomy, is the better developed of the two, and the ulnar tubercle is produced a little beyond the bone distally, while the oblique tubercle is brought down on the shaft. The olecranon fossa is rather shallow in the Grouse, being decidedly better shown among the Quails. There are no prominent points of difference in this bone among the *Tetraonidæ*, except in regard to size; *Cupidonia*, which has rather a heavy skeleton any way, the humerus is moderately robust in accordance.

In the *Ortygince* the same characteristics are to be seen; but we discover in addition at the proximal extremity of the bone, on its anconal aspect between the greater and lesser tuberosities, a deep fossa that has a great resemblance to the pneumatic orifice externally, and of about the same dimensions, being only separated from that depression by a thin bony wall; it seems to be designed simply for muscular insertion, and has no communication with the general cavity of the hollow humeral shaft.

The *radius* and *ulna* are also singularly typical in their avian characteristics, as might have been looked for after our remarks upon the bone of the brachium; their principal difference lies in their being non-pneumatic, although they are hollow like all long bones.

In the right arm of *Lagopus leucurus*, which we have before us, carefully dried, in its position of rest, with all the ligaments still attached, *in situ*, we find the *radius* to be unusually straight, in fact almost in line between the oblique tubercle of the humerus and the bone it meets in the carpus. Its shaft is nearly cylindrical, and shows a muscular line, upon an otherwise smooth surface, that travels along its proximal two-thirds beneath. Distally it overlaps the cubit by a transversely dilated extremity to articulate with its carpal bone. The head of the *ulna* is large, and betrays the fact that it belongs to a bird of considerable power of flight; the olecranon process is a blunt, tuberous apophysis, slightly bent anconad; the greater and lesser sigmoidal cavities are distinct and fairly marked, particularly the former.

The shaft of the bone is more than twice the bulk of that of its companion, decidedly convex outwards, the curve being greatest at the junction of the proximal and middle thirds; it is elliptical on section, the major axis of the ellipse being vertical. The muscular lines of the ulna are but faintly developed, as are the row of minute tubercles for the bases of the quills of the secondaries.

Anteriorly the bone displays its usual trochlea head for its own carpal segment; this surface is bounded palmad by a sharp and even curve, convex distally, while the inner articulating surface beneath the expanded end of the radius is uneven and applied to the concavities and convexities of the free pair of carpal elements.

These bones among the Partridges and other Grouse, except in size, present to us no extraordinary departures from the description just given of *Lagopus*. This remark applies also to the Wild Turkey, but the wing-bones in this bird seem to be shorter in comparison with its general size.

We do not believe there is a bird in our country that can offer us better facilities for the study of the bones of the carpus than the young of *Centrocercus urophasianus*. Anchylosis of the various segments involved is exceedingly tardy, and it is not at all necessary for the student of this joint, that has puzzled so many comparative anatomists and ornithotomists, to seek the primoidal ossicles in the very young chick, unless he desires to ascertain the points as regards priority of ossification of the carpal bones, a question we will evade here entirely, for these bones are quite distinct and easily detached in the bird at six weeks or more of age, such as we offer our reader in the plates.

In the adult Sage Cock, the carpus has the appearance of this joint, as it is seen in nearly all of the class where there are two free carpal bones, and the os magnum confluent with the proximal extremity of the metacarpus, and the mode of articulation is the same. This we know to be, first, a free, six-sided, uneven bone, the *scaphoid*, articulating chiefly with the distal extremity of the radius and the metacarpus. This is the *scapho-lunar* of my former papers, and we retain the same name for it here; it is also the *radiale* of Prof. Edward S. Morse, who has made such positive advances in the elucidation of the tarsus and carpus in birds.

The second bone is the *cuneiform*, larger than the first, and engaged principally by the cubit, but having also a process and an articulating surface for the confluent carpal and metacarpals; this is the *ulnare* of Morse.

These are the two carpals that remain free during life.

We will now devote ourselves to the joint as observed in the bird at six weeks of age. We have no trouble in finding *scapho-lunar* and *cuneiform* whatever. At the summit of the second metacarpal there is found a concavo-convex segment, that is universally taken to be the *os magnum*, termed also *carpale* by Morse (Plate VII, Fig. 59, *om*). It articulates anteriorly with the upper end of the index metacarpal, covers the entire proximal extremity of the second, and nearly or quite meets another bone behind that is grasped by *cuneiform;* this is the *unciform* (Plate VII, Figs. 57 and 59, *z*). It has the appearance of being a detached and bulbous extension of the third metacarpal, and is about the size and shape of an ordinary grain of rice, having a shallow concavity on its anconal aspect.

There is yet one perfectly free and distinct bone to be observed; it is found on the inner aspect, very near the extremity of second metacarpal, just below *os magnum;* it nearly meets *unciform*, and articulates with the process of *cuneiform* behind. This little segment is flat and very nearly circular, being applied by one of its surfaces against the shaft of the metacarpal, and held in position by ligaments. This segment we do not find described by any author known to us, and here call it the *pentosteon*.[1] The manner in which it eventually joins the metacarpus and

[1] This little bone of the carpus, which I still believe was originally described by myself, was called in the first edition of this Monograph the *pisiform*. This name might lead the student into the belief that I considered it either the analogue or even

the conformation it gives to that bone in the adult are shown in Plate VII, Fig. 58, and it is marked 8 in Fig. 59 of the young Sage Cock. The metacarpal for the index digit is likewise detached, although even at this early date it begins to assume a likeness to the bone as found in the adult.

Medius and annularis metacarpals are also distinctly free, and their size and position faithfully portrayed in the figure alluded to above. The prominent process on the rear and upper third of the shaft of medius of the adult is now found only in cartilage in the younger individual. The rest of the bony part of the pinion is familiar to all of us; it consists, in the adult "Cock of the Plains," as in all Grouse and the *Ortygincæ*, of a trihedral phalanx for the first metacarpal, constituting the index. We have found this phalanx in *Meleagris* and *Ortyx* bearing a well developed claw, covered with horn as in the ungual phalanges of of the feet; this is also the case in *Numida* and *Pavo*, and there is hardly a doubt but that this is the case with all of the American *Gallinæ*, and in this respect they agree with this class of birds of the Old World. Two more phalanges are devoted to the medius metacarpal, the superior joint or phalanx having the usual expanded blade, with the long free and pointed finger-bone below; and finally the smallest phalanx of all, freely attached to the distal end of the third metacarpal or annularis.

These bones are non-pneumatic, as are all the bones beyond the brachium in the *Tetraonidæ*.

Of the Pelvis and the Pelvic Limb.—After what we have said and seen in regard to the dilatory manner in which originally primitive elements in these birds anchylose, and only after the lapse of weeks condescend to amalgamate and form the confluent bones and cavities that occur in the major division of the Class, we must not be surprised to find the same routine and a like tardiness exhibited in the pelvic hæmal arch, or the pelvis, and its appendage the lower extremity.

A glance at the figures illustrating the condition of the bones in question, of birds from one to two months old, will convince us at once that the rule still obtains; in them we find the sutures among the ossa innominata still ununited, and the three bones of either side of the pelvis independent, and easily detached from each other about the cotyloid ring.

In the young chick of *Centrocercus* (Plate VIII, Fig. 62), the ilium is a scale-like bone that rests against the sacral vertebræ. The preacetabular portion is excessively thin and delicate, and at this period constitutes the longest and widest part of the bone; its border mesiad bears no vertebral impressions, but is sharp and brittle; the outer margin is slightly rounded; this condition increasing as we near the diminutive acetabulum, where it is the stoutest. The distal margin, imperceptibly continuous with the inner, presents a convex curve anteriorly; the included surface viewed from above has a general concave aspect, especially near its central portion. As we proceed backwards, however, it gradually becomes convex, to rise over the region opposite the cotyloid ring to form the general convex surface of the post-acetabular portion.

The distal margin of the bone is nearly square across, and does not extend as far back as the ischium, the two being bound together at this age by cartilage, which has been removed in the plate. The outer and exterior margin of this division of the bone is rounded and fashioned

the homologue of the *pisiform* as found in the Mammalia; such at present being by no means the case, and all things considered, I have taken the liberty to change its name to the *pentosteon*, it being the fifth bonelet in the avian wrist. The same argument might be urged against the unciform, but I had nothing to do with the christening of that bone.

to the cotyle, the anterior half of which it eventually forms. From this point it arches backwards over the future ischiatic foramen. The inner margin of the post-acetabular portion is rather more rounded than its anterior extension, and directly opposite the "ring" presents for examination the depressions of the tranverse processes of the ninth and tenth sacral vertebræ in elongated and concave facettes. The ninth vertebra seems to be the first to come in contact with the ilia, and the pelvis is so inclined that the remaining vertebræ soon, by their outgrowing apophyses, come in contact with it, ultimately fusing to develop the compound bone, usually termed sacrum. A good idea may be gained of the form of the ischium and os pubis by an inspection of Fig. 62, Plate VIII, at this stage of the bird's existence. For very obvious reasons the stoutest part of the ischiatic element surrounds the acetabulum; an inferior process, extending towards a similar one directed backwards by the ilium, grasps the head of the os pubis between them. From this point the ischium sends backwards a triangular thin plate, rounded behind, that is intermediate in length between ilium and pubis. This latter is satisfied to follow suit and direction by contributing a simple and diminutive spine. This crosses soon after the pubis has given its share to the cotylis, the obduratic notch of the ischium, converting it, as the bones fuse, into the obdurator foramen.

We give an additional figure in the Plate, Fig. 63, that exhibits the further advances of these elements towards maturity. The bird is now nearly two months old, and it will be seen that one after another the vertebræ impinge upon the iliac margins within. The ilia and ischia extend behind, including vertebra after vertebra, from a series that at this age might be easily taken for an extraordinary number of coccygeal segments. The head of the pubis at this time is entirely out of proportion with its rib-like extension, it having so spread and insinuated itself into the formation of the cotyloid ring as to form about one-fifth of its circumference. At this stage, too, the necessary cartilage begins to be thrown out to form the future anti-trochanter on the ilium.

So much for pelvic development; now let us examine this bony basin as it is seen in the full-grown representatives of the genera.

The manner in which the confluent sacral vertebræ meet the ossa innominata forming the ilio-neural canals and sacral sutures has already been defined above, so that here nothing more need be said of the mid-section of the pelvis taken as a whole. We give among the plates figures of the pelves of *Centrocercus*, *Canace canadensis*, *Lagopus*, and *Cupidonia* from the skeletons of the adult birds, and if the reader will compare the lateral views given of the Ptarmigan and the Sage Cock he will see how few the differences are that exist between the two birds, and the same may be said, we assure you, for its superior and inferior views; in fact in the case of *Logapus* it may be stated that its pelvis *in most instances* is the perfect miniature of this bone found in *Centrocercus* in all respects. This applies, also, though not quite as strictly, to *Canace* and *Bonasa*. Of course certain minor differences are easily to be picked out, such as a greater fullness there, as slightly deeper depression here, and so on; still our plate of *Tetrao canadensis* represents the general pattern of the pelvis among all the North American Grouse, save *Pediœcetes* and *Cupidonia*. In the superior aspect of this confluent bone in a fine specimen of *Canace obscura*, we find the pre-acetabular portions of the ilia very much depressed below the general surface of the bone, and quite concave. The convex anterior borders are embellished with a flattened rim that bounds them, often produced forwards as two median sharp-pointed processes. The post-acetabular surface is raised, and including the sacrum forms a gently convex surface; the "gluteal ridges" dividing these two regions commence with the anterior iliac borders and are conveyed clear round to form the posterior ones of the same bones, describing two great Ss, the lower and outer curves of which pass by the acetabular projections, points where in some birds they terminate.

Among the principal features to be noted in a lateral view is that the shaft of the pubis is in nearly all instances free from the ischium after quitting the cotylis and forming the elliptical obdurator foramen. If it anchyloses with this bone at all it usually occurs just behind that orifice.

The ischium overlaps the pubis at two points—one quite broadly near its middle, and, again, by a process at its outer and inferior angle.

The "ischiatic foramen" is the largest vacuity of the group of three that here present themselves; its boundary is sub-elliptical, with its major axis depressed posteriorly if it were produced.

Both the internal and external margins of the cotyloid cavity, or ring rather, are circular, the former of which is not a little smaller, thus affording a very good and quite extensive surface for the head of the femur; the anti-trochanterian process or facet directed backwards is likewise ample, so that the femora are well supplied with articulating surfaces.

There seems to be among the Grouse a predisposition for the ilia to overhang the region of the ischiadic foramina; it is most successfully carried out in *Cupidonia*. Viewed from below, we are struck with the amount of room and space these combined bones inclose; the profundity of the pelvic basin. This is very much enhanced by broad reduplicatures of the ilia and ischia behind, and a general though even constriction of a prominent rounded border or rather ridge that extends from the fourth diapophysial abutment of the vertebra against the ilia on either side to the outer angles of the ischia. Within, too, we often find about and at the base of these iliac fossæ apertures for the entrance of air into these bones; such pneumatic foramina are also seen beyond the os pubis and below the cotylis on either aspect.

Ortyx virginiana.

The pubic extremities never meet behind, though in many species they are very long and usually take the curve given them by the ischia just before leaving these bones. Their distal extremities are flattened in *Centrocercus* and generally more expanded than among the other varieties.

The pelvis of *Cupidonia* is so different from the general description we have just given, that the author feels justified in giving his reader two addittonal figures, that present superior and lateral views of the bone in this bird; in comparing it with other figures given one cannot avoid being struck with these marked departures from the common type. There is one other Grouse that affects this style of pelvis, and that is *Pediœcetes*, and the attempt is not a bad one. The principal points wherein the Sharp-tailed Grouse has failed to make a perfect imitation of the unique pelvis of his ideal are, the ilia have failed to produce such ponderous overhanging lateral flaps, that nearly shut out from view the ischiadic foramen on either side. Again, these bones in *Pediœcetes* meet the sacral vertebræ for their entire length internally; and in this bird, too, the pubic elements often unite all along the inferior borders of the ischia. This does not occur in the Pinnated Grouse; otherwise the bones are very similar and marked exceptions to the general pattern of the other members of this subfamily.

After examining a large number of the pelves of our Grouse, and noting their capacious cavities and great width from side to side, one cannot help but be surprised at the complete change in outline, on turning to these bones as they are found among the Partridges.

As a rule in these birds, the pelvis is elongated and unusually narrow, though the drooping ischia behind give it additional depth in its more posterior parts; the pubic bones are turned up behind after they extend beyond the elements above them, and the lateral walls formed by the ilia are, just beyond the acetabula, almost vertical; in fact, one would almost suspect the pelvis of the common Virginia Partridge as belonging to the skeleton of some variety of Curlew, had he not been sure of the owner. This apparent departure from the more general model of this bone in gallinaceous fowls, however, is not nearly so decided in other varieties of the *Ortygincæ*, as for instance in *Lophortyx californica*, and a very good drawing of the pelvis of this bird can be seen and studied, in Mr. T. C. Eyton's Osteologia Avium, London, 1867, Plate 22, figs. 1, 1, 1, 1; three of the figures here cited, however, are for the palatine bones, inferior view of sternum, and anterior and posterior views of the tarso-metatarsus. We have carefully compared the diameters of these representations with the skeletons of the species in question, and find them quite accurate.

The pelvis in the Wild Turkey has the general resemblance of this bone as found among the gallinaceous birds at large. The sides of the ilia, in the preacetabular portion are nearly vertical, spreading out only anteriorly into the horizontal plane. We are struck with the unusual size of the ilio-neural canals. These passages are over three centimeters long, having a complete bony septum dividing them, composed as usual of the neural spine of the leading sacral vertebræ. The major part of the common roof above is formed by the meeting of the ilia. The postacetabular region is quadrilateral in outline, rather extensive and very flat. In this locality the iliac borders meet the vertebræ, but only partially to anchylose with them. The sides of the pelvis are broad and deep, and the pubic bones never join with their lower margins. Just beyond the cotyloid ring, on either side, we find a stumpy spine, very much the same thing as we see in the common fowl. Between the ischiatic and obdurator foramen a deep triangular pit occurs, that usually has a few pneumatic foramina at its base. Five caudal vertebræ are found in the Wild Turkey, and the pygostyle is very long and sharp, being produced backwards. In the Peacock we find the pelvis shorter than in *Meleagris* and generally arched above, as if the bone in this locality had gradually been distorted by the burden of feathers it bears above which pull upon the muscles overlying it. To afford additional support for this beautiful appendage in this fowl, we find the four coccygeal vertebræ very broad and spreading, while the pygostyle is equally extensive, being composed of two horizontal plates connected by a vertical one, lying longitudinally in the middle plane. The pelvis and the caudal vertebræ, including the pygostyle in the Guinea Hen, are very much the same pattern as we find them among the Grouse generally, and both this bird and *Pavo* have the characteristic spine protruding anteriorly beyond the acetabulum on either side.

The *femur* in the young chick of *Centrocercus* is but partially developed; above, the head is almost entirely cartilage, while below the condyles are very indistinct and the bone bears no signs of pneumaticity. In a few weeks, however, these points rapidly exhibit themselves: a rounded trochanterian ridge is thrown out; the head essays to assume its sphericity; the condyles become evident; the fibular groove appearing last of all and about the same time with the vascular foramen or medullary orifice at junction of upper and middle thirds. In our examination of this bone in a fine old cock *Cupidonia*, and comparing it with others, we find that it is remarkably well balanced in point of length and general development.

The trochanterian ridge is prominent and arches over the articular facet for the ilium; the neck is distinct and makes an angle of 45° with the shaft; the head is well formed, spherical, and in all Grouse seems to bear a double depression for the ligamentum teres. Anteriorly below the trochanterian eminence there is an extensive collection of pneumatic foramina. The "trochanter minor" never develops.

The shaft is smooth, bent slightly forwards; displays the usual muscular lines and the medullary orifice; it is nearly cylindrical on section about its middle, and before terminal expansion takes place. Below, the rotular channel is deeply grooved, separating the prominent condyles; of these the external and lower one presents the usual fibular fissure; behind, the popliteal depression is well sunken, one of the muscular lines running into it, and often a foramen is found at its base. Shallow fossæ are found laterally at the outer surfaces of the condylar enlargements, and sometimes a notch where shaft meets the internal one anteriorly. The bone is usually slenderer in *Bonasa*, *Pediœcetes*, and *Canace canadensis*.

Among the *Ortyginæ* the femur has the same general characteristics; it is, however, *non-pneumatic*, the double pit for the ligamentum teres is better marked, and the muscular lines are scarcely perceptible.

Orortyx picta.

The *patella* is never absent in the *Tetraonidæ*, and occupies its usual position as a free bonelet protecting the anterior aspect of the knee-joint. It accommodates itself to the conformation of the rotular channel, having a flattened surface superiorly, a rounded border below, and a double surface behind, the most extensive aspect of which is applied to the side towards the internal condyle.

The proximal extremity of *tibia* in the young chick of *Centrocercus* has advanced so little towards assuming any of the definite characteristics of the full-grown bird, that, almost in self defense, we take up for examination the bone from a skeleton of a bird of the same species several weeks older; here we discover the superior general condylar surface still capped with cartilage, and the borders confining it, as yet, but feebly produced. The most interesting point, by far, is the appearance of an unusually large epiphysis, if it may be so termed, fashioned to and resting upon the future location of the "rotular crest."

Why this bone should be here added we cannot, as far as our knowledge extends, exactly comprehend, for in the old and mature birds of any of the Grouse the epi-cnemial crest is never very prominently produced, nor is it in any of their near kin. As age advances this segment becomes thoroughly confluent with the tibia, and leaves no trace of its early existence.

The head of the bone in the adult Sage Cock is a very substantial affair, with pro- and ecto-cnemial ridges, well produced, that soon merge into the shaft; the latter ridge is usually dilated on its anterior aspect, and the rather extensive concavity between them is directly continuous with the shaft below.

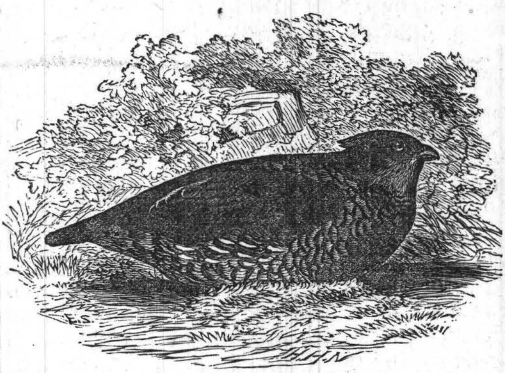
The tibia never becomes pneumatic either in the Grouse or Quails, and in the former, sections of its shaft are universally transversely oval; the fibular ridge of the upper and outer third of this portion of the bone in *Centrocercus* is about 2 centimetres long, and appears to be little more than a raised and roughened line. Below the fibular ridge we find the nutrient foramen, but otherwise the tibial shaft is very straight and almost entirely devoid of any markings, at least to that point anteriorly, where the ascending groove coming from between the condyles impresses it, and that, with an increasing intensity to its termination over the intercondyloid notch; at this point a bony bridge is thrown across obliquely, the outer abutment of which is the lower. (Plate IX, Fig. 69.)

The most engaging points of interest, so far as the tibia is concerned, center about the distal extremity of the bone. After careful examinations of the recently-killed subjects, dried skeletons, and carmine-stained specimens, the following result seemed to be presented with greater or less distinctness in every case, and these results correspond very nearly with Professor Morse's invaluable investigations and studies: In the young of *Centrocercus*, several days after leaving the nest, we observe at the future site of the tibial condyles, encased in the then articular cartilage, on either side, a free reniform ossicle. These ossify to the surface in time, and the outer becomes the *fibulare*, the inner the *tibiale;* both are tarsal bones. It will take time and further research to decide definitely as to which is the os calcis, and which the astragalus. Above the former, and a little towards a mid-shaft position, there is yet another free ossicle; it is the *intermedium* of Morse. That it is another tarsal bone, there can be no doubt, we believe, at this date; but before we decide upon its special homology we must satisfy ourselves by further research and dissection of the young at various stages of development in birds and other vertebrates where this bone constitutes a feature of the skeleton.

It soon fuses with the *tibiale*, and the latter with the *fibulare*, so that the faintest traces are alone discernible in the bird at two months of age. (Plate IX, Fig. 67, E′). At this period the subsequent bony span for tendinous confinement above them has not commenced to ossify.

In the adult the apex of the *intermedium* affords attachment to the oblique ligament that is attached higher up on the inner aspect of the shaft, that also holds some of the extensor tendons in position. The condyles in mature birds have an antero-posterior position at the extremity of the tibia; these are of a uniform outline, and the inter-condyloid notch that separates them is of no particular depth until it arrives on the anterior aspect of the bone. Externally and laterally almost within the limits of the outline of the outer condyle we find two tubercles, one above another; the lower is for ligamentous attachment, the upper is the remnant and only existing evidence of the lower extremity of the fibula. A similar tubercle is found on the opposite, side corresponding to the lower one just described on the outer aspect.

The *fibula* is freely detached and never completely anchyloses with the tibia. Its proximal extremity is clubbed, enlarging very much as it rises above the condylar surface of its companion from the fibular ridge; it is laterally compressed and convex above at the summit. In many Grouse the attenuated remains of its extension below can be traced on the shaft of the tibia, which bone has nearly absorbed this third of its weaker associate.



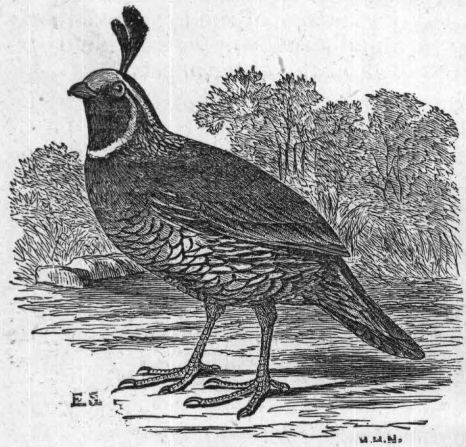
Callipepla squamata.

In the early life of the chick of the Grouse we have been discussing, the combined tarsals are surmounted by a third plate of cartilage, that subsequently ossifies, apparently by one center. The bone thus formed, the *centrale*, we believe undoubtedly to represent either a single tarsal element or the connate bones of the second row.

At this age the metatarsals that combine to form the shaft of the tarso-metatarsus are still easily individualized, though well on the road toward permanent fusion. It will be observed that we still retain the term *tarso-metatarsus*, and we think justly so, as the compound bone of the mature bird has combined with it at least one of the tarsal bones. The tibia could with equal reason be termed the *tibio-tarsus*, and again the compound bone in manus, the *carpo-metacarpus*, but for obvious reasons such innovations are not always advisable.

We discover in *Centrocercus* and *Canace canadensis*—in that strong inelastic cartilage that is found at the back of the tarsal joint in all the Grouse, on the inner side—a concavo-convex free bone, nearly a centimeter long in the Sage Cock, and two or three millimeters wide; this ossicle must be regarded only as a sesamoid, though it is nearly as large as the patella, and in no way as constituting one of the tarsal bones.

It will be remembered that in the first edition of my monographs upon the osteology of *Speotyto* and *Eremophida*, the old term of the "calcaneal" process was retained for that prominent projection found at the superior and hinder end of the bone *tarso-metatarsus*. It having anything to do with the calcaneum or the os calcis in the homologies of the avian tarsus, was stoutly denounced in the first appearance of my monograph upon the osteology of the North American *Tetraonidæ*. In these papers, as well as in my osteology of *Lanius ludovicianus excubitorides*, it was given the name of the *tendinous process*, from the well-known fact that by one means or another it transmitted the flexor tendons at the back of the tarsus. At the present writing we know of no author who has very recently added anything to the literature of this subject, bearing upon this particular point, and the writer was quite confident that all he had said in his Grouse paper could be sustained; for if this process did not separately ossify in the *Tetraonidæ*, and thus weaken its claim as being a homolonge of one of the tarsal bones, why should this not be the case among all birds? A few months ago we made a discovery that again shook our faith in this matter, and led us to believe that perhaps this process was more entitled to the appellation of the *calcaneal* than we had previously supposed. The facts in the case are these, and we must leave our reader to draw his own conclusions. We have before us the tarso-metatarsus taken from the young of two widely-separated genera and families. The first is that of the chick of *Pediœcetes*, one of our present genera; the second is from the young of *Cinclus mexicanus*, the American Water Ousel. In the first we observe all those characteristics that we have already ascribed to this family in general, and elucidated above; but in the tarsal joint of the Dipper, our second example, we find that the *centrale* and the so-called calcaneal process are connately developed; the latter element being of good size already shows the grooves for the flexor tendons. Of the number of points of ossification in this development in *Cinclus* the author can say but little, as his material has been chosen from a few of these birds, furnished by the Smithsonian Institution. The subject is an extremely interesting and important one, and will well repay further investigation and research, and the author only regrets that at this date he can make but such slight additions to what we already know of it through the exertions and examinations of others. In any of our adult Grouse, this process is vertically grooved and perforated for the passage of tendons; from its inner and posterior angle in many of the *Tetraonidæ* it sends down a thin plate of bone that usually meets the shaft at junction of upper and middle thirds, occasionally running further down to become confluent with it in every instance; this feature is rarely present in the Quails. In *Centrocercus* and others the hinder aspect of the tarso-metatarsus is sharply marked by muscular ridges. The superior and articulating surface of this bone displays eminencies and depressions fashioned to accommodate themselves to the condyles of the tibia; a tuberosity on the anterior margin in the articulated skeleton fits into the intercondyloid notch of the bone. Below this the shaft in front is scooped out, having at the base of the depression two small elliptical foramina, side by side, and to the inner side of its boundaries one or two pointed muscular tubercles. The distal and transversely expanded end of the bone presents the foramen for the anterior tibial artery, occupying its usual place, and the three trochlear apophyses for the toes, the middle one being the largest and on the lowest level. The two lateral ones, separated by wide notches from the former, are thrown but a limited distance to the rear, so that the concavity behind them is not peculiar for any great amount of depth.



Lophortyx californica.

The *os metatarsale accessorium* is situated rather high upon the shaft, and bears more than an ordinary semblance to a demi-phalanx, with its distal articular trochlea. As usual it is freely attached by ligaments.

The *internodes* are based upon the more common plan as applied to the avian foot; *i. e.*, in the order of the phalanges, from the first to the fourth, 2, 3, 4, 5 joints. They are in proportionate sizes for their several owners, and possess nothing peculiar about them, having all the usual characters as found in the gallinaceous foot generally.

They possess the usual enlarged and biconcave proximal extremities, with the distal and convex bitrochlear ends, with a more or less subcylindrical shaft; the ungual joints being but moderately curved downwards.

There are but few or no striking differences to be noted as existing among the lower extremities of our *Tetraonidæ*.

The bones are very delicately fashioned in *Canace canadensis* and the Sharp-tailed Grouse; that is, the calibres of their shafts seem to be less as compared with their general lengths, but they belong, we must remember, to very trim little game birds, as contrasted with our heavy and ponderous old Sage Grouse of the western prairies. Our specimens of *Lagopus* and *Canace obscura* do not show the bony extension from the *tendinous process* at the back of the *tarso-metatarsus*, apparently present in all the others and alluded to above—*Centrocercus* sometimes proving an exception—and this bone never normally develops a spur in any of our North American Grouse, as seen in birds of near kin.

Tendons of the anti-brachium and pinion are very prone to ossify, and one is quite constant on the anterior aspect of the metacarpus. This applies with still greater force to the lower limb, where it seems that every tendinous extension of the muscles of thigh and leg become bone for their entire lengths, then forking sometimes over the fore part of tarso-metatarsus as they branch to be distributed to the podium.

It may be found that *Bonasa* can claim normally six segments as representing the caudal vertebræ, and we have in our possession a pelvis of this bird where a rudimentary second sacral rib is evident, but this can only be regarded in the light of an anomaly.

The pelvic limb of the Wild Turkey has nothing about it of peculiar interest, *i. e.*, in the adult fowl, and we have never been so fortunate as to examine the young of this bird. The entire extremity is non-pneumatic, and composed of quite powerful bones. From the lower and outer angles of the tendinous process of the tarso-metatarsus, a thin plate of bone is thrown down that gradually approaches but does not touch the shaft until it arrives opposite its middle, when it merges into it. The lower portion of this lamina bears the short spur in *Pavo*, but of my three specimens of *Meleagris*, no such appendage is seen; they are no doubt all females or perhaps young males before the development of the spur, as we believe old male Turkeys. always possess it.

Interesting osseous malformations are occasionally to be seen, but they are beyond the jurisdiction of this monograph to treat; nor will it be practicable to enter into the engaging subject of the differences between the pelves in the male and female birds, but that such differences do exist there can be no reasonable doubt.

Our Grouse and Quails all belong to the *Alectoromorphæ* of Professor Huxley's classification, sharing in common with the representatives of that group many of their osteological characters; some of these characters, such as the general form of sternum, certain cranial peculiarities and others, are positively distinctive and differ from all other groups. Our *Tetraonidæ*, with the exception of *Pediœcetes*, and *Cupidonia*, have certain similarities or osteological resemblances found among the more prominent bones of the skeleton, as the pelvis, sternum, and scapular apparatus, that bind the remaining genera very closely together. The same may be said in a general way of the Quails, or *Ortygincæ*, taken as a subfamily, have many such characters in common, as compared among themselves.

Cyrtonyx massena.

Cupidonia and *Pediœcetes* although they possess the usual tetraonial osteological characters referred to above, have in addition quite a number of mutual external characters, that compel us to regard these two forms as being of very near kin, and our osteological studies of the sub-family have certainly demonstrated the fact that this relationship is by no means weakened by the latter investigation. In short, although ornithologists will no doubt always retain these two forms in separate genera as the classification of birds goes, still it may be well to bear in mind that nearly or quite all of the anatomical characters of *Cupidonia* and *Pediœcetes* when compared together bring these two Grouse nearer to each other than any other two forms of the group in our fauna; so near, in fact, that but little violence would be perpetrated by restricting them both to one and the same genus, and no doubt there are not a few instances in our present classification of birds where forms not so nearly related as these two Grouse are that have been retained in one genus.

WASHINGTON, D. C., *May* 1, 1882.

PLATE V.

FIG. 47.—Cranium of young *Centrocercus*. three or four days old, viewed from above.

FIG. 48.—The same; lateral view, with lower jaw added, showing articular element detached.

FIG. 49.—The same, viewed from below.

FIG. 50.—*Centrocercus*. Lateral view of skull of "bird of the year" four months old; the hyoid arch has been detached.

FIG. 51.—The same aged bird as in Fig. 50, showing the disarticulated segments of the four cranial vertebræ: OV, neural arch of the occipital vertebra (epencephalic arch), first of the skull; OV', its hæmal arch in outline (scapular arch); *so*, superoccipital; *eo*, exoccipital; *po*, the connate paroccipital; *bo*, basioccipital; PV, neural arch of the parietal vertebra (mesencephalic arch), second of the skull; P. V.'. its hæmal arch (the hyoidean); P, the parietal; *ms*, the mastoid; *as*, the alisphenoid; *bs*, the basi-sphenoid; *gh*, the glossohyal; *ch*, the ceratohyal; *bh*, the basi-hyal; *uh*, the urohyal; *hb* and *cb*, the hypo-branchial and cerato-branchial elements of the thyro-hyals, respectively; F. V., neural arch of the frontal vertebra (proencephalic arch), third of the skull; F. V.', its hæmal arch (the mandibular); Fr, the frontal; *x*, the site of the postfrontal in some of the class; *os*, the orbito-sphenoid in outline; *ps*, the basi-presphenoid; Tp, the tympanic; *ar*, the articular; *S. an*, the surangular; *an*, the angular; *se*, the splenial element; and *de*, the dentary element; N. V., the neural arch of the nasal vertebra (rhinencephalic arch), the fourth and last in the skull; N. V.', its hæmal arch (the maxillary); N, the nasal; *Pf*, the prefrontal (ethmoid); *Vr*, vomer in outline, as it does not occur in this bird, (see description in text); *Pl*, palatine; *mx*, maxillary; *i. mx*, intermaxillary (or premaxillary); 1, the petrosal; 2, the sclerotals; 3, the lacrymal; *Pty*, the pterygoid, the diverging appendage of *Pl*, the palatine; *sq* and *ma*, the *squamosal* and *malar*, respectively, are diverging appendages of *Tp*, the tympanic.

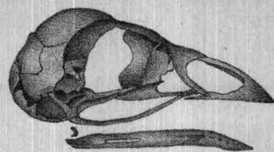


Fig. 48.

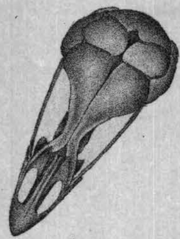


Fig. 47

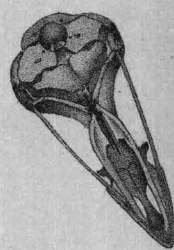


Fig. 49

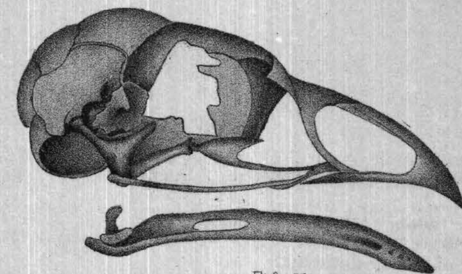


Fig. 50

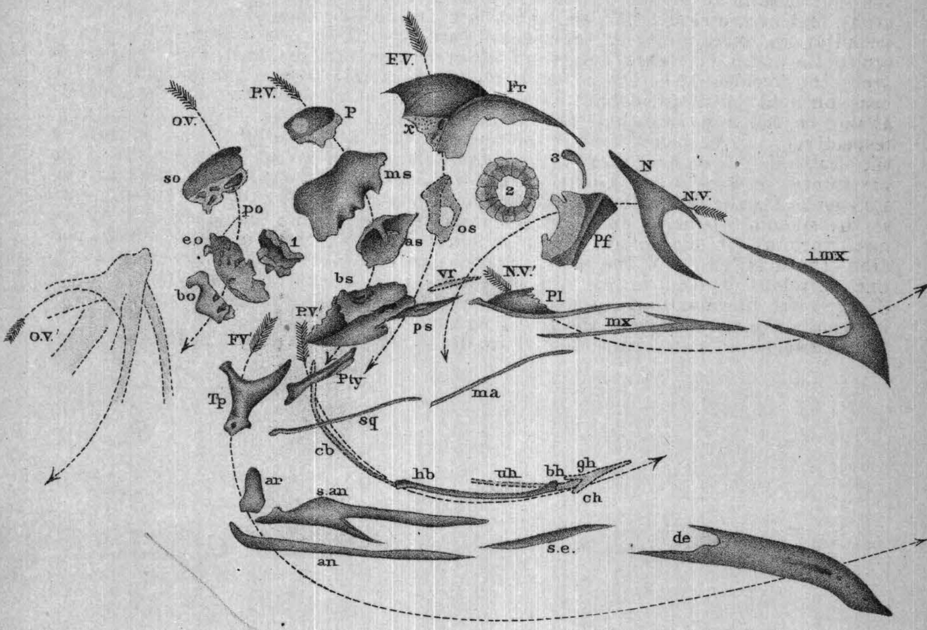


Fig. 51.

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PLATE VI.

FIG. 52.—Lateral view of skull of *Centrocercus*, adult ♂, hyoid arch removed. Figs. 54, 55, 58, 61, 64, 65, 66, 68, 69, and 70 are from the skeleton of the same specimen.

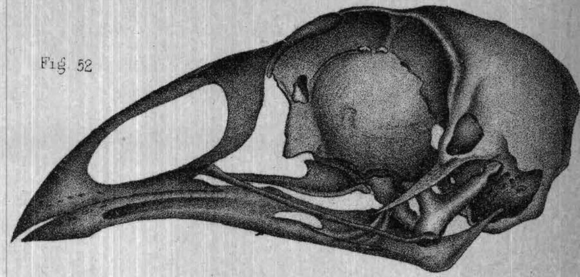
FIG. 53.—Sternum of the chick, three or four days old; *Centrocercus*.

FIG. 54.—Sternum of *Centrocercus*, viewed from below; adult ♂.

FIG. 55.—Dorsal vertebræ, lateral view, left side, from the same.

FIG. 56.—Sternum of *Centrocercus*, "bird of the year" (two months old), showing development of this bone: 4, *lophosteon;* 5, *metosteon;* 6, *pleurosteon.*

Fig. 52



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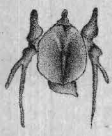

Fig. 54

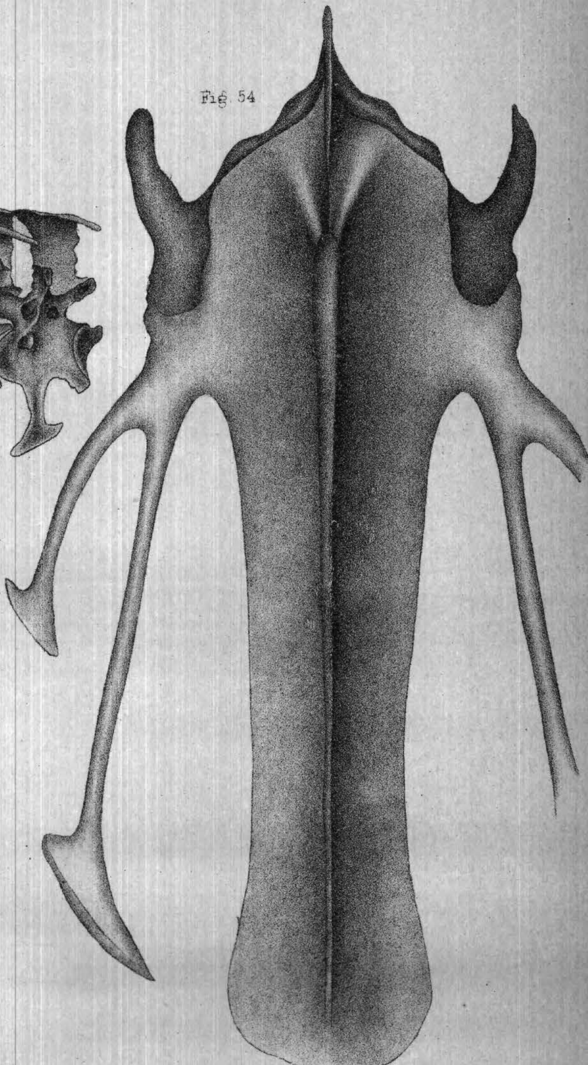

Fig. 55.

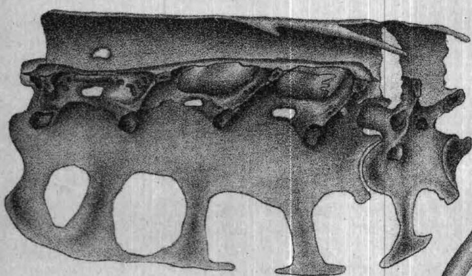

Fig. 56.

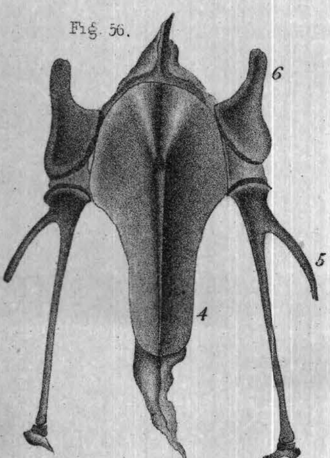

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PLATE VII.

FIG. 57.—Right pectoral limb of *Centrocercus*, same bird as the sternum in Fig. 56 was taken from. H, humerus, palmar aspect; *r*, radius; *u*, ulna; *s*, scaphoid (radiale); *c*, cuneiform (ulnare); *z*, unciform; *d*, index digit; 9, third metacarpal (annularis); 9′, second metacarpal (medius); *d′*, *d′′*, phalanges of the second metacarpal; *d′′′*, phalanx of the third metacarpal.

FIG. 58.—Left metacarpus of an adult *Centrocercus*.

FIG. 59.—Left metacarpus of the same bird as figured in 57, showing all the segments that go to make up the bone in Fig. 58: *om*, carpale or os magnum; z, unciform; 7, index or first metacarpal; 8, *pentosteon*; 9′, second metacarpal; 9, third metacarpal (annularis).

FIG. 60.—Left humerus (*Centrocercus*), taken from the same bird as in Fig. 57.

FIG. 61.—Left humerus, anconal aspect, *Centrocercus*; adult.

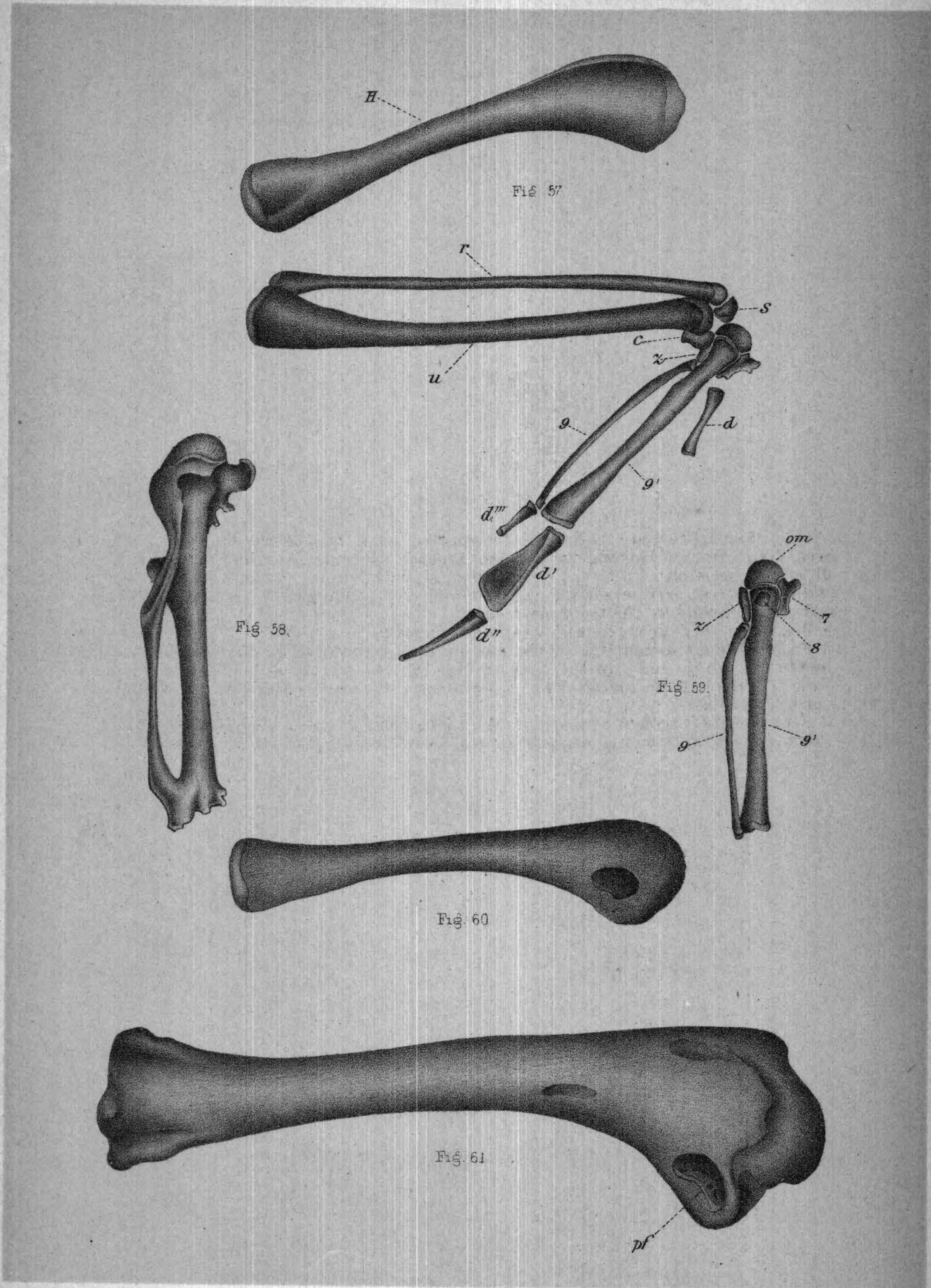

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PLATE VIII.

FIG. 62.—Ossa innominata, *Centrocercus*, three or four days old, showing how the pelvic bones form the acetabulum: *X*, ilium; *Y*, ischium; *Z*, os pubis.

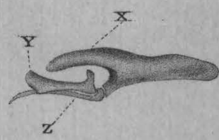
FIG. 63.—Pelvis, same bird as in Fig. 57; *Centrocercus*; *X*, ilium; *Y*, ischium; *Z*, os pubis.

FIG. 64.—The perfect pelvis, lateral view, as in 62 and 63, of *Centrocercus*; adult ♂

PLATE IX.

FIG. 65.—Posterior view of pygostyle, adult *Centrocercus*.
FIG. 66.—The same, left lateral view.
FIG. 67.—Pelvic limb, anterior view, *Centrocercus*, taken from same bird as in Fig. 57: *E*, *Epicnemial epiphysis* of the tibia; *E'*, the confluent tarsal bones found at the distal extremity of the tibia at this age, *tibiale* (astralagus), and *fibulare* (os calcis): *E''*, *the centrale*.
FIG. 68.—Left *tarso-metatarsus*, inside view, adult ♂, *Centrocercus*.
FIG. 69.—Anterior view of right tibia and fibula, from the same skeleton as 68.
FIG. 70.—Anterior view of right femur, same bird as shown in Figs. 68, 69.

PLATE VIII



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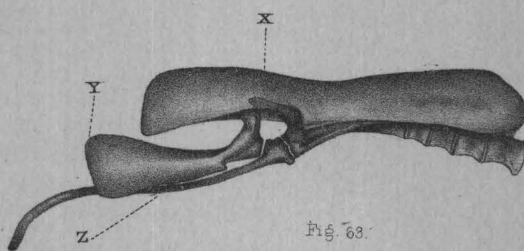

Fig. 63.

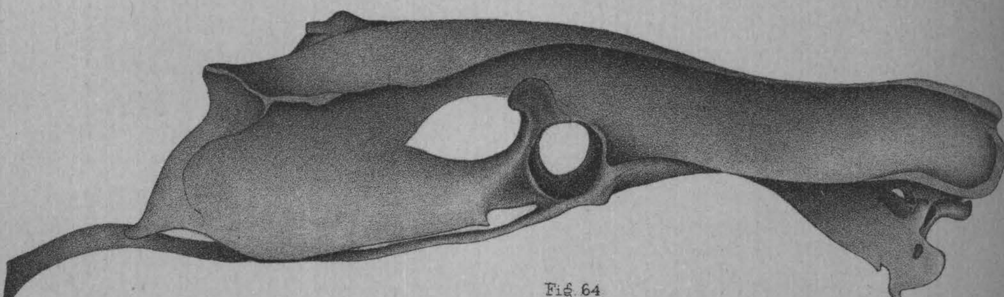

Fig. 64

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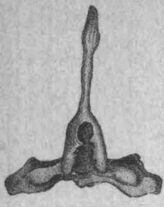

Fig. 65.

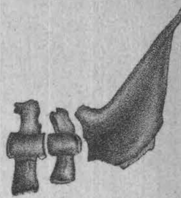

Fig. 66

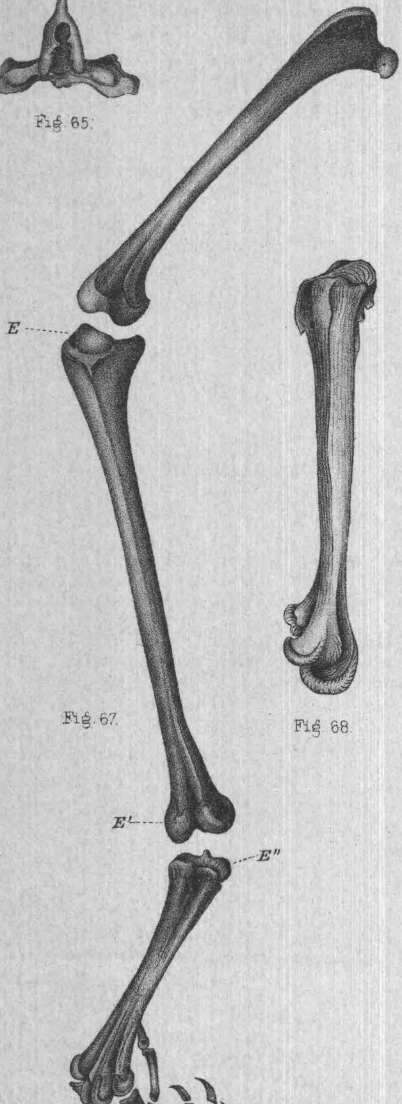

Fig. 67.

Fig. 68.

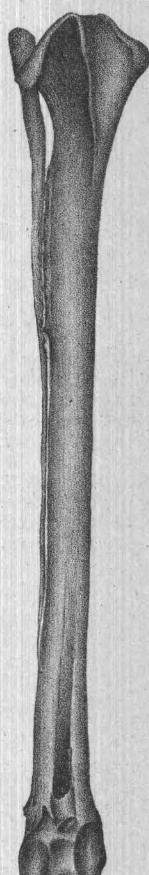

Fig. 69

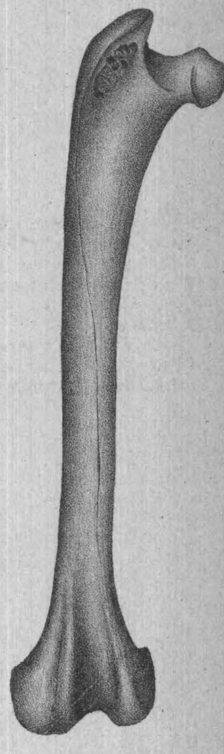

Fig. 70

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PLATE X.

FIG. 71.—Right lateral view of skull of adult ♂ *Cupidonia cupido*.
FIG. 72.—Lower mandible from the same, viewed from above.
FIG. 73.—Skull from the same, lower jaw removed; seen from above.
FIG. 74.—The same from below.
FIG. 75.—Sclerotals, right eye from the same.
FIG. 76.—Right humerus, from the same, palmar aspect.
FIG. 77.—The same, anconal aspect.

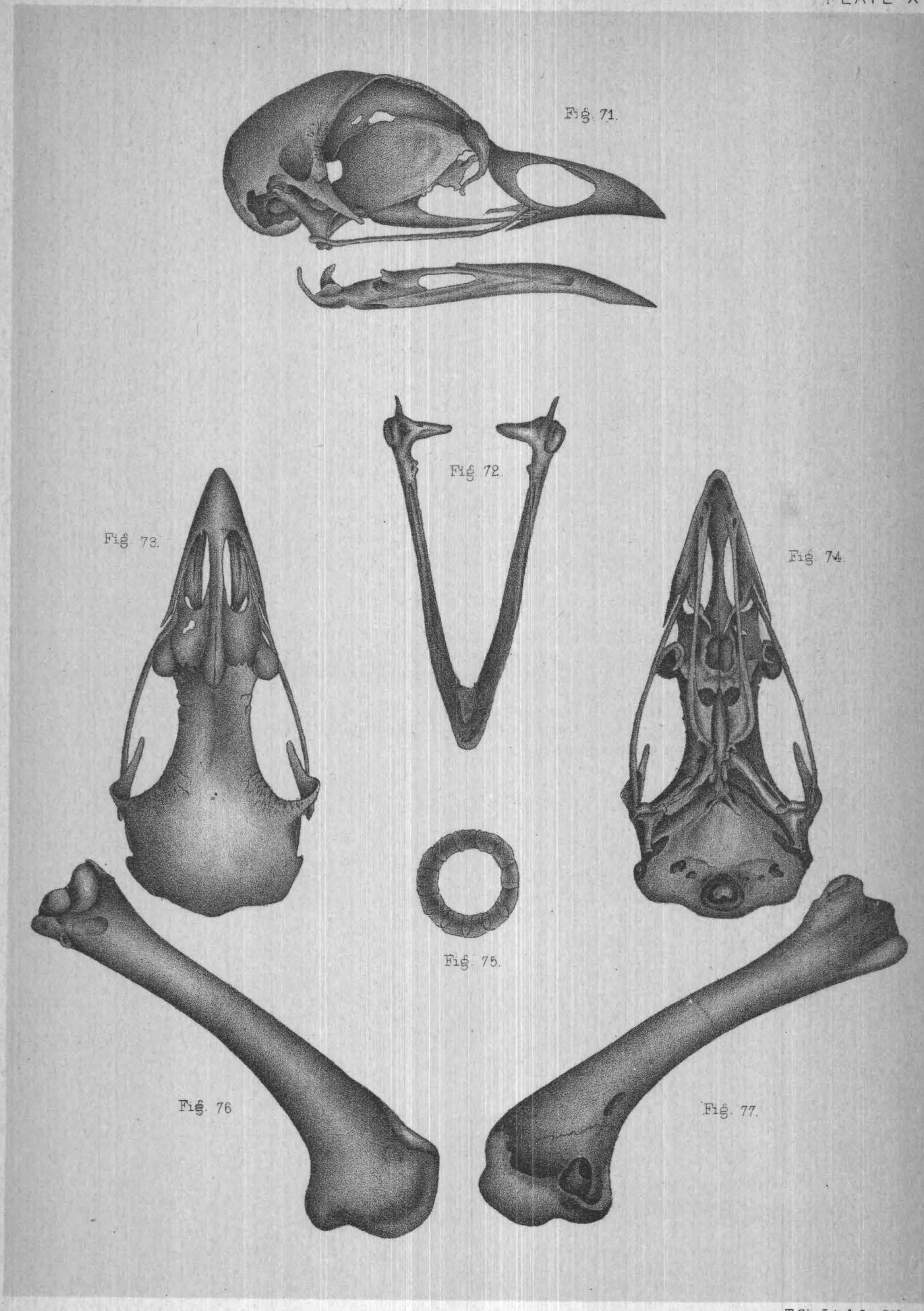

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PLATE XI.

FIG. 78.—Sacral vertebral rib with its hæmapophysis, left side; *w'*, the pleurapophysis, posterior view; *w*, the corresponding hæmapophysis.

FIG. 79.—Fifth pleurapophysis with its corresponding hæmapophysis attached; from the same bird, dorsal vertebræ, inside view.

FIG. 80.—Fourth pleurapophysis with its corresponding hæmapophysis attached; from the same bird, (*Cupidonia*), dorsal vertebræ, outside view.

FIG. 81.—Sternum from below; same bird.

FIG. 82.—Sternum, left lateral view; same bird (***Cupidonia cupido***).

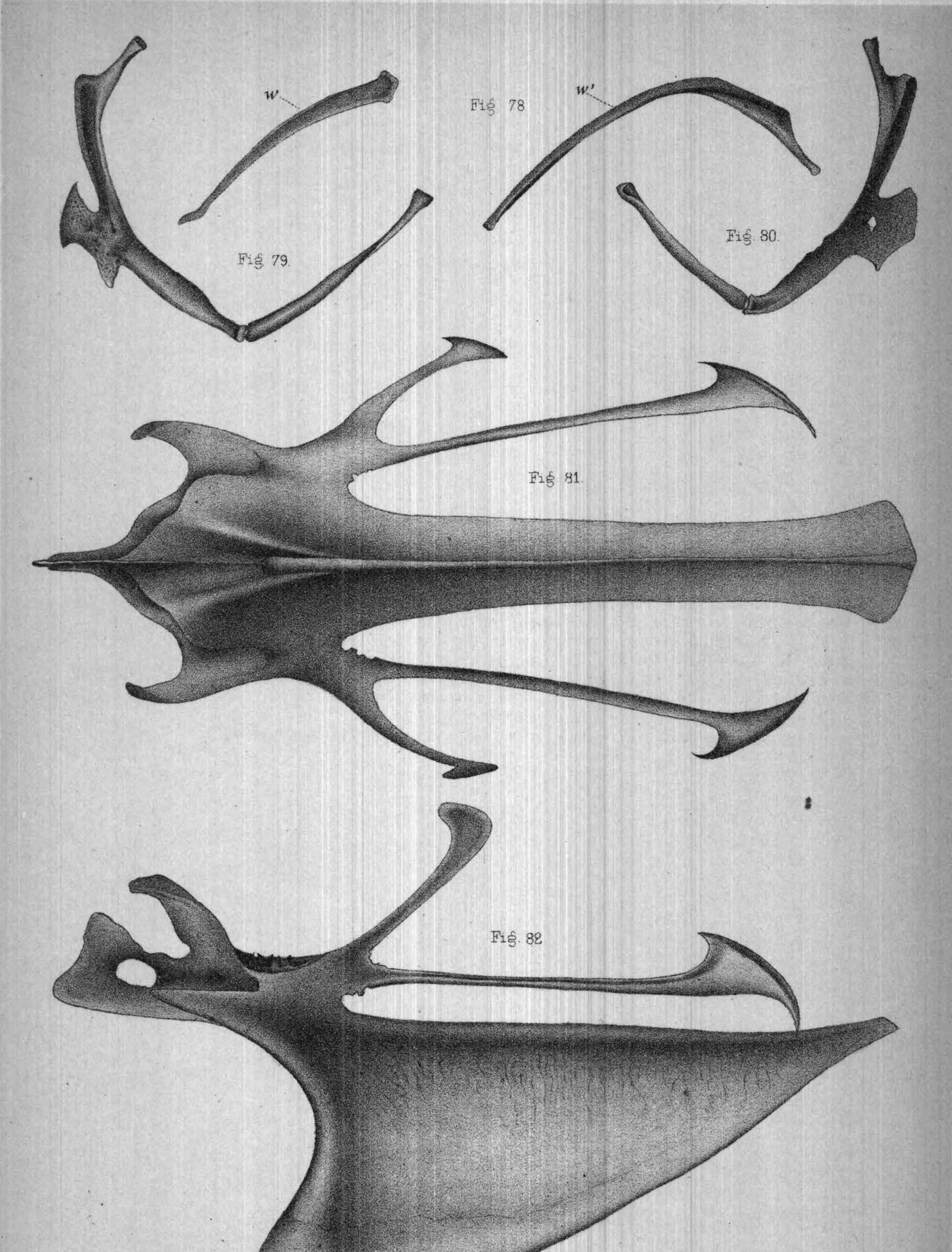

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PLATE XII.

FIG. 83.—Pelvis from above; *Cupidonia cupido.*
FIG. 84.—Pelvis, right lateral aspect; same bird.
FIG. 85.—Right scapula and coracoid, *in situ;* same bird.
FIG. 86.—Left coracoid, posterior view, from the scapular arch of the same bird.
FIG. 87.—Right lateral view of clavicles, from the scapular arch of the same bird; dotted lines show the outline viewing it from behind.

PLATE XII.

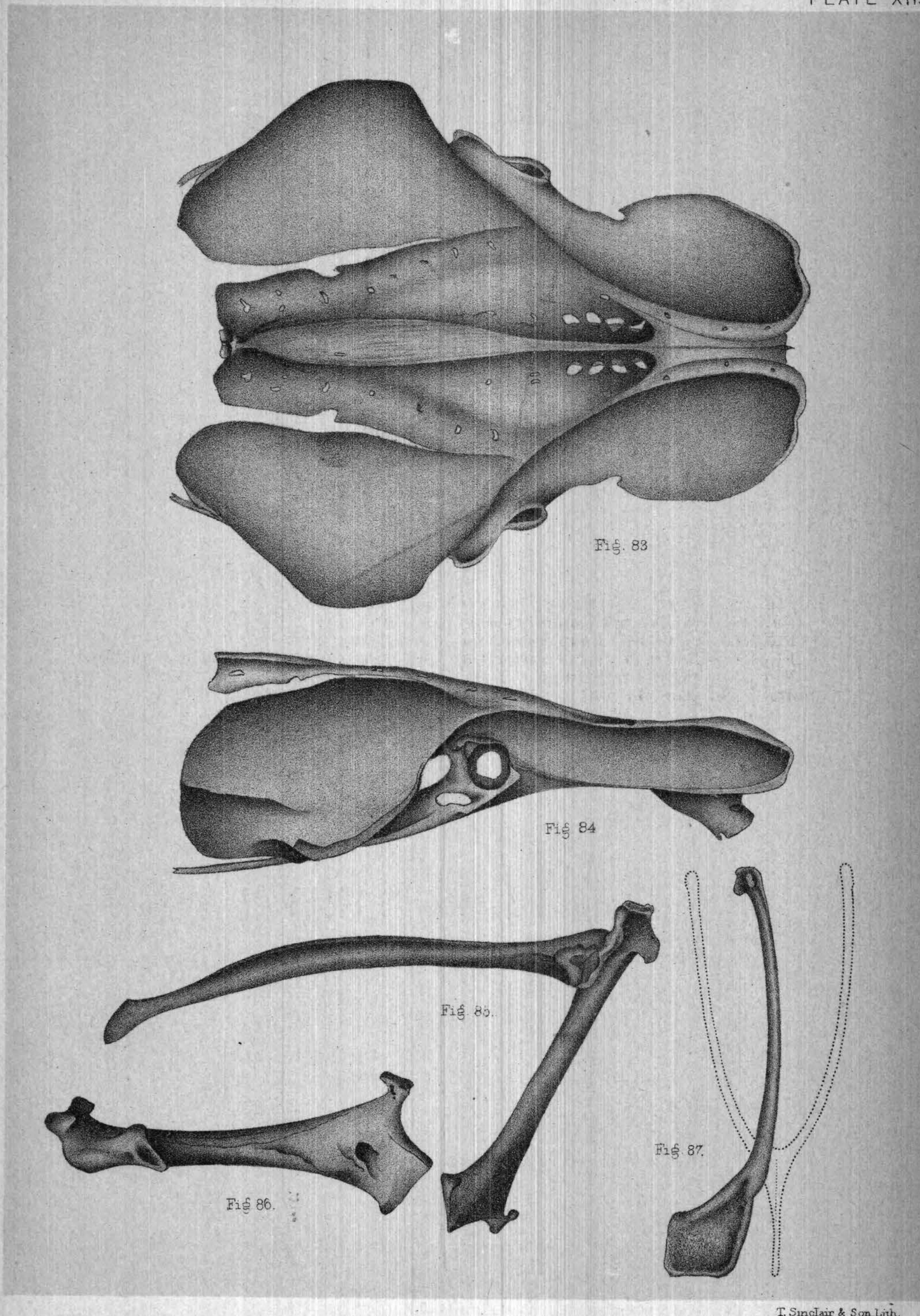

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PLATE XIII.

FIG. 88.—Right lateral view of skull of adult ♂ *Lagopus leucurus*; hyoid arch has been removed.

FIG. 89.—Cranium of *Pediœcetes phasianellus*; lacrymal, nasal, and intermaxillary still attached.

FIG. 90.—Pelvis, adult ♂ *Canace canadensis*, viewed from above.

FIG. 91.—Portion of skeleton of Ptarmigan, *Lagopus leucurus*, showing thoracic and pelvic bones *in situ*, with the scapular arch and caudal vertebræ. The last cervical vertebra still remains attached in order to show its free pleurapophysis.

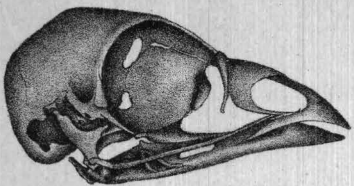

Fig. 88.

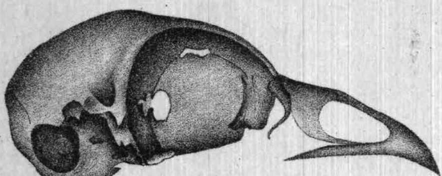

Fig. 89.

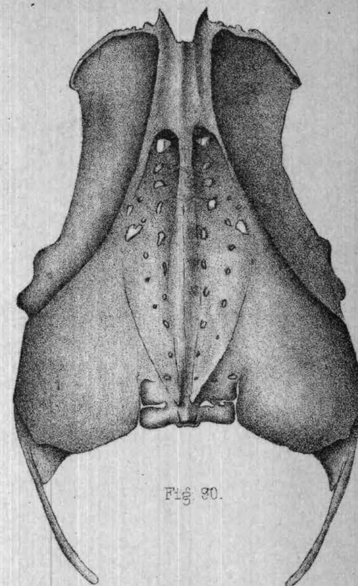

Fig. 90.

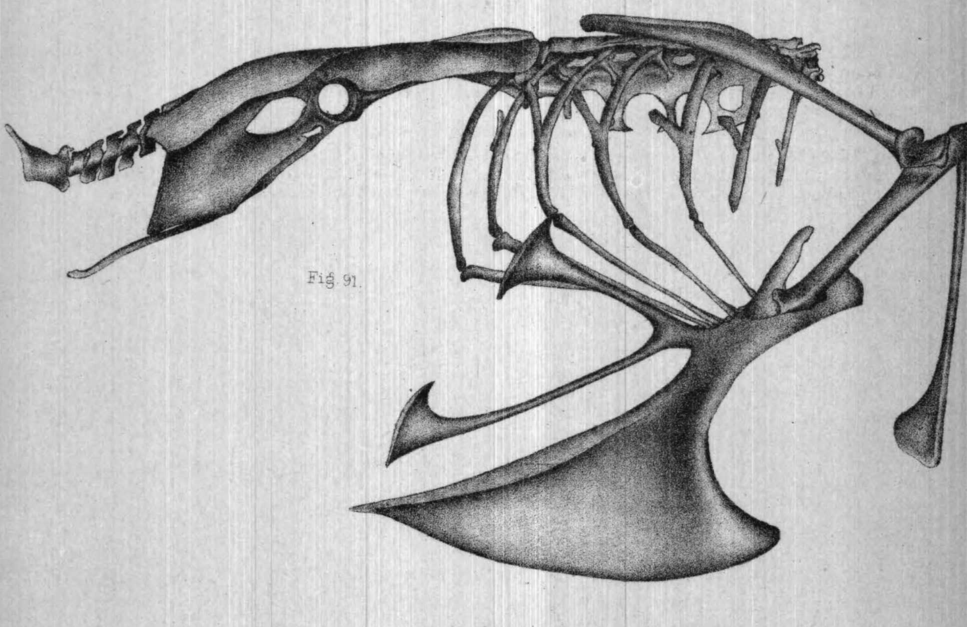

Fig. 91.

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OSTEOLOGY OF LANIUS LUDOVICIANUS EXCUBITORIDES.

By R. W. SHUFELDT, M. D.,

Captain, Medical Department, United States Army.

Mr. Robert Ridgway, in his carefully prepared check-list of North American Birds (Bull. No. 21, Nomenclature of N. American Birds, chiefly contained in the U. S. Nat. Mus., Washington, D. C.), gives us the representatives of *Laniidæ*, the species *borealis* and *ludovicianus*, with the two western varieties of the last, *robustus* and *excubitorides*, which latter form we have chosen as the subject of this paper to demonstrate the peculiarities of the skeleton of these interesting birds. The habits of the Shrikes are well known to all ornithologists, so one will not be surprised, after a view of Fig. 100, in the plate (where our subject has been made, by the aid of the dissecting knife and maceration, to exhibit one of the truest indices of his character), to find the large, semi-hawk like skull surmounting the remainder of a bony frame-work, that might easily be mistaken as belonging to a Thrush or any other Oscine; but it is this very characteristic that individualizes these truly passerine-raptorial birds.

In the skull, divested of the lower jaw and hyoid arch in the adult, we find that anchylosis of the primoidal segments has been very thorough; outside of the bony parts of the sense capsules—the ossa quadrata and the pterygoids are the sole escapers of this notorious feature in avian craniology—indeed, we discover in the skull of this species, before it has left the nest, that the primitive segments that go to make up the group of bones that we described as the occipital vertebra in former papers are well advanced towards permanent union, especially about the condyle, traces of its formation being extremely difficult of discernment, and in the mature bird this hemispherical facet for the atlas is exceedingly diminutive, measuring only .5 of a millimeter in diameter. About the basi-cranii we find the usual foramina for the exit and entrance of vessels and nerves, and note in our examination that the anterior apertures of the Eustachian tubes are double, very small, and protected by an osseous lip from the basi-sphenoid The foramen magnum is sub-circular and of medium size; together with the basi-cranii, it makes an angle with the horizontal plane of 25°, the anterior bearing point being the tip of the beak, and the two posterior bearing points being the internal facettes upon the ossa quadrata. That part of the cranium above, formed by the frontals and parietals is very broad and smooth, and quite often the sutural traces are easily made out, and in cases where maceration is persisted in, the coronal suture may gape; beyond, the interorbital region becomes slightly depressed. The pseudo fronto-maxillary articulation is denoted by a transverse line nearly a centimeter long, and is moderately flexible; the superior tips of the lacrymals form its lateral boundaries. The superior mandible is made up of the usual bones, it is very broad at its base, and gently deflected throughout; the nasal bones bound posteriorly on either side vacuities that lead into the rhinal chambers, but the true nostrils are found beyond these, as distinct elliptical apertures. It is, however, the horny integumental sheath that really gives to this bird's beak its peculiar raptorial aspect, for when stripped of this, the osseous tomia show no sign of tooth or notch beyond. Below, the palatine fissure is quite wide, and through its opening we discover that the ethmo-turbinals are more or less developed, together with a partial septum narium, and the space is further intruded upon by a sub-compressed and originally distinct vomer, that is bifurcated behind to receive the rostrum of the basi-pre-sphenoid, lodging a portion of the prefrontal in its fissure above.

The palatines have become amalgamated with the inter-maxillary anteriorly, and form, with the pterygoids, the usual joint on the rostrum of the sphenoid behind; they throw out sharp lateral apophyses that are directed backwards. The pterygoids are very much expanded at their mesial ends, their shafts being straight and delicate; and there are no pterapophysial processes; they meet the tympanics in sub-circular heads, of no great size, just below the orbital processes. These latter elements possess very broad and twisted mastoid prolongations, with the usual double facet and intervening depression below; and the orbital apophyses are pointed at their extremities, sometimes slightly clubbed, being turned gently upwards. The segments composing the infraorbital bar have long since become one single bone, a slender style fulfilling its ordinary functions. A sub-elliptical sesamoid is found at its proximal end, between it and the tympanic. The orbital cavities are capacious, and well divided from the rhinal chambers by the broad, quadrate lacrymals on either side; their vaults are concavely arched, and their posterior walls quite extensive, looking almost directly forwards. The foramen for the exit of the first pair from the brain-case has run into one irregular aperture; but rarely joins, in the adult, with the elliptical foramina for the optic nerves below them. The orbital septum is never complete, a vacuity of greater or less extent occurring near the center of the plate. Laterally we observe shallow temporal fossæ above elongated openings to the otocrane, that look downwards, forwards, and outwards, standing out quite prominently from the side of the skull. The squamosals throw forwards and downwards horizontally flattened apophyses, which by the aid of smaller ones from the alisphenoids, help it to guide the temporal muscles to their points of insertion. A moderately marked "cerebellar prominence" is found at its usual site, above the foramen magnum behind; but we have never observed the foramina, caused by bone thinning, to occur on either side of it. In removing the cranial vault, we find the various fossæ unusually well defined, and bounded by sharp borders; the carotids enter by separate openings at the base of the "sella turcica," which latter has a deep notch, mesiad, in its posterior wall.

In the recent cranium, the internal and external tables are separated by an interspace of a millimeter or more, that is sparsely filled in by diplöic tissue; but upon examining skulls that have been kept for a long time, and consequently become thoroughly dried, we cannot distinguish between the two tablets; the diplöic tissue has entirely disappeared, and the whole roof is extremely attenuated and *flexible*. We are not prepared to explain how this remarkable change comes about.

The *hyoid arch* bears out its usual ornithic and oscine characteristics, and does not require any special description here, as the author intends to furnish a more elaborate description of the skull when he comes to touch upon the *Vireonidæ;* a faithful outline of this arch is given, however, from a superior view in Fig. 101 of the plate.

Before the young of this Shrike has left the nest the numerous elements of the lower jaw have become fused together, so that during maceration the two rami rarely separate at any other point except the symphysis between the dentary elements. In the old bird it is a stout and strong bone, with sharp-pointed extremity beyond, and deeply scooped-out articular ends posteriorly, with blunted processes behind, and up-turned ones looking towards each other, mesiad. Externally the "sides of the jaw" are concave for their posterior two-thirds, and exhibit the usual elliptical foramen (Fig. 102); while the superior ramal borders are rounded and rise into slight prominences at the junction of the outer and middle thirds. As to the sense capsules, we find that the sclerotals are well developed and very accurately matched together; the usual ossicles of the organ of hearing likewise ossify.

There are thirteen vertebræ devoted to the cervical portion of the spine, and, although they make a faint attempt towards a raptorial appearance, they are more oscine in their character than anything else, and are not noted for the prominence of any of their outstanding processes; d sregarding the atlas, the first four bear neural spines, this feature not showing itself again until we find it in the last two, the thirteenth posessing it as well developed as any of the dorsals. The post- and prezygapophyses are markedly short, thus bringing all the segments quite near together, giving considerable stability to this division of the column. The parapophyses are very delicate where they are produced anteriorly at mid-neck, and quite inconspicuous above; the first four and the last six vertebræ bear hypapophyses, they being three-pronged on the last two; this limits the carotid canal to the fifth, sixth, and seventh cervicals, unusually slight protection for this important arterial branch. The vertebral canal commences in the tenth—*i. e.*, in this segment it is completely surrounded by bone, and continues its course through the axis; the last two or three vertebræ are very broad from side to side, the ultimate one bearing a free pair of vertebral ribs that have in their turn distinct uncinate processes.

The neural tube as found in this section of the spine commences and terminates broadly and transversely elliptical, merging into the subcircular as it nears its mid-portion at the middle of the neck; it is of considerable caliber throughout. The dorsal division of the spine has allotted to it five vertebræ, closely locked together, yet easily detached by ordinary maceration; their combined neural spines form one continuous quadrate crest. These are fastened together above by the "arrow-head" joint that we have described in other papers. There is very little difference in the lengths of the transverse processes, from first to last, so we do not find much change in the processes of the ribs they sustain, as to length of pedicles and tubercula. Short metapophysial ridges are found above the transverse processes; they never seem to attain sufficient length to connect the vertebral segments, however.

The neural canal commences transversely elliptical, to terminate, much diminished in caliber, in the subcircular form. In the first dorsal we find a thin quadrate lamina of bone, projecting downwards and forwards in the mesial plane, as a well-developed hypapophysis; the second supports the merest apology for this process, and the remaining dorsals have none at all, though by compression of the centra a low ridge presents itself along their middles, which is only faintly perceptible in the last. There is a free pair of ribs for each dorsal vertebra, and these are movably connected with the sternum by corresponding pairs of costal ribs, the whole structure and appearance being distinctly oscine in character. The vertebral ribs are very slender below and not so much expanded above as they are in some other birds. Commencing with the last cervical rib, and continuing entirely through the dorsals, we find the series of epi-pleural appendages complete on either side, and freely articulated with the posterior borders of the ribs, with which they make an angle of about 45°, and attain sufficient length to overlap the rib in their immediate rear, though often in younger birds, and even some old ones, the last uncinate process does not reach the free sacral rib. The sternal ribs are quite delicately fashioned, and support, as usual, anteriorly the transverse heads for articulation with the costal border of the sternum, while posteriorly we discern the moderately upturned and clubbed extremities with shallow facettes for the inferior ends of the vertebral ribs.

The *sternum* of the Loggerhead Shrike is almost or quite typically "cantorial" in its outlines, but only feebly pre-eminent in those features that stamp it as belonging to a bird of any great power of flight. The manubrium, directed upwards and forwards, springs from a solid base to become bifurcate at its anterior extremity and throw down a sharp border below, that becomes continuous with the carinal margin in front; the coracoidal grooves pass round laterally well beneath the costal processes, and merge into each other, mesiad, their point of meeting being denoted by an elliptical depression, at the base of which we occasionally find a single pneumatic foramen. The costal processes rear themselves upwards, forwards, and outwards, being broad but thin laminæ of bone, impressed upon their posterior margins by the five transverse facettes for the sternal ribs. The "body" is concave above, sloping to a shallow, osseous gutter, lying in the mesial plane directly over the keel; beyond, in this groove we observe a few scattered foramina for the admission of air to the more solid structures of this confluent hæmal spine. Behind, the bone is one-notched on either side, cutting out lateral processes with expanded posterior ends and a broad mid-xiphoidal portion—the direct continuation of the sternal body—(Fig. 92). The "carina" below averages about 7 millimeters at its deepest part; anteriorly it protrudes as a rounded carinal angle, from which point its inferior boundary sweeps backwards by a gentle convex curve to terminate in a diminutive triangular space at the middle of the xiphoidal process beneath.

The sides of the keel present for examination well-defined subcostal, pectoral, and carinal ridges; the latter falls on either side from the base of the manubrial process to near the carinal angle, just within the border, and sometimes has a thickened backward branch starting from its lower end. The confluent pelvis, in common with the majority of passerine birds, has that strikingly angular outline, due largely to sharpened borders and outstanding spiny processes. There are ten vertebræ in its "sacrum," all unusually firmly fused together, vacuities only occasionally occurring among the diapophyses of the ultimate few, three or four at most. The pre-acetabular region of the ilia on either side is deeply concave, this concavity being carried up over the anti-trochanters to terminate in shallow grooves over the ischiatic foramina. The greater share of this surface looks almost directly outwards and only slightly upwards. The ilio-neural canals are divided by the confluent spines of the first four or five vertebræ, they vary in width in different individuals, and terminate at points opposite the cotyloid cavities, at which point the neural spine suddenly becomes compressed, or rather annihilated, and the sacrum sustains a flattened surface to the ultimate boundary of the bone. The post-acetabular regions are of about one-third the extent of the surfaces anterior to the cotyloid rings; they are produced behind in strong and clubbed processes, the outer margins of which are the terminations of the gluteal ridges or lines continuous with these ridges; these surfaces are convex and narrowed by the encroachment of the broad sacrum (Fig. 103).

Laterally the ilium overhangs the extensive and elliptical ischiatic foramen, which is bounded in front by the anti-trochanter, directed backwards and slightly outwards; the cotyloid ring is circular and but little difference exists between the diameters of its inner and outer peripheries. The obdurator foramen is very small and varies in the figure of its outline, though generally assuming more or less the form of the ellipse; the broad and thin hinder blade of the ischium again dips down to meet the slender pubic shaft, just before its termination, to shut in an elongated spindle-shaped tendinal vacuity. (Fig. 100.)

Upon the ventral aspect of the pelvis, we note that the bone affords no shelter whatever for the important organs it incloses until we pass the fourth sacral segment and the very decided vertebral swelling to form the sinus rhomboidalis; it then drops into a deep depression on either side, whose concavities and convexities correspond with those described and attributed to the dorsal surface. The apophysial braces thrown out by the vertebræ are extremely slender, except in the cases of the first and fourth: the former segment bears a free pair of slender pleurapophyses, whose hæmapophyses articulate along the posterior border of the ultimate sternal ribs, as do some of the inferior so-called "costal cartilages" in anthropotomy, lacking the necessary length to arrive at the costal borders of the great ventral hæmal spine, constituting a common ornithic character. These sacral ribs rarely or never support uncinate processes.

Six segments are devoted, in this Shrike, to the coccygeal division of the column, exclusive of the pygostyle; they share the same fate, with their fellows and representatives in nearly all of the class Aves, in having many of their original vertebral components either rudimentary or entirely suppressed; the neural spines, hooking over each other, anteriorly, become more and more feebly developed as we proceed backwards; this order of things is just reversed when we come to examine the hypapophyses on the nether aspects. The neural canal that passes through them dwindles to mere capillary dimensions before reaching the pygostyle, into which bone it enters but a very short distance.

The transverse processes of the caudal vertebræ are bent downwards, compressed horizontally, broad, and show but slight differences in length, before reaching the last one, in which they are shorter. The lamina of the pygostyle has the outline of an isosceles triangle, being truncate at its apex; the "body" below is of a substantial structure, barely dilated behind, and otherwise presenting the usual characteristics as found among the oscines.

The bones of the *scapular arch* are all free and independent of each other, the stability of their relative position depending upon strong ligaments in the living bird. The blade of the *scapula* is quite narrow, and, in the vast majority of cases, extends across the dorsal pleurapophyses, or vertebral ribs, its distal end being obliquely truncate, from within, outwards; the blade-like portion is brought up in close juxtaposition with that portion of the bone that affords the scapular moiety of the glenoid fossa. Its acromial process is very short, owing to the fact that it has to proceed but a short way before it abuts against the much-expanded head of clavicle, on either side; it forms with the coracoid the usual tendinal canal between the two bones. The head of the *coracoid* rears well above the glenoid cavity, in order to afford the required surface upon its mesial aspect for the broad clavicular extremity that rests against it; upon its opposite side it offers the usual surface to assist in completing the cavity for head of humerus. The shaft of the bone is very slender and cylindrical for its major part, and the wing-like extension, so broad in many birds, is here but a meager osseous scale attached to the side of the shaft, for its outer and lower half, becoming continuous with the formal dilatation of the bone below; for the sternal articulation, this is transversely concave and very narrow.

The minute pneumatic perforations of the scapulæ and coracoids occupy their usual sites back of the glenoid cavity, under the protection of the tendinal canal, at the heads of the bones. The united clavicles, or the *furculum*, inclines decidedly to the U-shaped variety (Figs. 94, 95); we have already alluded to the fact as how broad, yet compressed, their scapular ends are found to be; from these heads the shaft-like portions fall downward, with a gentle curve backward to meet and support the mesial and usual clavicular lamina, which here lies in that recess formed by the anterior and concave border of the carina of the sternum (Fig. 100).

Directing our attention again to the shoulder-joint we discover that this Shrike is another example of those birds in which that little peg-like ossicle, the *os humero-scapulare* is found, here attached by its usual ligaments to the upper and back part of the articulation and fulfilling its ordinary function. The *humerus* of *Lanius* bears the closest resemblance to that bone as found in many of the family *Turdidæ*—particularly does this apply to *Mimus polyglottus*, a bird the Shrike not unsuccessfully apes in point of external coloration.

The head, in most individuals, is well bent, anconal, and supports a short radial and not lofty crest, with the usual ulnar tuberosity overhanging an ample pneumatic fossa. The shaft is quite straight and nearly cylindrical, its distal and expanded extremity presenting quite a unique appearance (Figs. 96 and 97). The internal and external condyles are distinct processes, the former projecting almost directly backwards, the latter forwards and upwards; the olecranon fossa is likewise clearly defined, and on the palmar aspect we observe the oblique and ulnar facets unusually prominent. The humerus is the only bone of the pectoral limb that has air admitted to its interior, the bones of the antibrachium and pinion lacking this rather rare prerogative.

The *ulna* is more than four times the bulk of the radius, being, as in most vertebrates, the main support of the forearm; there is scarcely any perceptible curvature along its well-balanced and cylindrical shaft, which presents a row of distinct little tubercles for the bases of the quills of the secondaries. Its proximal end presents for examination a prominent olecranon process, directed backwards, and the greater and lesser sigmoid cavities on its anconal aspect; the distal extremity is rather under the average in point of eminence, but shows all the usual indentations and surfaces to accommodate this end of the bone to the wrist and radius. The *radius* differs principally in having a general curvature distributed along its subtrihedral shaft, rather than having it confined to its proximal third, as in many birds; otherwise it presents its ordinary ornithic characteristics.

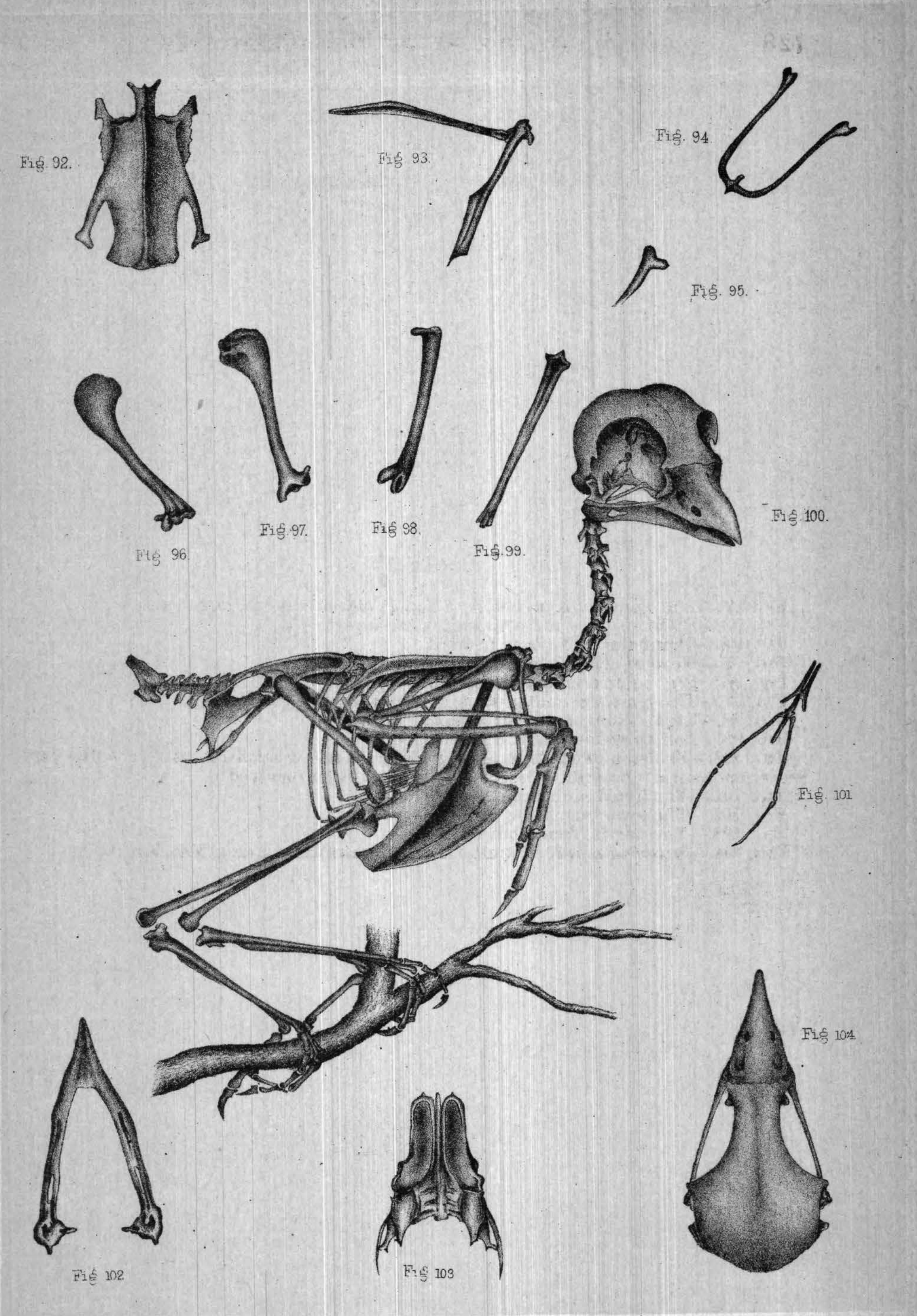
Among the mature birds representing the *Laniidæ*, as in so many other families, the carpus is composed of the two free ossicles, the *cuneiform* and the *scapho-lunar*, which are here impressed by their usual articulating facettes, for the radial and ulna trochleæ and the metacarpus, and although we have the young of this Shrike before us, the limits of this paper will not allow a critical description of this interesting and important region of the skeleton, that can only be obtained by careful study of the youngling.

The *manus* contains its customary complement of bonelets, as seen in the pinions of the major part of the class in general (Fig. 100); medius and annularis metacarpals are firmly united together, and with the short first metacarpal that bears the index; the broad phalanx of the second is concave upon its anconal aspect and supports below the distal joint of the hand; the smallest phalanx of all is freely attached to annularis, which latter metacarpal extends some little distance below its stouter fellow, the medius. The pelvic limb is non-pneumatic, and consists in the adults of the usual number of bones, the patella being present. The *femur*, less than 2.5 centimeters long, has no trochanter minor, and the larger process of this name is but feebly produced; the head, with its single depression for the ligamentum teres may justly be said to be at right angles with the cylindrical shaft, which latter is slightly convex forwards; the condyles are well developed and the outer one presents the usual fibular groove. The *tibia* presents nothing that differs in any marked extent from the oscines in general; it has no rotular process, but the pro-and ecto-cnemial apophyses are well produced and turned slightly outwards; at its distal end we observe, anteriorly, the usual tendinal bony bridge for extensor tendons. The *fibula* can be detached from the tibia by maceration, but its lower extremity spins out into a mere thread at the junction of mid and lower thirds of the latter bone. There are no free tarsal segments, and the same remarks apply here as we used in speaking of the wrist-joint above. The *tarso-metatarsus* (Fig. 99) is very delicately constructed below, while above it is stouter and presents immediately back of its head the process we have called *tendinous*, pierced by two pairs of foramina. A thin lamina of bone extends along its shaft behind. We observe that the *os metatarsale accessorium* is unusually large, as is the toe it supports; but otherwise the internodes are arranged upon the general plan of the oscine foot, which brings to our mind nothing of a raptorial type, except, perhaps, *as we know the bird*, the decided curvature of the hind claw, which is still further ncreased and lengthened when armed with its horny theca.

PLATE XIV.

FIG. 92.—The sternum, from below. *Lanius ludovicianus excubitorides.*
FIG. 93.—Right scapula and coracoid, outer aspect.
FIG. 94.—Clavicular arch, from in front.
FIG. 95.—Head of clavicle, right limb, outer aspect.
FIG. 96.—Right humerus, palmar aspect.
FIG. 97.—The same, anconal aspect.
FIG. 98.—Right femur, posterior aspect.
FIG. 99.—Left tarso-metatarsus, anterior aspect.
FIG. 100.—Skeleton of adult ♂, *Lanius ludovicianus excubitorides*; the left free vertebral and costal ribs and the pectoral limb have been removed.
FIG. 101.—The hyoid arch, from above.
FIG. 102.—The lower mandible, from above.
FIG. 103.—The pelvis, from above
FIG. 104.—Superior aspect of skull, the lower mandible having been removed.

PLATE XIV.



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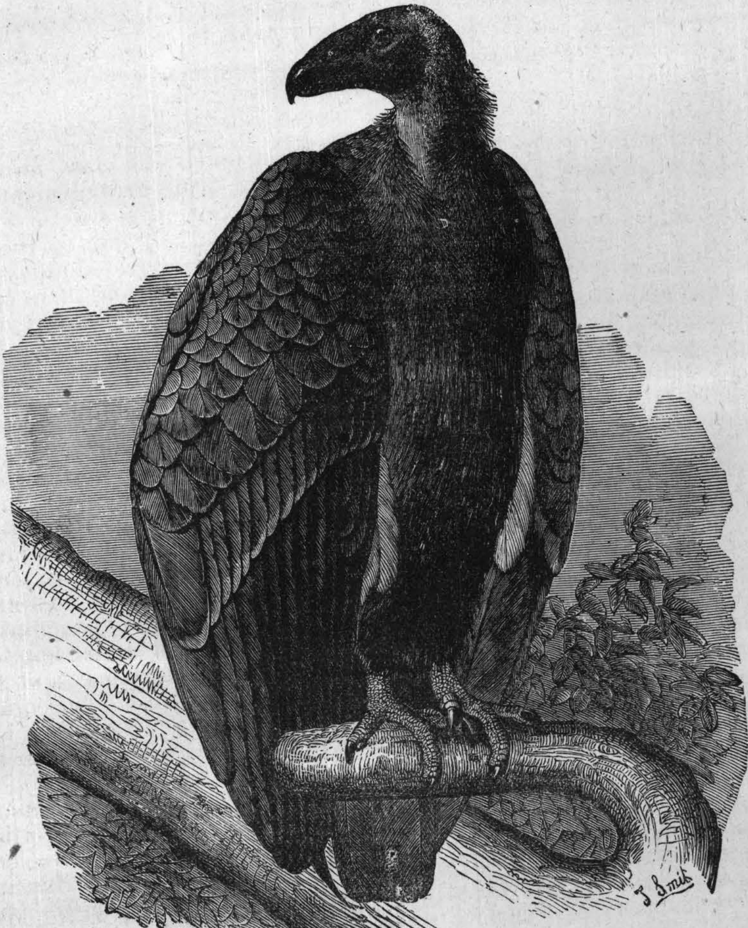
SHUFELDT ON THE OSTEOLOGY OF LANIUS LUDOVICIANUS EXCUBITORIDES.



[Face p. 727, Hayden's 12th Annual.]

OSTEOLOGY OF THE CATHARTIDÆ.

BY R. W. SHUFELDT, M. D.

Captain, Medical Department, U. S. Army.

Notwithstanding the fact that living birds, taken as a class, form one of the best isolated groups we have in nature, their arrangement into families and the division of these families into genera is still on a very unsatisfactory basis. This, no doubt, has been largely due to the fact that all of the variously proposed classifications have rested almost exclusively upon external characters; only an author here and there pointing out in his writings differences in internal structure. Of recent years, however, this imperfect system and highly uncertain course has been very much modified and improved by the attention given to avian anatomy by quite a number of earnest and painstaking zootomists. The published labors of these gentlemen and the facts they have succeeded in elucidating have already made their impression upon the problem to be solved, and in many cases the family lines are now more sharply defined.

We must all agree, though, that this good work is yet in its infancy, and that the question of the classification of birds can only be definitely settled when we are thoroughly familiar with the habits, external structure, and characteristics of each species, and these are combined with a complete knowledge of their internal anatomy in all of its minutest details. The classification resting upon the digested and compared facts of such a knowledge as this can be the only perfect one, and the only one that will not be subject to sudden surprises and consequent changes, rendered necessary by periodical discoveries in structure and the development of new anatomical facts. In short, as distant as the day may seem, we will only be able to devise a perfect classification of living objects in nature when we have mastered their anatomy, using the word in its broadest sense. So that well-established and recorded anatomical data become particularly valuable to descriptive zoologists, and we feel sure that it is the aim of every one interested in this important subject to further the efforts of those now engaged in this particular branch of the science, in anyway in their power, in order to meet the end in view. Probably there is no better illustration afforded us anywhere in the recent literature of the science of ornithology, in which anatomy has played a more prominent part in deciding classificatory division, than in the separation of the *Cathartidæ* from the Old World Vultures, nor in none, if it had continued to be relied upon, where simple external characteristics could have been more misleading. In this particular instance the osseous system was the one that finally rendered the principal assistance in determining the dividing line.

Accepting as we must, then, these prerequisites to a sound classification, how idle it is for any one to attempt to define permanent family lines that will stand the test of time and research by any single set of characters; as, for instance, cranial peculiarities, or such forms as the sternum may assume. It seems to me that this latter bone would be particularly unreliable to adopt for any such purpose, for we will soon see in the *Cathartidæ* that its shape appears to vary with the age of the individual, and a description of the bone in one bird, apparently an adult, would not answer for another of the same species, and perhaps of the same, or nearly the same, age.

At the present writing it is well agreed among ornithologists, and, no doubt, very correctly so, that the *Cathartidæ*, or American Vultures, form a family of themselves quite distinct from the vulturine *Falconidæ* of the Old World. This rather recent step, taken as it was through the aid of modern researches in the matter, will, in all probability, be a final one, and the Vultures of our continent will, we think, always be considered as forming a well-defined family to which we can now hardly look for any new additions. The writer trusts that in the present paper he will be able to demonstrate to his readers, by the study of the skeletons of these birds, that the osteological characters of the group, some of which are new, go still further towards sustaining the division made and referred to above. The question as to how the *Cathartidæ* should be divided generically is quite another thing, and its discussion will be postponed until we have examined the various skeletons of the members of the family and compared our data with our present knowledge of the other systems of these birds' economy.

Vultures, as a rule, are found in the warmer climates, where they pursue their useful avocation as scavengers, feeding upon all carrion that chance may throw in their way. To carry on this mode of living we find certain marked features presenting themselves to us in their superficial anatomy or external topography that are common to all of them. The most important of these points we will hastily review here, so that the reader may have them at hand as external landmarks or references to compare, where comparison becomes possible, with points upon the skeleton within. In the first place, we find that their upper mandibles terminate anteriorly in a well-developed hook, which is much better defined when encased in its horny covering; in fact, it requires the addition of this integumental sheath to approximate the mandibular margins in any of the *Cathartidæ*. The head and a greater or less extent of the upper third of the neck is devoid of feathers, a fine down being found only in the young birds. There is no osseous septum narium present, and the external bony nasal apertures or nostrils are made to assume different degrees of perviousness by the surrounding cere. They have an external claw covered with horn, as in the ungual joints of the feet, that articulates by its base with the apex of the first digit in manus. A web is found between the inner and middle and middle and outer toes occupying more or less of the basal thirds. Claws of the feet large, strong and curved, though these members are not fashioned for grasping purposes, as we believe Vultures never carry their plunder away by means of their feet, they being given these curved claws rather to hold down firmly the portion of the carcass upon which they may be feeding while they tear it in shreds by their powerful hooked beaks. It will be recognized at once that some of the characters just enumerated have nothing whatever to do with the present mode of living of these birds, but may have done so in their ancient ancestors; we refer particularly to the external claw exhibited on the manus, a character they possess in common with some, if not all, of the Old World Vultures.

The family *Cathartidæ*, as defined by its most recent describers, consists of the following genera and species: First. *Sarcorhamphus*, containing *S. gryphus*, the Condor of the Andes, a bird whose range is so well known as not to require any definition from me here. *Gyparchus papa*, the King Vulture, a species which, until recently, was supposed never to enter the confines of the United States, but inhabited the subtropical countries to our southward. Its presence at the present writing, however, is strongly suspected in the Territory of Arizona, as referred to by Dr. Coues in the Bulletin of the Nuttall Ornithological Club for October, 1881, under General Notes. Third. *Pseudogryphus*, containing the single species *P. californianus*, the Californian Condor, a huge Vulture that is confined to our western coasts and principally to the State from which it derives its name. Fourth. *Cathartes*, containing *C. aura*, *C. burrovianus* and *C. pernigra*. The range of the first of these, the common Turkey Buzzard, is thus defined by Mr. Ridgway:

"Probably none of the birds of America have so extended a distribution as this Vulture, occurring as it does in greater or less abundance from high northern latitudes at the Saskatchewan, throughout North America, from the Atlantic to the Pacific, and in all portions of South America, even to the Straits of Magellan. (Hist. of N. A. Birds; Bd., Brewer & Ridw., pp. 345.)"

From my own experience it can be said that this Vulture was found to be quite common during the years 1877–'80 throughout the northern territorial districts of the United States.

In April, 1880, Ridgway calls our attention to *C. burrovianus* and *C. pernigra* in the following words (Nutt. Ornith. Bull., Apr., 1880, p. 83):

Cathartes burrovianus, Cass.—Recent authorities* having almost uniformly ignored the claims of this bird to specific rank, I have, in the absence of any opportunity to examine the type specimen in the museum of the Philadelphia Academy, carefully read Mr. Cassin's description in order to satisfy myself whether we are justified in the suspicion that Mr. Cassin's supposed species was based on a small specimen of *C. aura*. Upon reading Mr. Cassin's description I was surprised to find how well and unmistakably it applied to the bird usually called *C. urubitinga* Pelz. in every particular. In the description, as quoted below, I have italicized the phrases which are strictly and peculiarly diagnostic of *C. urubitinga*, in order to show at a glance how certain it is that Cassin's *C. burrovianus* is the same bird. The only question, it appears to me, can be as to the locality, which may be erroneous, since *C. urubitinga* is not known to occur anywhere out of Eastern South America, though the evidence to this effect, it should be remembered, is purely negative.

The earliest notice of this species is that of Brisson (1760), the *Vultur brasiliensis* of this author being unquestionably the same species, as his full and very accurate description clearly shows. Therefore, it is quite possible that some author may have applied the name *brasiliensis* to the species under consideration before Mr. Cassin's name *burrovianus* was bestowed upon it, in which event the proper specific term would be *brasiliensis*, and not *burrovianus*. I cannot find, however, that such use of Brisson's name has been made. It is altogether probable that *burrovianus* will stand.

Mr. Cassin's description (Pr. Philad. Acad., March, 1845, p. 212) is as follows:

"Head naked, smooth, with the nostrils large and oval; plumage of the body *entirely black*, with a greenish-blue gloss, paler beneath; *the feathers extend upwards* on the back of the neck; a small bare space on the breast. Wings long, the quills and tail-feathers black, with the shafts of the primaries white and conspicuous; third primary largest. The smallest American Vulture known.

"Total length (of skin) 22 inches, bill 2½, wing 18, tail 8½.

Hab.—Near Vera Cruz.

"This species resembles *C. aura*, Linn., in the shape of the bill and the nostrils, and in having the tail rounded, but differs from it not only in size, but *the feathers extend upwards on the back of the neck and lie flat instead of forming a ruff;* the plumage of the specimen now described is black, *none of the feathers having pale margins*, as is commonly the case in specimens of *C. aura;* the shafts of the primaries are clear white, and the head is more entirely destitute of downy feathers. The tarsi are longer and more slender.

* Conf. Elliot, Illustr. Am. B., II, 1866; Allen, Bull. Mus. Comp. Zoöl., ii, 1871, p. 311; Sharpe, Cat. Acc. Brit. Mus., i, 1874, p. 28; Gurney, The Ibis, 1875, p. 94.

"The head of *C. burrovianus* is quite smooth, in which, as in other respects, it is very different from *C. atratus*, Wilson.

"This new species was obtained in the vicinity of Vera Cruz, by the late M. Burrough, M. D., in honor of whom I have named it, as a slight acknowledgment for his very valuable services to natural history and to this academy."

Cathartes pernigra, Sharpe.—A specimen of this species is in the Maximilian collection, at the American Museum, New York. It appears quite distinct from both *C. aura* and *C. burrovianus*, being, in fact, somewhat intermediate between the two. In size it is nearly, if not quite, equal to *C. aura*, and, like the latter, has the nape entirely bare of feathers, the plumage commencing abruptly about half way down the neck. The shafts of the primaries are a lighter brown than in *C. aura*, but not so white as in *burrovianus*. In regard to the plumage, however, there is a much closer resemblance to *C. burrovianus*, the back and wings being wholly black, like the lower parts, without a trace of the light-brownish borders to the feathers, so conspicuous in *aura*. The black is also much less glossy than in the latter.

The specimen (male) is, unfortunately, not quite adult, the bill being partly blackish, and the nape covered with a soft dusky down. The measurements are as follows: Wing, 20.00; tail, 12.00; culmen (chord of the arch), .85; tarsus, 2.50; middle toe, 2.40.

The bill and feet appear more slender than those of *C. aura*.

In conversation with Mr. Ridgway at the present date (November 12, 1881) we find him still adhering to the views he so clearly set forth in the Bulletin the year before, still declaring that *C. burrovianus* and *C. pernigra* are both " good species."

We had the opportunity to examine a mounted specimen of the former in the cabinet of Vultures at the Smithsonian Institution on the same day, and must agree with Mr. Ridgway, that as far as external characters are concerned, as compared with *aura*, the birds certainly appear distinct. We observed the additional fact that the nostrils in *burrovianus* were far more pervious than those in *aura* even

A specimen of *C. pernigra* we never have had the good fortune to examine; in fact, both of these Vultures are uncommonly rare in collections, and the writer has thus intentionally taken the pains to bring out all of the data that he has at his command bearing upon these two birds, as he must here confess to his reader that it has been found impossible to secure a skeleton of either *burrovianus* or *pernigra*, so that the characteristics of the genus *Cathartes* must be drawn from its common representative, *aura*. We do not know of a skeleton of either *burrovianus* or *pernigra* being in any of the osteological cabinets in the United States, and it must be left to some more fortunate ornithotomist to compare the osteological characters of these two birds, with what the author hopes to bring out in regard to the genus in which have been placed, from their northern representative.

Pseudogryphus californanus.

Fourth, and lastly, we have the genus *Catharista*, containing the single species *C. atrata*, the Carrion Crow, or Black Vulture. This bird is confined more or less to our Southern States, inhabiting particularly the maritime districts, and to various localities in South America, its habits and tastes always being those of a true Vulture, which it is. It will be remembered that for a long time many authors placed all of our North American Vultures in the one genus *Cathartes*; the group containing, according to Coues' Key of North American Birds (1872), *Cathartes californianus*, *C. aura*, and *C. atratus*. They appear in Mr. Ridgway's Nomenclature of North American Birds (Bull. U. S. Nat. Museum, No. 21, 1881) as we have given them above (*G. papa* not being included), viz, *Pseudogryphus californianus*, *Cathartes aura*, and *Catharista atrata*.* We shall soon see, when the skeletology of these have been compared, how far the osteological characters will support this generic division.

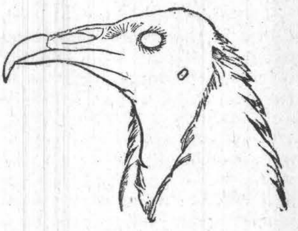
Before passing, however, to the examination of the skeletons of these birds, the author proposes to present his reader with a short table showing additional points in external structure that have been gleaned from various sources and authorities as well as from his own memoranda. We feel sure that although in a paper proposing, as its title indicates, to be purely osteological in character, such a diversion will hardly be considered amiss.

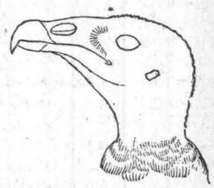
*Dr. Coues, in his Check List and Ornithological Dictionary of 1882, also adopts this arrangement.

TABLE.

Name.	Characters.					
	Beak.	Irides.	Nostrils.	Head.	Color.	Other features.
S. gryphus	Strongly hooked	Pale brown ♀; carbuncle red.	Open; cere not encroaching beyond osseous borders of nostrils.	Blackish gray; neck flesh color.	White ruff	Fleshy caruncles on head and neck in ♂, absent in ♀; tail even; entire neck bare.
G. papa	Hooked	White in adults; yellowish gray in juv.	Same as in *S. gryphus*	Adult ♂ head, neck, &c., mingled tints of orange, crimson, purple, and brown; dark lead color in juv.		A medium fleshy caruncle on the cere immediately above nostrils.
P. californianus	Hooked, but weaker	Carmine	Cere closing in the opening to the nostrils; all to the posterior third.	Orange and red (smooth).	General plumage dull black.	Has 14 tail feathers, all other *Cathartidæ* having 12.
C. aura	Hooked	Grayish brown	Entirely open; large	Naked, as is upper portion of neck; slightly wrinkled; livid crimson.	General plumage black	Bill chalk white; a patch of antrorse bristles before the eye; tail rounded.
C. burrovianus	Hooked	Carmine red	As in *aura*, open	Orange; feathered to the occiput.	Feathers of upper surface without brown borders, as in *aura*.	Smallest American Vulture known.
C. pernigra	Hooked	White	Open	Yellow; otherwise as in *aura*.	Resembles *burrovianus* more than *aura*.	About the size of *C. aura*.
Catharista atrata.	Hooked; having the appearance as if added to end of upper mandible.	Reddish brown	Closed in by cere all to the posterior third; long and narrow.	Naked, as is upper portion of neck; blackish.	Uniform dull black	Size of *aura*, though more robust; heads of all the *Cathartidæ* naked, except in the young, where it is downy.

Many of the characters noted in the above table are from those observed by John Henry Gurney (Descrip. Cat. of Rap. Birds in Norfolk and Norwich Mus., Lond., 1864), others are from Mr. Ridgway's *Falconidæ* and *Cathartidæ* (Hist. of N. A. B. by B., Br., and Ridgw.). This latter ornithologist describes still one other Vulture found in South America (Nutt. Ornith. Bull., Apr., 1880), but it seems to us that it is not yet sufficiently proven that this bird is not *S. gryphus* in immature plumage. Particularly may this be the case, as we do not positively know how long the Condor requires to attain the adult plumage, and, furthermore, we can hardly believe that a bird of the size of the one described could have so long escaped observation. However, in case we may be wrong in the matter, and future developments prove this to be a new Condor, we will here insert Mr. Ridgway's notes upon this Vulture, taken from the bulletin above quoted.


Cathartes burrovianus.


Cathartes aura.

Sarcorhamphus æquatorialis, Sharpe?—In the vivarium at Central Park, New York City, I saw in December, 1878, a Condor of uniform brown plumage, which Mr. Conklin, the director of the menagerie, informed me had been received July 23, 1875, and that it was three months old when captured. It was obtained on Mount Conquences, Chili, and was presented by Rear-Admiral Collins, U. S. N. The fact that this example had not yet, when nearly four years old, begun to assume the plumage of *S. gryphus*, proves conclusively either that the latter species retains the livery of the young until four or more years of age, or that there really is, as has been asserted by authors, a species of Condor among the Andes which has permanently a uniform brown plumage, something like that of *Gyps fulvus.** The locality of this specimen would extend considerably the range of *S. æquatorialis*, Mr. Sharpe giving only Ecuador, and doubtfully Colombia, as the habitat of his species.

I will also remark here, and I have noted it in birds of various species, more especially in a living specimen of *Haliaëtus leucocephalus* that I had in my possession for a long time, that birds do not seem to acquire their adult plumage nearly so soon when they are kept in a state of confinement as when leading their natural life. Other authors have likewise noted this fact. With so many curious cases on record among other species, it is hard telling exactly what effect such an entire change would have upon *S. gryphus*, having been taken *young*, removed to an entirely different climate, kept confined, and no doubt having a radical change made in its diet.


Catharista atrata.

Before closing what we have to say upon the external characters of

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*Since the above was written, Mr. Conklin has favored me with the following particulars, under date of February 10, 1880, in response to my inquiry as to the present condition of this specimen: "The plumage remains still unchanged, except that the ruff about the neck is somewhat fuller, and has a little sprinkle of white through the down . . . It has not increased much since then (July 23, 1875, the time when received at the menagerie), either in size or weight. The bill is black at the base, the apical half ivory-white; head bare, no wattles; iris dark brown." Mr. Lawrence has also favored me with the following transcript from his note-book, April 1, 1876: "Condor, said to be nine months old. Bill black; cere and naked sides of head grayish-black; head sparsely covered with short downy feathers of a smoky black; plumage, in general, of a dark snuff-brown." August, 1877: "No change except the development of the ruff, which is colored like the back." "The ruff is now (February 23, 1880) more full, but no appearance of becoming white; underneath the feathers are whitish."

these birds, the writer inserts the following valuable quotations from Nitzsch, an author who paid no little attention to the external characteristics of birds, more particularly the feather tracts.

The chief pterylographic character of these, as of the Old World Vultures, is to be found in the formation of the pectoral portion of the inferior tract. This is not separated by a space from the jugular portion, but the two sections of the tract are perfectly continuous. Just as the inferior tract, gradually enlarging, has arrived over the pectoral muscles, it receives the axillary tract, and thus acquires a very remarkable breadth. It then divides into two branches, which, however, are generally weak, and are rendered indistinct by the circumstance that the feathers of the tract are more scattered. The two branches are at first of equal width, and run parallel; towards the extremity of the great pectoral muscles they curve in towards each other; and whilst the inner one is continued unchanged as the ventral portion, the outer one is narrowed, and returns by a narrow process, running along the margin of the *musculus pectoralis major* to the ventral part again.

In this way the two branches inclose a pretty large insular space, the whole tract thus presenting very close resemblance to that of *Centropus* (refers to plate). This, however, does not conclude the list of the pterylographic peculiarities of the American Vultures; but we must add: 1. The amalgamation of the jugular part of the inferior tract with the cervical portion of the spinal tract, which would convert the plumage of the lower part of the neck into a continuous one, *if the space did not entirely or partially penetrate it.* 2. The remarkable narrowing of the dorsal portion of the spinal tract, which frequently consists only of two rows of feathers, gradually diverging anteriorly, and connected with the branches of the fork of the cervical part. 3. The presence of a large lumbar tract. 4. The constant and invariable presence of *twelve* feathers of the tail. 5. The absence of a circlet of feathers at the apex of the oil-gland. The broad, obtuse form of this organ seems to stand in relation to this. At its extremity there are two distinct orifices. 6. The covering of the feet may also be cited as a characteristic element; it consists of small scales upon the tarsus, but of scutes upon the whole of the toes; moreover, besides the outer and middle toes, the middle and inner toes are united by a membrane.

The elongated nostrils, parallel to the longitudinal axis of the beak, certainly remind one of *Neophron;* but the absence of a bony septum between them is one of the most characteristic external distinctions of the American Vultures; the tongue, moreover, has a series of teeth on its margin, at least in *C. papa* and *C. aura.*

I have examined *C. gryphus, papa, aura,* and *uruber* (*fœtens* Illig.), and found in all some little differences in the form of the tract, but no characters from which I could justify their division into the genera *Sarcorrhamphus* and *Cathartes.*—(Pteryl. Trans., from German Ed., by P. L. Sclater, Lond., 1867, p. 50.)

From this point the author goes on to give, under "Cathartes," descriptions of the feather tracts of the birds that he mentions as having examined in the above list, in detail.

The writer has to present to his reader the following material for examination, of the skeletons of the *Cathartidæ*, upon which to base the results of his monograph. At the outstart we must deplore the fact that we do not possess the skeletons of the young of any of the family under consideration. To be sure, specimens of the young of *Pseudogryphus* have been obtained on several occasions, but at the present writing there are none in the Smithsonian Institution, and should such be obtained at a later date they can be discussed in some future paper. Of *Sarcorhamphus gryphus* we have in our study one very good skeleton, the property of the Smithsonian Institution, and kindly lent us for the purpose in hand; it however lacks the osseous part of the claw of the first digit of the hand. This is also the case in our skeleton of *Gyparchus papa*, an unusually fine skeleton belonging to the Army Medical Museum, prepared by Prof. H. A. Ward, of Rochester, and obtained in Ecuador, probably by some of his collectors. Of *Pseudogryphus californianus*, also from the osteological cabinets of the Smithsonian Institution, we have two imperfect skeletons; they, however, show the cranium and the majority of the principal bones. We may consider ourselves fortunate, however, in having even this much, for this Vulture is becoming rarer and rarer each year that slips by, a fact that is to be accounted for through many causes, chief among which is its destruction by poisoned flesh and carcasses thrown out by the cattle-owners of the countries it inhabits, to destroy the wolves and bears. Then, too, it no doubt, being a bird not difficult to approach, forms a good target for many a hunter who chances to meet it with rifle in hand, and happens to be ambitious to add to his record the fact of having slain the largest bird in North America. For *Cathartes aura* we have numerous skeletons and parts of skeletons obtained from various sources, some from the Smithsonian collection, others from the Army Medical Museum, and one or two from my own cabinet, obtained by myself while in the territorial districts of the interior. We have already stated that we lack any osseous material from the two remaining species of this genus, *C. burrovianus* and *C. pernigra*, and are of the opinion that the skeletons of these birds are not to be found in any of the collections in this country.

Lastly, *Catharista atrata* is represented by several good skeletons and many crania and separate bones, placed at our disposal by the institutions above mentioned, being amply sufficient for the purposes of description and comparison with the other members of the family. In addition, we have before us a good skeleton of *Gypogeranus serpentarius*, one very complete mounted skeleton of *Neophron percnopterus*, from Abyssinia, from the collection of the Army Medical Museum, and finally a mass of odds and ends of skeletons of Hawks, Eagles, and Falcons, that bear more or less upon the discussion of such a subject as we have undertaken, the majority of which latter material we are deeply indebted to the kindness of Professor Baird, and the exertions of Mr. Ridgway, in the way of selection.

In the matter of plates, we trust we have laid a sufficient number before our reader to thoroughly illustrate all we have to say in the text, and the author assures you that he has not spared his pains in choosing subjects such as he deemed would best fulfill the end in view. Perhaps *Pseudogryphus* in this choice has taken the lion's share, but we must remember that in extenuation of this claim our Californian Vulture will soon be reckoned among the birds that were, and life-size portraits of the bones of his skeleton will be ranked among those of the famed Dodo, and the great Auk. His cranium and the outline sketch of the metacarpus are from my own pencil, but the remainder of the bones of his skeleton are from photographs taken at the Army Medical Museum, under my own supervision, and are all life-size. The skull of *S. gryphus* was kindly drawn for me by Dr. J. C. McConnell, of the Army Medical Museum, to whom science is so much indebted for illustrations in so many of its branches. In another plate we present an entire skeleton of *G. papa* from a photograph and reduced to one-third of its size; this figure shows well the *tout ensemble* of the bones of the skeleton in one of our typical Vultures, as well as the relations of size and position of these bones as compared with each other. It is the Equador specimen referred to above. The two plates, figuring three views of the cranium of *C. aura*, with two views of its sternum and its furculum and remainder of scapular arch, are India ink productions of the writer's, being drawn from a fine specimen of this bird, secured by him in the Laramie range of hills in Wyoming. The remainder of the figures are life-size views of the subjects they represent, from photographs taken at the Army Medical Museum, and are very accurate conceptions of the bones they depict. Their detailed descriptions must, however, be deferred until we come to describe the parts of the various skeletons from which they were taken.

Upon viewing the skeleton of one of these birds for the first time, such as we offer in Plate XV, fig. 105, *G. papa*, we are struck with the vulturine appearance of the skull, with its more or less open, capacious external nasal orifices, its hooked beak, its rather large orbital cavities and the good size of the bones at the bases of these orbits. The segments of the vertebral column, or the vertebræ, are all free, from occiput to sacrum, with their processes and arches well developed. We observe, too, the great length and size of the bones of the extremities; particularly those of the brachium and anti-brachium of the upper, and the robust femora of the latter. To support these great limbs, we find these birds possess correspondingly well developed arches of the axial skeleton. Nor are the bones of the feet backward in indicating to us the avocation of their owners, attached as they are, too, to powerful leg bones. In short, the *Cathartidæ* must be regarded as possessing skeletons composed of bones above the average, for the size of the bird, in point of volume and length. These characteristics, however, do not bring with them a correspondingly heavy skeleton, but quite the contrary, for if we pick up the bony framework of any of our Vultures we cannot help but being struck by its unusual lightness; this is due to almost a universal pneumaticity of the bones composing it, and so marked a feature is this of the birds we are describing that it will not be considered out of place to give a general description of this condition here, so as to avoid, as much as possible, what would have to be a constant reference to the many pneumatic foramina that occur in nearly all of the bones that we shall come to describe further on.

Let us choose a specimen of *Catharista atrata* that we have before us for this purpose, simply reminding the reader that at least some of these openings will necessarily have to be referred to again, while with others their description will cease here. In the skull of this Vulture, as in all others of the family, the only elements that seem to possess this property are the quadrate bones (the tympanics of my former papers), the posterior thirds of the limbs of the lower mandible, and the lacrymals. In the quadrate bones we usually find a single, rather large, sub-elliptical opening at the bases of the mastoid ends or processes with a large one at their summit in *Pseudogryphus*—while several such foramina occur on the superior aspects of the articular extremities of the lower jaw; two of these latter seem to be constant and are found towards the points of their in-pointing prolongations. On the inner aspect of the lacrymals we find either one such pneumatic orifice or a group of several of them, and the air seems to attain complete access to these bones, and perhaps enters to a limited extent the wings of the ethmoid that they anchylose with on either side. It is very apparent that the walls of the brain-case or the bones that go to form the beak could not afford to make any such sacrifice of stability for the little additional lightness that would be gained thereby—the functions of these parts would evidently be weakened by it, affording as it would insufficient protection for the brain, and rendering the beak constantly liable to fracture.

The author is free to confess that at the present writing he knows not of a single instance among the class where to look for a bird possessing an atlas endowed with this property, and we find here in the *Cathartidæ* again, this bone apparently solid, or at least absolutely non-pneumatic, while the following vertebra, the axis, is quite so. Constituting, as its occurrence does in this bone, rather an uncommon condition for it, knowing as we do that in many birds where every vertebra will be found to be pneumatic, the atlantal and axial segments remain exempt.

In the cervical portion of the column one or more of these little apertures are found to pierce the centrum of each vertebra, within the vertebral canal or just outside of it, anteriorly. This is not a circumstance, however, we will find when we come to examine the dorsal segments, for here about the bases of the diapophyses or transverse processes great circular openings occur that allow one a view directly through the vertebra, and the center of these segments are in some cases riddled with similar though smaller foramina. Such openings, likewise, are found to exist at the inferior aspects at the extremities of the diapophyses, and sometimes a few minute ones in the metapophysial off-shoots beneath.

The position of these foramina are but little changed, much less their number or size materially decreased or diminished in those vertebræ constituting the sacrum. After we pass the first three or four segments of this division in *C. aura*, however, we seem to lose sight of them in the diapophyses, which is not the case among the species of the other genera, though they are very sparsely distributed in *C. atrata*. Arriving at the coccygeal vertebræ, we find that pneumatic foramina have disappeared entirely, and this holds good for all the Vultures and applies equally well to the ultimate segment of this division, the pygostyle. We present two or three figures in which the extensive pneumatic openings that occur on the outer aspects of the expanded heads of the clavicles may be seen. In *C. atrata*, as in the others, these consist essentially, one each side, of a large cloaca that extends immediately into the bone, rendering it one of the lightest for its size of any of the skeleton. About the entrance of this general opening we observe many smaller and circular or variously shaped ones irregularly arranged in groups, with sometimes only a single one beyond, isolated from the rest (*Pseudogryphus*), or another separate little collection in this situation (*C. aura*). In the scapula the openings occur near the glenoid cavity, and again a grouplet beneath the ridge found at the crest of the acromial process, on its outer aspect, but the number or size of these foramina in this bone is never very great.

In any member of the family, a careful search about the head of either coracoid is usually rewarded by the discovery of a few scattered openings of this sort, but these bones seem to depend almost entirely for the admission of air into their shafts and extremities upon a cluster of these foramina that are met in the recess of the dilated ends below, on their posterior aspects.

Passing next to the sternum, we find in all the Vultures, less marked in *C. atrata* than any, a rounded and prominent ridge, extending backwards from the anterior margin immediately posterior to the manubrial eminence, to the middle line of the concave and superior aspect of the body below. It is on either side of this ridge that we find pneumatic perforations that lead into the heavier portions of the bone, more particularly the promintory of the manubrium, and downwards into the thickened carinal ridge. Again, in the recesses above the subcostal ridges we discover irregular groups of these pneumatic foramina, that pass into the lateral portions of this bone; while lastly, the apertures through which additional ærification of the sternum takes place occur in the pits along the upper side of the costal borders, that we find among the facets of articulation for the sternal ribs. In these localities they have a tendency to gather around the bases of the eminences that support these facets, rather than be generally distributed throughout the depressions in question. (Plate XVII, fig. 107, *Pseudogryphus*.)

In the free ribs, both those of the cervical division of the column, as well as the dorsal ones, we find these pneumatic foramina entering the bone as one large opening (*C. aura*) or by a group of several smaller ones (*C. atrata*) at the outer extremities of their necks, just below the tubercula, anteriorly. We have just said that they occur in the free ribs of the cervical portion of the spine; this is indeed the case, but of very rare occurrence, and we may almost add in perfect safety the ribs of the sacral vertebræ to the list of non-pneumatic bones of the *Cathartidæ*.

The sternal ribs, at their inferior extremities, show like perforations, more commonly on their anterior aspects, though by no means do we always find them wanting on the posterior faces; more likely would we be disappointed in our search for them in the last sternal ribs; and we doubt of their ever occurring in the set that articulate with the first pair of sacral ribs.

The osseous portion of the basin, completed by the parial pelvic bones, is not usually permeated by air as thoroughly as it might be; indeed, in all those parts of the pelvis where the component bones become plate-like in character or flatten out, this property is denied them, and it is only where ridges become thickened from any cause whatever or other prominences take place that we find pneumatic foramina present. Notably these localities are three in number: Externally, in the recess on either side, just below the angle formed by the deflection of the gluteal ridge, and above the antetrochanter. Internally, in two places about the cotyloid ring at the extremities of its horizontal diameter slightly produced, at a greater or less distance from its periphery, and again at the base of the posterior concavity formed by the ilium and ischium, immediately within the rounded margin of the ischiatic foramen.

Of the Vultures, *C. atrata* seems to possess the most pneumatic sacrum, while that of *C. aura* is the least so. In *Pseudogryphus* the foramina are particularly well supplied, forming good-sized groups at all the localities just specified. They are absent in the last situation mentioned, in *C. aura*, *Sarcorhamphus*, and *C. atrata*, but in the last species quite a cluster occurs in the ilium on its internal surface, well within the upper margin of the ischiatic foramen.

The pectoral limb of the *Cathartidæ* is highly pneumatic from humerus to the last joint in manus, with the sole exception of the osseous core of the claw on the first digit.

In the humerus the large pneumatic fossa, with the collection of smaller openings at its base on the anconal aspect of the head, is never absent; in all but *aura* a few additional ones are found at this extremity of the bone, on the opposite side, just beyond the articular surface. At the distal end of humerus other openings occur of no mean size, especially in *G. papa* and *C. atrata*. These are generally situated on the anconal aspect of the bone, in a shallow but circumscribed depression that is found there, beyond the tubercles for articulation; sometimes a large one is found quite near the ulnar tubercle.

The cubit and radius both have these little perforations well supplied them, especially about their proximal extremities, anconad; the number not being nearly so great at the other end of the bones. The two free carpal bones possess at least two or three of these foramina apiece, and we note on the anterior face of scapho-lunar in *C. atrata* two very sizable ones, that seem quite constant for this species.

In metacarpus, the bone is pierced by a single foramen just beyond os magnum, at the point where index and medius metacarpals joined in the growing bird. Other perforations are found about both extremities of this segment in the angles and recesses formed by the conformation given it by the amalgamation of second and third metacarpals.

The palmar aspect of all the long digits show one or more such aerial penetrations, while the blade-like expansion of the first phalanx of second metacarpal seems to be absolutely riddled by these foramina, lending to it a decidedly honeycomb appearance.

The femur is the only bone of the pelvic limb that enjoys the condition we are discussing. In it air gains access to its interior through a single opening (*C. aura*), or, as in most cases, several of them, on the anterior aspect of the bone, below the great trochanter, close to the prolongation of its curling crest. In *Pseudogryphus* we discover a few additional ones on the upper face of the trochanter major, beyond the usual group.

We may say, then, that as a rule for the *Cathartidæ*, the only bones in their skeletons that do not receive air into their interiors through pneumatic foramina are certain portions of the cranium, lower maxilla and pelvis, the hyoid arch, the atlas, the coccygeal vertebræ, including the pygostyle, the bones of the pelvic limb below the femur, and all sesamoids and ossifications pertaining to the sense organs.

Passing to the *Falconidæ* and the Old World Vultures, we observe in the latter that although they have the greater share of their skeletons pneumatic, it is not nearly so perfect a condition as it has just been shown to be in our *Cathartidæ*. In *Neophron percnopterus* the axis is non-pneumatic, as are all the segments of the pectoral limb save the humerus. To these must be added the bones that we have just passed over and enumerated in the family in hand, as being so.

We find the furculum in the *Vulturinæ* a bone not nearly so well ærated as we have described it for the New World Vultures, it is still less so in *Gypogeranus*, and the same remarks will apply here in general for the remainder of the skeleton of this bird that we have this moment made in regard to the *Vulturinæ*. In general they are equally applicable to the remainder of the family *Falconidæ*. We believe that we will not go far astray in laying it down as a rule for the entire order Raptores, that this attribute of the skeleton seems to have arrived at its acme in *Catharista atrata*, exists to a greater or less degree in all of the American Vultures, then becomes less marked as we pass to the vulturine Raptores of the Old World, among which we believe that the clavicles will be found to be far less pneumatic throughout, though the femora still remain so, down among the diurnal and nocturnal Raptores of both continents, until we arrive at such forms as *Speotyto*, where we know the entire pelvic limb to be exempt from this condition, and that air is excluded from more than half the bones of the skeleton of this ground-abiding Owl.

Having dwelt now, and we trust with sufficient thoroughness, upon the present classification of the *Cathartidæ*, their leading and more important external similarities and differences, and then touched upon some of the more general characteristics of their skeletons, we will proceed to investigate these latter more in detail, beginning, as we have done in former memoirs, with the skulls of the species to be treated. It is the object of the author during this investigation to keep these two things prominently before his reader, the first being the prime object of the work we have to do, viz, an accurate description of the skeleton of each species of the family as far as our material will allow us to give it; and, secondly, from time to time, to compare the principal bones of these birds with those of members of their own family, and then with those of other families of near kin; our second aim being, so far as osteology will justify it, to test the all-important question as to whether the *Cathartidæ* have been wisely arranged and distributed in the genera created for them, and, if such prove to be the case, to present the results of our labor, and so apply it as to settle these birds in the places they now occupy upon a still firmer basis, to the end that we may have it said that classification has been assisted and furthered.

Of the skull.—It will be remembered that when we treated of the osteology of the *North American Tetraonidæ* (Bull. U. S. Geol. and Geogr. Surv. Terr. Vol. VI, No. 2, pp. 311, and Plate V, fig. 51) we made a careful dissection of the skull in the young bird before the segmental anchylosis commenced, and figured and named all the various bones that enter into the cranium of the majority of the class. At this date, however, the author does not advise the student to implicitly follow the nomenclature there given, nor accept all of the deductions set forth. We have already informed our reader of the fact that it will be impossible to carry this interesting part of the subject out in the case of the *Cathartidæ* as we do not possess the necessary material. Still, the figure above referred to, and the description given for the young of *Centrocercus*, will no doubt assist us in approximating very closely the boundaries and limits of many of the cranial bones, not that there is the slightest relationship among the species of the two families, *i. e.*, the *Tetraonidæ* and the *Cathartidæ*, but that certain rules hold good in each. The outward appearances, though, in one case is quite striking, and led Dr. Coues to say in his Key:

"In a certain sense, they represent the gallinaceous type of structure; our species of *Cathartes*, for instance, bear a curious superficial resemblance to a turkey."—(Key to N. A. B., pp. 221, ed. 1872.)

It is hardly necessary to say here that osteologically the species are quite distinct, as *Meleagris* has its skeleton unmistakably stamped with all the characteristics of the *Gallinæ*, as *Cathartes aura* has all those of the Vultures, the two being very different.

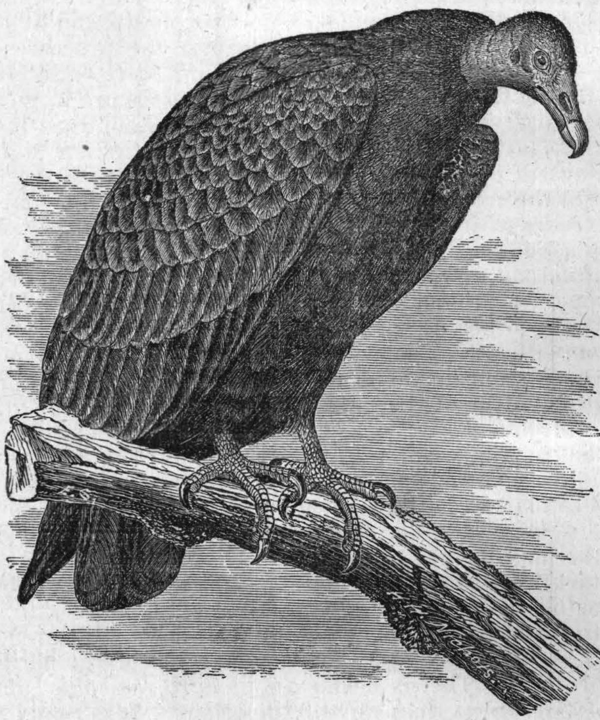
In the crania of the *Cathartidæ* we find that, after the different species have arrived at maturity, a union has taken place among the various segments of the so-called vertebral arches that is quite above the average result or condition in birds generally, for upon examination we find that we have only as free bones the ossa quadrata, the pterygoids, bones of the sense capsules (except the ethmo-turbinals), the hyoidal segments of the tongue, and the inferior maxilla, all the others having firmly united together, very few sutural traces of original separation being left.

Plates XXII and XXIV, figures 119 and 127, respectively, give good representations of the superior aspects of the skulls of *C. aura* and *C. atrata*. Many of the peculiarities we discern in these figures are common also to the other members of the family. We are struck at once with the great breadth of the pseudo-articulation that goes generally by the name of the "fronto-maxilliary." This is due principally to the fact that the nasal bones are unusually broad, in order to encircle the great sub-elliptical nostrils of these birds. This articulation, notwithstanding its width, is very mobile, and offers several departures from the usual mechanism of the system to which it belongs to interest us. We find that from the anterior border of the united *lacrymal*, on either side, a niche exists that gives rise to a process, below which process, in turn, has its superior border grooved lengthwise and converted into an articular surface for a quadrate apophysis thrown out by the outer and posterior angle of either *nasal*. In a position of rest a foramen remains at the base of this niche in the lacrymal formed by the two bones in question, allowing in action or movement the process of the nasal to glide into it. (Pl. XXII, fig. 118.) This is the state of things in *C. aura*.

In *Pseudogryphus* the nasal process is much longer, curved upwards, and glides over a greater surface on the lacrymal. The quadrate form of the nasal process becomes peg-like in *atrata*, really articulating in a socket on the interior aspect of the lacrymal. In the remaining species we find this joint more or less persistent, perhaps less so in the South American Condor. This mobility produces rather a confusing condition at the pterygo-basi-sphenoidal articulation, for we have observed in all of the *dry* skulls of the *Cathartidæ* that the pterapophysial processes of the basi-sphenoid never meet the facets on the pterygoids that are evidently intended for their articulation. This seems to be due to a warping upwards of the superior mandible during the process of drying, drawing both the palatines and with them the pterygoids away from these pterapophyses. If we take the pains, however, to dissect the head of a recently-killed Vulture, as the author has done, we will at once appreciate the normal state of affairs, and find that by the slightest pressure downwards of the upper bill the facets upon the pterygoids glide over the pterapophyses. We will find many of the illustrations representing them with the interspace between. Our own plates do so, and Professor Huxley has done so before us, as we find about 2 millimeters of space between the pterygoids and the processes from the sphenoid in his view of the base of the cranium in *C. aura*, although he remarks in the text, "The basipterygoid processes are large and articulate with the pterygoids." (Class. of B., Proc. Zoöl. Soc. Lond., 1867, pp. 440, fig. 22.) The reader will remember that in our figure of the base of the skull of *Speotyto* they remain *in situ* even in the dry condition.

To return to the fronto-maxillary joint we find in all of our Vultures the sutural traces of about the upper third of the *intermaxillary*, persisting, with a line between them, indicating to us that the process of the bone is bifid, as we found it in the *Tetraonidæ*. There are no good evidences that the ethmoid has not been completely hid beneath the frontals and the other segments that surround the point where it is sometimes superficially observed in other birds. In this position we find a more or less marked depression occurring in all of the *Cathartidæ*, caused by prominence of the frontals behind and alike elevation of the culmen in front, and the lacrymals and nasals on either side. This depression is shallow and broad in *Pseudogryphus* and *Cathartes*; deeper and more decided in *Sarcorhamphus* and *Catharista*, where a slight median elevation in the latter, better shown in *G. papa* than any, gives it the appearance of being double. From this point the upper and convex surface of the nasals, and the wide intermaxillary, cause the osseous culmen to start broad and spreading—to rapidly contract again between the capacious nostrils, then suddenly fall roundly convex to the tip of the beak, after first passing over a rise that occurs with greater or less abruptness just in front of the anterior margins of the peripheries of the nasal apertures. This is best seen in *Sarcorhamphus*, and less decided in *Pseudogryphus* than any of the others. It is really the upper culmenal depression that persists down the sides of the bill to cause the "swell" at its extremity in the Condor and Carrion Crow. (Fig. 118, Pl. XX.) The osseous tomia of the superior maxillary are sharp from a point taken below the center of the nostril, until they terminate at the point of the beak. This much of this margin at first presents a long convexity, then a corresponding concavity, to drop suddenly to the tip of the bill where the two meet anteriorly. A row of nutrient foramina are found at a greater or less distance above this margin in all the *Cathartidæ*, with numerous other smaller ones scattered about above them, without any apparent attempt at order or regularity. Venations caused by the vessels running into them are permanently impressed upon the bone in many instances; they are less perceptible in *S. gryphus* than in any other member of the family. The remainder and undescribed half of each tomium running backwards is flat or slightly rounded, and includes on either side about the anterior fourth (*C. aura*) to the seventh of the maxillary (*Pseudogryphus*). Owing to the deep sides, the inferior aspect of the upper mandible is very much scooped out, and strongly reminds one of a well-shaped canoe; two sharp little ridges, one on either side, start from the tip of the beak here, and run backward as far as the palatine articulation, being nearly parallel with the tomial edges at the middle of their course. The maxillo-palatine fissure is wide and sub-elliptical in outline, terminating posteriorly by an opening in its arc that leads into the true inter-palatine cleft. (Fig. 120, Pl. XX.)

In all of the *Cathartidæ* we find just within the lower border of each nostril a diminutive bony shelf, formed partly by the palatine, partly by the lateral processes of the intermaxillary; following this along



Cathartes aura.

towards the tip of the beak we find it to terminate in a conical socket on either side. In *C. atrata* they can be seen just within the anterior margin of each nostril, while in *Pseudogryphus* they are a full centimetre beyond.

The bony nostrils in these birds are placed upon the sides of the superior mandible and very nearly in their same planes. In form they assume more or less of an oval outline, being long and narrow in *atrata*, high and broad in the Californian Condor and the Turkey Buzzard.

In *Pseudogryphus* and *Sarcorhamphus*, less so in *Cathartes*, their inferior and posterior margins blend with the transverse plate of the ethmo-turbinal coming from within; this can hardly be said of *C. atrata*, as the latter bone in this Vulture is so far removed backwards into the rhinal cavity. The forms of the nostrils among the *Cathartidæ* can be better studied from the various figures in the plates than from any detailed description we might give, however elaborate it might be. Thus far we have spoken of the irregular wing-like bone found in the rhinal chamber of any of the *Cathartidæ* as the ethmo-turbinal, and it certainly fulfills the functions of that bone as found in others of the class, where it occurs. Not having the young of any of the Vultures at hand, however, we cannot say that its representative here ossifies as a separate segment, though to all appearances it does.

Huxley seems to refer to it when he says: "In the genera *Cathartes* and *Sarcorhamphus* the cleft between the thin and scroll-like maxillo-palatines is very deep and wide, and the ossification of the septum is small in extent, and only forms a sort of bridge over the deep and wide valley between the maxillo palatines."—(Classification of Birds, Proc. Zoöl. Soc. Lond., 1867, pp. 441.)

It consists essentially of a horizontal plate of bone extending across the nasal cavity to the rear of the nostrils, and about half way between the roof of the rhinal chamber and the palatine plates beneath. Mesially it throws out a sharp process in front (*C. aura*), which curls up in *Pseudogryphus* (Plate XVI, fig. 106), and another plate, that reaches to the roof of the cavity, where it extends backwards to meet the ethmoid in *C. aura* and *C. atrata*, and in all of the species spreads out more or less laterally, thus forming a strong abutment above, while it divides the space into two, that by the curling edges of the plates appear like true nostrils within.

The horizontal plate blends with the inferior borders of the external nasal orifices, and at their posterior peripheries throws up another brace, forming a foramen at these points in *Pseudogryphus* (fig. 106), and in the other species, but not so well marked (figs. 116, 118). On either side below the horizontal plate, lateral wings are developed, that curl inwards and backwards, reaching forward to be inserted with the palatines, showing an elliptical foramen in their sides just before arriving at the articulation. No doubt but this irregular ossification that we have been describing affords additional surface, when it is covered with the nasal mucus membrane, for the ramification of the nasal nerves. We have in our possession a specimen of a skull from *Catharista atrata* that shows extensive and distinctive necrosis of this region, the infraorbital bars being destroyed for their anterior thirds, with a terrible loss of structure to the ethmoid and lacrymals and the palatine plates beneath. Can we account for this state of affairs by saying that it is due to the entrance of putrid matters while feeding upon carrion through the apertures in these ethmo-turbinals? We believe that the disease in this Vulture before us must have eventually resulted in its death. It may be the cause of death among many of its kind, and, if so, would be another cause for the decrease in birds, and constitute an item to be taken in connection with Henshaw's interesting treatment of this subject. (Nutt. Ornith. Bull., Oct. 1881, pp. 189.) We would add that on the under side of the horizontal plate of the ethmo-turbinal we always find little pits existing, the only exception to the rule being, in the material we have—the cranium of *Pseudogryphus*. They are grouped without any particular regard to any special arrangement, varying in specimens of the same species.

The elevation existing immediately to the rear of the fronto-maxillary articulation has already been alluded to as a feature of the superior aspect in the skulls of our *Cathartidæ* from this locality as far back as the well-defined line limiting muscular attachment on the posterior aspect of the cranium and between the upper boundaries of the orbits. The surface of the skull presents a very evenly distributed convexity, it being most decided as it slopes away over the auricular entrances on either side. The median groove, present in so many of the class, is absent. The surface exhibits many osseous venations, the majority of which run to the foramina that exist in an irregular double row, removed by a few millimeters from the orbital peripheries. These foramina lay along in a shallow groove in these localities. From them the bony and sharp-edged brows overhang the orbital cavities below to a greater or less degree; we say for a greater or less degree because this is one of the characteristics of the skulls of these birds that seem to vary in every individual and in every species. As a prominent instance, look at the two crania of *Pseudogryphus* that we have before us; in one the superior orbital peripheries are jagged and thin, coming very close to the row of foramina described above, being only a little over 2 centimeters apart, measuring between points in the two lines that are the nearest together, while in the other they are rounded and arched over the orbital cavities, thick and heavy, the edges being nearly 5 centimeters apart, lending to the general aspect of the skull a far more raptorial look, as the osseous brows are thus made to be permanently arched and overhanging. This variance in the integrity or completeness of the vaults of the orbit may be due to the age of the specimen—the older the individual the more complete the roof of his orbit may be; but we have nothing to offer to sustain any such theory.

Ridgway in his "Outlines of a Natural Arrangement of the *Falconidæ*" [read before the Philosophical Society of Washington, April, 1875] gives us some very interesting and valuable studies upon the lacrymal and its superciliary process as found among these genera, illustrating his remarks with very good outline drawings of the species treated. We find that the lacrymal is subject to a great many changes as to its form, its method of articulation, the bones it comes in contact with, and so on. As these changes are quite constant for the species where they occur, they become valuable as points of distinctive differences for diagnostic purposes. Among the majority of the Hawks and Eagles the superciliary process stands out from the head, at a varying angle for different species, and may have articulating with its extremity an "accessory piece" (*Harpagus bidentatus*).

In *Micrastur brachypterus* so long and prominent has this superciliary process become, that, aided by the intervening membrane, it makes up the major part of the orbital vault.

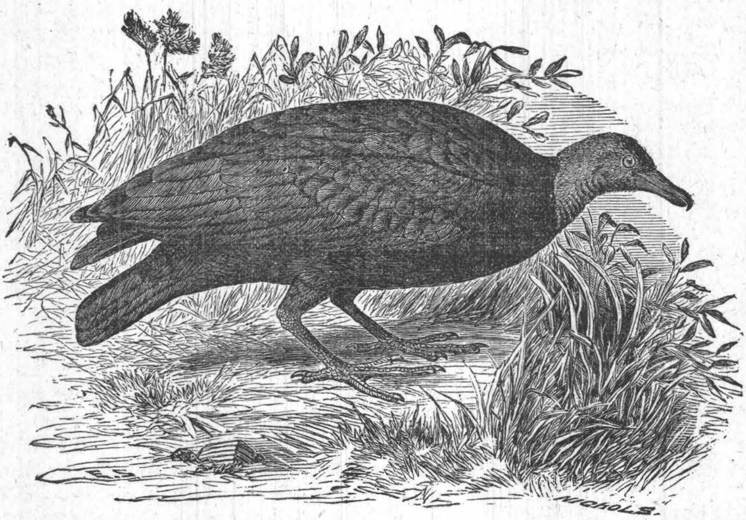
In *Polyborus auduboni* we find the body of the bone, freely articulating with the entire border of the wing of the ethmoid and three-fourths of the inner margin of the supercilary process, freely, though very intimately, meeting the frontal and nasal; the membranous interspace being limited.

The next interesting step we observe in the cranium of *Gypogeranus serpentarius*, where the superciliary process forms much the larger share of the entire bone, while the body becomes a mere inbent osseous bar that touches the ethmoidal wing at the angle. Here the inner border of the superciliary process meets the nasal and frontal segments for its whole length; the union being very close, but the suture plainly visible.

In *Neophron percnopterus* the arrangement leans more towards the *Falconidæ* than towards the *Cathartidæ*, though there is a positive step vulture-wards. In this bird the superciliary process has shrunk up in size, articulates principally with the margin of the nasal, while the body of the bone below engages the entire border of the ethmoid, all the natural traces being evident. The roof of the orbit is formed by the frontal. A very decided change takes place among the *Cathartidæ;* here complete anchylosis with the surrounding bones has taken place, obliterating all traces of original individuality on the part of the lacrymal. By its aid the great width is attained across the fronto-maxillary articulation. (Pl. XXIV, fig. 127.) Its body below knits with the ethmoidal wing, and is produced downwards, backwards, and outwards so as to almost touch the infraorbital bar, as a club-like process in *Sarcorhamphus gryphus* and *P. californianus.* Its outer side shows the groove for the lacrymal duct. By the assistance of the lateral extensions of the ethmoid, these bones make a very substantial partition between the orbital cavities and the rhinal chamber; above and between the two there is an opening for the passage of the nasal nerve and vessels.

It is difficult to say, from an examination of the skulls of the adult birds, whether the *vomer* exists in them as a separate ossification or not; we are of the opinion, however, that it does not; at any rate, there is no such bone present as we find among many of the Ducks and Geese (it must be remembered, however, in this connection that this delicate little bone is often lost in the maceration and preparation of *avian* crania).

The *ethmoid* (the *mesethmoid* of Parker) meets the vault of the rhinal space above in a spreading abutment; from this point it takes a direction



Catharista atrata.

downwards and backwards in the mesial plane, to become consolidated with the extremity of the basi-presphenoid, below. Behind, by extension of its median osseous plate, it assists to complete the orbital septum, while laterally it develops on either side alar productions that amalgamate with the lacrymals, as pointed out above. On its anterior face we have presented us a sharpened edge, extending up and down the bone in the mesial plane. The lateral wings in *C. aura* are removed far to the back, and they have from their lower boundaries horizontal plates developed that reach forward beyond the basi-presphenoidal tip, to the anterior base of the bone. This is a constant character and is only to be observed in *Cathartes aura*. The *palatines* are broad plates of bone, with a wide fissure separating them; anteriorly their extremities are wedged into the anchylosed articulation in common with the lateral processes of the premaxillary and the maxillaries. The posterior and upper thirds of their inner margins are fashioned to glide over the inferior and rounded surface of the sphenoidal rostrum, the articulation being a remarkably free one. Their posterior ends turn outwards and accommodate themselves to the entire crown of the heads of the pterygoids (Plate XXII, fig. 120), constituting the usual pterygo-palatine articulation. Descending lamina are developed from the inner margins of these bones, along the posterior half of the palatine clefts in all of the species. There is a disposition on the part of these plates to curve downwards, so that their outer margins are in a lower plane than their inner ones, their surfaces being smooth, and as a general thing their salient angles rounded. *G. papa*, in comparison with its size, seems to possess the largest and widest palatine bones of any of the *Cathartidæ*, while *C. atrata* has the narrowest.

The sutural traces of the three primary segments of the *infraorbital bar* have all disappeared, and we have remaining only the strong style that bounds on either side the orbital cavity below. On the inner side of its posterior end we observe a conical tooth-like apophysis placed at right angles with the continuity of the bone that fits deeply into a socket intended for it on the lateral aspect of the quadrate. The distal extremity of this malo-zygomatic link is firmly wedged into the articulation described above, being superior to the palatine, and slightly dilated in the horizontal plane, as the maxillary usually is. This bar has a gentle fall from before backwards until it arrives at the os quadratum. In *Pseudogryphus* it is much compressed from side to side, and presents a decided vertical swell in its anterior third. (Plate XVI, fig. 106.)

So large are the quadrate bones in the skull of any of these Vultures that they form one of the most prominent features on the lateral view of the cranium. The "mastoïdal process" looks very much as if it might originally have been a broad lamina of bone, facing directly forwards, but subsequently had been seized by the condyle, twisted one-third upon itself, and its articular facet placed in the concave depression in the squamosal; the long diameter of this latter lies in an oblique direction, and if its imaginary line were produced it would pass from the upper and outer margin of the auricular process towards the occipital condyle. This articular facet on the mastoid process is long and narrow, being convex from side to side, as well as from above downwards. The orbital process of either quadrate, though it looks very formidable from a lateral view, consists merely of a very thin, though broad, oblong lamina of bone, projecting at a right angle from the stouter mastoid process into the orbital space. Its inner extremity is finished off by a little raised rim. At its base, above the inner condyle of the mandibular end, we have presented to us for examination the sub-elliptical convex facette for the pterygoid, a special elevated crest being thrown out to support it. In all, with the exception of *aura*, a marked depression occurs just anterior to the articulation and immediately above the inner mandibular condyle. The Californian Condor seems to have this characteristic best shown. The condylar surface on the under side of the quadrate intended for the lower jaw is, as usual in so many birds, divided into two irregular, undulating facets, separated by a mid-depression; the long diameter of the whole being situated transversely. Quite a decided constriction exists between the mastoid and orbital processes and the mandibular end. The portion bearing the outer condyle is produced, outwards, forwards, and upwards, as a sub-cylindrical, stout apophysis, having in its extremity the deep, conical pitlet for the reception of the process upon the squamosal end of the infraorbital style.

The *pterygoids* are horizontally compressed and exhibit upon their mesial edges the elongate facettes for the pterapophysial processes of the basi-sphenoid; these facettes are towards the anterior and broader ends of the bones. The posterior extremities of the pterygoids are constricted and twisted upon themselves, so as to bring their articular facettes to meet those that were described for their reception upon the quadrates, while the anterior ends are dilated to afford the necessary articular surface for the palatines. These bones do not meet anteriorly in any of the *Cathartidæ*, but form the usual palato-pterygoidal articular apparatus for the rostrum of the sphenoid.

We cannot state at present with any degree of confidence whether the orbito-sphenoids develop in these birds from separate centers of ossification or not; at any rate, as a general thing, the orbital septum is quite complete in the smaller varieties of the family, but in the Condors and *G. papa* large and more or less circular deficiences, most usually only one, exist in this partition, about its middle. This sometimes fuses with the perforation that is found just anterior to the optic foramen. In all of our skulls of *C. atrata* this inter-orbital wall is entire and quite thick, but in all, with the exception of this Vulture, it is in either orbit, produced out, by division above, in connection with the ethmoidal wings, to the vault, and in so doing leaves a covered duct (double in *Pseudogryphus*) for the passage of the first pair of nerves from the rhinencephalon to the rhinal chamber beyond. So deficient are the walls of this osseous duct in *C. atrata* that it is really reduced to a canal. Even in *Cathartes aura* we occasionally find foramina, due to the too great thinning of the walls, present, and opening into the passage. In the back part of the roof of the orbit we find the usual circular foramen for the orbital vein, with a shallow groovelet leading from it in all of the *Cathartidæ.*

In *Neophron* this arrangement is like it is in the *Falconidæ*, *i. e.*, an open channel is provided for the nasal nerves.

The orbital septum sustains one other perforation, already referred to, and can be best described by saying it is a piercing of the partition immediately in front of the orbital foramen proper, thus allowing very nicely the passage of the branches of the crossed optic chiasma. Other nervous foramina are found to be distinct. The only example of the *sclerotal plates* that we have are a set from the eyes of a specimen of *C. aura*. In this Vulture they number fifteen in each eye, are very broad, overlapping each other by about one-fifth of the extent; their corneal margins are turned outwards, while their sclerotal ones are reflected in the opposite direction. We have but little doubt that when opportunity for examination offers, this description will apply very closely for these platelets among others of the *Cathartidæ*.

All of the cranial segments, or rather such of them as usually go to form the brain-case, have become thoroughly anchylosed in this family. Original sutures, boundaries, and land-marks have disappeared in the adult birds, leaving not a trace behind them to acquaint us as to the position of the primoidal elements. A study of the superior aspect of the skull has already been submitted to the reader and its leading features sufficiently well dwelt upon; now, viewing the cranium from a lateral standpoint (see plates of skulls), it presents for our examination, in addition to other points that we have already considered, 1. The entrance to the organ of hearing; 2. Two prominent processes; 3. The general surface.

The posterior boundary to the aural aperture is formed by a strong, raised, semi-elliptical rim, the upper border of which is produced forwards in all of the *Cathartidæ* to terminate in a horizontal and conical apophysis, one of the two mentioned above. (Fig. 113, Plate XX.) This flaring entrance to the ear gives us a very good opportunity to examine into some of the osteological features of this organ as seen in the vulturine head. We observe the funnel-shaped opening of the Eustachian tube; the foramen leading to the inner ear, as well as several vascular foramina.

In fact, in our California Condor, so shallow is this outlet that by the inexperienced it might be easily overlooked as not forming any part of the aural apparatus.

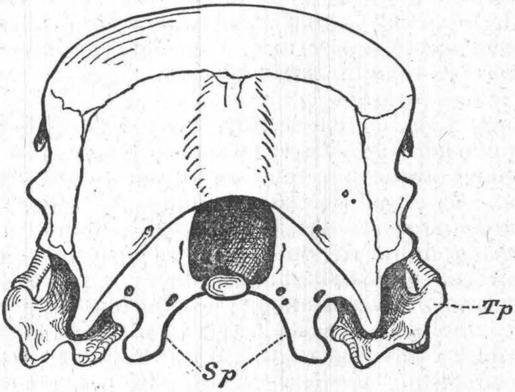
The remaining process found on the lateral aspect of these skulls is above the one we have just described, and is directed almost directly downwards, having only a slight inclination outwards and forwards. We are of the opinion, and believe our reader will agree with us after an examination of the segmented cranium that we presented in the *Tetraonidæ*, that this process was no doubt developed by the alisphenoid. It becomes compressed from side to side in *Neophron*, still more so in the Secretary Vulture, while it is positively wing-like in *Aquila canadensis* and in the majority of the Hawks and Owls. The intervening valley between these two processes is roundly concave, as the squamosal surface of this lateral aspect is generally convex outwards above and slightly concave below, forming, as it does, the temporal fossa on either side, and showing a limital muscular line above. The uppermost of these two processes is called the sphenotic.

The posterior wall of the orbital cavity is quite smooth and concave from above downwards in *C. aura* and *C. atrata*, less so in *G. papa*, while in *Pseudogryphus* and the South American Condor it is nearly flat and slopes away rapidly towards the sphenoidal suture, being marked by several transverse lines or ridges. The "foramen ovale" is unusually large in these birds, and is to be found rather low down in the orbit, almost hidden in the shadow of the great quadrate bone on either side.

Passing to the basi cranii we find in *Cathartes* and *Catharista* the *foramen magnum* to be nearly circular in outline, while in *Pseudogryphus* and *Sarcorhamphus* its vertical diameter is the longer. The bony walls of the back of the brain-case project beyond this important aperture in the median line and with a gradually lessening amount on either side, due to the fact that these birds all have long and markedly prominent "cerebellar prominences," which rise, dome-like, above the foramen of the occiput. This is strikingly the case in *Pseudogryphus*, in which, as among others of the *Cathartidæ*, the inferior border of the cerebellar prominence and the superior arc of the foramen magnum lie in the same line, which line slopes away on either side to terminate in the paroccipitals or lower angles of the raised ridges that bound the ears. This line or ridge forms a striking feature in rear views of the skulls of the *Cathartidæ*, and is present to a greater or less degree in many of the diurnal and nocturnal Raptores. The condyle, situated at its usual site in the median line, fairly on the lower border of the foramen magnum, is broadly and transversely elliptical; in fact, it may be said to be semi-ellipsoidal in form and nonpedunculated, though prominent. It has a faint median notch above in all except *Pseudogryphus*, where it is very feebly marked, if it occurs at all. We have specimens of *C. atrata* before us in which the occipital condyle is fully as large as in our specimen of *Aquila canadensis*; indeed, as a rule it seems to be larger throughout the Vultures than in the *Falconidæ*.

In *Polyborus tharus* it is completely sessile and hemispheroidal in form, being still smaller, and in the Crows and Jays we know it is comparatively still more diminutive. The area that includes the foramen magnum and the occipital condyle, and is bounded laterally by the elevated aural ridges, is depressed below the surrounding points in the basi-cranii of all of the *Cathartidæ*. In this space on either side we discover the usual venous and nervous foramina, the precondyloid foramina, and those for the vagus and jugulars, the latter group occupying the base of a special depression for themselves.

We find in many birds, beyond the condyle, on either side, a descending tuberous process; they show pretty well in a fine specimen of the Canada Goose that we have at hand, while they are entirely absent in our skull of *Circus*, and only moderately developed among the Eagles. In the *Cathartidæ*, however, this pair of processes become the leading feature of the base of the cranium, though it must be remarked that they are not always equally well developed, for we have crania of *C. atrata* in our possession in which one would hardly be struck by them as worthy of particular notice. In one of our skulls of *S. gryphus*, however, and another of the Californian Vulture, these processes are remarkably well developed, being great tuberous projections that spring from extensive bases, taking a direction downwards, outwards, and a little backwards. Their inferior extremities seem to be designed for muscular and ligamentous attachment. In the accompanying cut, *Sp* designates this pair of processes, and *Tp* a quadrate bone. This figure is life-size from the smaller skull of the two specimens we have of our Californian Vulture; it illustrates many of the points that we have just passed over in our description of this view of the cranium. These basal processes form the outer angles of an isosceles triangle, the apex of which is the lip beneath the Eustachian tubes (Plate XXII, fig. 120, *C. aura*), and the sides, the lateral portion of the basi-cranii. The Eustachian tubes open at their usual site in one capacious common aperture, the gutter leading from the entrance of which is seen on the basi-pre-sphenoid. These tubes are conical, the apices being at the anterior opening; it is not uncommon in *C. aura* to find these passages not closed in by the anterior bony wall, and the general aperture is quite wide in *Pseudogryphus*. The foramina for the passage of the carotids are found near at hand in the recess. On either side of the Eustachian groove, jutting from the base of the sphenoidal rostrum, we observe the pterapophysial processes; they are directed forwards, outwards, and a little downwards, each being crowned by an elliptical facette, the major axis of which in each case is nearly in the horizontal plane. We have already dwelt upon the fact as to how these apophyses meet and articulate with the pterygoids. They are



Rear view of cranium of *Pseudogryphus californianus*.

more prominent in *Gypogeranus* than they are in the largest of our Condors, while in *Neophron percnopterus* the pterygoids stand well away from the basi-sphenoid and no such processes are present. In *Polyborus* not the slightest evidence of them exist, but in *Aquila* and *Circus* we find diminutive sharp spines jutting from the usual points, but they do not possess articular extremities, nor do they ever meet the pterygoids in these birds. It will be remembered that we found them in quite a number of the American Owls, and we believe they are present in all of them.

Gently inclined upwards, very long and robust, we find the basi-presphenoid in all of the *Cathartidæ*, carrying out its functions in the median cranial plane. Above it has become thoroughly blended with the interorbital septum and the mesethmoid, below it is rounded and smooth, and affords the common articular surface for the pterygoids and palatines. In *Pseudogryphus* it has a length of four centimeters, and in *C. aura* develops a little spine anteriorly that projects beyond the mesethmoid.

We show in our cut of the rear view of the cranium in *Pseudogryphus* how the region of the occiput is bounded by the superior muscular line, both laterally and above; this line is well marked in all of these Vultures. The lines at the sides are quite ridge-like in the California Condor, parallel and in the vertical plane, while the line forming them above is a long, shallow arc, with its concavity towards the cerebellar prominence; this is also the case in *C. atrata*. In *Cathartes aura* the side lines are curved outwards, while the superior line is broken at its middle point, which point is carried down on the cerebellar prominence for about one-third of its distance from above, in the median plane, where the extremities of the broken line join it at a gentle curve on either side. This is nearly the pattern as seen in *G. papa*, but in *S. gryphus* we again find it as we described it in the Northern Condor, only we have in the former a slight inclination for the point to come down on the prominence.

If we remove a section of the vault of the cranium, and this has been done here in *C. aura* and *Catharista*, in specimens of skulls of these birds that have been in collections for several years,* we find that the internal and external layers or the cranial tables are very thin, and that a fair amount of diplöic tissue is placed between them, especially towards the occipital region, where, as we approach the locality of the internal ear on either side, it becomes several millimeters thick; the cellular network being more or less coarse in texture. The internal walls of the brain-case as thus exposed are smooth, being traversed only here and there by vascular tracts and grooves for the exit of certain nerve branches. The fossæ designed for the reception of the different cephalic lobes are moderately well separated, the one that contains the epencephalon being the most distinct, aided as it is by the internal concavity of that external feature of the occiput that we described above as the cerebellar prominence; the usual transverse groovelets do not mark this section here on the internal table. This distinctness is further assisted by thin horizontal off-shoots from the united bones of the ear-cell. The internal auditory foramen is unusually large and predicts a correspondingly good size for this important nervous branch; the same remark applies to the trigeminal and its orifice of exit. Remarkab e depth and space is allotted to the fossa for the lodgment of the hypophysis, the "sella turcica," as this receptacle is known by in anthropomy,

* For changes that may possibly take place, see author's remarks in Osteology of *Lanius ludovicianus excubitorides* (Bull. Geol. and Geogr. Surv. of the Terr., Vol. VI, No. 2).

its posterior wall being as high as the anterior, and the cavity having a depth of three or four millimeters or more. In our specimen of *C. atrata*, an elliptical perforation exists in its hinder wall near the bottom; the carotids seem to invariably pierce its base within, by two openings. Immediately above and anterior to it we find the optic and other nervous foramina spoken of when engaged with the orbital cavities. Passing to the rhinencepalic fossa, we are not disappointed in finding that this cavity is also equally spacious and well developed, and lodging as it does, the encephalic lobe that presides over the sense of smell, this fact becomes particularly interesting, insomuch that it may indicate extraordinary powers on the part of this faculty. The orifices of exit for the olfactory nerves are *double* in the *Cathartidæ*, which is an exception to the general rule. Professor Owen found the same state of affairs in a Vulture that he dissected, and this able anatomist made this remark upon what he observed: "In the Vulture the olfactory nerve is single on each side, and continued from an olfactory ganglion or "rhinencephalon" along the upper part of the interorbital space to be distributed upon an upper and middle turbinal, the latter being the largest."—(Anat. of Verts., Vol. II, pp. 123.)

Along the roof of the cranial cavity, in the median line, the "longitudinal crest" is seen to pass. This may become grooved as it approaches its anterior termination, or for its anterior half, which indeed is the case in the majority of these birds; the groove dilating, and the whole merging into the general surface immediately before arriving at the conical rhinencephalic recess just referred to above.

Fig. 115, in Plate XXI, gives us a very accurate idea of the *hyoid arch*, taken from an adult specimen of *Cathartes aura*. Like the other subjects presented the reader, it is life size; in it we notice that the glossohyal remains in cartilage during the life of this Vulture, and that the ceratohyals, as two slightly curved, elliptical osseous plates imbedded in it at its base, articulate by the margins of their posterior arcs with facettes on the anterior aspect of the basihyal; they are also tangent to each other at their middle points in the median line. In its turn, the basihyal seems to share largely the requisite support for the broad fleshy tongue in this bird; to do this, it has been given an extensive horizontal plate that is further strengthened by a keel below. This horizontal plate is concave above, dilated at its extremities, more so at the posterior one, where it produces a rounded process, mesiad, that is continuous with the carina beneath. This keel is deepest behind, sloping gradually to the anterior part, where it merges into the horizontal plate and the thickened, elliptical facettes for the ceratohyals. Posteriorly, it is produced downwards as a long, slender apophysis, terminating in cartilage, that no doubt represents the connate urohyal. At the sides of this keel, opposite its deepest part, there are, on either lateral aspect, cup-shaped depressions to receive the expanded heads of the hypobranchial elements of the thyrohyals that articulate there. These latter are found to be two rather robust, long bones, with upturned and cylindrical shafts, that articulate in their turn with the anterior heads of the ceratobranchial elements behind them. The ceratobranchials are still more curved than their stouter companions, and gradually taper off to cartilage-tipped points posteriorly.

In contradistinction to the *Falconidæ* and the Old World Vultures, the members of this family are armed with much more powerful lower maxillæ, this increased strength lies principally in the greater depth of their rami and consequent breadth of the symphysis, as well as the ponderous articular extremities, that these jaws possess.

The vacuity, forming such a characteristic feature on the sides of the jaw in so many of the class, is here rarely or never present. In *Pseudogryphus* its location is merely indicated by a shallow slit, that does not penetrate to the bone, though in *G. papa* it does for a limited distance along the base of a similar slit, but in our specimen of *S. gryphus* every trace of the locality of the foramen has been obliterated; again in *Cathartes* and *Catharista* narrow and faint groovelets are the sole indicators of its position, or the margins of the elements that originally bounded it.

Deep pits are found in the centers of the upper surfaces of the articular ends; these are bounded externally by narrow, longitudinal facets, as do the inturned conical processes support more irregular ones. In the Californian Condor there is a predisposition to develop from these articular ends quadrate apophyses behind, in weak imitation of the spur-like affairs that we found so characteristic of the *Tetraonidæ;* this effort does not seem to be so thoroughly entered into by the others. The under surface of either articular end is divided into two by a longitudinal ridge, continuous with the lower ramal border; of these two surfaces the lesser and outer faces outwards and downwards, while the inner and larger faces downwards and towards the median plane.

Almost an unbroken smoothness characterizes the internal and external surfaces of the sides of the jaw; this is extended to the entire dentary region beyond. Even the ramal borders bounding these surfaces above and below are notorious for the nice manner in which they are evenly rounded off, there being scarcely any evidences of the coranoidal projections to interrupt this general smoothness; it is only in the superior one, that for its anterior third on either side, and as it sweeps around the curve of the symphysis, that it becomes sharp, to correspond with the tomial edges of the mandible above.

The depth of the symphysis in *Pseudogryphus* is about two centimeters, and the deepest part of the jaw, the ramus just beyond the articular ends, is 1½ centimeters; for *aura* and *atrata* the measurements are equal. The curve that is continuous with the lower ramal borders, limiting the symphysis posteriorly, is parabolic in outline. Viewing the mandible in the *Cathartidæ* from a lateral aspect, when it has been articulated with the cranium, we observe that it is bent downwards from a point a a little posterior to the distal end of the maxillary, from which point it is obliged to accommodate itself with the superior mandible. A row of foramina is always present just within the sharp edge of the superior border beyond, and still within these a few others are scattered about; one or two isolated, though parial, nutrient and vascular foramina are found at corresponding points, along the sides of the mandibles of all these Vultures.

Having now passed, and we trust with sufficient thoroughness, over the osteology of the vulturine skull in general, and the osseous portions of its sense organs, may it not be in place and an advantage to us to ask the question here, Where have we detected any differences among these birds, so far as we have carried the subject? To present, or really to recapitulate, these for our reader, we will here arrange the most prominent departures among the species in a tabulated form, or at least such of them as we deem worthy of reconsideration. This method we shall follow, after the discussion of each of the parts or divisions of the axial skeleton or its appendages that may be thus separated, grouping as much as we can into one table, without jeopardizing its utility, deferring, however, general conclusions and comparisons for the concluding paragraphs of this monograph.

Table of the chief cranial differences and similarities.

Name.	Form of nostril, &c.	Articulation of nasal process with lacrymal.	Arrangement of the mesethmoid and its lateral wings.	Rhinal septum, present or absent.	The superior muscular line of the occiput.	The condyle and the descending processes at the basi-cranii.
S. gryphus	Sub-elliptical; superior half of the arc being the flatter.	Very intimate, apparently by a stout process from the nasal, being wedged into the upper side of the lacrymal.	Anterior surfaces of the bodies of the lacrymals about in the same plane with the same surface on the ethmoid; wings of the ethmoid anchylose completely with the lacrymals.	None; ethmo-turbinals encroach slightly on the posterior curve of external nostril.	Nearly straight across, forming only a slight point on the cerebellar prominence.	Condyle is broadly elliptical; indented above; the processes well marked.
G. papa..........	Same; only the nostril is deeper for its length.	Same; though apparently freer and more movable.	Same; *i. e.*, anterior surfaces of the bodies of the lacrymals are about in the same transverse plane with the same surface on the ethmoid.	None; otherwise the same.	Same	Same.
P. californianus .	Same; although the anterior curve is the broader.	Very much freer, by a flat process from the nasal on the upper surface of the lacrymal.	Wings spring from the body further back, towards the orbital cavity; otherwise the same.	None; the descending process of ethmo-turbinal forms a foramen with posterior border of nostril.	Convex above; nearly straight across.	Nearly hemispherical superior indentation barely perceptible. Processes well marked.
Cathartes aura...	Nearly as in *G. papa*; twice as long as deep.	By a process sliding into a socket in the lacrymal; quite evident in square lateral view.	Same; with the marked exception that horizontal wings are also developed that join the vertical ones, and with them the lacrymals.	None; less encroachment on the part of the ethmo-turbinals.	Deep; point descending on the cerebellar prominence.	Subelliptical indentation more decided; descending processes are smaller.
Catharista atrata.	*Long and narrow;* four times as long as deep, and placed more horizontally.	By a nasal process in a slit-like socket; nearly concealed in lateral view.	Same; wings spring from the body well forward, anchylose thoroughly with the lacrymals. Passage for the nasal nerves always more or less open.	None; same as in *aura*..	About as found in *P. californianus*.	As in *C. aura;* descending processes ridge-like.

Of the vertebral column.—The manner in which the vertebral column of birds should be divided has been differently viewed by ornithotomists. The two principal reasons for this difference of opinion, no doubt, has arisen from the various arrangements assumed by the free ribs at the anterior part of the column, and the equally diverse manners in which the innominate bones of the pelvis attach themselves to the column. Without entering very extensively into the literature of the subject, let us first examine into the question as to where the line shall be drawn between the cervical and dorsal vertebræ. We seem to have presented us here two very uncertain guides; the first being whether the first free ribs are connected with the sternum by sternal ribs or hæmapophyses, and the second upon the character of the vertebræ—that is, whether they have the appearance of dorsals, as we usually find them, or cervicals as we usually recognize them. Professor Huxley sharply defines the line when he says: "The first dorsal vertebra is defined as such by the union of its ribs with the sternum by means of a sternal rib; which not only, as in the *Crocodilia*, becomes articulated with the vertebral rib, but is converted into complete bone, and is connected by a true articulation with the margin of the sternum." (Anat. Vert. An., p. 237.) Professor Owen takes a different view of the subject when he states that "In the first and second dorsals the pleurapophysis (1 and 2) terminate in a free pointed end, like the "false floating ribs" of Anthropotomy; in the third the pleurapophysis, *pl.* 3, articulates with the hæmapophysis *h;* which, in connection with its homotypes, constitutes the bone called 'sternum,' *f.*" (The letters given refer to a cut showing the first three dorsal vertrbræ and scapular arch of a bird, in diagrammatic side view. (Anat. of Verts., Vol. II, p.15.) It will be remembered that when we examined into the osteology of *Eremophila* we found sometimes that the second pair of free ribs, or rather freely articulated ribs, were connected with the sternum by hæmapophyses, so that in this case some would claim them as true dorsals, or as dorsals any way (Owen); while others could but say that the number of pairs of dorsal ribs varied. This state of affairs in *Eremophila* is no more an impossible thing or unusual occurrence than the occasional presence of cervical ribs in man. (Owen, Anat. Verts., Vol. II, p. 298.)

Now, among the *Tetraonidæ* we found another condition that proved equally puzzling; with them it will be recollected that there were, in the backbone in the dorsal region, four vertebræ that in the adult were completely fused together, and that the pairs of ribs that articulated with the anterior vertebra of this compound bone did not connect with the sternum by hæmapophyses. Here we must, if we consider the floating ribs in this region as cervical ribs, consider that a cervical vertebra has become anchylosed with three dorsals, together forming a bone that we believe every one would, as the writer then did, say was composed of dorsal vertebræ alone, in spite of the anterior ribs not joining the sternum by sternal ribs. One other case, and let us take a specimen of *Asio wilsonianus* to illustrate it. In this bird we discover, passing from before backwards, that the first pair of free ribs hang from beneath the transverse processes of the vertebra as diminutive bonelets, as we found them in *Speotyto*. Now, the next vertebra behind this one has all the appearances of a true dorsal vertebra, (possessing the lofty neural spine, etc.); but the ribs still fail to connect with the sternum by sternal ribs. These three varieties may be again divided when we come to consider the appearance or non-appearance of uncinate processes upon these ribs, a condition which likewise varies. At present I do not propose to definitely state my views in regard to this matter, but it will be seen from what follows that I consider the free ribs in this locality in the *Cathartidæ*, as well as the *Falconidæ* referred to, as cervical ribs. This may be my final opinion.

Now, so gradual is the passage from the processes on the cervical vertebræ from which the ribs are formed to free ribs among the Vultures, that indeed, the first cervical *rib* has more the appearance of a bony plate than a rib, yet it freely articulates with its vertebra as the rest of the dorsals do, and its presence makes the number of cervical ribs in *C. atrata* reckon *three.* Again, the vertebræ possessing these free ribs are situated opposite the clavicles and other parts of the scapular arch, and form the "root of the neck," being so far removed from the dorsal region that we can only regard them as true cervical vertebræ, The rudimentary manner in which these ribs are first exhibited on these vertebræ is well shown in Plate XXI, fig. 114, *cy, cy*, for *Cathartes aura*, while in *C. atrata*, as we have remarked, the par-pleurapophysial plates are free as ribs in the vertebræ beyond these even.

This arrangement reduces the number of dorsal vertebræ in *Sarcorhamphus* and *Pseudogryphus* to only three; that is to say, that in these genera we find three free segments in the mid-column, where the pleurapophyses are connected with the sternum by the sternal ribs, while the vertebra immediately posterior to them is with these birds firmly anchylosed with the ossa innominata. On the same page, then, we have just quoted from Owen's Anatomy, it will not surprise us to find the statement in regard to the dorsal vertebræ that "they have not been observed to be fewer than four (in some Vultures) nor more than nine throughout the class; the latter number obtains in *Apteryx;* the most common numbers are six and seven." Now, if we accept this, and also this anatomist's arrangement that the free ribs are dorsals and the vertebræ bearing them dorsal vertebræ, and there being "usually two of them," then it would leave us a very limited number of vertebræ between them and the sacrum that were connected with the sternum by sternal ribs (at the most two) in the Vulture referred to; so we are compelled to think, knowing as we do the usual condition of the ribs in these birds, that on this occasion the distinguished zoötomist himself reckoned his four vertebræ as those that were articulated with the sternum by the intervention of sternal "hæmapophyses," and for the moment did not note the free ribs. This would give the same formula as *C. aura* and others.

With the exception of the vertebræ that are grasped by the pelvic bones, these segments in all of the *Cathartidæ* are freely articulated with each other. This is likewise the case with *Gypogeranus* and *Neophron percnopterus*, and obtains also with our *Circus hudsonius*, in which species *five* vertebræ are allotted to the dorsal division of the column. Again, we find it in *Accipiter cooperi*, while in *Tinnunculus sparverius* and *Polyborus tharus* at least four of these vertebræ form one solid bone in the adult specimen; in *Micrastur brachypterus* there are again five dorsals, and all independent segments.

Unfortunately, all that remains of our specimens of *Pseudogryphus*, so far as the vertebral column is concerned, are a few of the free ribs and several scattered vertebræ; two of these are the third and fourth cervical, another one from the middle of the neck; one of the last cervicals and lastly the ultimate dorsal—this latter we have devoted a figure to, representing as it does no doubt the largest avain vertebræ of any living form to the northward of the range of the South American Condor—nevertheless, we think we may predict, almost with certainty, that even from these few fragmentary pieces it will be found to be the case, that when the opportunity offers for an examination of a perfect skeleton of this bird, that the number of segments in the spinal column will be the same as in *Sarcorhamphus;* we have been assisted in arriving at this conclusion by a critical examination of the ribs we have, as well as the sternum and sacrum, that come very near to *S. gryphus.*

We have carefully counted the vertebræ in the different species before us, and in order that the reader may have them for easy comparison, we present the various results in the form of a table, here subjoined, in which will be found other important and useful data. The number of sacral vertebræ must be accepted with a due amount of caution, as we all know it is quite difficult to decide on the number of segments devoted to the "sacrum" in adult birds, after anchylosis has thoroughly been accomplished.

Table for the comparison of the vertebræ.

Species.	Cervicals.	Dorsals	Sacral.	Cocoygeal, exclusive of the pygostyle.	Number of pairs of free pleurapophyses or cervical ribs.	Number of pairs of sacral ribs.
P. californianus	......	......	13	......	......	......
S. gryphus	17	3	13	6	2	3
G. papa	17	3	13	6	3	3
C. aura	15	4	13	5	2	2
Catharista atrata	15	4	14	5	3	3
Neophron percnopterus	15	4	15	6	2	2
Micrastur brachypterus	14	5	13	7	3	1

The specimen of *Micrastur* shows an interesting phase on the part of the "hæmapophyses" of the pair of sacral ribs, for we observe the one on the left side articulates with the sternum by expanded extremity on a perfect facet as the other sternal ribs do, while on the right side the "hæmapophysis" of the sacral rib does not reach the sternum, but on the other hand lies along the posterior border of the sternal rib next beyond, as it does in many other birds. This gives us in this bird six facets on the costal border of the sternum on the left side, and only five on the right.

Then, in our skeleton of *Neophron* we find a pair of sternal ribs, the last pair, springing from perfect facets on the sternum, that do not meet corresponding sacral ribs coming from above, but are apparently held in their position mainly by the intercostal muscles and membranes. Such facts and instances as these must make us necessarily a little wary, when we have only parts of skeletons in our possession, from which we have to decide as to the number of vertebræ or ribs in any particular instance.

The *Cathartidæ* being large-boned birds generally, we find that this feature is extended to the segments of the spinal column. The vertebræ are large, and all their various processes well marked and strong.

In the cervical region or division of the column we find the vertebral canals as usual, passing from vertebra to vertebra, along on either side; in each segment the tube remains throughout more or less subcircular, and is closed in the ordinary manner by the parapophyses and pleurapophyses of each vertebra. The protection afforded the vessels is markedly complete, for it is only in the atlas and axis that we discover slight deficiencies in their lateral walls. The neural canal as it passes through the vertebræ of the upper half of the neck is nearly cylindrical, but as we approach the middle of the neck it gradually becomes compressed from side to side, and assumes the vertical ellipse, to become circular again before arriving at the dorsal region. In the *atlas* the facet for the condyle of the occiput is semilunar in outline, and the neurapophyses are broad above, but as usual exhibits no sign of a neural spine. Below we commonly find a well-marked hypapophysis, though this feature is absent in *C. atrata;* laterally we have the unclosed vertebral canal of this bone, the processes receding from each other as sharp spiculæ. These points are still nearer together in the *axis*, and in this segment we find a thick, quadrate, neural spine occupying the center of the arch above. Below, the hypapophysis is carina-like in character, traversing in the median line the entire centrum of this bone. The odontoid process is an insignificant tip, being quite broad from side to side, while the postzygapophyses are tuberous lateral projections, with the facets on their under aspects in the horizontal plane, looking directly downwards, with the anapophysial projections above, elevated into prominent though blunt tuberosities.

The facet for the third vertebra is convex from side to side, and looks almost directly upwards, it facing slightly backwards; the similar surface for the atlas, anteriorly, being much more extensive, twice as broad, continuous with the articular surface beneath the odontoid process, is directed forwards. Solidity and great breadth marks the third cervical vertebra; in it bony laminæ connect, on either side, the pre- and postzygapophyses, an elliptical foramin being found in the surface near each lateral margin.

There is a conspicuous neural spine with thickened crest, while below we have a quadrate hypapophysis. The vertebral canal is completely closed in, and parial parapophysial processes begin to make their appearance, being directed backwards; in all of the Vultures these spine-like appendages are long and styliform in mid-neck, to become broad and tuberous as we proceed dorsalwards.

Facets upon the pre- and postzygapophyses of this vertebræ are elliptical in outline and comparatively large; the former are directed upwards and a little forwards, the latter almost directly downwards. The anterior facet of the centrum, below and immediately outside of the neural canal, partakes of its usual ornithic characters; it is very narrow from above downwards and decidedly concave from side to side. In this vertebræ, the last remnants of the carotid canal are present in all of the *Cathartidæ;* it is formed in its usual manner as we pass down the serial segments. In *S. gryphus* its first appearance is made in the eleventh cervical, but in the tenth in *G. papa*, as is also the case in *C. aura* and *Catharista*. More or less complete interzygapophysial bars are found joining the process laterally in the fourth vertebra. The hypapophysis of this segment is reduced to a low ridge beneath, while superiorly the neural spine still projects from the lamina, mesiad, as a vertical peg-like process. The articular facets are about as we found them in the preceding vertebra.

As a rule, the hypapophysial process throughout the cervical series, after passing it when it is double for the carotid arteries, is found better marked on the next two or three ultimate vertebræ. Those cervical vertebræ that possess free ribs rarely show a distinct hypapophysis, but in them the centrum beneath is broad and oblong in figure, with a faint ridge mesiad at the usual site.

Another suppression takes place on the part of the neural spine among the vertebræ found in mid-neck; it is but feebly developed in the fifth segment, still more so in the sixth, and is nearly lost in the few following vertebræ as we proceed down the neck. It soon reappears again, however, as a broad, knob-like apophysis, to become compressed from side to side, quadrate, and finally like the anterior dorsals.

In the *Cathartidæ* we find a diapophysial process jutting out from the wall of the vertebral canal, laterally and at the anterior part of the vertebra; this character is best marked as we approach the dorsal region, and we find that upon those cervical vertebræ with the free ribs it is quite broad and exhibits a metapophysial ridge.

Upper cervical vertebræ show long postzygapophysial processes, and throughout the series the arms bearing these articular facets are shortened or lengthened in such a manner as to preserve the decided sigmoidal curve so characteristic of the vulturine neck. As we arrive at the middle of the cervical chain of segments, we notice that the anterior articular facets are barely concave, face directly inwards, and so, each other, occupying a position, on either side, on the bony ridge that spans the vertebral canal above.

Epipleural appendages are never found upon the free ribs of the cervical vertebræ of the American Vultures, and this condition seems to obtain pretty generally among the *Falconidæ*, though these ribs become more and more like the true dorsal ones as we advance in that direction.

In a communication just received from Mr. Frederic A. Lucas, Ward's National Science Establishment, Rochester, N. Y., we learn that this observer found in *Otogyps calvus* "fifteen cervical vertebræ; two pair of cervical ribs, first very small, both without uncinate processes. No uncinate process on last rib." This last remark probably refers to the sacral rib, which rarely bears an epipleural appendage. This observer further states that he found "a bony internasal septum (in this bird), with a skull proportionately shorter and higher than in *Vultur cinerea*." From the sketch he kindly presented me the nostril has its long axis inclined nearly vertical rather than longitudinal. And, further, for *Vultur cinerea* we find "fifteen cervical vertebræ; two cervical ribs, first smaller than in *O. calvus*, both without processes, small uncinate process on last rib" (sacral?). "A bony internasal septum" was found in *V. cinerea*.

Then for *Gyps bengalensis*, "Cervicals seventeen; last two cervicals bear a rib, the first of which is 45 millimeters long, being 40 millimeters longer than same rib of *V. cinerea*, and 38 millimeters longer than in *O. calvus*. Second cervical rib with long uncinate process. Last rib with uncinate process" (sacral?). "A nasal septum, but no bony projection within nostril, as in *V. cinerea* and *O. calvus*. Skull much more like *Cathartes* in its shape than any other large Vulture I have examined." No doubt means general contour, as *Cathartes*, we know, has not a nasal septum present.

Lateral wings are seen to project horizontally from the centrum of the ultimate cervical beneath, and so we pass to the first dorsal, in the majority of the *Cathartidæ*, these wings still persist, but are not so far-spreading, and are, as it were, drawn downwards at the expense of the centra, the latter becoming more compressed, the former, now attached by a quadrate pedicle, are true hypapophyses with flattened and expanded extremities, which latter contract, and the pedicle becomes longer as we approach the sacrum. These are very prettily shown in *S. gryphus*, and in all of our Vultures are a striking characteristic of the dorsal series.

Rim-like projections are observed to bound the facets of articulation among the centra in this portion of the column; these latter are sub-compressed at their middles and quite deep—this does not seem, however, to influence the form of the neural tube in this region to any great extent, as it remains almost uniformly circular throughout, markedly so in *C. aura*. Piercings into this passage on either side for the exit of the dorsal nerves are made at the expense of certain parts, both before and behind, in each vertebra, giving rise to rather small irregular openings for this purpose. At the base of the transverse processes of the dorsal vertebræ, and again at their extremities, semi-circular facets exist for the capitula and tubercula of the dorsal ribs. Those at the bases are upon slightly raised elevations and look almost directly outwards, those at the extremities look downwards and outwards, in *aura* and *atrata*, but in *S. gryphus* and the California Condor almost directly outwards, especially in the last dorsal.

The diapophyses become progressively longer as we near the sacrum, at the same time more inclined upwards; they are compressed from above downwards, being dilated at their outward extremities, where they bear distinct and styliform connecting metapophyses, the last pair being extended to the pelvis in *Cathartes*.

Close and mutual locking is accomplished in this region, principally by a shortening of the pre- and postzygapophyses, the facets upon the former facing upwards and slightly inwards, upon the latter downwards and slightly outwards, so as to be nicely approximated in the articulated skeleton.

Sharpened ridges beneath the transverse processes connect the facets for the capitula and tubercula of the ribs; this feature is best marked in *C. aura* and next in *G. papa*, less so in the others.

Vertically elongated but shallow depressions occur above the centra on the anterior and posterior margins of the neural spines, for the insertion of the broad connecting ligaments; the spines themselves spring almost abruptly from the neurapophysial arch, are uniformly quadrate plates of an equal height, with thickened crests above, that become united at their anterior and posterior ends by a modified arrow-head joint, such as we described in *Speotyto*, where the points were more acute.

Mr. Lucas tells us, in the same communication cited above, that he found five dorsals in the spinal column of *Vultur cinerea* and *Gyps bengalensis*, six in *Otogyps calvus*.

Owen clearly defines the condition of the hypapophyses in some of the Old World Vultures in the following words:

> From some or most of the dorsal centrums inferior processes (hypapophyses) are sent down, for extension and favourable origin of the flexor muscles, *longi colli* and *recti antici*, of the neck. In a Vulture (*Gyps fulvus*) the hypapophysis is a low median ridge in the first and second dorsals; to this, in the third dorsal, is added a pair of outstanding depressed plates; in the fourth the pair of plates are smaller, and, with the medial ridge, are supported on a common stem; in the fifth dorsal the hypapophysis is again reduced to a median compressed plate, but it is expanded at the end; the vertebra, which by anchylosis has become the foremost sacral, has a similar but stronger and slightly bifurcate hypapophysis. In both Vultures and Eagles the parial hypapophyses are seen to be due to modified parapophyses, which descend and are progressively lost in the median hypapophysis of the fourth and fifth dorsals (*Harpeya*, Cuv.); the sixth and seventh have only the low median ridge. (Anat. Verts. vol. II, p. 17.)

The caudal vertebræ are very much modified, as they are as a rule, throughout the class; the number possessed by each species has already been given in one of the tables accompanying this monograph. They are considered next in order after the dorsals, as the author believes, and the reader will surely agree with him, that in the present subject the sacral vertebræ had better be taken up with the pelvic bones as an entirety and treated under the section devoted to the pelvis.

In the South American Condor a complete arcade is formed by the neurapophyses of the coccygeal vertebræ, over the ultimate division of the myelon, and even the pygostyle is pierced for a short distance to allow the entrance of the nervous cord. These bony arches are surmounted by knob-like tubercles throughout the series, that show a very feeble disposition to become bifurcated at their summits. Many of the lateral elements of the vertebræ are combined to form diapophysial processes, which, in this bird, are heavy and broad projections jutting from the centra on either side, bent downwards, and becoming wider and wider as we near the coccyx, to be suddenly suppressed in the ultimate segment. Very faint indications of a hypapophysis occur in any of the first three caudals; in the fourth a cleft but sessile tubercle is seen, that leans forwards to rest upon the under surface of the centrum of the vertebræ beyond; in the last two this process becomes much larger, and is evidently made up of the hæmapophyses of the vertebræ, for in each case it is pierced by a delicate hæmal canal, while the true hypapophysis is still below and still exhibits the disposition to overlap the vertebræ beyond. The centra of the coccygeal segments of the spinal column in the *Cathartidæ*, as among the class generally, are procœlian. In the coccygeal vertebræ of *G. papa* we find the same general characters present that we have just attributed to *S. gryphus;* the principal differences are that the neural spines are more lofty and only the ultimate hypapophyses form a perfect hæmal canal, the anterior ones being only grooved. Among the Vultures there is sometimes an extremely intimate relation existing between the first caudal vertebræ and the last sacral, amounting to, in some cases, positive anchylosis.

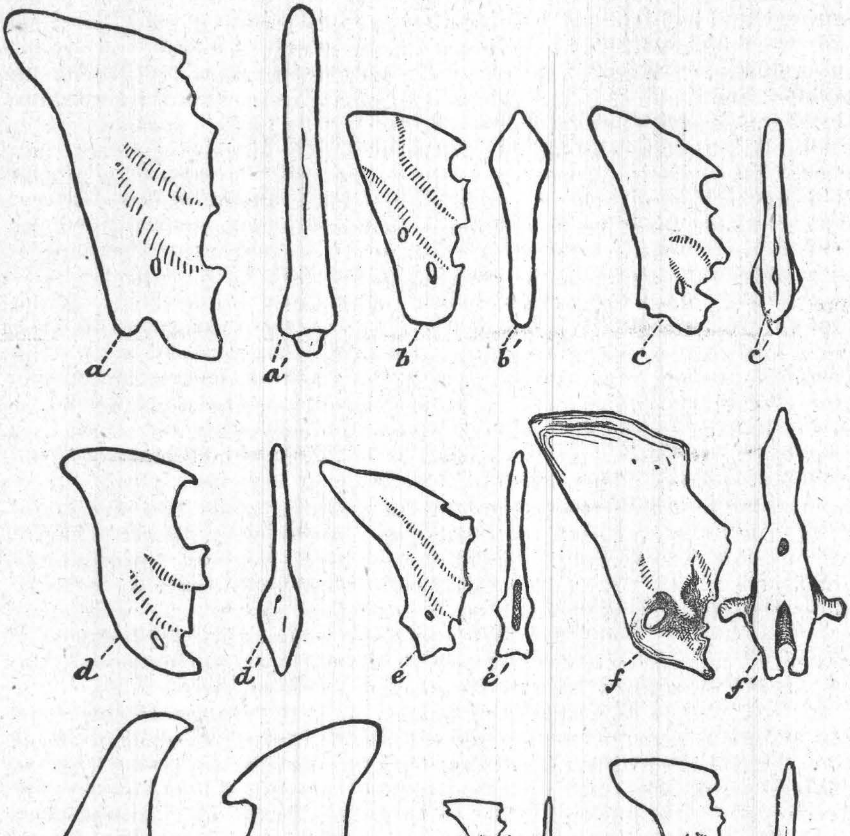
In *Cathartes aura* the neural canal is complete throughout the chain and enters the pygostyle for some little distance; the hæmal canal does this also below, but this latter only passes through two of the hypapophyses of the last two caudals, these processes being but feebly developed in the others. The diapophyses in this Vulture become gradually broader and shorter as we leave the sacrum. *Catharista* exhibits about the same peculiarities with regard to its caudal vertebræ as we see in *Cathartes aura.*

Mr. Lucas tells me that he counts seven caudal vertebræ both in *Otogyps calvus* and *G. bengalensis;* he also kindly furnishes us with outline sketches of the pygostyles of these two Vultures, which we give below as we compare them with others.

It will be observed that, as a rule the coccyx among the *Cathartidæ* is more or less parallelogramic in outline, with well-defined angles; on the other hand, among the *Falconidæ* and the Owls and their allies this bony plate is drawn upwards and backwards into a rounded point; we give examples of this in the cuts, as well as exceptions to the rule. *Neophron* has a strong tendency Falcon-wards in this respect, less marked in *Gypogeranus.*

We also present the reader, in each case, except in the two outlines from Mr. Lucas, with a posterior view of this bone, which will show the great variability of outline of the pygostyle, better than any description could do, however elaborate it might be made. An elliptical foramen, in some cases two (*Gyparchus*), pierce this plate at about the locality the last coccygeal vertebræ fused with the one next behind, forming, as it were, a point that the process of osseous amalgamation failed to fill in. This feature is rare among the *Falconidæ.* Among

PYGOSTYLES OF VARIOUS OLD AND NEW WORLD VULTURES AND HAWKS.



a and *a′*, lateral and rear view of pygostyle of *Sarcorhamphus gryphus*, respectively; *b* and *b′*, the same for *Gyparchus papa*; *c*, *c′*, for *Cathartes aura*; *d*. *d′*. *Catharista atrata*; *e*, *e′*, *Neophron percnopterus*; *f*, *f′*, *Gypogeranus serpentarius*; *g*, *Otogyps calvus*; *g′*, *Vultur cinerea*; *h*. *h′*. *Tinnunculus sparverius*; *i* and *i′*, *Accipiter cooperi*; *j*, *j′*, *Micrastur brachypterus*; *k*, *k′*, *Circus hudsonius*; *l* and *l′*, *Polyborus tharus*.

the cuts, *a*, *a'* is an outline sketch of the pygostyle from *Sarcorhamphus gryphus*; it shows very well, and is, in fact, typical of the parallelogramic form this bone assumes in the *Cathartidæ*; *b* and *b'* is the lateral and posterior view of the bone from *Gyparchus papa*; in this Vulture we observe that the upper portion of the bone, or rather the upper and posterior angle, is very much thickened.

Cathartes aura, shown in *c* and *c'*, still retains the usual outline of the other Vultures of this family, while in *Catharista atrata*, *d* and *d'*, the lower and outer angle is rounded off, but the common form is still very decidedly retained in its upper half. In *Neophron percnopterus*, seen in *e* and *e'*, we discover a marked leaning towards the form of the bone as it is known to us among the majority of the *Falconidæ*.

Eccentricity of form stamps nearly every part of the bony framework of the African Secretary Bird, *Gypogeranus*, so we are not so much surprised to find the shape the coccygeal vomer takes on, a shape that we present in *f* and *f'*. That the diapophyses of the anterior vertebra that assisted in making this bone have been retained with great prominence is very evident to us, and they are shown both from lateral and posterior aspects. The size of the usual foramen still further individualizes this vertebra.

Approximate outlines of the bone for *Otogyps calvus* (*g*) and *Vultur cinerea* (*g'*) are next in order given, and we note that in the first the tendency is decidedly to partake of Falco-form type of the segment, while just the reverse is seen in the second, where it assumes a shape quite like the *Cathartidæ*.

The two more common patterns, as seen among the vast majority of Hawks, Owls, and Eagles, we find sharply portrayed in *Circus hudsonius* (*k*, *k'*), and in *Polyborus tharus* (*l*, *l'*). On the other hand, we give notable exceptions to this triangular style in *Tinnunculus sparverius* (*h* and *h'*), *Accipiter cooperi* (*i* and *i'*), and in *Micrastur brachypterus* (*j* and *j'*). So we see that among these Vultures, as well as the *Falconidæ*, the form that the pygostyle takes on can only be utilized as a distinctive mark in the question of differential diagnosis, when taken in connection with other groups of characters found either in the bird's external topography or its internal structure.

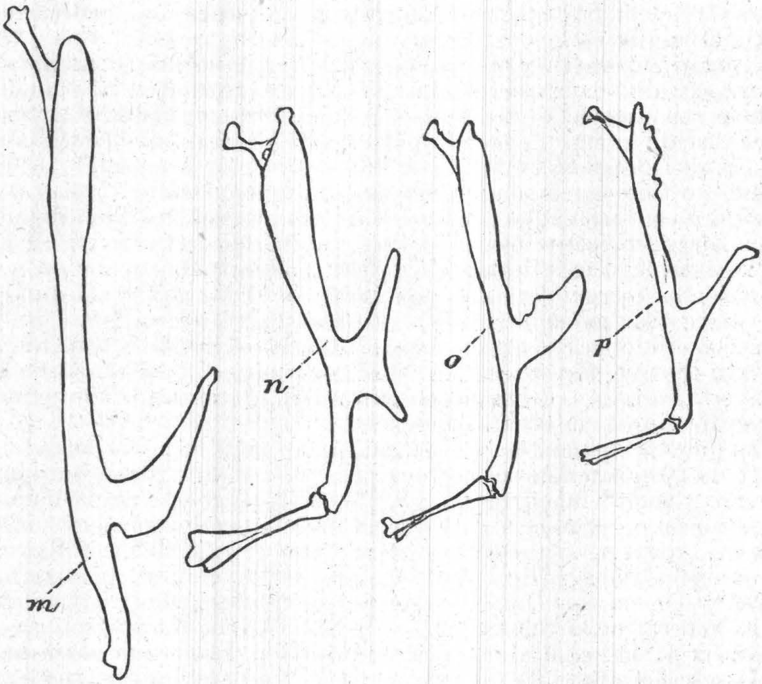
The number of the dorso-vertebral ribs in any of the *Cathartidæ* can easily be ascertained by consulting the table of vertebræ (the second accompanying this monograph), as, of course, every dorsal vertebra has its pair of free dorsal ribs, these being articulated in the usual manner with the sternum, by the intervention of the sternal ribs. The ribs as found among the American Vultures are very robust and strong bones, representing, as they do, fit accompaniments of a skeleton notorious for its general massiveness. As is most usual in the class *Aves*, the neck bearing the capitulum of the rib at its extremity lengthens as we pass backwards towards the pelvic end of the body, in due proportion does the one bearing the tuberculum shorten, until in the latter we have the transverse process of the vertebra, in the last dorsal resting for the outer third of its length against the true neck of the rib apposed to it, and the tubercular pedicle has become sessile with the body.

The ribs of the *Cathartidæ*, or such of them as are found in the dorsal division of the column, are very broad throughout their entire lengths, the broadest part being found at their superior thirds; this transverse compression gives rise to sharp anterior and posterior borders, and long elliptical facets, placed longitudinally below for the sternal ribs.

All of the dorsal ribs support *epipleural appendages*, in this family, anchylosed to the posterior margins of these bones, below the middle of the shafts. We believe that this is the case in the vast majority of the *Falconidæ*, including the Old World Vultures. These unciform offshoots are very wide-spreading and prominent, more so among the American Vultures than in any of the Hawks or Eagles, and as a rule overlap the rib immediately behind them, but never two consecutive ones, as in some birds.

There are some very interesting and distinctive differences between the ribs of the *Cathartidæ* and these bones, as found among the *Falconidæ* and the vulturine Raptores of the Continent; these differences are largely due to the form assumed by these very epipleural appendages, taken in connection with the greater breadth of the pleurapophysial bodies as already referred to, and shown to be characteristic of the family we are describing.

We present a few outline, but accurate, sketches of these bones, chosen from several species, given in life size, as the best way to demonstrate these very striking and really diagnostic features. The first, marked *m*, is the rib from the anterior dorsal vertebra, taken from the left side



of *Pseudogryphus*; *n*, *o*, and *p* are the ribs, from the same side, of the second dorsal vertebræ of *Catharista atrata*, *Neophron percnopterus*, and *Circus hudsonius*, respectively. The feature which we desire to direct the reader's attention to particularly is the descending process of this pleurapophysial appendage, here best seen in *C. atrata* (*n*), though it is no better marked in this Vulture than in others of the family to which it belongs. This peculiar form of the epipleurals of the ribs in the *Cathartidæ* is most decidedly marked among these bones chosen from the middle of the series, though it persists in a less degree in the first dorsal rib, as seen in *m* (*Pseudogryphus*), as well as in the appendage when it occurs on any of the sacral ribs. We know of no instance among the *Falconidæ* where it ever assumes such a form; and its outline as seen in *Neophron* (*o*) leads us to believe that this is only an additional example where these birds depart from the *Cathartidæ* and tend towards the *Falconidæ*.

The first dorsal rib in *Gypogeranus serpentarius* bears no epipleural appendage; in the second it is broad and short, with a minute descending process below, very close to the margin of the rib; in the third this unciform appendage is long and narrow, and is in contact with the rib for its entire length, sloping away below; in the last dorsal it appears only as an increased widening of the rib for a certain distance along the usual site of its occupancy. Sternal ribs that in descending meet the dorsal ribs are, like these bones, strong and robust; they possess quite extensive quadrate facets for sternal articulation at their lower ends, that when placed *in situ* in the skeleton cause these bones to be turned outwards, so that their anterior faces are visible from a direct lateral view. Their posterior ends are progressively from before, backwards, curved in such a manner as to preserve the oval form of the chest walls, and are very much dilated as we proceed in that direction; at their distal extremities they support the usual facets for the vertebral ribs. In the Secretary Vulture they become very much compressed from side to side as we examine them successively in the order referred to, and in this course, too, in some of the *Falconidæ*, they become curved in an antero-posterior direction, the concave margin being in front. In these birds and in our specimen of *Neophron* the sternal ribs are seen to be much slenderer than corresponding bones in the *Cathartidæ*.

Additional protection is afforded the contents of the thoracic and abdominal cavities by ribs descending from the sacral vertebræ; by free sternal ribs in other species, and by the meeting and articulation of both in others. To complete the description of these important and serial auxiliaries to the stability of the chest walls, we will say what we have observed in regard to these *sacral ribs* here, so that we will be left comparatively free to describe that bone as a unit.

Sarcorhamphus gryphus has three of these ribs on either side; the first two pair support epipleural appendages and articulate with the sternum through the agency of well-developed sternal ribs. The last pair are devoid of the unciform projections, and their sternal ribs in turn articulate by their distal extremities and a small portion of their distal and anterior margins along the posterior borders of the sternal ribs in front of them, their points coming within about a centimeter of the costal border of the sternal body on either side. We believe, after an examination of such parts of our skeleton of *Pseudogryphus* as refer to this region, that the arrangement will be found to be the same as we have just attributed to the South American Condor. *Gyparchus* possesses two pair of these ribs, both articulating with the sternum by sternal ribs that are the largest and longest of the series. The first pair have unciform processes. Sometimes in this species an additional rudimentary pair are found to exist, and belong to the next vertebra beyond, but all the distinctive characters of the upper part of a rib have been absorbed by the under surface of the illium, so that this pair almost has the appearance of being offshoots from the ossa innominata.

In *Cathartes aura* we discover two pair, the first connecting with perfect sternal ribs coming from the sternum below, and support epipleural appendages; the last are without them, and otherwise behave as we described the ultimate pair in *Sarcorhamphus*. Passing to *Catharista*, we find the same arrangement present as in *C. aura*, but in addition a pair of rather long styliform rudimentary ones are found, with their capitula, tubercula, and necks absorbed as we saw them when they occurred in *Gyparchus*, though evidently belonging originally to the next vertebra in order. So that among the *Cathartidæ* the variations observable among the plans for the sacral ribs resolve themselves into the following four classes: They vary as to the number of pairs; as to the presence or absence of rudimentary ribs; as to the method of articulation of the last pair of sternal ribs, whether these descend to the sternum or articulate along the posterior border of the pair in advance of them, thus constituting what might almost be termed "floating sternal ribs"; and, finally, as to the arrangement of the unciform processes.

Turning to such specimens of the Vultures of the Old World as we have been able to learn anything about in this regard, we perceive at once that we have an entirely different set of "plans of arrangement" presented to us. In *Neophron percnopterus* we have a free pair of sternal ribs that articulate with their anterior ends on facets in the costal borders of the sternum, just as any other pair of the series do; no evidences of a corresponding pair of sacral ribs descend to meet them.

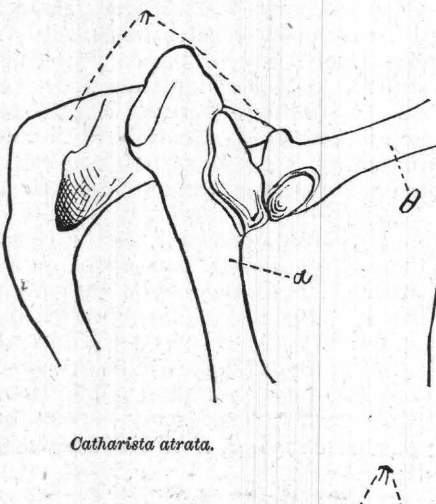
Mr. Lucas tells me that he found in *Vultur cinerea* and *Gyps bengalensis* that the ultimate pair of sternal ribs were still free as we found them in *Neophron*, but that the anterior extremities articulated with facets in the posterior margins of the next pair of sternal ribs beyond them. He further says that in *Otogyps calvus* "a very small floating rib is attached throughout its entire length to the last articulated sternal rib." This no doubt occurs on both sides, and is the same condition as we find in *Gypogeranus*, only the rib is longer in this latter vulturine Falcon. Cases of asymmetry no doubt occur among many or all of these various arrangements, as, for instance, in the skeleton of *Micrastur brachypterus* that we have before us we find that on the left side six sternal ribs spring from the sternum, while on the right there are only five, the last or sixth one articulated with the posterior border of the sternal rib beyond it.

Of the scapular arch, sternum, and pectoral limb.—As in the majority of the class *Aves*, the scapular arch of the *Cathartidæ* consists of its pair of scapulæ, its pair of coracoids, and its furculum, or the united clavicles. This group of bones enjoys the usual amount of independence that we find in nearly all birds, in being distinct from each other and from the sternum. There is a very great similarity, both in outline and general appearance of this arch as it is found among the *Cathartidæ*, and to this we may add that when the bones forming it are *in situ* in the articulated skeleton they present a pattern that not only possesses a common resemblance, but is peculiar to the family, and differs very decidedly from the Vultures of the Old World and from the *Falconidæ*. We find in our present subjects that the sternal extremites of the *coracoids* are very much expanded in a transverse direction, that they touch each other, mesiad, when articulated in the sternal grooves or beds designed for them. These dilated ends are scooped out on their posterior aspects where the pneumatic foramina occur, and roughened, while in front the surface is smooth, convex from side to side, and continuous with the general surface of the shaft. The inferior side is occupied for more than its inner half by the facet for articulation with the sternum; this is broadest mesiad, narrowing in each bone as we proceed outwards. The outer angle is truncate and presents an upturned tip of bone, and a face that is directed outwards. Very little shaft can be boasted of by these bones, for no sooner do the fan-like lower ends commence to contract to merge into a shaft than dilatation immediately sets in again to form the great tuberous heads that constitute the opposite and superior extremities. More of a true shaft exists in *Catharista* than in any other of these Vultures, for the coracoids are proportionately longer in this species; in all it is more or less compressed from before, backwards, rounded externally, sharper within, where in each bone it is pierced midway by an elliptical foramen, such as we found in *Speotyto*. This last feature is scarcely perceptible in the Carrion Crow. In each the facet for the scapula is behind and rather towards the median plane; it is placed transversely upon the bone, occupying the upper surface of the scapular process, and is continuous with the shallow glenoidal facet that is seen on the outer aspect. The coracoids terminate superiorly in rounded heads that are flattened from side to side, and present upon their mesial aspects smooth surfaces for the broad clavicular limbs. The blades of the *scapulæ* are short and broad, being curved outwards, with rounded points; they never reach back nearly so far as the pelvis, but generally overlap the last pair of dorsal ribs. The heads of these bones are flattened from above downwards, curled up on their inner aspects, so as to afford surface to articulate with the points of the clavicular ends, while externally they present raised elliptical facets that go to complete the glenoid cavities of each shoulder joint. The entire anterior margin of a scapula is devoted to the articular facet for the coracoid.

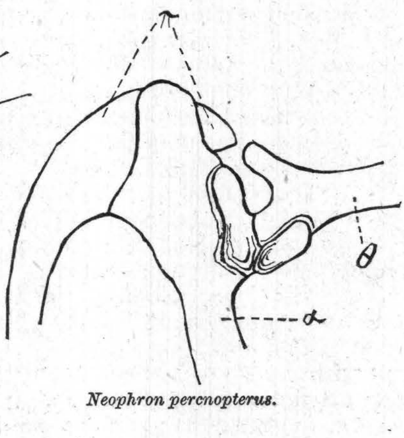
Right coracoid of Pseudogryphus, viewed from in front; life size.

The glenoid cavity formed by the approximation of these two bones is quite deep and extensive, and thus far we have failed to discover the presence of the *os humero scapulare*, and its assistance is apparently not in demand as an additional aid to retain the humeral head in the socket in these birds (Plate XVIII, fig. 108), the usual ligament being substituted for it. Our figures for the representation of the *os furcatorium* show it to be the very type of the broad U-shaped variety or form (Plate XXIII, figs. 123 and 125, *C. aura*), and such it pre-eminently is. Superiorly this bone presents for examination the great flattened ends that articulate with the coracoids and scapulæ on either side; these are drawn out into rounded points behind to reach the latter, while a limited smooth surface on the outer aspect of either limb comes in contact with a similar surface on each of the former. All of the surface within the U is smooth and devoid of any points of particular interest. Without it, and above, in the expanded heads we find the entrances to the great air passages, for they are more than foramina, that lead into the bone. No hypocleidium is found attached to the thoroughly united clavicles of these birds, below, but a little ridge occupies the usual site beneath and a characteristic tip projects from in front in all of them. Behind the borders are rounded, in front they are sharpened and produced out to the point of the aforesaid tip or anterior projection. With the scapular apparatus in position, we find that the axis of the shafts of the coracoids are in line with the long axis of the sternal body; that these bones diverge from each other at an angle that is equal to the angle of the clavicular fourchette. From behind their heads the articulated scapulæ spring out at nearly right angles, and pass backwards parallel with each other, to be deflected outwards only as we near their posterior points or extremities. After closing in the large "tendinal foramina" by its broad superior dilatations, the furculum dips directly backwards to bring its lower arch into the recess of the anterior concavity of the carina of the sternum, but it never touches this bone at that point, and its near approach seems to vary for the same species; it is quite distant in the specimen of the King Vulture we present in figure 105, but in another it comes much nearer.

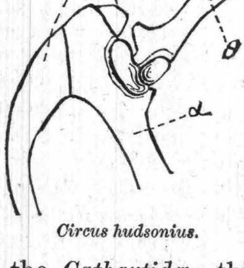
In the vast majority of the diurnal *Falconidæ* of this country, and, no doubt, in those of the Old World too, the clavicular heads have a much more extensive articulation with the superior ends of the coracoids than



Catharista atrata.



Neophron percnopterus.



Circus hudsonius.

we have just ascribed to the *Cathartidæ;* this arrangement is closely followed by *Neophron*, and, in short, the entire scapular apparatus of this bird is indubitably stamped with the well-known characteristics that mark this arch among the Hawks and Eagles. So interesting and important a matter is this, that we feel sure that our reader will be glad to examine the cuts we present illustrating these points in representative members of several of the families involved. The views are from an outer aspect of the joint in each case, showing the heads of the three bones of the scapular arch and the glenoid cavity. The bones are all lettered to correspond, and π directs attention to the furculum, θ to the scapula, and a to the coracoid.

The figure in the upper left-hand corner is of *Catharista atrata*, the figure below is of *Circus hudsonius;* the remaining one is of *Neophron percnopterus*.

In *Catharista* we see the common plan for all of the *Cathartidæ*, in which the clavicular head simply *rests* against the inner side of the coracoidal capitulum, while on the other hand, in *Neophron* and *Circus*, as representatives of the *Falconidæ*, the coracoid is actually molded to receive a corresponded surface on the clavicles.

Taken in consideration with other characters, we are compelled to regard this arrangement of the bones of the scapular arch as still another valuable and reliable character differentiating these birds from the Old World Vultures and still further establishing Professor Huxley's sound classification, as far as the *Cathartidæ* are concerned, in awarding them a family of their own. No one could be more disposed to draw family lines in birds with greater caution than the author, nor one more adverse to establish such lines upon any single set of characters, chosen either from points in external differences or internal structure; still such decided distinctions as this must have their due weight, occurring as it does, too, in a set of bones that, taken in connection with the sternum, have always been regarded by ornithologists the world over as containing some of the most distinctive features in the avian skeleton, and even carried by some to such unwise extremes as to be chosen for, and considered of sufficient importance to even construct and base a system of classification upon.

The scapular arch in the *Cathartidæ* is far more constant in its characters than the *sternum* itself, a bone we will now consider; and it strikes us, as we glance at the many specimens before us, still more forcibly how totally impossible it would be to take this segment alone as a criterion upon which to classify the class and yet have genera and species of known affinities arranged anything like approaching proper order. My views upon the value of such single characters coincide so well with those of Wallace, who so long ago as 1864 appreciated and recognized the truth of what we have been saying, that we give some of his sound remarks upon this subject:

* * * No one can be more convinced than myself of the utility of osteology, and especially of the *sternum*, in the classification of birds, and I sincerely trust that this great work may be brought to a conclusion (referring to a paper of M. Blanchard's). I cannot, however, allow that *osteological* characters are an all-sufficing guide. Like every other character taken singly, osteology is a very uncertain and irregular test of affinity, and is, moreover, in almost every case accompanied by parallel external characters. Sometimes one, sometimes another part of the bird's organization has varied more rapidly, so that one group exhibits the most striking constancy of a part which, in another group, is subject to extreme modifications. The sternum is no exception to this rule, and by following it alone we should make the greatest errors in classification. For example, the sterna of the Finches and the Flycatchers are scarcely distinguishable, notwithstanding the great dissimilarity in almost every part of the structure of these birds—their bills, their feet, their plumage, their habits, food, and digestive organs. On the other hand, the sterna of the several genera of the *Caprimulgidæ* differ from each other more than do those of the most distinct families of the restricted Passeres. The Bee-eaters, the Barbets, and the Woodpeckers, again, are three very distinct families, which, in a classification founded upon all parts of a bird's organization, cannot be brought in close contact; and yet, their sterna, according to

M. Blanchard, much resemble each other. It is evident, therefore, that the whole structure of a bird and its corresponding habits may be profoundly modified, and yet the sternum may retain a very close resemblance to a common form; and, on the other hand, the sternum may undergo the important changes, while the general organization and habits are but little altered.

To prove that true affinities indicated by the sternum are also in most cases exhibited in external characters, it is only necessary to refer to the paper above quoted, in which the relation of the Hummers to the Swifts, and the separation of the Hornbills, the Rollers, the *Musophagidæ*, and the Parrots, from the Passeres, were pointed out from the consideration of such characters alone. In that paper, however, I made two important errors, namely, putting the Todies with the Passeres (from the descriptions given of their habits) and including the Swallows among the Swifts. The character of the sternum is undoubtedly of great importance in finally settling such points as these.

I also at that time included the *Psittaci* among the Scansores; but I am now quite convinced that they deserve to rank as a primary division of the class of Birds, a rank to which the great peculiarity of the sternum, the large brain-cavity, and highly organized cranium fully entitle them.

With regard to M. Blanchard's determination of affinities from the body of the *sternum* only, without its appendages, I must remark that it often leads to erroneous results. For example, he says that the *sterna* of *Merops* and *Tamatia* do not differ enough to deserve a separate description, and he includes *Megalæma* with *Tamatia* in one section as having the same form of sternum. He notices some differences in the *Picidæ*, but remarks on their resemblance to *Megalæma* and to the Toucans.

Now in all these points an examination of the entire sternum, with the *furcula*, coracoids, and clavicles attached, leads me to very different results. * * * These remarks are made in no spirit of depreciation of this very interesting and valuable work, but for the purpose of showing that isolated characters may lead to erroneous conclusions from whatever part of the organism they are chosen, and that in this respect osteological have no positive superiority over external characters. M. Blanchard tells us, in the introduction to this first instalment of his work, that he proposes to examine successively each separate part of the bird's skeleton. His future researches may therefore seriously modify the conclusions he has hitherto arrived at.

I cannot but think, however, that he would have produced a more satisfactory work if he had based it upon the comparison of the entire sternum, with its appendages attached, and also on the cranium, these two parts being of the greatest importance in classification.

It has been well observed by Professor Owen that those parts of an animal which have the least immediate connection with its habits and economy are exactly those which best exhibit deep-seated and obscure affinities. The wings, the feet, and the beak in birds may undergo the most extraordinary modifications in the same group in accordance with differences of habits and of external conditions, while at the same time such apparently insignificant characters as the general coloring, the texture of the plumage, the scaling of the tarsi, or the color and texture of the eggs remain constant and reveal the true relations of the species. Thus it is that the form of the sternum is of such importance, since it has no immediate dependence on external form and habits. The Sparrow, the Flycatcher, the Wren, and the Sunbird all have one characteristic form of sternum, while between those of the Swallow and the Swift there is the greatest diversity.

It is evident, also, that the modifications of form immediately dependent on habits and external conditions are generally to be seen in the skin even better than in the skeleton of a bird. These are principally changes of form, size, and proportion in the bill, feet, and the wings, which are excellent characters for distinguishing genera and even families; while for determining the true affinities of isolated groups we must have recourse to those characters which, having no direct dependence on habits, &c, are often persistent in a remarkable degree. Of these, no doubt, the sternum is of the highest value; but there are many others of almost equal importance. * * * Now that true principles of classification are becoming so much better understood, we may, I think, hope that the chaos which has so long existed in ornithology will soon give way to a truly natural system which must obtain general acceptance.—(Remarks on the Value of Osteological Characters in the Classification of Birds, by Alfred R. Wallace, Ibis, Lond., 1864, pp. 36–42.)

In some birds the coracoids and consequently the coracoidal grooves on the sternum decussate; now such a marked character as this would certainly have to be taken into consideration should we lay too great a stress upon this bone as a means of differential diagnosis in classification alone; and we might add to Mr. Wallace's examples such problems as how we would treat or dispose of *Polyborus tharus* and *Ardea hero-*

dias by the decisions of such a system, as the condition just referred to is found to be present in both of these birds.

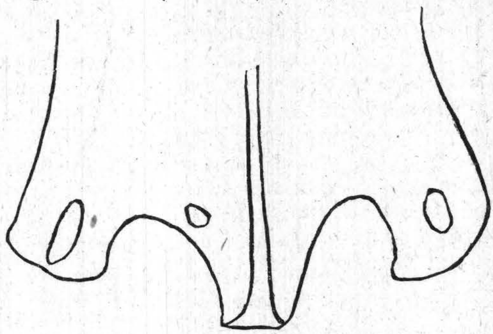
There is no distinct manubrium in the sterna of the *Cathartidæ*, as we find in *Neophron* and among the Hawks; this feature being supplanted by a massive and tuberous promontory in the median line, over which the broad concave coracoidal grooves meet at the middle point above, to be produced shallower, narrower, and less distinct to the deep pneumatic fossæ that are found on either side, just below the facet of the first sternal rib in the costal border, in all of these Vultures. The body of the sternum is oblong and deeply concave, being wider behind than it is anteriorly, and longer for its width in *Catharista* than any other. The general internal surface is very smooth, and so evenly distributed is the concavity that marks it that no distinct furrow defines the position of the carina below, as in so many other birds. All of the borders are sharp and thin, except the anterior moieties of the lateral ones, that are more (*Pseudogryphus*) or less (*Cathartes*) occupied by the facets for the sternal ribs. These are small parallelograms, varying in size according to the rib they support, placed transversely and tipped slightly outwards, being separated from each other by subelliptical depressions that show the pneumatic openings at their bases. Beneath, the body is likewise smooth, and presents for examination the prominent pectoral ridges on either side, originating in eminences in the middle of the costal borders to be produced backwards and terminate just anterior to the mid-xiphoidal process, at the base of the keel. This latter is very deep and strong in all of the *Cathartidæ;* commencing below and within the manubrial prominence, it is carried out, mesiad, to the very posterior end of the bone; its anterior margin is always thickened, but in the Condors and *Gyparchus* the entire inferior rim is found to be very much more so; in this latter Vulture, too, we observe that the anterior carinal margin is wider above and scooped out throughout its extent, having the fine median line passing down from the manubrial eminence to the carinal angle, that is present in all of these birds. A well-marked muscular line is found on either side of the keel, a few millimeters within its inferior boundary, extending from the carinal angle to be gradually lost before arriving at the posterior termination of this plate. It is less distinct in *Gyparchus* and the Condors.

There seems to be no exception among the *Cathartidæ* as to the fact that the xiphoidal end of the sternum exhibits many patterns for the same species; a circumstance that may be due to slight differences in age, but which certainly robs this bone in this family and in others where it may occur of a great share of its importance as possessing distinctive character in this respect. It is not strange, then, that scarcely two drawings agree as presented us by divers authors and ornithologists, much less any two verbal descriptions, so that, as far as these Vultures are concerned, a question of accuracy has arisen on many occasions, on the part of one observer examining the work of another, when, perhaps, a mistake very rarely occurs with any of us in one description of the con dition in which we found the notches or foramina at the xiphoidal end of the sternum in any of these American vultures.

One pattern is shown for *C. aura* in Plate XXIII, fig. 122, from a specimen secured in Wyoming by the author, and we will give a few outline sketches here as the best means of showing the wonderful diversity that may exist, not only for the bird we have just mentioned, but for all, and even this characteristic is extended to the Old World Vultures (*Neophron*).

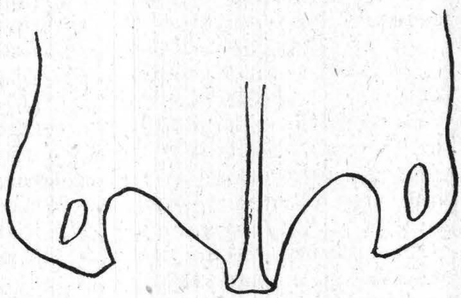
For *Cathartes aura* we present the reader with the principal variations that we have found to exist, carefully selected from various sources and collections.

Mr. T. C. Eyton, in his Osteologia Avium (London, 1867), in a half view of the sternum of this Vulture, found it as in spec. No. 692, here given, only the foramen was a little larger (Pate I, fig. 2, of Eyton's work). We, however, read in the text of this book, page 19–20 (*C. aura*), "Sternum in general shape similar to *Sarcorhamphus*, but with two large fissures on the posterior margin next the keel, and two fissures exterior to them; the remaining portions of the skeleton are very similar except in measurements." Now here is a writer that actually contradicts his own drawings by the statement he makes in the text, and we can only believe that Mr. Eyton could have been led into such an apparent mistake by having several specimens of the sternum of this bird at his disposal, availing himself of one for his plate and another for his description, perhaps at a later date.



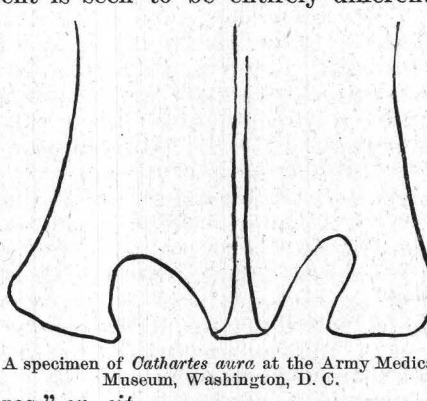
Cathartes aura, No. 6897 of the Smithsonian collection.

This gentleman found his specimen of "*Cathartes niger*," as we see from an examination of the plate presented, with a large elliptical foramen on either side; while, on the other hand, in a specimen we received from Florida, and shown in the cut, the arrangement is seen to be entirely different.



Cathartes aura, No. 3102 of the collection of the Smithsonian Institution.

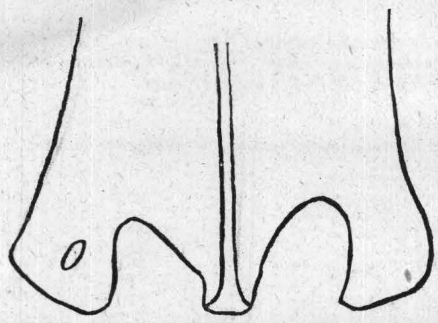
Gyparchus papa apparently shares the same fate that *C. aura* does in this respect, for in one Ecuador specimen (Plate XV, fig. 105) the xiphoidal margin is encroached upon on either side of the keel by a broad and rather deep notch, each being of the same size, while, in a specimen of this Vulture from Mazatlan, this is the condition of the bone on the right side of the keel, the left having an additional small notch to the outer side of the large one. Mr. Eyton found his as in our Ecuador bird, and describes it as having "two large open fissures," *op. cit.*



A specimen of *Cathartes aura* at the Army Medical Museum, Washington, D. C.

Referring to these matters, Professor Owen says:

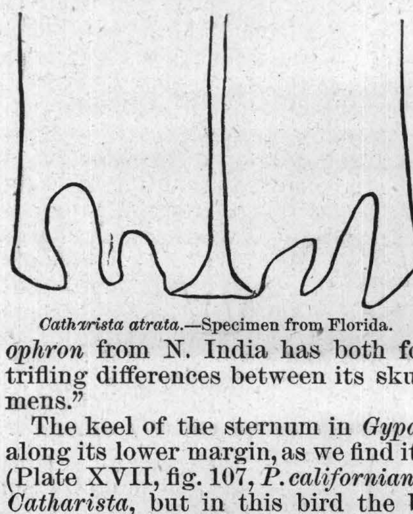
In diurnal *Raptores* the sternum is a large elongate parallelogram convex outwardly, both transversely and longitudinally. The manubrium is short and trihedral; the lower border of the keel is convex; the front border concave; their angle of union rounded off. The instances where the sternum is entire have been cited; in other birds of prey the arrest of ossification is limited to very small parts of the hind border, usually a foramen, rarely a notch (*Sarcorhamphus*) on each side, one of which may be filled up, wholly or partially. Eyton figures two small notches on each side of the posterior border in *Hierax bengalensis;* and both hole and notch on each side in *Cathartes aura.*


Cathartes aura, No. 692 in the Smithsonian Institution.

In our specimen of *Sarcorhamphus gryphus* a faint indentation marks this posterior border on each side, but in *Pseudogryphus* two well-defined notches of equal depth are observed on either side of the keel.

Eyton states for the South American Condor:

Sternum:— * * * Posterior margin in a young bird with two indentations, which are nearly obliterated in the old one.—(*Osteologia Avium*, p. 18.)


Cathæristа atrata.—Specimen from Florida.

Mr. F. A. Lucas, who kindly examined the specimens of the Old World Vultures in the Natural Science Establishment at Rochester for us, writes me that, "You will notice that the right sternal foramen of *Neophron* is closed (referring to a specimen sent to the Army Medical Museum); this was also the case with a second specimen, while a third, somewhat younger, had the foramen open, but much smaller than the left. A specimen of *Neophron* from N. India has both foramina open, and there are a few trifling differences between its skull and that of the Abyssinian specimens."

The keel of the sternum in *Gyparchus* has the antero-posterior curve along its lower margin, as we find it in *Pseudogryphus* and *Sarcorhamphus* (Plate XVII, fig. 107, *P. californianus*); this outline is faintly imitated by *Catharista*, but in this bird the border is not nearly so thick even in proportion. *Cathartes* has a convexity peculiarly its own, as distinguishing it from others of the family. The sternum is eminently falconine among the Old World Vultures in its general form and outline.

Professor Owen, contrasting the relative lengths of the segments of the pectoral limb as observed in the class, refers to it as found in the "powerful Raptorial flyers," as showing an intermediate and more harmoniously balanced proportion of the several segments. This is the case, in a marked degree, with our American Vultures, for here we find almost a perfect condition of relative equipoise among arm, forearm, and pinion, not only as regards lengths, but calibers of the interested long bones. To place the former property in a more satisfactory manner before the reader, we present a table of the lengths of segments of the pectoral limb, given in centimeters and fractions of the same, of the members of the family under consideration, and add also measurements taken from *Gyporgeranus* and *Neophron percnopterus* simply for the sake of comparison. In all of the long bones the straght line joining the points furthest apart in distal and proximal extremities was taken as the line to measure upon; in the pinion, it was the straight line let fall from the highest point in the metacarpus to the extreme tip of the distal phalanx, the limb being closed.

Table showing the length of the bones of the pectoral limb in the Cathartidæ, given in centimeters; also of Neophron percnopterus and Gypogeranus.

Species.	Humerus.	Radius.	Ulna.	Pinion.
P. californianus	27.8	31.2	32.8	24.5
S. gryphus	27.	30.3	31.6	23.5
G. papa	17.	20.4	21.6	15.1
C. aura	14.5	16.6	17.5	14.5
C. atrata	14.	15.1	16.	14.
N. percnopterus	14.5	16.7	17.1	14.
G. serpentarius	18.5	19.	19.8	18.3

In considering the relative position of points upon these segments during the course of our remarks, we must consider the bony framework of the wing as drawn up alongside the body in a state of natural rest, as seen in the King Vulture in Plate XV, fig. 105. The head of the *humerus* is bent not only downwards, but anconad, the reverse being the case in the distal extremity of the bone; these deflections, gentle as they are, and extended to a certain share of the shaft, give to this segment, both from superior and lateral aspects, the usual sigmoidal curvatures.

At the proximal extremity we find a well-developed "greater tuberosity" in the form of the ordinary smooth convex and curling facet for the glenoidal cavity of the shoulder; below this occurs the tuberous and projecting "ulnar crest" or "lesser tuberosity" overhanging a large subcircular fossa, at the base of which we note the many pneumatic perforations, to allow the entrance of air at this end of the bone. The radial crest occupies a position for nearly one-third (*Gyparchus*) or more (*C. aura*) on the superior aspect of the shaft, proximad, exhibiting all of its most usual points of interest. It is quite vertical, turning outwards but very slightly, and strongly marked at the common sites by elevated muscular lines; this crest terminates over the greater tuberosity in a special broadened prominence, the continuation of its plate-like portion beyond. (Plate XVIII, fig. 109.) From the dilated humeral head, we pass to a smooth and even shaft, that presents but little for our examination; it is elliptical on section throughout, the long or major axis being vertical, while below and nearly midway between the extremities we observe a minute nutrient foramen that pierces the bone from before backwards. Nearing the distal end of the humerus, the shaft gradually expands in a vertical direction, to support at its termination all of the characters commonly found there; these, like the ones we have just left at the proximal extremity, bear out their ordinary ornithic types. The external condyle is raised above the bone as a tuberous projection for muscular insertion; both internal and external condyles are produced anconad to form outstanding and lateral boundaries to a shallow olecranon fossa, into which pass longitudinal muscular groovelets. Beyond the prominent and strongly developed "oblique tubercle" and "ulnar convexity," we find in all of these birds a triangular depression on the palmar aspect of the bone, which lodges pneumatic perforations already referred to. These bones are very much alike in their general characteristics, among these Vultures there being no very decided points of difference in them beyond their size; this applies pretty generally to the remaining segments of the pectoral limb. On the palmar aspect of the bone, at the base of the greater tuberosity, in *Gyparchus*, we find a deep pit that is not observed in the humerus of any other member of this family, though its site is marked in all by a very shallow depression.

In the Condors we find the *radius* straight and nearly parallel with the ulna; particularly is this the case in *Pseudogryphus*, where for the distal two-thirds of its extent the interosseous space is of nearly an equal width; on the other hand, the bone is very much bent in *C. aura*, but here it corresponds with a compensating curvature of its fellow, and little change is experienced in the interosseous space. Strong muscular lines and decided development of the ornithic characters of the two extremities mark this bone. As a rule, the shaft is subtrihedral throughout, this being due to the prominence of the muscular lines aforesaid. A transverse facet occupies the entire extent of the distal aspect of its expanded outer end, and articulates as usual with the scapho-lunar of the carpus. The facet for the oblique tubercle on humerus is seen to be an elliptical concavity, placed vertically, with a broad, articulating surface, to its outer side for the ulna. One of the most striking features of the *ulna* that attracts our attention upon first examining this bone is its well-defined and double row of elevated quill-knobs for the bases of the quills of the secondaries; these are placed at about equal distances apart, along the palmar aspect of the shaft for nearly its entire length (Plate XV, fig. 105, *Gyparchus*), the fainter row being seen beneath them, the knobs being placed opposite each other. About its proximal end we note that the olecranon is but feebly produced, being nothing more than a general extension of the shaft, just sufficient to afford the necessary surface for the circular facet for the ulnar convexity on the humerus, the radial one being continuous with it, quadrate in outline, and much shallower. Upon the inferior face of the subtrihedral or proximal end of the shaft, we find in all of the *Cathartidæ* a long elliptical depression, that is quite characteristic, and is absent in *Neophron* and the majority of the *Falconidæ*. Beyond this locality the shaft soon assumes the subcylindrical form, becomes gradually smaller in caliber to bear distally the trochlea surface for the remaining bonelet of the carpus.

All the members of this family after they have attained their full growth possess but the two usual carpal segments, the *scapho-lunar* (radiale) and the *cuneiform* (ulnare); these articulate with the long bones of the antibrachium proximad, and the trochlea surface afforded by *os magnum*, anchylosed with medius metacarpal, distad. Their general form varies but very little throughout the species, they bearing the common characteristics as we find them described for the class generally.

These remarks apply with equal truth to the *metacarpus* (Plate XV, fig. 105, and Plate XIX, fig. 110 *m.*), a bone that is strikingly similar among the *Cathartidæ*, except in point of size, which, of course, varies with the species. It is constituted, as the bone usually is among birds, of the three united metacarpals; the short and projecting anterior one, or the poll x metacarpal, being the first of the bird hand; next, the stout and largest of all, the second or mid-metacarpal, forming, as it does, the proper shaft of this compound bone; finally, the compressed and arched third metacarpal, thrown across, as an osseous span, between the proximal and distal extremities of the latter at its posterior aspect. On the palmar side of the second above, we find a prominent projection in all of these Vultures, that in the *Tetraonidæ* was described as the *pentosteon** that became anchylosed at this point as the bird advanced towards maturity. This is a characteristic feature in *Neophron* also. The trihedral and robust pollex with its undulating and superior facet for articulation with its metacarpal, bears below, in all of our American Vultures, a freely movable ungual joint; this appendage we have already described elsewhere, as well as the circumstances attending its discovery. (Am. Nat., Nov., 1881, p. 906.) In the prepared skeleton, freed from all ligaments and soft parts, this joint consists simply, and in general terms for all of the *Cathartidæ*, of a compressed, usually from before, backwards, curved, and pointed bone, articulating upon a facette found just below the anterior margin of the pollex.† (Plate XV, fig. 105, *Gyparchus*, and Plate XIX, fig. 110 K, *Pseudogryphus*.) Now this terminal phalanx of pollex may be found covered by the common integuments, and not visible when the wing has been stripped of its feathers, *e. g.*, in *Limosa fœda* and *Numenius longirostris*, or it may pierce the skin to be covered by a horny sheath, *e. g.*, in many of the Ducks, Geese, and Swans.

The particular interest which attaches to the joint in the *Cathartidæ* is, that it passes through the integument, up as far as its base, to be covered with a horny sheath outside, and so armed bears a very close resemblance to any of the *claws* of the feet. This is not the case among many other birds, as we have cited above; at least the writer, who has had the pleasure and opportunity to examine a large number of these birds in company with such an astute ornithologist as Mr. Ridgway, failed to find it, and we are indeed moreover compelled to acknowledge here that it

* I have proposed elsewhere the above term for this ossicle when free; I first detected it in the carpus of *Centrocercus;* it is the fifth segment of the avian wrist now recognized. It formerly bore the name of the *pisiform*, which I gave it, and with which it must not be confused, nor with a bone so termed by Dr. Coues in his osteology of the *Laridæ*. (Birds of the N. W., p. 600.)

† The discovery of this claw excited not a little interest at the time. Mr. Forbes, of London, kindly noticed it in the following letter to the editors of the American Naturalist, which contains so much of interest on this particular point, that I take the liberty in republishing it.

[DECEMBER 7, 1881.

To the Editors of the American Naturalist:

Gentlemen: I read with much interest Dr. Shufeldt's article in your journal for November last, on the claw on the "index"[1] of the *Cathartidæ*, to the existence of which he had previously called my attention when I had the pleasure of making his acquaintance in Washington last month. Dr. Shufeldt certainly deserves great credit for being the first to detect a structure, which has previously, so far as I am aware, escaped the notice of all observers. I may add that since my return I have been able to confirm the truth of Dr. Shufeldt's statements on specimens of *Cathartes aura* and *C. atrata* in my possession.

Allow me, as one perhaps more favorably situated than Dr. Shufeldt has been as regards the literature of ornithology, to call my friend's attention to Nitzsch's "Osteographische Beiträge zur Naturgeschichte der Vögel," published at Leipzig in 1881. In that[2] he will find an excellent account of the claw and phalanx in question as it exists in many other birds.

Nitzsch does not seem to have observed it in the *Cathartidæ*, but found it in *Haliaëtus albicilla*, *Tinnunculus alaudarius*, and some others of the *Falconidæ*. It is very conspicuous in *Pandion*. In fact the occurrence of such a claw is of very frequent occurrence in the class Aves, though by no means universal amongst them. Amongst birds in which it may be well seen, I may mention *Struthio* and *Rhea*, *Cypselus*, *Caprimulgus*, the *Rallidæ* and *Parridæ*. Such a claw must not be confounded, as has been done by some writers, with the long "spurs" covered by epidermic tissues, formed by outgrowths from the *metacarpal* elements, of most birds, as *Parra*, *Palamedea*, *Plectropterus*, &c. In fact, the two may, as in *Parra* or *Plectropterus*, co-exist. Believe me, yours very truly,

W. A. FORBES,

Prosector to the Zoological Society of London.]

(Am. Nat., Feb'y, 1882, p. 141.)

[1] The digit of the Avian manus, called "index" by Professor Owen, is now universally recognized by anatomists as really the pollex.

[2] Ueber das Nagelglieh der Flügelfinger, besonders der Daumen," pp. 89-97.

was only very recently, and when in the study of this accomplished naturalist, who was present, and to whom the fact was also new, that this characteristic occurred in *Fulica*, *Gallinula*, and no doubt in the *Rallidæ* generally, not only those of our American avi-fauna, but among their cousins on the other continents. Mr. James Bell, of Florida, an excellent observer of the habits of birds in their native haunts, had that same morning (Dec. 28, 1881), narrated to Mr. Ridgway how, when he was in Florida, he had noticed that the young of *Ionornis martinica* actually put these claws to practical use by holding on to twigs in climbing out of their nests, and sometimes even suspended themselves like bats do.

Professor Owen distinctly states that the Swan does not possess an *external claw*, when he says, after describing various claws and spurs as they occur among birds: "Although the instances of these weapons, and the occasional use of the wings in birds not so armed, *e. g.*, the swan, show them in the light of means of attack, the bones of the pectoral limb in birds are modified mainly for volant action."—(Anat. Verts, Vol. II, p. 74.)

Mr. J. A. Jeffries does not state exactly whether in the birds he examined the *claw* made its appearance through the integuments or not, in his interesting paper, upon "The Fingers of Birds." (Bull. Nutt. Ornit. Club, No. 1, p. 6, 1881). This writer remarks towards the close of his article, that "also where there are two or three joints respectively in the finger there are often claws on the end, thus pointing to ungual phalanges."

Since writing the article in the American Naturalist just referred to, I have, after more careful search among the specimens at the Smithsonian Institution, found this claw in *Neophron percnopterus*, *Gyps fulvus*, and *Vultur cinerea*, and it, no doubt, occurs in all of the Old World Vultures, so that denying this fact was the most serious oversight that I allowed to creep into that paper.

So far as our knowledge carries us at the present writing, however, we know of no author who has *directly* attributed this character to the *Cathartidæ* except ourselves. At the time the above paper appeared in the Naturalist such able ornithologists as Dr. Coues and Mr. Ridgway were unacquainted with its existence, the author having the pleasure to call Dr. Coues's attention to the fact himself in a specimen of the Californian Condor; and Mr. William Brewster, an ornithologist whose knowledge of the external characters of birds and ability the writer holds in the very highest esteem, writes to me as follows:

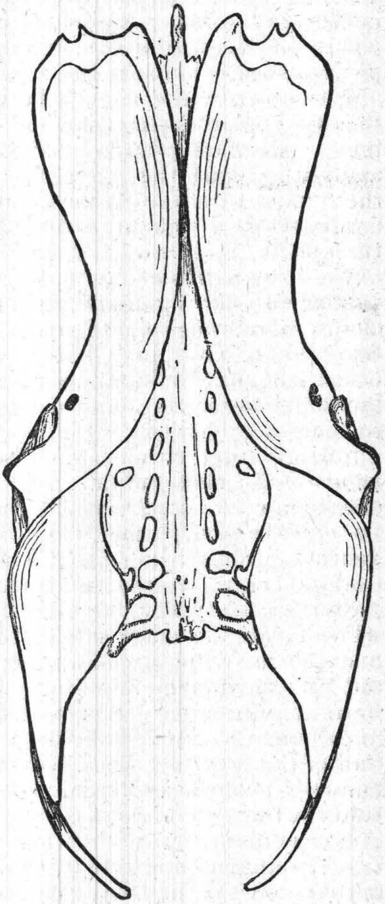
"Your discovery of the claw on the index digit of the *Cathartidæ* is most interesting and unexpected. I am no anatomist, or I might have anticipated you, as I have had the pleasure (?) of shooting and skinning both the Black Vulture and Turkey Buzzard."

The second metacarpal supports its usual number of phalanges, the upper one presenting the ulnar expansion, common in so many of the class and here well developed, affording below a broad facet for the most distal phalanx of manus, the second of this metacarpal being very much like the one representing pollex, only shorter and more delicately constructed. A phalanx is also freely suspended from the last metacarpal. This is the smallest one in the hand, being about half the length of the broad one of the second metacarpal, alongside of which it lies. This sometimes develops a tuberous process from its ulnar border, a feature that becomes quite prominent in *Neophron*.

Of the pelvis and the lower extremity.—We have already enumerated, in our table of the number of vertebræ present in the different divisions of the spinal column, the number of the sacral segments as they occur in these Vultures. In every instance they form a thoroughly anchylosed "sacrum," which in turn combines with the ossa innominata by perfect osseous amalgamation along the borders, more particularly anteriorly, for posteriorly or in the post-acetabular region the union with the ilia always is visible, and in some species allows a thin knife-blade to be inserted in the interstice by moderate force (*Pseudogryphus*). The complete pneumaticity of the sacrum has already been cited and dwelt upon, and the facets for the sacral ribs, and how these ribs in some species unite with the ilia, has likewise been referred to in sufficient detail.

Viewing this compound bone from above, we find that it is only in *C. aura* of the species we have before us where the ilia fail to meet in the median line, and thus conceal the common neural spine of the pre-sacral vertebræ (Plate XXI, fig. 117). In this Vulture quite an interspace exists between the ilia, 8 millimeters at the narrowest place, which is filled in by the much compressed and very broad neural spine. *Gyparchus* makes the next nearest approach to this condition. In all the others of the *Cathartidæ* the ilia meet for a greater or less distance mesiad, and also slope downwards more rapidly from the line of junction, these bones in the pre-acetabular region of *Cathartes* being quite in the horizontal plane anteriorly. Without exception, the neural spine of the first sacral vertebra juts out beyond the anterior borders of the ossa innominata, as the anterior moiety of the segment does below.

Cathartes aura, from the arrangement just described, seems to be the only one of the family that has a posterior opening on either side for the "ilio-neural" canals, the close approximation of the ilia in others of the group precluding it.



Sacrum of *Catharista atrata*; viewed from above; life size.

The thoroughly united neural spines on this their superior aspect in this bird are also broad and flat from one extremity to the other, while in *Catharista* and *Gyparchus* such portions of them that show behind are slightly rounded from side to side, a condition well marked in the Condors.

Referring the reader again to Plate XXI, figure 117, we observe how complete is the series, on either side, of interapophysial foramina in the Turkey Buzzard, and how an additional row of smaller ones exist outside of these; then by examining our cut of the sacrum in *Catharista atrata* (and the condition obtains next best in *Gyparchus*), we observe how it occurs among others; they are confined almost to the few ultimate vertebræ in *Pseudogryphus* and *Sarcorhamphus*. The anterior margins of the ilia are finished off above by a smooth and raised border, which seems to be produced over the extremities of the diapophyses of the first sacral vertebræ in *Cathartes* and the Condors. This border is carried backwards a certain distance to be lost in the true gluteal ridge, of which it is the anterior extension. It is less prominent in *Gyparchus*, as seen in a good life-size figure of the sternum of this Vulture given by Eyton in his *Osteologia Avium*. Posteriorly, and where the sacral vertebræ are visible from above, the outline of the area they appropriate, is lozenge-shaped, the anterior angle being in the locality of the point where the ilio-neural canals terminate posteriorly in most birds; the posterior angle is in the last sacral vertebra, while the lateral angles are about opposite the acetabula, corresponding to the longest processes thrown out from the vertebra below as abutments at this important point. The last sacral vertebra, in all of the *Cathartidæ*, although well anchylosed with the one next beyond, is never completely grasped by the ilia, its transverse processes always projecting a little beyond.

The *gluteal ridges* meet then at a point, mesiad, in such of these Vultures as we have described the ilia meeting at a greater or less distance beyond the antitrochanters, they diverge to form bounding lines to the post-acetabular region, being carried in their course above the antitrochanters, in whose neighborhood they form lateral angles to be directed backwards, to terminate behind in the produced processes, or process on either side, of the ilium. Such part of the superior pelvic surface as is generally known as the *pre-acetabular* is carried or continued backwards to the space between the antitrochanter and the lateral angle of the gluteal ridge, on either side, consequently, for description's sake, slightly back of the acetabulum. This well defined region is formed on each side by an iliac bone, and confining ourselves to one side, we find it to be concave from before, backwards, as well as from side to side, the general surface being smooth and its narrowest part just beyond the cotyloid ring. In the Condors, less so in the rest of the family, the posterior moiety looks almost directly outwards, only slightly upwards, while in all the outer side of the anterior portion is directly upwards, and the inner nearly as in the posterior half; in *Cathartes* all of the anterior portion looks directly upwards, this Vulture having a much flatter and broader pelvis generally than the others of the family.

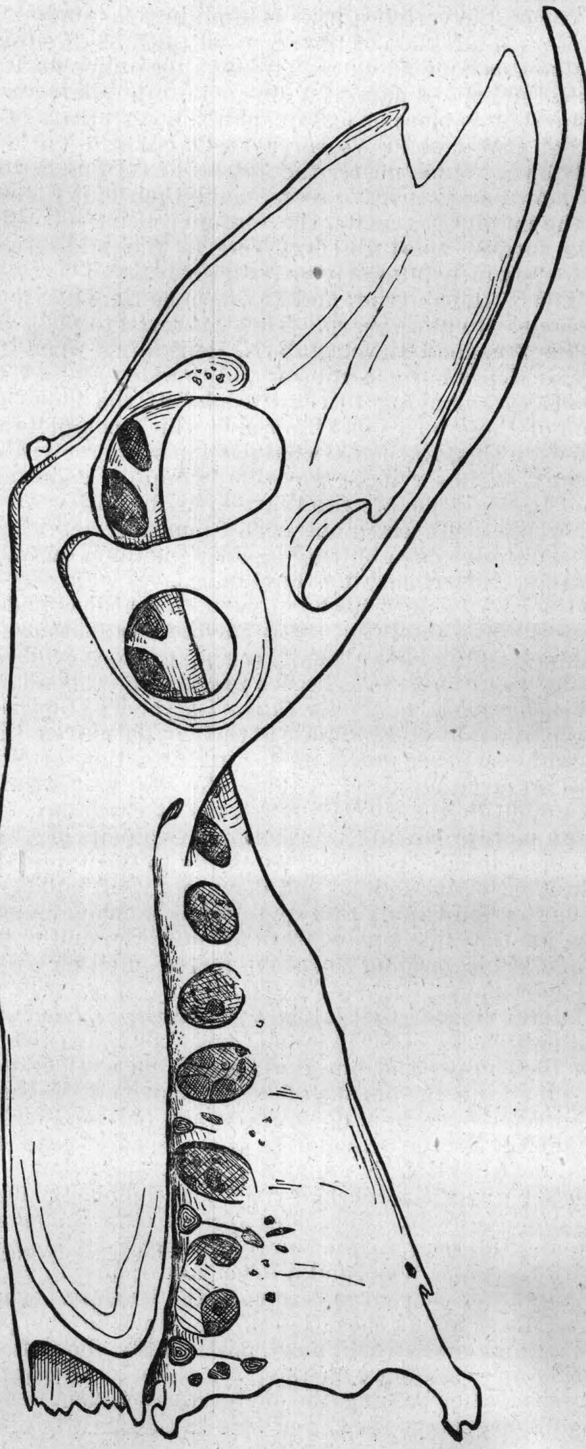
As among Eagles and many other diurnal Raptores, the posterior half of the pelvis of the *Cathartidæ*, as well as the Old World Vultures, is bent downwards from a vertical plane passing through the bone tangent to the anterior arcs of the ischiatic foramina; this causes the post-acetabular surface or region to face backwards and upwards, it being bounded anteriorly by the gluteal ridges, posteriorly by a rounded border concave inwards, composed of the iliac margins and the last sacral vertebra.

The under side of the iliac surfaces, or such portions of them as are seen upon an inferior aspect, are in the horizontal plane anteriorly, and up to that point, as we proceed backwards to where the pleurapophyses and transverse processes of the first four or five vertebræ are thrown out to abut against and anchylose with them. The anterior face of the first sacral vertebra possesses all of the necessary elements to articulate with the last lumbar; its neural spine is quadrate and produced beyond the ossa innominata; the prezygapophyses look upwards and inwards; the entrance to the neural canal is elliptical with the major axis vertical. In all of the *Cathartidæ* the first sacral vertebra supports more or less of a well developed hypapophysis; this process is very large in our specimen of *Pseudogryphus*, possessing lateral wings and upon its anterior face bearing a small facet for articulation, with a similar process upon the last dorsal. This plate-like hypapophysis, merging with a more feebly developed one on the vertebra next behind, in this Condor, added to the marked lateral compression of the centra of the first three or four sacral vertebræ, give this bone an extremely odd appearance for its under and anterior half, the bone dipping far down into the abdominal cavity, a characteristic that is more or less evident among others of the family, but we do not find it so in *Neophron*, an Old World Vulture that possesses a pelvis very much nearer the *Falconidæ*. Branches of the sacral nerves, the motor and sensitive roots, make their exit from the sides of several of the middle segments, the foramina being placed one above another, the largest apertures occurring in the mid-series, becoming smaller as we advance anteriorly or posteriorly.

The margins of the anterior, and at the same time horizontal, portion of the iliac bones are quite sharp. They converge to points at a greater or less distance beyond the acetabula, depending upon the species, where they suddenly become robust and rounded and continuous with a similar surface belonging to the "heads" of the pubic elements, or that portion of these bones on either side which complete the cotyloid rings. Opposite this, the constricted portion of the pelvis, or rather its narrowest part, we observe the greatest amount of enlargement of the neural canal to accommodate the ventricular dilatation of the myelon; here, too, short parapophysial braces come from the vertebræ, to be directed upwards, the anterior one abutting against the ilium on either side, the posterior rarely, if ever, meeting these bones.

Viewing the under side of the bone, we note that it is just beyond this locality that we drop into what really may be designated as the "basin of the avian pelvis," and here usually the next three vertebræ throw out only their superior processes as braces to the ossa innominata, while the last five (*Pseudogryphus*, *Cathartes*, *Catharista*) or six (*Gyparchus*) sacrals have strong parapophyses that unite at their outer extremities with each other, and with the other processes coming from the vertebræ all along the iliac borders on either side; of these, the first pair is the longest and are the ones opposite the cotyloid rings, the last two having all of their processes run more or less together, forming two pairs of strong rounded braces that are extended nearly horizontally to the "side bones." This pelvic basin is very commodious and deep, more particularly in the Condors and the Carrion Crow; this condition is much enhanced by a sort of reduplication that takes place from the posterior and united portions of the ilia and ischia, forming a concave recess on either side just within the ischiadic foramen.

Upon a lateral view of the pelvis, we find the *acetabular ring* nearly circular, the peripheries of the inner and outer boundaries coming nearest together in their upper and anterior arcs, while at their posterior and upper arcs they form the outline of an extensive antitrochanter, whose surface is directed forwards, downwards, and outwards. The greatest amount of surface for the articulation of the femoral head, between the internal and external ring, is found anteriorly and below. A stout osseous pillar separates the cotyloid ring from the much larger and subelliptical *ischiadic vacuity*, which is posterior to it. Below and between the two we find the long, oval *obdurator foramen*, its major axis nearly parallel with the pubic bone, and a deficiency occurring at its posterior arc, where this latter element fails to meet the ischium. The separating and outlying bone about these lateral openings in the pelvis of the *Cathartidæ* is thick and strong, more particularly about the acetabular ring, affording ample support for the powerful pelvic limb of these birds. The pubic style, after passing the obdurator foramen, is a moderately wide strip of bone, compressed from side to side, nearly or quite touch-



Left lateral view of pelvis of *Pseudogryphus californianus*; life size.

ing for its entire length the lower ischial border, except in *Gyparchus*, where quite an interspace seems to exist. Its outer or posterior extremity is produced well beyond the other pelvic bones, to curve inwards towards its fellow of the opposite side, from which it is separated by a varying space two and a half centimeters in our specimen of *Sarcorhamphus*, nearly one and a half in *C. aura* and *Catharista*. That portion of the outer and lateral surface of the ilium that is posterior to the ischiadic foramen, and below the continuation of the gleuteal ridge, looks downwards and outwards; opposed to it, below, is the ischial surface looking upwards and outwards; these bones thus form a longitudinal and shallow furrow between them, the anterior extremity being in the posterior arc of the ischiadic foramen, the posterior extremity terminating in the apex of a notch that is found between the ilium and ischium in the posterior pelvic margin. This notch is acute or angular in the Condors and the King Vulture, but rounded in the Turkey Buzzard and the Carrion Crow; it is very distinctive of the *Cathartidæ*, none of the Old World Vultures or the *Falconidæ* apparently possessing it, it being absent in all of the representatives of these latter birds that we have before us, the nearest approach to it being in *Gypogeranus*.

In reviewing the forms of the pelves of these Vultures and comparing them with each other we find, of course, for size, that the bone is largest in *Pseudogryphus* and *Sarcorhamphus gryphus*, and indeed in these two birds the pelves are very like each other. In general outline, and differing from the Condors, we find the pelves of *Catharista* and *Gyparchus* to be nearest alike, and to this couplet the pelvis of *Neophron percnopterus* approaches quite near, while *Cathartes aura* has a pelvis of a form differing from all the rest, and peculiarly its own, being at once recognized by the separation of the ilia anteriorly by the broad neural spine, and by its greater width as compared with its depth and length.

As already hinted, the *pelvic limb* of these Vultures is a very well developed one, and in every respect equally so with the pectoral extremity, which we have described above.

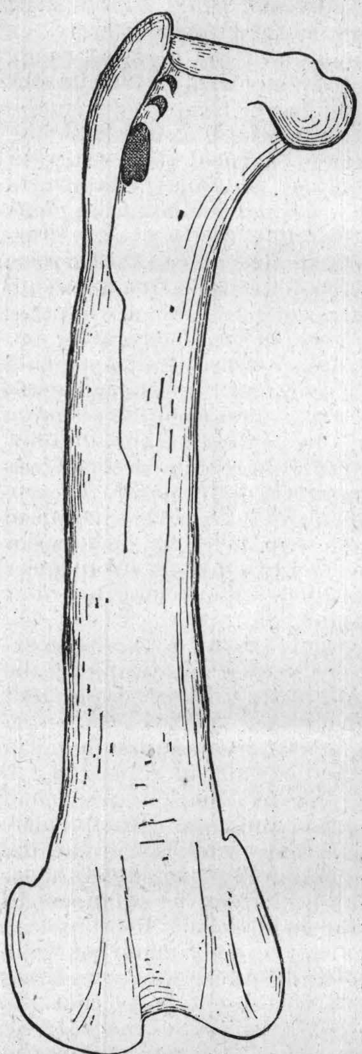
Among the species there are but few and trifling differences, except in point of size, though we note some departures from the typical form assumed by the *Cathartidæ* in *Neophron*, a Vulture that has a lower extremity more like the true falconine birds, as it did an upper one.

We find the pelvic limb in the *Cathartidæ* to consist of the usual number of bones for birds throughout the class, and, as a matter of some interest and no little importance, we insert here a table showing the comparative lengths of these segments, given in centimeters and their fractions, just as we did for the pectoral limb, choosing the same species and specimens to measure from, so that the two tables can be compared and the balance between the two limbs of any species taken into consideration; this will show at once the well-known discrepancy existing in *Gypogeranus*.

Table showing the lengths of the bones of the pelvic limb in the Cathartidæ, given in centimeters; also of Neophron percnopterus and Gypogeranus.

Species.	Femur.	Tibia.	Tarso-metatarsus.
P. californianus	13.6	22.	12.
S. gryphus	14.8	23.	12.5
G. papa	10.1	17.	9.2
C. aura	7.	11.9	6.4
Catharista atrata	9.3	14.8	8.6
N. percnopterus	7.3	11.8	7.5
G. serpentarius	11.	30.1	29.1

These measurements show us that among the *Cathartidæ*, the Condor of our western country possesses the greatest extent of wing, although the South American one (*Sarcorhamphus*) has the longest legs; the same condition is also seen to exist between *Cathartes aura* and *Catharista atrata*. Also, in comparing *C. aura* with *N. percnopterus*, we observe that although the measurements of the segments of the pectoral limb are very nearly alike, the latter bird has a longer tarso-metatarsus in comparison, even where the femur and tibia are nearly as in the first; here again we find in this Old World Vulture a balance among the segments of this extremity that similates the *Falconidæ*.



Anterior view of right femur from *Pseudogryphus californianus*; life-size.

The *femur* is so bent that a longitudinal line drawn along its anterior surface is convex outwards, the greatest curvature existing at the junction of middle and lower thirds of shaft. A similar line drawn down its inner aspect is found to be concave.

The upper surface of the semi-globular head is in the same horizontal plane with the extensive articular facet at the summit of the bone for the antitrochanter of the pelvis, while above this rises the broad and prominent ridge of the great trochanter; below and to the outer side of which we find the pneumatic foramen (*C. aura*) or foramina (*Pseudogryphus*), for generally the species show more than one.

The femoral head is eminently sessile with the shaft, and presents for examination above an extensive though single excavation for the *ligamentum teres*. Below the characters we have just enumerated as pertaining to the proximal extremity of the bone, the shaft rapidly becomes subcylindrical, to dilate transversely at its distal or condylar end in the usual way. Near the middle of the shaft behind we observe the medullary orifice, and the ordinary muscular lines are tolerably well produced.

The rotular channel on the anterior aspect is moderately deep, rather wide, and of nearly the same width throughout; it passes beneath into a shallow, intercondyloid notch. In the popliteal depression, above the condyles behind, a deep pit exists; a few foramina are found at the bottom of it in *Catharista atrata* that may be pneumatic. The fibular cleft at the back of the external condyle is very decided, the inner half formed by it being produced well backwards in all of the *Cathartidæ*, as a prominent process to be applied to the internal aspect of the fibula in the articulated limb. Slight depressions are found, one on either side, in the broad lateral surfaces of the condyles, intended for ligamentous insertion. If a plane is brought tangent to the lowest point in either condyle, so as to include them both, it will be seen that the axis of the shaft is nearly perpendicular to such a surface, showing that the outer condylar tuberosity to be but very little lower than the inner, not nearly so much so as in some birds.

The patella in these Vultures is of fair size, and bears out its most common ornithic characters, being more or less flat superiorly, convex in front, and divided into two unequal faces behind, the inner being the larger; it is situated well above the cnemial crest of tibia in the tendon of the quadriceps femoris.

Quite an intimate union exists between *tibia* and *fibula*, although positive anchylosis never takes place, along the produced and prominent fibular ridge on the outer aspect of the shaft of the tibia, occupying a good share of the upper third of this bone. Above this point the *fibula* is very much enlarged, and drawn backwards into a laterally compressed tuberous head, with a smooth, nearly horizontal facet above, that in none of the species rises much above the summit of the articular surface of its companion. Below the fibular ridge this bone dwindles to its usual styliform dimensions, being compressed from before, backwards, and running well down the tibial shaft into its lower third, to terminate in a free pointed end, in all of the *Cathartidæ*, except *Cathartes aura*, though the union is very intimate at the lower extremity in the skeleton of *Sarcorhamphus*. The *tibia* has a large cuboid head, but the undulating articular surface at its summit is not profoundly impressed by condylar depressions, for the trochleæ of the femur, and, indeed, the *pro-* and *ecto-cnemial* ridges are but feebly developed; the latter is produced fibularwards as a strong though blunt tuberosity, shielding the superior tibio-fibular articulation in front. The *cnemial crest* above these processes is likewise low and not raised to any extent above the general articular surface to which it forms the anterior boundary.

A section of the tibial shaft, made anywhere between the distal extremity and the fibular ridge, shows it to be broadly elliptical, and the entire shaft is bent so as to be convex anteriorly, concave throughout its length posteriorly; it expands transversely as it approaches the distal extremity, where we find the usual points for examination found in the vast majority of the class. A broad and strong osseous bridge is thrown obliquely across the groove that is the continuation upwards of the intercondyloid notch, to retain the extensor tendons. The trochleæ are reniform in outline, placed in antero-posterior and nearly parallel planes, the fibular one being the broadest anteriorly; the notch separating them is deepest just below the bony bridge for the extensors in front, while behind it is not carried very far up the shaft and becomes very shallow, the trochleæ apparently running into one common surface.

The bones of the leg of *Neophron percnopterus* are very similar to those found in the *Cathartidæ;* the principal differences seem to be that the pro- and ecto-cnemial ridges at the proximal extremity and the trochleæ at the distal are placed rather farther apart; the bony span to hold the extensor tendons is the same. We mention this fact because in some of our American Hawks (*Tinnunculus*, *Polyborus*) it is found to be double, *i. e.*, the bridge above is thrown across a wider tendinal groove in these birds, and from the lower margin of the span another bony piece is joined that is carried down to the inter-condyloid notch. This arrangement gives one opening above and two below, one on either side of the last bony span mentioned.

Unfortunately we will not be able to enter into the subject of the tarsal segments, and their mode of union to the bone we are now about to describe, and to the distal end of the tibia, as this requires the skeletons of the very young of the subjects in hand, material that I unfortunately do not possess.

The study of the forms assumed by the process or processes at the proximal and posterior aspect of the *tarso-metatarsus* is extremely interesting, and as important as many of the results are, the author is obliged to confine himself here to a hasty sketch of the general appearance of this tuberosity as it is found in the *Cathartidæ* and some of the Old World Vultures and the *Falconidæ*. Among all of the American Vultures it is a broad cuboidal process, placed at the extremity of the posterior aspect of the shaft, mesiad. It has leading away from it below a raised crest, that soon merges into the shaft, or the amalgamated mid-metatarsal.

In *Cathartes* this process is sharply grooved in a vertical direction behind. This is also the case in *Catharista;* the King Vulture has the process broader transversely, the grooving shallower, with its outer and posterior margins slightly produced. This condition is still further advanced in the Condors, while upon turning to *Neophron* we observe that it has been carried still further, so much so that the mid-vertical groove is now a broad concavity and the lateral productions appear as separate and rounded processes.

In *Polyborus tharus* it is a distinct, broad quadrate plate at right angles to the shaft. In *Tinnunculus*, this plate is not distinct, or rather it is carried far down the shaft to merge into it in the lower third; an intermediate form between the last two is presented by *Micrastur brachypterus*.

Gypogeranus presents it very much the same as in *Cathartes aura*, only rather longer for its width, which is quite natural in this bird of a stilt-like tarso-metatarsus. An instance of its being apparently double is seen in *Buteo cooperi*, one stout and quadrate lamelliform process, crowned by a transverse, subelliptical plate, standing prominently out from the fibular side of the bone, while absolutely separated from it on the tibial side we find a smaller though eminently distinct apophysis with its summit slightly bent outwards, the intervening surface being broad and only moderately concave between the two. Other Hawks also assume this form, as *Circus*. A tough piece of cartilage is placed over this process in the *Cathartidæ*, through which many of the flexor tendons pass. The summit of the bone presents two lateral concavities with a median anterior rounded tip, all for the accommodation, in the articulated skeleton, of the trochleæ of the tibia.

Horizontal sections made at almost any point of the shaft are more or less parallelogramic in outline, and this portion of the bone is markedly straight in all of these Vultures, for we know that in many of the *Falconidæ*, and the condition is slightly observable in *Neophron*, that the tarso metatarsus is often more or less bent in the reverse direction of the tibia above. The shaft of this, the last long segment of the hinder limb, is very much scooped out on its anterior and upper surface; this disappears as we approach the distal end of the bone, where we find the large foramen for the anterior tibial artery occupying its usual site. Behind, the shaft is doubly grooved, in a longitudinal direction, markings that are about equally distinct throughout their course, each groove passing down alongside the plate that was described as coming from the process at the upper and hind end of the bone. Two foramina pierce the bone at its upper part, appearing posteriorly on either side of the plate just mentioned. The three trochlear projections that terminate this bone distally are large and well separated from each other, the mid one being the largest, standing out in front of the others, and possesses a very decided median groove that passes clear round its entire surface; this feature is usually absent on the lateral processes, of which the outer is the smaller; these are placed slightly to the rear of the middle one, particularly in the Condors, least of all in *Catharista*, in which Vulture all three are nearly in the same transverse plane. The concave facet for the *os metatarsale accessorium* is more than usually distinct, and this bone in the recent skeleton is attached after the common rule by ligament merely; it is twisted upon itself, rather long, but not so long as in *Neophron* in proportion, and supports its ordinary toe, of a joint or phalanx and an osseous claw.

Perhaps there is no better way of calling the reader's attention to the points of interest that are to be found in the feet of these birds than by comparing such a Vulture as *Gyparchus papa*, that has represented in these parts all of the characters of the *Cathartidæ*, with *Neophron percnopterus*, that as far as we know possesses in its foot all of the striking characteristics of the vulturine birds of the Old World. The joints of the toes follow the usual avian rule of 2, 3, 4, and 5 segments to the first, second, third, and fourth toes, respectively. In the first or hind toe of *Gyparchus*, and in all of the *Cathartidæ*, the proximal joint is long and about equally dilated at either extremity, while in *Neophron* the end that articulates by its concave trochlear surface with the *os metatarsale accessorium* is very much expanded transversely, while at the same time it is compressed from above downwards. The bony tubercle found at the under side of the proximal extremity of all of the claws is quite an insignificant affair in our Vultures as compared with the protuberance we find in *Neophron*, and, moreover, the claws are very much more curved in this latter bird than they are in the *Cathartidæ*. The proximal joint of the inside toe of *Gyparchus* is long, having all the characteristics of the other long segments of the foot, while in *Neophron* it is a markedly *short* and irregular bone, having, to be sure, its ordinary articular surfaces, one at either extremity. This difference can be made more evident by simple measurement; the first and second joints of the inside toe of *Gyparchus* measure respectively 2.2 and 2.5 centimeters in *Neophron percnopterus* the same segments .7 and 2.4 centimeters, respectively. It is very interesting for us to know that in this matter of the shortening of the first joint of the inside toe *Neophron* follows all of the *Falconidæ* or their American representatives that we have been able to examine. Differences in the hind toe are not so striking, the segments in both birds being long and proportionately balanced, but in the outside toe again we discover a leaning on the part of *Neophron* towards the *Falconidæ*, while *Gyparchus*, in common with the rest of its well-marked family, still adheres to a proportionate equipoise in length of the internodes, this time it occurs in the second and third joints of the toe in question. These we will also compare by measurement: in *Gyparchus*, first, second, third, and fourth segments measure 1.8, 1.4, 1.1, and 1.6 centimeters, respectively; in *Neophron* the same segments measure, in the same order, 1.2, .5, .4, and 1.5 centimeters.

In closing this monograph the writer did intend to give a general synoptical table, but upon second consideration believes the various tables already presented will sufficiently illustrate and compare, not only the decided generic differences among the *Cathartidæ* themselves, both as to external characters and the more deep-seated internal and osseous distinctions, but also serve sufficiently to individualize the group as a family; so that, upon reviewing all that we have endeavored to present upon the osteology of these birds, we firmly believe that the reader will agree with us that our investigations have not only confirmed the fact that the *Cathartidæ* are widely distinct from the Old World

Vultures but enough so among themselves as to certainly warrant the family divisions into genera that we have followed in this paper. We further believe that the time is not far distant when the fact will be generally acknowledged, and Professor Huxley's admirable arrangement is this regard followed, that the Old World Vultures are only entitled to the rank of a sub-family under the *Falconidæ*. It is hard to perceive, even, how Mr. Sharpe can still adhere to his classification as given in the catalogue, where both New and Old World Vultures have been placed in the same family, *Vulturidæ*, and then divided into the two sub-families, I. *Vulturinæ* (Old World Vultures), and II. *Sarcorhamphinæ* (New World Vultures.) (Cat. Birds of Brit. Mus., Vol. I, 1874.) Let us take the very good example of *Gyparchus papa* from the second of these groups, and *Neophron percnopterus* from the first; snow-white skeletons of both of these birds, mounted upon their museum perches, are now standing before me, silent attestors, as far as their osteology goes, of the violence perpetrated by such an arrangement.

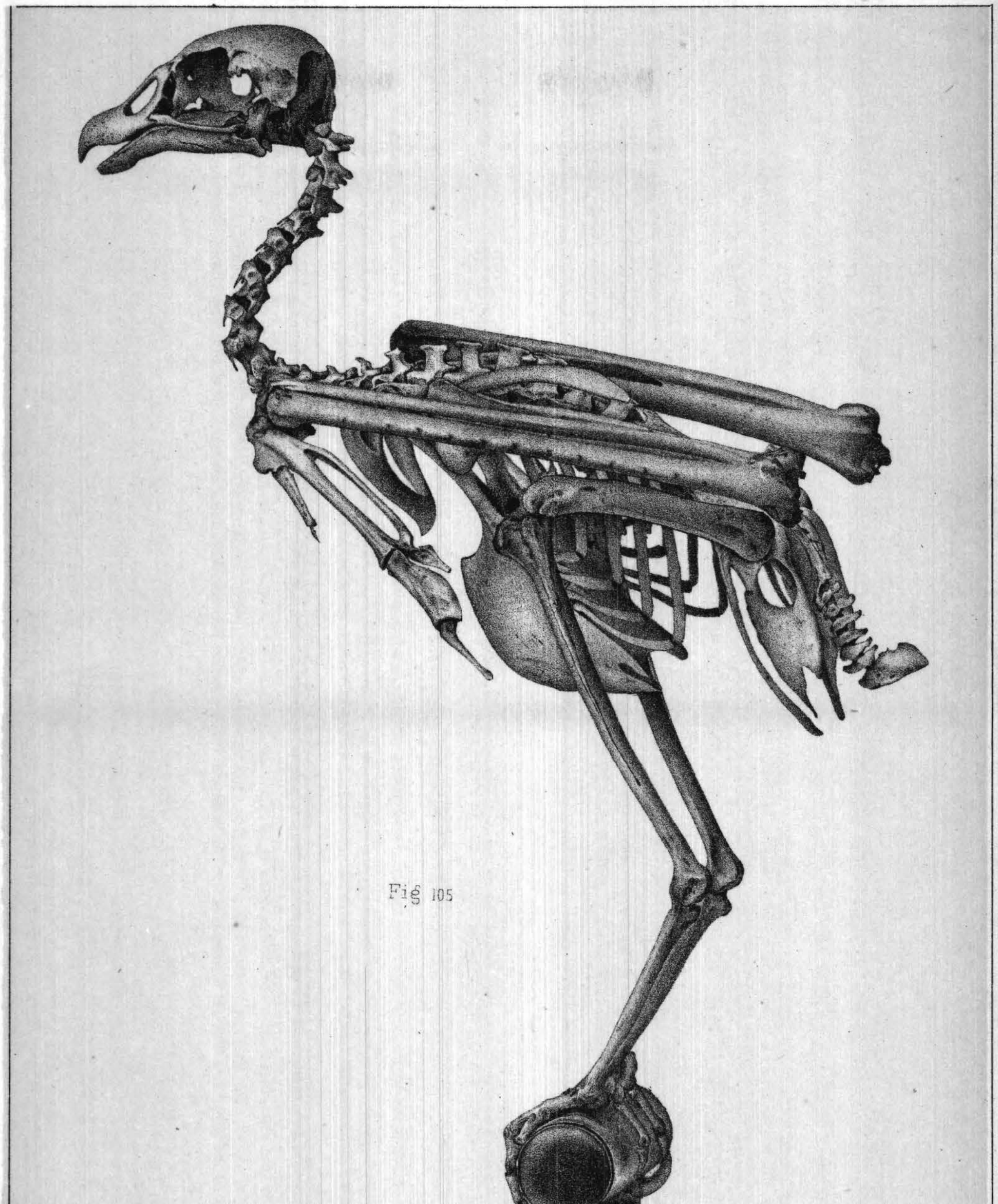
In *Gyparchus papa* we have the pterapophysial processes of the basisphenoid, the peculiar arrangement of the lacrymals, and the absence of the nasal septum, cranial distinctions of great importance and weight, while in *Neophron* a complete septum narum exists, and the pterapophysial processes are missing, characters it has in common with the *Falconidæ*.

Then, again, the differences in the scapular arch and sternum, the pneumaticity of the skeleton on the part of the King Vulture, a condition not enjoyed to any such extent by *Neophron*, the arrangement of the sternal ribs, and, in short, down to the very toes, these two birds are stamped with characters that compel us to acknowledge that they belong to two very different families, and to such, along with others of their kind that possess similar and such undoubted differences in structure, they must eventually be assigned by universal consent.

WASHINGTON, *August* 31, 1882.

PLATE XV.

FIG. 105.—Skeleton of *Gyparchus papa*, ♂, one-third the size of life.



T. Sinclair & Son, Lith.

SHUFELDT ON THE OSTEOLOGY OF THE CATHARTIDÆ.

PLATE XVI.

FIG. 106.—Skull of *Pseudogryphus californianus*, left lateral view, life size.

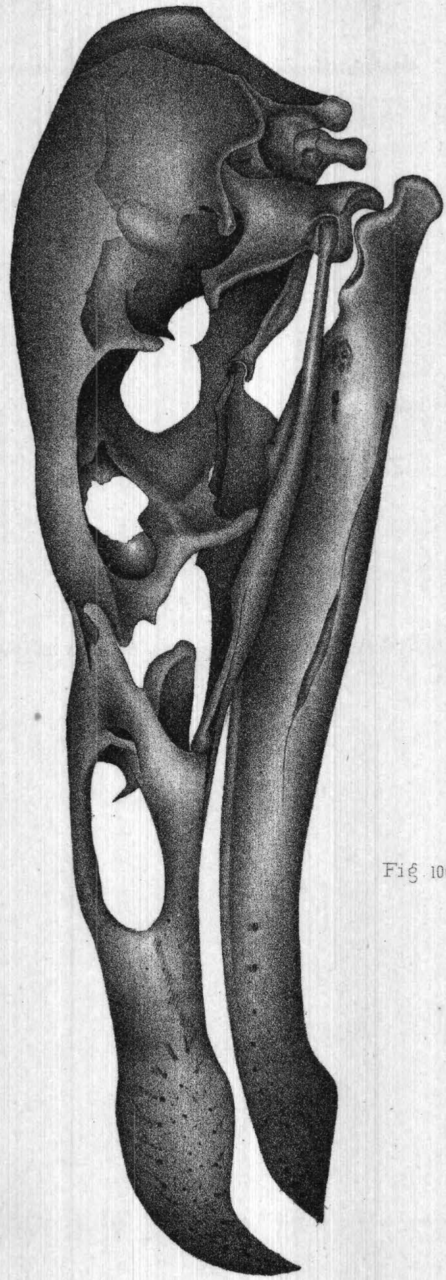


Fig. 106.

T. Sinclair & Son Lith.

SHUFELDT ON THE OSTEOLOGY OF THE CATHARTIDÆ.

PLATE XVII.

FIG. 107.—Right lateral view of sternum of *P. californianus*, from same specimen as figure 106; size of life.

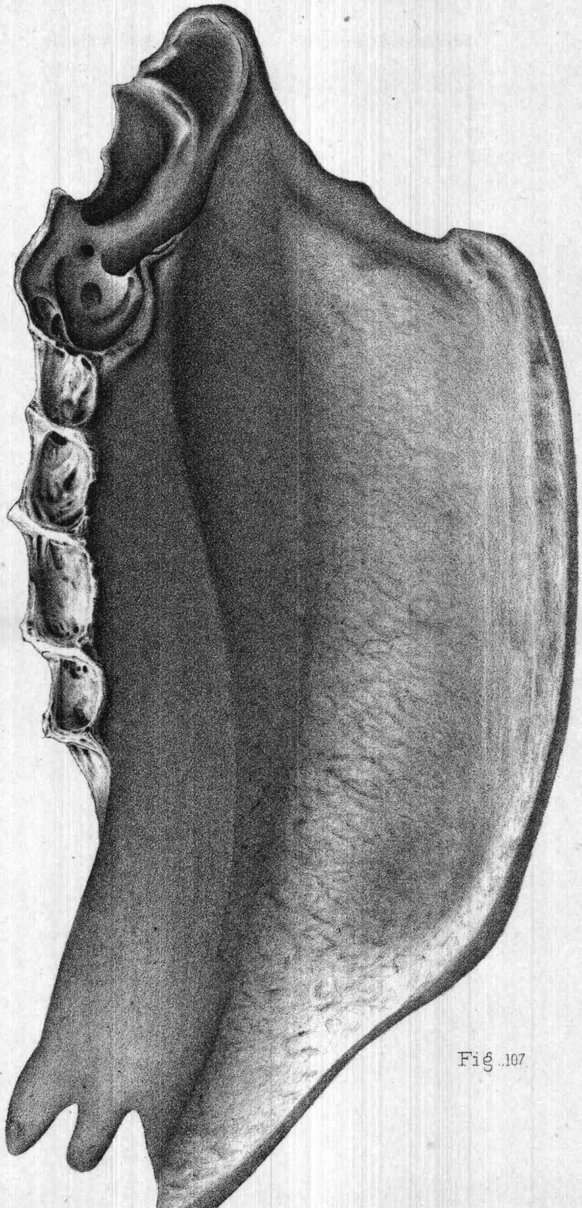


Fig. 107

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SHUFELDT ON THE OSTEOLOGY OF THE CATHARTIDÆ

PLATE XVIII.

FIG. 108.—Right coracoid and scapula of *P. californianus*, size of life; the dried tissues, stretching across the glenoid cavity, assist in retaining these bones in their proper position.

FIG. 109.—Right humerus, anconal aspect, from the same individual; life size. The dark pit at its lower side shows the entrance to the largest of the pneumatic fossæ.

PLATE XVIII

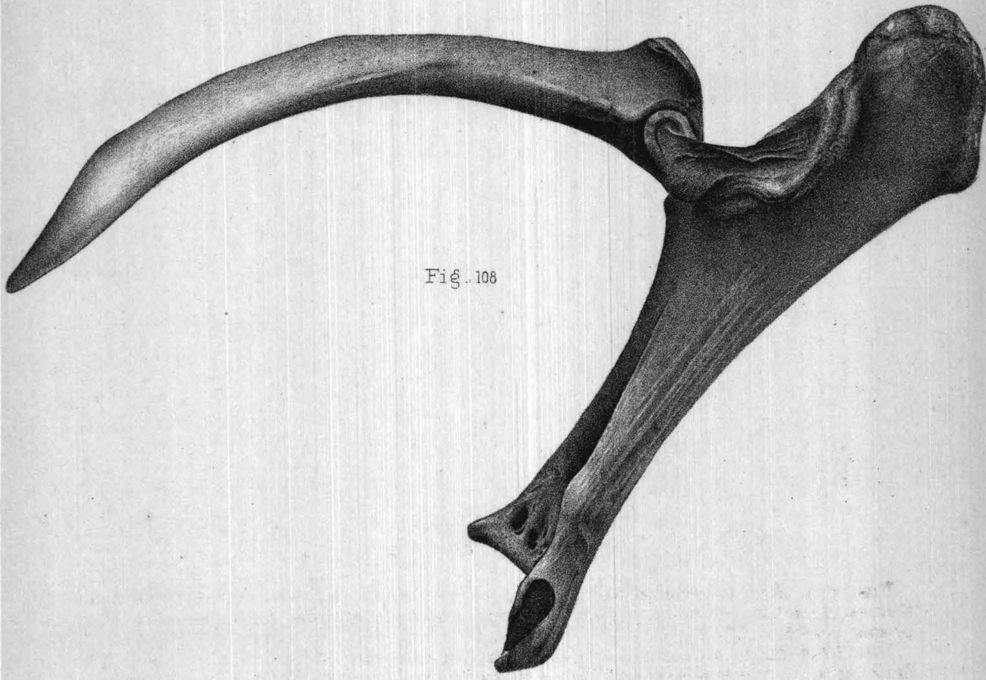

Fig. 108

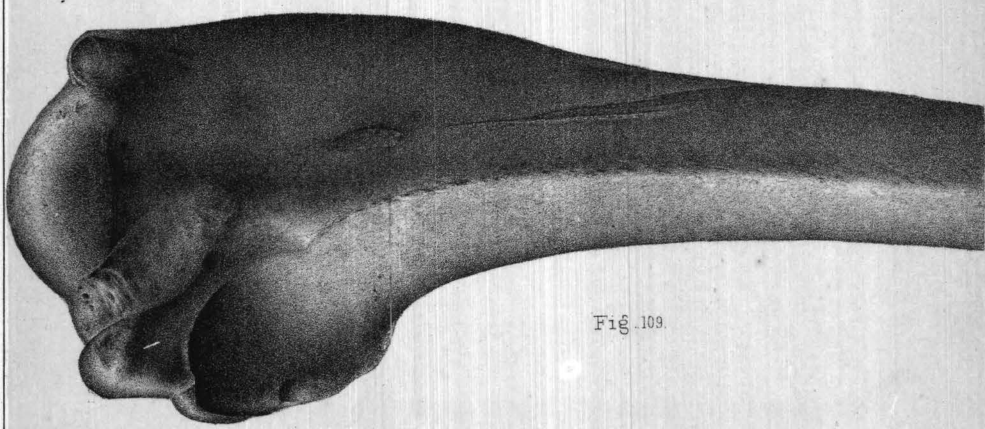

Fig. 109.

T. Sinclair & Son, Lith.

SHUFELDT ON THE OSTEOLOGY OF THE CATHARTIDÆ.

PLATE XIX

FIG. 110.—Outline sketch of the left metacarpus, *P. californianus* (same bird), with pollex (K), and the bony core of the claw it bears, *in situ;* life size. *m*, metacarpus; *d*, pollex.

FIG. 111.—Furculum of *Pseudogryphus californianus*, size of life, from the same specimen; viewed from the left side, showing the positions of the pneumatic foramina and the roughened surfaces for the attachment of ligaments.

FIG. 112.—The last dorsal vertebra, from the same bird, life size, posterior aspect, showing the facets that articulate with the first sacral vertebra. *pf*, large pneumatic foramen.

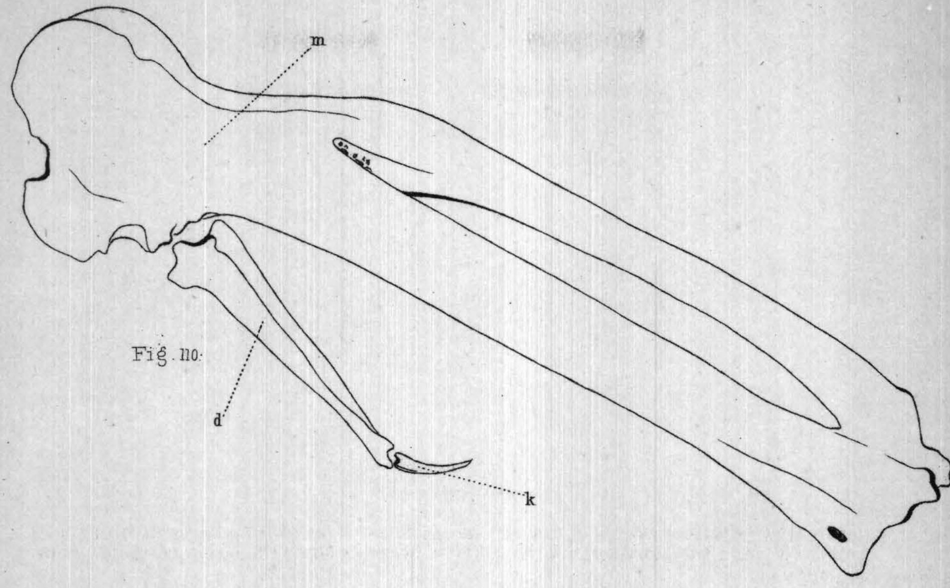

Fig. 110.

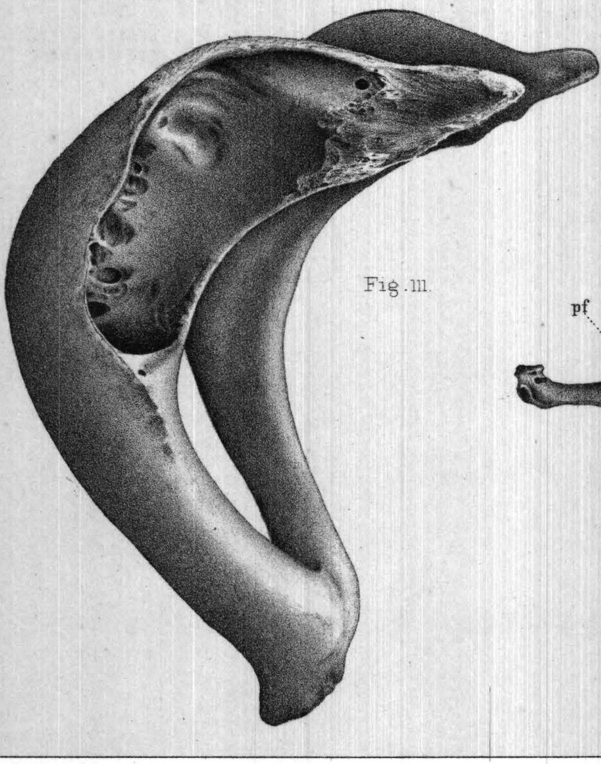

Fig. 111.

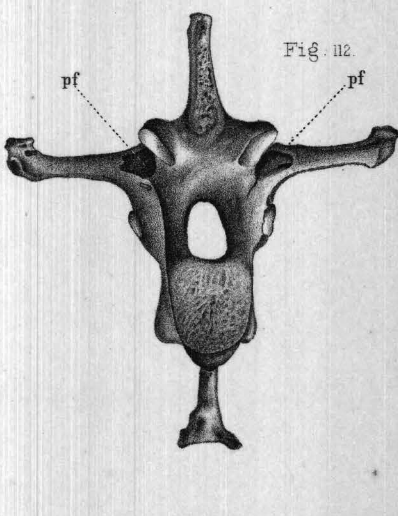

Fig. 112.

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PLATE XX.

FIG. 113.—Left lateral view of life-size skull of *Sarcorhamphus gryphus*.

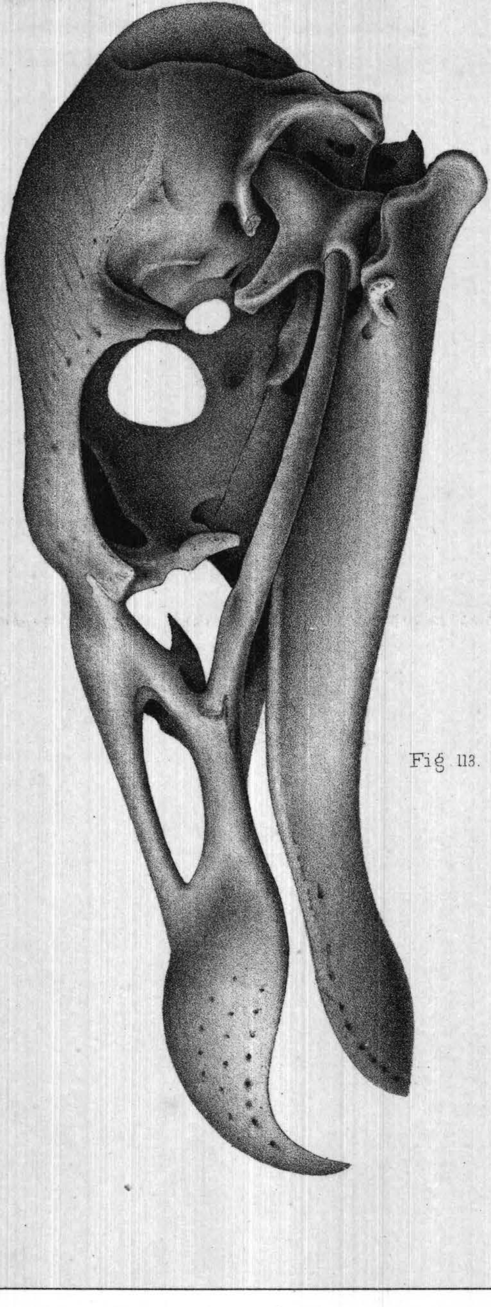

Fig. 113.

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PLATE XXI.

FIG. 114.—The three last cervical vertebræ from *Cathartes aura*, seen from below, showing the formation of the cervical pleurapophyses from the processes of these vertebræ by gradual metamorphosis as the bird passes from young to maturity; specimen size of life. *cy*, ribs that remain free in the adult and after the change just referred to is complete.

FIG. 115.—Hyoid arch of the same bird.

FIG. 116.—Left lateral view of the skull of *Gyparchus papa;* size of life.

FIG. 117.—Superior aspect of pelvis of *Cathartes aura*, life size; caudal vertebræ still *in situ*.

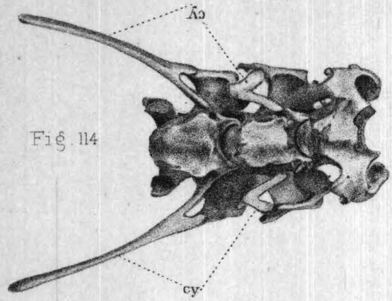

Fig. 114

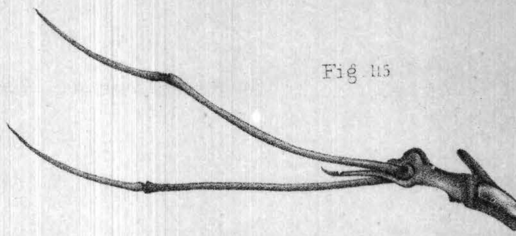

Fig. 115

Fig. 116

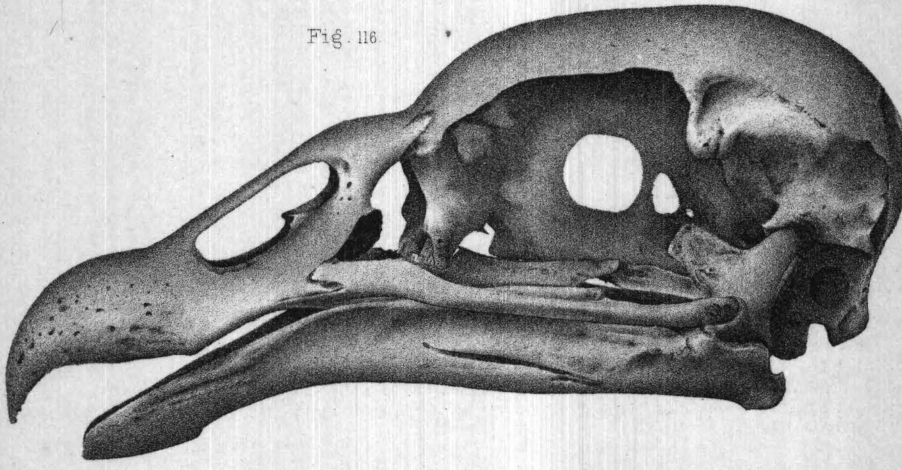

Fig. 117.

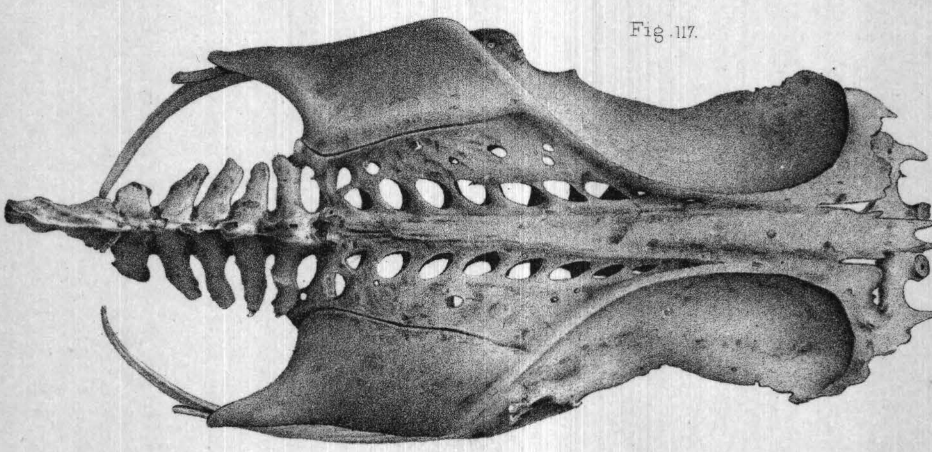

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PLATE XXII.

FIG. 118.—Left lateral view of skull of *Cathartes aura*, size of life; same specimen from which the parts referred to in the other plates were chosen.

FIG. 119.—Same, viewed from above.

FIG. 120.—Same, viewed from below.

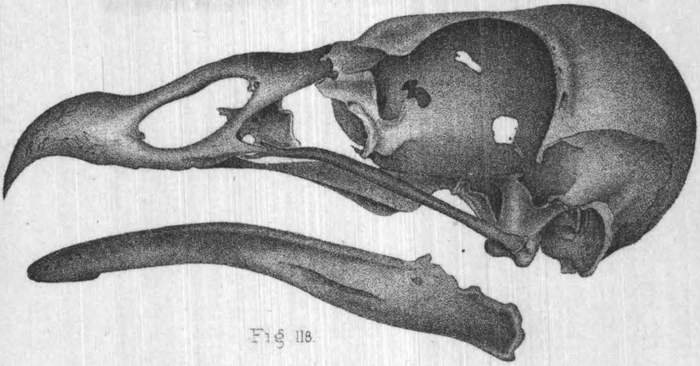

Fig. 118.

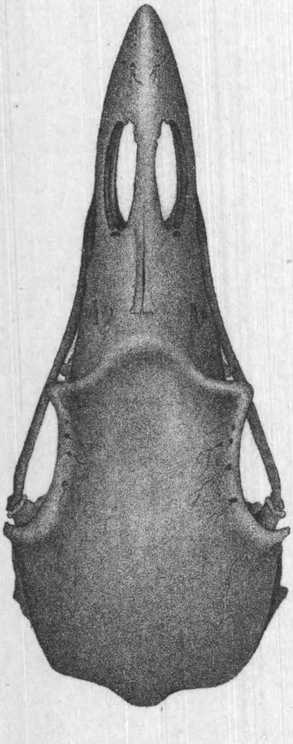

Fig. 119

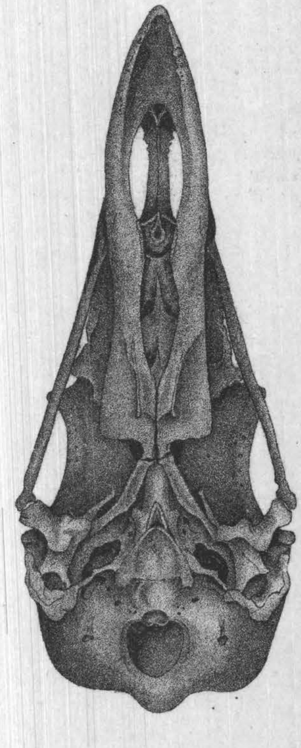

Fig. 120

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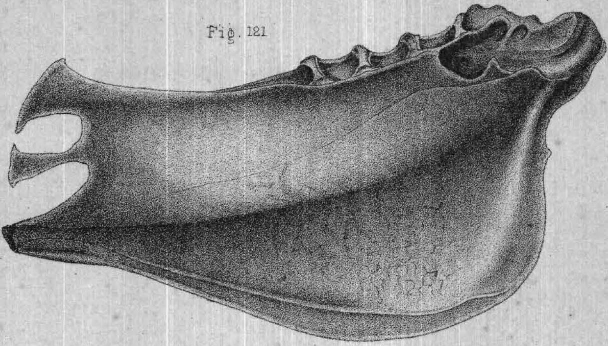

Fig. 121

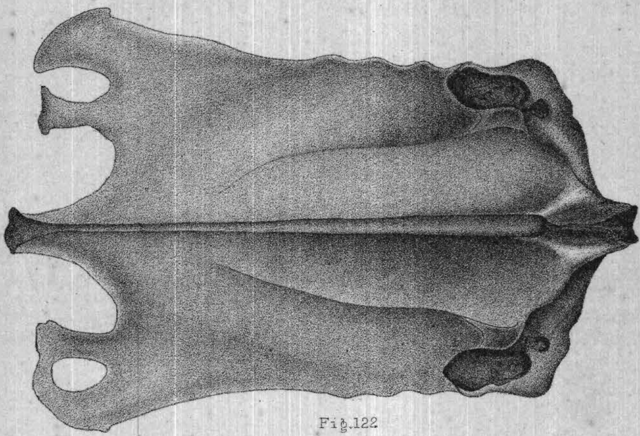

Fig. 122

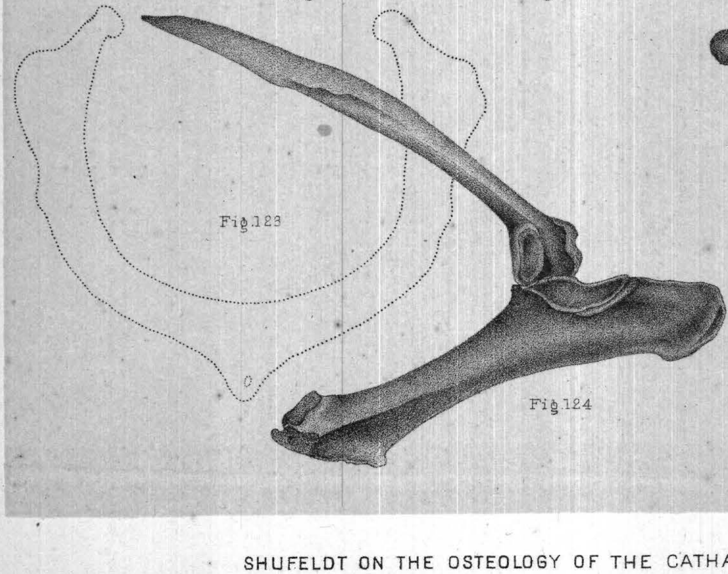

Fig. 123

Fig. 124

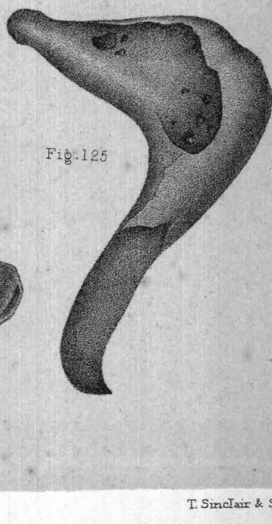

Fig. 125

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PLATE XXIV

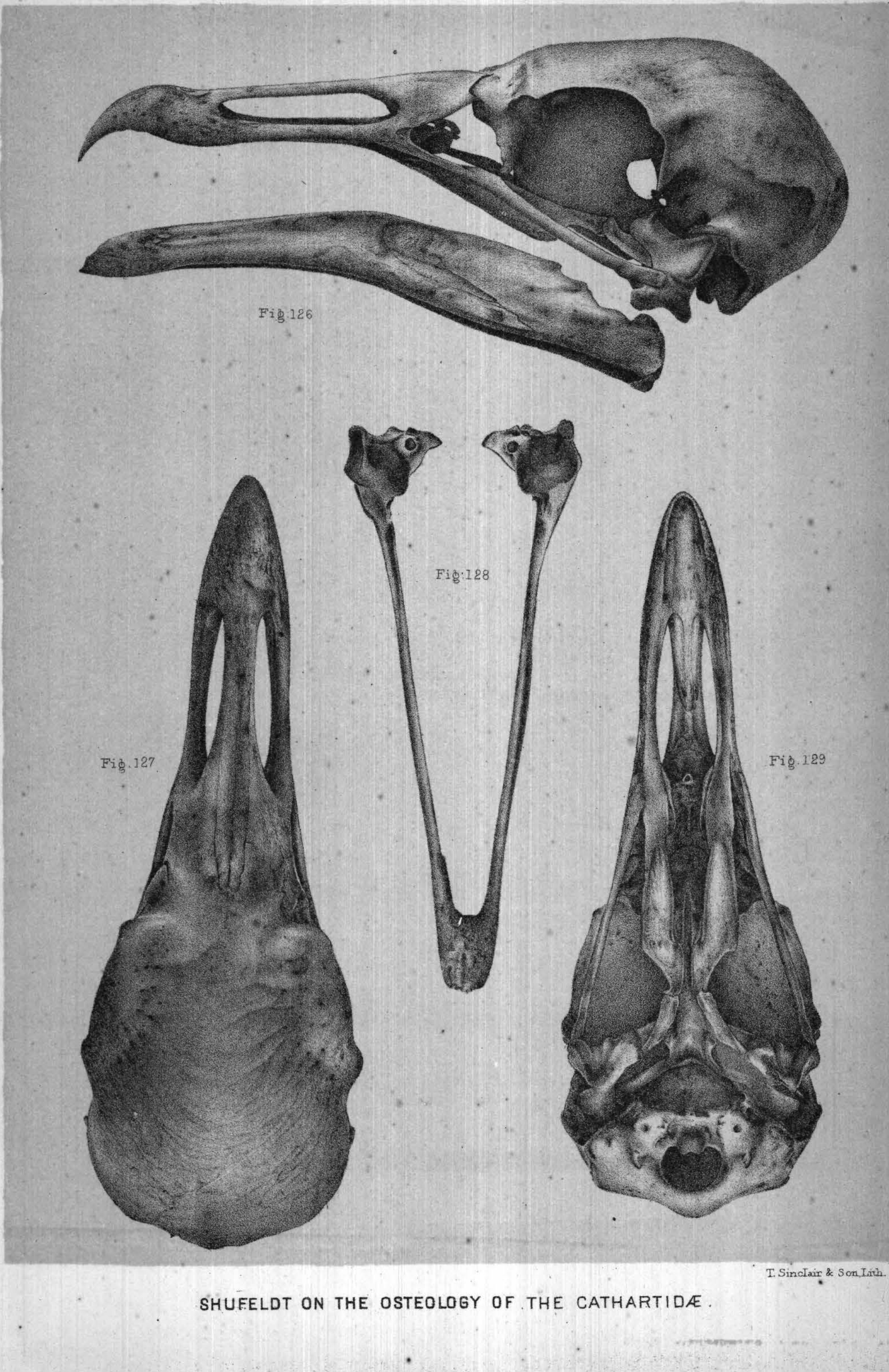

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PLATE XXIII.

FIG. 121.—*Cathartes aura*, same as in Fig. 118; right lateral view of sternum; size of life.

FIG. 122.—Same, seen from below.

FIG. 123.—Same specimen; dotted outline of furculum, life size, from in front; giving the general outline from this aspect of this bone as it occurs in the *Cathartidæ*.

FIG. 124.—Same specimen (*C. aura*); right outer aspect of coracoid and scapula; life-size. The bone is represented as resting on the plane of the paper.

FIG. 125.—Same specimen; right lateral aspect of the furculum, size of life, showing entrance to pneumatic fossa, and the distribution of the smaller foramina.

PLATE XXIV.

FIG. 126.—Left lateral view of the skull of *Catharista atrata;* life size.
FIG. 127.—Same, from above.
FIG. 128.—Lower jaw, from above; same specimen.
FIG. 129.—Same specimen; the skull from below; life-size.