Art. V.—Osteology of Eremophila alpestris.

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The 11th of March, 1880, was a particularly severe day at Fort Fetterman.* 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 feel sure my reader will pardon the liberty I take in adding to an article upon the osteology of this interesting bird a life-size portrait of it, selected from the large number before me on the occasion referred to. The hind claw in this individual (Pl. IV, Fig. 22) was longer and straighter than any of the others examined by me, but this member, as well as the areas of the different colors of its plumage, are, in my representation, the results of careful measurements and comparison. 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., VIII, No. 100, Pl. 497), where he figures his *Alauda rufa*, the Western Shore Lark. The bird figured in my plate was taken in that section of our country where the variety *leucolæma* is usually found breeding during the season, and probably belongs to series described as such, but certainly has attained a style and brilliancy of coloring that brings it very near to true *alpestris*, its size excluding it from the variety *chrysolæma*. Interesting and important as this part of the subject is in the life history of this bird, we must, with these few re-

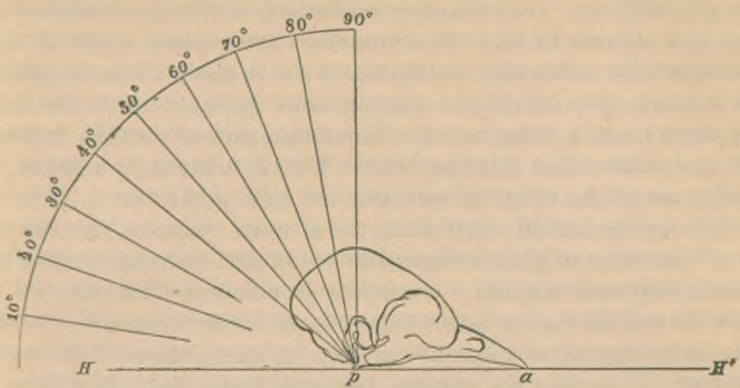
* Wyoming Territory, United States, lat. 42° 23′ 35″ N., long. 105° 21′ 4″ W.

marks, allow it to rest here and proceed with the true object of this paper, a description of its skeleton, simply reminding the student that of all the several genera that go to make up the family *Alaudidæ*, or Larks, but one genus has fallen to the lot of the North American fauna, and that the genus contains but one species, with its varieties, the osteology of that species being the subject of the present article.

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*, 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 skull we are studying, we find, when it is placed as directed above, of the skull rests on the horizontal plane. To illustrate this in the 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, 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 vertebræ 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 lachrymals, 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 lachrymals and maxillaries form, respectively, the posterior boundary and base. These triangles are not complete, insomuch as the lachrymals 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 lachrymals, assisted by the prefrontal, effectually separate the orbital vacuities from the rhinal chambers. The latter are remarkably 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 osseus septum narium. The anterior olfactory foramina, narrow slits one millimetre long, are found between the lachrymals 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. Anteriorly 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 lachrymals, 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 lachrymal; 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 lachrymal, 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, immovable, with the maxillary and intermaxillary. Back from this point as far as the under surface of the lachrymals, 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, vomerine, 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 maxillary articulation to the tympanic, about 4 millimetres, the skull being horizontal.

The coalescence among its three original elements is unusually perfect. Its 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 pterygoidal 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, withoutits 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. These latter 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 the uro-hyal, by cartilaginous tips.

The shaftlets of these delicate elements are slightly flattened from above downwards, as are the 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 tomal 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 to be 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 ornithol-omists 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 entrance 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. (For names of parts, see Explanation of Plates at the end of this paper.)

It will be seen that the carotid in this Lark is single, and bifurcate at a point about opposite the third cervical vertebra, the branches pursuing their usual courses above.

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 from 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 cord 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.

What could be more exquisite in texture or offer a prettier subject for study than the atlas of one of the smaller vertebrates such as our present subject? When we see it analyzed in the minutest details, carried beyond its mere gross anatomy, what interest, what wonder we experience, and how we marvel still when we realize the significance of this bone, with its variously modified autogenous and exogenous parts—a vertebra.

Here, in the atlas of *Eremophila*, the bird-head, as far as its bony support is concerned, rests in a diminutive cup not half a millimetre wide or deep, that may or may not be perforated by the odontoid process of the axis; in fact, quite an amount of osseous tissue intervenes, which seems to be due to a short odontoidal style in the majority of instances, rather than a lengthening of that part of the atlas that receives it.

A square bony plate projects from below, 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 vertebra 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 longer 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.

Through the teachings of philosophical anatomy, we must recognize in the avian hæmal spine or the bone sternum, developed as it may be, the confluent hæmal spines; 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. III). 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 markedly impressed 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 vertebræ 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 remarkable 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 markedly 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.

The ornithotomist will find, in reviewing the skeletons of our avian types that the ilio-neural grooves, as seen in this bird, are very frequently converted into *canals* in other orders, by meeting of the interested bones above. The condition as defined, however, 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 markedly 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, this bone, 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 notoriously angular and 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 truly 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 encloses 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 firmly united; any attempt to remove the ossa innominata, in the adult bird, from the sacral border, invariably results in failure and usually longitudinal iliac fracture.

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* lays 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 likenesses; 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.

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*, as perhaps the best representative of avian structure among the *Oscines*, we find the scapula *shorter* in proportion when 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 carpus, one to the metacarpus, and four to the phalangeal portion of the manus.

In ornithotomy we find the head of the *os humeri* playing in a shallow glenoid cavity, composed of the glenoid process of the scapula, the humeral facet of the coracoid, and here, in addition, the os humero-scapulare; the homologue of the humerus summus not entering into the scapulo-humeral articulation as an overarching and protecting process, as we find it in human anatomy.

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, surrounded 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 formed 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 mid-shaft 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 ulná, 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 truly 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 markedly 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 elliptical 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; but the bones *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, though the general surface is 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 finger, markedly compressed, that completes the skeletal bird-arm distally, it 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 its 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, markedly straight, and devoid of those evidences of being acted upon by powerful muscles, would require but a single 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 pneumatic, 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 failed to reveal any other opening. The trochanter minor is not represented.

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

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 Gengenbauer 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. 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 its 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, falling between the thigh and leg-bone.

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 "calcaneal" 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 larger 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 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.

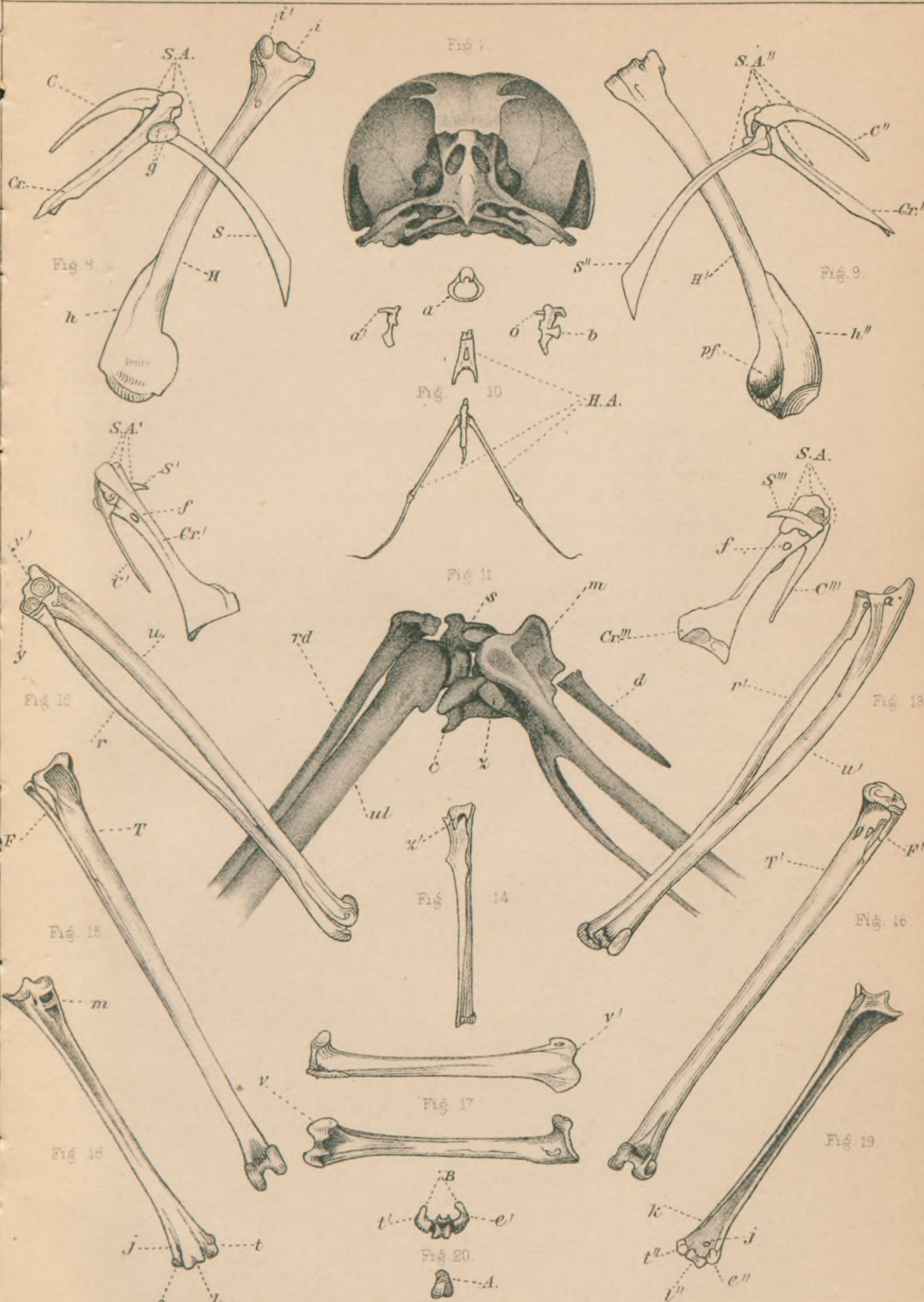
Fig. 16. Posterior surfaces, same bones; *F'*, fibula; *T'*, tibia.

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.



Thos. Sinclair & Son, Lith.

OSTEOLOGY OF SPEOTYTO CUNICULARIA VAR. HYPOGÆA.

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 vertebra, 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.

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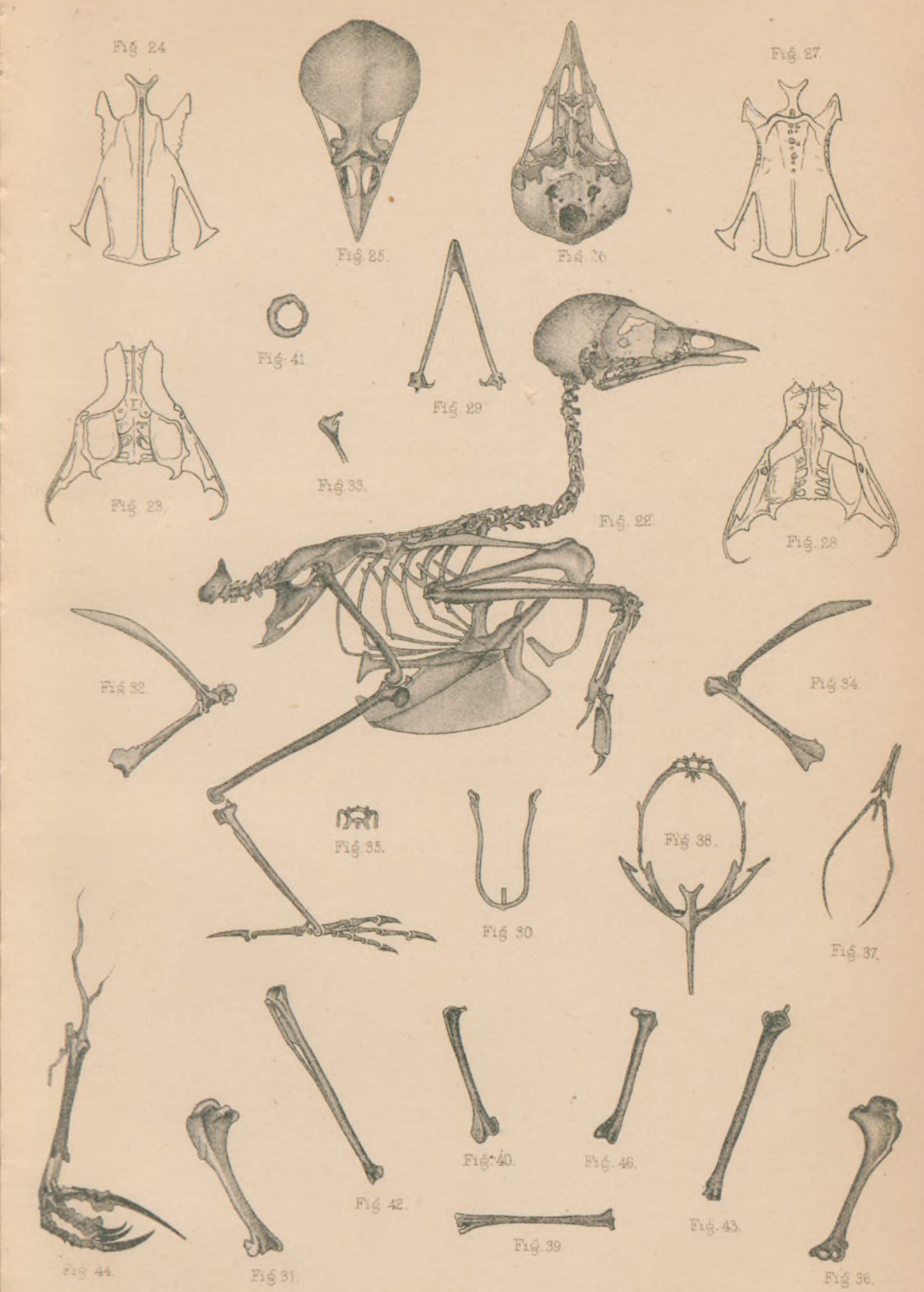
* The figures on this plate are numbered in continuation with the author's plates and figures to his Memoir on the Osteology of *Speotyto cunicularia hypogæa.*



OSTEOLOGY OF EREMOPHILA ALPESTRIS.