The skeleton in the flying lemurs, Galeopteridae / by R.W. Shufeldt.

ibrary Royal College of Surgeons of Englan
Compliments of Dr. Shufeldt.

THE SKELETON IN THE FLYING LEMURS, GALEOPTERIDÆ

25

By R. W. Shufeldt
(Washington, D. C.)

Reprinted from
THE PHILIPPINE JOURNAL OF SCIENCE
Published by the Bureau of Science of the Philippine Government, Manila, P. I.
Vol. VI, Nos. 3 and 4, Section D, General Biology, Ethnology and
Anthropology, June and August, 1911

MANILA
BUREAU OF PRINTING
1911

104561

Order No. 406.

THE HISTORY OF SULU.

By NAJEEB M. SALEEBY.

275 pages.

A complete History of the Moro People in Sulu, with maps and many translations from the original documents.

Price $0.75, United States currency.

Order No. 407.

THE BATAN DIALECT AS A MEMBER OF THE PHILIPPINE GROUP OF LANGUAGES.

By OTTO SCHEERER.

AND

"F" AND "V" IN PHILIPPINE LANGUAGES.

By CARLOS EVERETT CONANT.

141 pages

Price $0.80, United States currency.

Order No. 402.

NEGRITOS OF ZAMBALES.

By WILLIAM ALLAN REED.

62 photographic illustrations. 91 pages.

An interesting ethnological study of the pygmy blacks of Zambales.

Price $0.25, United States currency.

Any of the above-announced publications may be ordered from the Business Manager, Philippine Journal of Science, Manila, P. I., or from any of the agents listed on the cover of this Journal. Please give order number.

THE PHILIPPINE JOURNAL OF SCIENCE.
D. General Biology, Ethnology and Anthropology.
Vol. VI, No. 3, June, 1911.

THE SKELETON IN THE FLYING LEMURS, GALEOPTERIDÆ.

By R. W. SHUFELDT.
(*Washington, D. C.*)

INTRODUCTION.

Osteological material for the present contribution has been furnished by Professor J. B. Steere of Ann Arbor, Michigan, and by Mr. Richard C. McGregor, of the Bureau of Science, Manila, P. I. What this material consists of, together with letters and other notes accompanying it, will be set forth further on in the present introduction.

A number of comparative anatomists have touched upon the morphology of probably several of the species of the flying lemurs, but until the present time it appears that no fully illustrated and detailed account of the osteology of these remarkable animals has been published.

Owen,[1] in giving the characters of the skeleton of the Insectivora, briefly refers to the skull and some few of the limb bones of *Galeopithecus*, but in the case of the skull, unfortunately, he does not make it sufficiently clear as to whether the description does not likewise apply to *Pteropus*. Thus he says:

> This [that is the skull] in *Pteropus* and *Galeopithecus* manifests the lissencephalous affinity by the squamosal being perforated by a venous canal behind the root of the zygoma, by the suspension of the malar, in the zygoma, by the distinct petrotympanic, by the vertical occiput, small cranial cavity, and blended orbital and temporal fossæ. The orbit is partly defined behind by long and slender processes of the frontal, which is perforated by a superciliary foramen. The parietals usually coalesce at the sagittal suture, but rarely develop a crest.

The paragraph continues in confused and inaccurate generalities to the end and closes with the statement that "in *Galeopithecus* the coronoid is small." Little more than this is added to his description of the skeleton, in fact only that

> In the Colugo (*Galeopithecus*) the ulna terminates in a point at the lower

---

[1] Anatomy of Vertebrates (1866), 2, 387, 388.

fourth of the radius;[2] all the five digits of the hand, like those of the foot, have claws supported on deep compressed ungual phalanges.[3]

Owen gives a figure of the skull of *Cynocephalus,* seen upon superior view, which is quite different from any of the specimens at hand. It is far more massive, broader for its length, and appears to be inaccurate in other particulars, although there exists considerable individual variation in skulls of this animal, when series of them are compared.[4]

The skeleton is not touched upon by Mivart,[5] although he makes record of the interesting fact that "in many tortoises both the knee and the elbow are rather twined outwards, than the former forwards and the latter backwards, as is also the case in the Flying Lemur (*Galeopithecus*) amongst beasts."

This anatomist placed *Cynocephalus* in the order Insectivora, and the Lemuridæ among the Primates, a classification which now few would agree to, in so far as the latter are concerned.

Five years prior to this Huxley[6] presents a much fuller account of the structure of the species here being considered and practically agrees with Mivart in the matter of their classification.

He sees "no reason for dissenting from Professor Peter's view that *Galeopithecus* belongs neither to the Primates, nor to the Cheiroptera, but that it is an aberrant Insectivore." In fact, as he says on the previous page of the same work, it is "the most aberrant form of the *Insectivora*."

When studying the skeleton of any animal among the Vertebrata, it is always interesting, and even important, to know something of that animal's habits, and no anatomist appreciated this fact better than Huxley.

We are not surprised then to find, in the work just cited, references to the "arboreal and frugivorous habit" of *Cynocephalus,* and to its "very long and slender limbs." Also that these limbs "are connected with one another, with the sides of the neck and body, and with the tail, by a great fold of the integument, which is called *patagium;* and, unlike the web of the Bat's wing, is hairy on both sides, and extends between the digits of the pes. By the help of this great parachute-like expansion, the *Galeopithecus* is enabled to make floating leaps,

---

[2] Authors do not agree with respect to the character of the articulation of the ulna with the radius, some stating that the two bones are ankylosed, and others that they are not. Huxley claimed that they are. It is to be noted here that Owen and others employed the name *Galeopithecus volans* for the flying lemur, and where quotations are made, as in the above instance, from those authors, that name will be used. For *Galeopithecus volans* we now write *Cynocephalus volans,* and the latter will be used in this paper, except in quotations. The Malayan genus is *Galeopterus.* See Miller, *Proc. Biol. Soc. Washington* (1906), **19**, 41; Thomas, *Ann. & Mag. Nat. Hist.* (1908), VIII, **1**, 252–255.

[3] *Op. cit.,* 393.

[4] *Op. cit.,* 388.

[5] Lessons in Elementary Anatomy (1877), 10.

[6] The Anatomy of Vertebrated Animals (1872), 383.

from tree to tree, through great distances. When at rest, the *Galeopitheci* suspend themselves by their fore- and hind-feet, the body and the head hanging downward; a position which is sometimes assumed by the Marmosets among the *Primates*."

Selecting from this account only such parts as refer to the skeleton, we note that Huxley observed that in *Cynocephalus* "the fore-limbs are slightly larger than the hind-limbs" and further that "the pollex and the hallux are short, and capable of considerable movement in adduction and abduction, but they are not opposable; and their claws are like those of the other digits.

"The occipital foramen is in the posterior face of the skull. The orbit is nearly, but not quite, encircled by bone. The lachrymal foramen is in the orbit. The bony roof of the palate is wide and its posterior margin is thickened. There is a strong curved post-glenoidal process of the squamosal, which unites with the mastoid, beneath the auditory meatus, and restricts the movement of the mandible to the vertical plane. A longitudinal section of the skull shows a large olfactory chamber projecting beyond that for the cerebral lobes, and two longitudinal ridges, upon the inner face of the latter, prove that these lobes must have possessed corresponding sulci. The tentorial plane is nearly vertical and the floccular fossæ are very deep." All these points are characteristic and correctly stated. "The ulna" he adds, "is very slender inferiorly, where it becomes anchylosed to the distal end of the radius, [?] which bears the carpus. When the ilia are horizontal, the acetabula look a little upward and backward as well as outward. The fibula is complete. As in the Sloths and most Primates, the navicular and cuboid readily rotate upon the astragulus and calcaneum so that the *planta pedis* is habitually turned inward."[7]

In giving the dental formula, Huxley also refers to the peculiar pectination of the lower, single-fanged, incisor teeth, but these structures will be touched upon later on.

Passing to the work of another writer who has investigated the anatomy of the family Galeopteridæ we find that Flower points out a number of the characters of the skeleton in these "aberrant Insectivores,"[8] now being examined. Briefly, he says:

> The characters of the family are those of the suborder *Dermoptera*, to which may be added that the orbit is nearly surrounded by bone, the zygomatic arches are well developed, the tympanics form bullæ osseæ, the ulna is distally united with the radius, the tibia and fibula are distinct, the pubic symphysis is long.

Then follow descriptions of other parts of structure of these animals. Flower, it is observed, agrees with Huxley with respect to the ankylosis of the bones of the forearm, but that is one of the points that the present paper will settle.

From another work[9] by the same author we learn that in *Cynocephalus* "each vertebra bears at its hinder end a pair of hypopophysial tubercles;" that the number of trunk vertebræ is 21 (15 thoracic and 6 lumbar); that the tail is

---

[7] The Anatomy of Vertebrated Animals (1872), 382, 383.

[8] Osteology of the Mammalia in Encyclopedia Britannica, 9th ed., **15**, 401.

[9] Osteology of the Mammalia, 39.

long; that the number of vertebræ in the spinal column apparently varies for the species thus:

	Cervical.	Thoracic.	Lumbar.	Sacral.	Caudal.
G. volans	7	13	5	5	15
	7	13	6	5	14+
	7	14	8	4	17
G. philippinensis	7	14	6	4	17+

That the "cranium much resembles that of the *Lemurina*, having a considerable and vaulted cerebral cavity, large orbits, nearly vertical occipital plane, large olfactory fossæ, a well-developed zygomatic arch sending up a postorbital process to meet a corresponding one from the frontal so as either partially or completely to encircle the orbit behind, and tympanics ankylosed with the other cranial bones, dilated into a bulla, and produced externally into a tubular auditory meatus. The face is generally elongated, and narrow anteriorly, but in *Galeopithecus* it is broad and depressed."[10] That the coracoid of the scapula "is greatly developed and bifurcated"; that "the radius and ulna are fused together distally"; "the symphysis of the pelvis, as already stated above, is long"; and, finally, that "the fibula and tibia are complete and remain distinct" throughout the life of the individual.

About a year ago, Mr. Richard C. McGregor, of the Bureau of Science, Manila, kindly forwarded to me for description two adult specimens of *Cynocephalus,* probably *C. philippinensis* (Waterhouse).

Mr. McGregor wrote as follows:

> We have on hand two skeletons of *Galeopithecus,* both of which are being sent to you by mail. These were collected near Guindulman, Bohol, where the species is fairly common. A considerable number are killed by the natives, but I did not learn that the fur was used by them. In Cebu there were between 20 and 30 skins of this species for sale in a store; they came from Bohol, of course, as the species is unknown in Cebu. It is found also in Mindanao, Samar, and Basilan.
>
> This animal seems to be strictly arboreal and to feed exclusively on the leaves of trees. It is an animal difficult to see, as whenever it suspects danger it remains perfectly quiet and hugs a branch. Its colors are quite protective. When moving in a tree it is very cautious and seems to glide rather than to move like a squirrel or other small mammal; in fact, its movements impressed me as being very snake-like. The native name is "Ca-guán."
>
> The color of the pelage, even of specimens from one locality, varies greatly, running from seal brown to light gray and from unspotted to thickly spotted with gray.
>
> Padre Elera, in Fauna de Filipinas (1895), 1, 16, lists five species: *Galeopithecus volans* (Shaw), *G. rufus* Geoff. & Cuv., *G. variegatus* Geoff. & Cuv., *G. marmoratus* Temm., and *G. philippinensis* Waterh. as being found in the Philippines, but I doubt if so many species should be credited to these Islands.

---

[10] In the paragraph just quoted Flower intended to cover not only *Cynocephalus,* but likewise *Tupaia, Macroscelides,* and *Rhynchocyon.*—R. W. S.

You may make such use as you wish of the specimens sent, and return them to the Bureau of Science at your convenience.

During the summer of 1908 I communicated with Professor J. B. Steere, of Ann Arbor, Michigan, whose work as a naturalist in the Philippines many years ago is well known. In his courteous reply Professor Steere wrote me that he had collected the skeleton of a specimen of *Galeopithecus* (adult), which he had preserved in the rough; he also had the young, consisting of two fœtuses in spirits. He later on donated the skeleton for my use, but was unable to find the preserved specimens of the young which would have been very valuable additions to my material. The letter he wrote me was interesting, but I have been unable to put my hand on it for some time past, and so recently wrote him again for data, but upon this occasion no reply has been received. In any event I remember Professor Steere wrote me that he collected the skeleton about twenty years ago (1887–88?), but upon which island he had forgotten, and he had no other data, and there was no label on the specimen, so the sex of the individual is likewise unknown. It has been carefully cleaned by me for description in the present connection. Without doubt it was a larger form than the ones from which Mr. McGregor obtained his skeletons, and it leads me to believe that the Steere specimen belonged to a different species. Mr. McGregor in his letter, given above, does not specifically diagnose the two specimens he sent, so that there is some doubt as to whether I really have the skeleton of a true "*G. philippinensis*" at hand, although the material admits of obtaining the characters of the skeleton at least in so far as the genus is concerned.

The McGregor specimens show numerous shot holes in the skulls, and these have given rise to considerable mutilation. This is not the case with the larger skeleton from Steere. It is possible that the examples from McGregor may not be fully adult, a suspicion which is borne out by an examination of the long bones where the epiphysial sutures do not, as yet, seem to have entirely disappeared. Still there are differences to be observed; and while the two McGregor specimens seem to be representatives of the same species, exhibiting only certain individual variations in the skull upon comparison, the skull of the one from Steere, which is fully adult, although possessing the same general characters, has the superficial appearance of having belonged to some other species of the genus.

The "hyoidean apparatus" is missing in the case of all three of these skeletons; all the skeletal ungual joints of manus and pes, so peculiar in their morphology, have probably been retained upon the skins in the case of the specimens from the Bureau of Science, while they are present upon the toes of the skeleton from Steere, and consequently their general characters can be given here.

OSTEOLOGY OF THE FLYING LEMURS.

THE SKULL.

As has already been pointed out in the Introduction, there exists considerable variation in the three skulls at hand for examination, which may be due to age, sex, individual variation, or to the skulls having belonged to different species, or to all of these factors more or less combined. Some differences are to be observed even in the case of the two skulls from the Bureau of Science, skulls which, presumably, are from representatives of the same species. The skull from the skeleton collected by Steere evidently belonged to a very old animal, the bones being hard and smooth, with all sutural traces entirely obliterated. Moreover, it is of a clear ocher color and the teeth are considerably worn down. The other two skulls present every evidence of having belonged to much younger individuals; they are quite white; the dental cusps are sharp, and some of the cranial sutures are still traceable.

In so far as size is concerned some of the apparent differences can be demonstrated by measurement, for which purpose the metric system is employed and the results set forth in the following table:

Measurements of the cranium of Cynocephalus.

Specimens.	Extreme length on median line from occipital crest to anterior end of nasal.	Greatest width; intermalar diameter.	Interapical distance between postorbital process of frontal and malar.	Greatest diameter of an orbital periphery.	Greatest transverse diameter at base of occipital area.	Median diameter from foramen magnum to anterior apex of premaxillary spine.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Professor Steere No. 1	66	43	10	17	31	61
Bureau of Science No. 2	63	42	11	17	27	61
Bureau of Science No. 3	64	45	5	17	30	61

In some instances, where convenient, in the following description of the skeleton of *Cynocephalus*, the numbers 1, 2, and 3, given to the specimens in the above table may be employed to designate the particular skeleton referred to. This will consist in placing the number in parentheses after any statement made or character described.

In form, after the removal of the mandible, the skull is broad, somewhat compressed from above, downward, and elongate in the anteroposterior direction. When viewed from above it will be observed that the facial portion, anterior to the orbits, contributes very considerably to the marked general breadth of the skull. Its surface is quite smooth, being broadly convex from side to side, and rounded off anteriorly, thus causing the superior mandibular arch in front to be likewise broadly curved. (Plate II, figure 3.) In some skulls a smooth, low, longitudinal elevation bounds the nasals upon either side, all to a few millimeters in front (1, 3), but this character is not invariably present (2), while in other skulls, the sockets of the canines, and to a lesser degree, the first one or two molars, are indicated on the sides of the maxillaries by smooth, vertical elevations (3), absent in others.

Posteriorly we find the smooth character of the facial portion carried backward to include the frontal region between the orbits, and the narrow parietal space as far back as the occipital crest. This median parietal space lies between the temporal ridges (the latter are always strongly marked), and is broadest where it passes into the frontal area, gradually contracting as we pass backward, to expand slightly again as it arrives at the occipital crest. Its area is determined by the temporal ridge bounding the temporal fossa upon either side. (Plate II, figure 3.)

Anteriorly we see the floors of the orbits, and upon either side, the arch of the zygoma, while posteriorly the broad, concaved piers of the zygomatic arches look directly upward. Between these is the rather ample, semiglobular cranium or brain-case, either side of which, within the temporal fossa, may exhibit considerable muscular rugosity (1), or it may be comparatively smooth (2, 3). Among the few distinctive characters upon this aspect of the skull are the very prominent postorbital processes of the frontals. They are more or less raised above the interorbital frontal area and jut out from it upon either side. As the periphery of an orbit is nearly circular in outline each contributes to this circularity at its supero-posterior arc. In some skulls the decurved free extremity of the process is produced backward and downward farther than it is in others, thus more nearly completing the bony circlet of the orbit, especially where the postorbital process of the malar is similarly produced, as it is in some skulls (3).

The opening for the supraorbital nerve may be either a "notch" or a foramen and, in any case, occurs far forward upon the orbital rim. It is more in evidence in some skulls (1) than in others, and in one of the specimens here being examined it is a notch on the left side and a foramen on the right (1), while in the other two skulls it is a less conspicuous foramen on both sides. The infraorbital foramen is usually very minute in all skulls and can be distinctly seen only upon lateral view. (Plate I, figure 2.)

Upon regarding the skull from in front there is to be observed the rather large, circular opening of the anterior nares, through which may be seen the vomer and the scrolled ethmoturbinals, two in number, on either side, with the smaller one beneath. The periphery of the anterior narial orifice may (1), or may not (2, 3), be completed in bone. Owen, in his figures of the skull of *Cynocephalus*, has it so completed by the otherwise intervened free angles of the maxillaries coössifying with the anterior apex of the vomer.[11]

Passing to the posterior view of the skull we find the entire occipital area to be in the vertical plane, the longitudinal axis of the skull being perpendicular to it. The line of the very definitely marked occipital crest is semicircular in outline and there is a strong, median, vertical crest, that passes from the middle point of the occipital crest to the supero-middle point on the periphery of the foramen magnum. The base line of the occipital area is perpendicular to this median crest, while the condyles project slightly below it. These latter are large, semi-ellipsoidal in form, inclined toward each other inferiorly, with their flat sides facing each other and the median plane. They project posteriorly considerably beyond the large and subcircular foramen magnum. The exoccipitals are massive projections with their flat bases in the horizontal plane. (Plate I, figure 1.) In some specimens each of these bases is marked with a deep groove, passing forward and inward toward the median plane (2, 3). A more or less median "occipital prominence" exists above the foramen magnum on the posterior aspect of the skull and is better marked in some specimens than in others.

Chief among the points of interest on the lateral aspect of the skull is the capacious orbit, which is posteriorly incompleted by bone (Plate I, figure 2), and with the plane of its periphery directed outward, forward, and upward. The orbital wall within is entirely completed in bone anteriorly, including the floor below, while posteriorly it is equally lacking in this respect, the whole space in this locality merging with the temporal fossa in its rear. The postorbital process of the malar occupies a mid-point on the strong and twisted zygoma. The posterior root of the latter is broad and starts from an extensive base line on the side of the cranium.

Within the orbit the foramen rotundum and foramen ovale are distinct and occupy their usual sites. The lacrymal foramen is well marked in some skulls (2), minute in others (1), while the other foraminal openings for nerves, are of remarkably small caliber. Elliptical in outline with its major axis vertical, the osseous meatus auditorius externus is likewise small as compared with the size of the cranium. It is found in the deep recess between the posterior root of the zygoma and the exoccipital of the same side.

The basis cranii (Plate I, figure 1) is especially remarkable for the fact that a large share of it lies in the same horizontal plane (see figure 2 of Plate I), which is rather unusual in mammalian skulls. Nearly one-

---

[11] Anatomy of Vertebrates (1866), 2, 388, fig. 253 and 3, 312, fig. 247. Both of these figures are very different representations of the basal view of the skull of *Cynocephalus*. They are altogether too wide for their length and they are quite crude in the matter of delineation.

half of the inferior portion of the occipital condyles constitutes the sole part of the skull that falls below this plane, the roof of the mouth being only slightly above it. This latter area is laterally bounded by the teeth, but has a free premaxillary margin in front. Its outline is a broad U with its convexity forward. All sutures among the bones, maxillaries, premaxillaries, and palatines have been entirely absorbed, without leaving the slightest trace of their original lines of articulation. The surface is extremely smooth, being slightly concave from before, backward, and rather more so from side to side. The palatine foramina are minute and are situated far back, one on either side, close to the margin of the posterior nares, and even posterior to the anterior peripheries of the same, indicating that the palatal bones contribute but a small share to the bony roof of the mouth. This latter, anteriorly, is deficient in bone, there being a median, circular vacuity found there between the premaxillaries.

Jutting into this anterior palatine fossa, in the middle line from behind, is a sharp, free spine; this is the anterior apex of the vomer. (Plate I, figure 1.) In some skulls (2, 3) this free anterior end of the vomer is in contact, or may unite, with the produced median extremities of the premaxillaries, and thus convert the palatine fossa into a pair of anterior palatine foramina, each elliptical in outline with the major axes directed longitudinally. Owen's skull had this formation, but not so the one collected by Steere, wherein the sharp-edged alveolar incisor margin is noncontinuous to the extent of at least 5 millimeters in the median part. Both skulls from the Bureau of Science agree with Owen's figures (cited above) in that the anterior spine of the vomer is produced forward, bifurcates, and each minute bifurcation either meets, or coössifies with, the premaxillary of its own side. This character at once commands attention upon glancing at the basis cranii of the skull. At the hinder boundary of the vault of the buccal cavity we see the posterior narial apertures. Each is rounded in front, with the convexity so directed, the free margins being embellished with a raised osseous rim that is continued backward, on either side, to terminate as the minute inferior fork of the bifurcation of the hamular process of the sphenoid. The posterior nasal spine is rather large with rounded apex. It occurs in the imaginary plane passing through the centers of the second molars. As apertures, the posterior narial ones are considerably compressed in the vertical direction, which is compensated for by their width.

Each zygomatic arch has a broad base anteriorly, being composed, as usual, of the malar and maxillary bones, its base line including rather more than the second premolar and all three molars. Standing well out from the side of the face, this part of each zygomatic arch has its inferior surface directed downward and outward at an angle of about 45° with the median plane (Plate I, figure 1).

Although the teeth are structures not belonging to the osseous system in the Mammalia, they are so intimately associated with the mandibles in the skull among all higher mammals and have been so extensively employed in the matter of classification, that to entirely ignore them in any general work upon the osteology of an animal belonging to that class would be considered an almost unpardonable oversight. Anatomists have by no means neglected the dental armature of *Cynocephalus* and we meet with accounts of it in a number of works on comparative anatomy. Here. however, reference will be made to only two authorities, Owen and Flower.

Owen and Flower agree on the dental formula of *Cynocephalus* and, as given in their works, it agrees with all three of the specimens at hand. According to Owen [12] the dental formula of the genus is:

$$i\,\frac{2.2}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3}=34.$$

Owen also states that—

> The two anterior incisors of the upper jaw are separated by a wide interspace. In the Philippine Colugo they are very small, with simple sub-bilobed crowns; but in the common Colugo (*Lemur volans* Linn.; *Galeopithecus Temminckii* Wat.) their crown is an expanded plate with three or four tubercles; the second upper incisor presents the peculiarity of an insertion by two fangs in both species of *Galeopithecus*.[13]
>
> In the lower jaw the crowns of the first two incisors (*i*), present the form of a comb, and are in this respect unique in the class MAMMALIA. Figure 249 [Owen's figure] shows a section of one of these teeth magnified. This singular form of tooth is produced by the deeper extension of the marginal notches on the crown, analogous to those on the edge of the new-formed human incisor, and those of certain shrews, the notches being more numerous as well as deeper.
>
> Each of these broad pectinated teeth is implanted by a single conical fang, and is excavated by a pulp cavity, which divides into as many canals as there are divisions of the crown, one being continued up the center of each to within a short distance of its apical extremity. The medullary canal or branch of the pulp cavity is shown in some of the divisions of the crown, (at *p*). Each division has its proper investment of enamel, (*e*), which substance is continued for a short distance upon the common base.
>
> The deciduous teeth appear not to cut the gum before birth, as they do in the true Bats. In a fœtus *Galeopithecus Temminckii*, with a head one inch and a half in length, I found the calcification of the first incisor just commenced in the closed alveolus, the second incisor and the rest represented by the vascular uncalcified matrices. The upper milk teeth consist of two incisors, a canine and two molars, which latter are displaced and succeeded by the two premolars. The deciduous teeth are six in number in the lower jaw, the incisors being pectinated, but much smaller than their successors. The true molars are developed and in place before the deciduous teeth are shed.

---

[12] Anatomy of Vertebrates (1866), 3, 311–313.

[13] If we rely upon this diagnosis based upon the teeth, the specimens here being studied are certainly not *C. volans*; but that would not prove them all to be *C. philippinensis*, as there may be other species having the two anterior incisors of the superior mandible like it.—R. W. S.

Flower committed one or two errors in giving the osteological characters of the *Galeopteridæ*[14] and then briefly dismissed the subject of the teeth thus:

> *Galeopithecus* ($i\ \frac{2}{3}$, $c\ \frac{1}{1}$, $pm\ \frac{2}{2}$, $m\ \frac{3}{3}$; second upper incisors and canines with two roots), with two species *G. volans* and *G. philippinensis.* The former, the Flying Lemur of Linnæus, distinguished from the latter by the form of the upper incisors, has a total length of nearly 2 feet.

Now in the upper jaw the two widely separated, anterior, incisors are not only "very small," as Owen points out, but they are, also, at least twice pectinated, and sometimes exhibit a faint indication of a third pectination, which may be discovered by the use of a lens (2). The second pair of upper incisors are the largest teeth in the upper jaw, extending downward below the canines, and very considerably below any of the molars. They are each two-fanged, distinctly triangular in form with a very sharp apex, and are compressed. Both their surfaces, as in the case of the canines, are fluted, the markings running from the base to the apex. A canine of the superior mandible has the same form as the second incisor, only it is somewhat shorter, and wider in the antero-posterior direction.

As stated upon a previous page both the molars and premolars of both jaws in the Steere specimen are very much worn and, therefore, do not present the true characters of these teeth. In the upper jaw the premolars are all two-fanged and offer certain definite characters, the second pair closely approaching in their morphology the anterior pair of true molars. A first upper premolar has a rather complicated tubercular crown consisting of two outer, triangular, sharp-pointed cusps arranged antero-posteriorly to each other; their outer surfaces are flat and longitudinally fluted; their inner surfaces are convex and similarly marked. The inner portion of the crown in the first upper premolar exhibits two more very rudimentary cusps; these in the second premolar tend to become three, as in the leading true molar. The outer cusps in all the true molars agree with those of the premolars, being the most reduced in the last molar. Their inner crowns, that is, the buccal aspect of the crowns, develop from three to four small, sharp, trihedral cusps, and these are partly overshadowed by the inwardly directed pair of outer cusps of any particular molar. All the true molars seem to be three fanged, the largest root being internal, with a pair of much smaller ones placed antero-posteriorly side by side externally. In one specimen (3) the crowns look directly upward, in another (2) they face more toward the median plane, which is decidedly the case in the specimen where they are much worn (1). Through this cause, in the latter, the second premolar has come to resemble very much the leading true molar next to it, its outer cusps being only a little sharper and more pronounced.

---

[14] *Encyc. Brit.*, 9th ed., 15, 401.

Before completing our study of the basis cranii, it will be as well to finish with the teeth, and to this end examine those of the mandible or the lower jaw. For this purpose one of the specimens (2) from the Bureau of Science will be used, as in it the dental armature is unusually perfect. (Plate I, figure 2.) This specimen presents other interesting features, for on the right side there is to be noted the eruption of a second canine tooth immediately external to the canine belonging to the full set. The former is closely pressed against the latter and is nearly of equal size, although only about two-thirds of the crown has made its appearance. A similar eruption is seen in the case of both second premolars. At the outer side of each, but not in contact with them, a minute cusp is making its appearance just within the alveolar margin. This is another second premolar struggling to the surface. The anterior cusp of the first premolar in this jaw closely resembles the canine next in front of it; the crown of the second premolar possesses characters very much like those of the first true molar, but the cusps are a trifle longer and sharper than they are in the latter.

Six perfect incisors are found in this specimen, three in either side of the mandible. The two pairs in front very closely resemble each other, while the last incisor upon either side is quite different. All are single fanged, and in the dried skull easily tumble out of their sockets. In this particular they markedly depart from the molars, which require some little force to extract them with the fingers. Owen, in his above-cited figure of a section of one of the first incisors of the lower jaw, makes seven elongate pectinations on the tooth, while in the four now being considered, there are at least eleven of these structures. The crowns of the two central incisors are somewhat narrower than in the pair to their outer sides, otherwise, as has been remarked, they are similar. The exposed part of the tooth in any case is nearly square in outline. As normally implanted the teeth point almost directly forward; that is, their anterior and posterior surfaces, including the cutting edges, lie almost in the horizontal plane, and, excepting prehension, it is difficult to understand the use for which they can be employed. In young specimens these four incisors are of a glistening, enamel white, while in old age they become stringy and flexible. Each is gently concave on its inner (here upper) aspect, and correspondingly convex on its outer surface or, in reality, its inferior surface. Owing to their pectination, the free distal edges are minutely serrated. The pectinations are of nearly uniform length, the proximal ones being the shortest in any particular tooth. They are subcylindrical in form, extremely delicate in structure, although very strong, and it requires a lens of some power to reveal the fact that the interstices among them are carried down to their bases; distally, they are apparently in close contact, but not fused. No other living mammal possesses such teeth as these.

Passing to one of the third lower incisors a very different tooth is seen. The coronal portion is antero-posteriorly elongated; as naturally implanted, it is directed upward; it is slightly concave on buccal aspect and correspondingly convex on its outer surface; it presents five pectinations which become smaller and smaller from before backward; the fifth pectination is sometimes very rudimentary. This tooth is much thicker than any one of the four thin, front incisors just described. These six incisors are very nearly, or quite, in contact and there is no true diastema among the teeth of either jaw. The very wide interval between the two anterior incisors of the upper jaw can hardly be considered a true diastema.

The last premolar, and the true molars of either side of the mandible, develop from four to five sharp-pointed, trihedral cusps that vary considerably in size and, packed together along the alveolar border, lend to the series a very complicated appearance. The largest cusps are external and median, while the much smaller ones are, as a rule, ranged internally.

With the jaws normally articulated and tightly closed, the abruptly inturned, sharp-pointed, external cusps of the molars and last premolars of the upper jaw lie entirely without the alveolar margin of the lower jaw, and in mastication act as true cutters rather than as grinders. When the mandible is thus normally articulated, and we regard the skull as a whole upon its basal aspect, all these aforesaid cusps are in full view, even their apices, which is a very remarkable arrangement.

Returning to the base of the skull we next observe the far backward extension of the pterygoidal wings of the sphenoid, with the rather deep longitudinal valley that exists between them. These wings turn slightly outward, and at the postero-inferior angle of each there is to be noted the not very large, bifurcated, hamular process already referred to above.

Passing mesially from the posterior end of the vomer from beneath the posterior nasal spine, there is a prominent ridge, or line, running backward almost to the anterior margin of the foramen magnum. This line is most conspicuous and sharpest in its anterior part, and at its posterior ending merges gradually into the general surface on the basitemporal. Between the backward sloping termination of a pterygoidal wing and the glenoid fossa, upon either side, occurs the foramen ovale, the largest pair of foramina in the basis cranii. Each transmits, on its own side, the third division of the fifth nerve, the small meningeal artery, and the small petrosal nerve.

The glenoid fossæ constitute prominent features on the base of this skull; either one is large (elongo-elliptical in outline, with the major axis perpendicular to the cranial axis), flat, and smooth, the articular surface being in the horizontal plane, and completely overlying the inferior surface of the posterior root of the zygoma. (Plate I, figure 1.) These fossæ are separated mesially by an average distance of 15 millimeters.

Below each glenoid fossa we meet with a prominent postglenoid process. These are vertically compressed, nearly square in outline, smooth on their upper articular surfaces, and roughened upon their lower. Both point directly forward and very slightly downward. Through the aid of the postglenoid process, a glenoid fossa is rendered deep and capacious, affording an ample socket for articulating with the powerful mandible upon either side.

Near the inner side of the postglenoid process occurs another conspicuous apophysis, which appears to correspond to the vaginal process of anthropotomy. It is triangular in outline and produced anteriorly into a sharp spine. The glenoid articular surface extends over the postglenoid process, while between it and the base of the cranium we find the orifice of the canal for the Eustachian tube, the foramen for the internal carotid artery, and other small foramina for nerves and vessels in the immediate vicinity.

The basioccipital area is smooth, rather broad, and mesially divided by the above-described crest. We find no tympanic bullæ as they occur in many of the carnivora and other mammals. Each exoccipital area in its place is roughened, flat, and quadrilateral in outline.

Foramen lacerum posterius, the foramen stylomastoideus, and the condylar foramen all occupy their usual sites, the first named being large and oval in outline. The external auditory meatus is small, vertical, and slit-like, being situated in a deep recess posterior to the glenoid fossa. A thin, sharp rim of bone surrounds it upon all sides save above.

The ossicula auditus, presumably consisting of the usual malleus, incus, and stapes, will not be described here, while it is much to be regretted that the osseous parts of the hyoidean apparatus are missing in all three of these specimens. (The hyoid and larynx are described at the end of this paper.)

Cynocephalus possesses only a fairly large cranial cavity. In two of these specimens (2, 3) it has been considerably shattered by shot, and in the remaining one (1) the vault of the skull was not removed for an examination of the interior of the cranial casket. However, a view of it was obtained in another (3), but the characters presented nothing remarkable. The cribiform plate is large and subcircular in outline; the perforations in it are rather minute and numerous. The "sella turcica" and the clinoid processes are but feebly developed, while the usual foramina are to be observed in the vicinity. More posteriorly, at the hinder part of the cavity, a raised osseous crest marks the line for the insertion of the tentorium cerebelli, dividing the fossa for the cerebrum from that for the cerebellum, the latter not being especially capacious. The internal vault of the cerebral cavity is fairly marked by the convolutions of the brain; a raised osseous crest in the median line divides the left from the right side. The internal entrances of the usual neural, venous, and arterial foramina are all to be observed at their ordinary sites.

As above remarked, *Cynocephalus* has a powerful mandible or lower jaw. (Plate I, figure 2, and Plate II, figure 4.) Taken as a whole this bone possesses a deep U-shaped outline, with the limbs of the body and the rami rather more diverging in some specimens (1) than in others (2, 3), where they may be quite parallel to each other anteriorly beyond its ramal portion. In front the symphysis is strong, deep, and firmly united, exhibiting a prominent mental process below, while its concave inner surface is smooth. Beyond either ramus the body of the jaw is thick from side to side, with its straight, upper, alveolar margin deeply marked with the sockets of the various teeth, and its lower border, parallel to it, rounded and smooth. The mesial line of the symphysis is directed from below, forward and upward, at an angle of about 45° with the imaginary mid-longitudinal line of the bone. The ramal portion of either limb is considerably deeper than the body, extending both above and below it, being as a whole gradually turned outward from it at an angle of 35° or more. Its outer surface is smooth and looks forward and outward, while its inner surface, also smooth, presents two conspicuous ridges for the pterygoidal muscles and is directed backward and inward. Again, the outer surface is very moderately convex below, as compared with the markedly concave inner surface. At the upper anterior margin of this concavity we note the inferior dental foramen situated almost in line with the alveolar border, at the base of the coronoid process, and some 6 millimeters posterior to the last molar tooth. The angular border is thickened, circular in outline, and finished off with a raised rim. Externally and superiorily, the ramal portion is concave, that is, between the coronoid and condylar process, a concavity that is gradually lost as we approach the middle of the ramal area, or surface, upon this aspect of the bone.

The mental foramina, upon either side, appear to be three or four in number, a few millimeters apart, and all in the longitudinal line extending from a point opposite the second incisor to include the last premolar, well within the lower border of the dentary portion of the jaw. Between the base of the coronoid process and the last molar tooth there exists a deep pit, the use of which can not here be determined, although in life it probably harbors the tendon of insertion of the buccinator muscle.

The coronoid process is, as a whole, situated above any other portion of the mandible, being flattened from side to side, slightly thicker at the base than above, and shaped like a cat's claw with the apex directed backward. (Plate II, figure 4.) It is directed upward and outward at an angle of about 45° with the transverse diameter of the condyle, from which it is separated by a considerable interval. The axis of the condyle is perpendicular to the median plane, its smooth articular surface extending entirely over its superior convex aspect. From before backward it measures about 2 millimeters; transversely it averages 1 centimeter, being very slightly larger at its inner than at its outer extremity; a concavity occupies the entire surface of the former, while the latter is bluntly rounded off. In very old specimens, and perhaps in others, the two limbs of the mandible after prolonged maceration part company at the symphysis, exposing there a roughened, subelliptical surface, whose major axis is identical with the symphysial axis.

THE TRUNK SKELETON.

There has been given on a former page (p. 142) of the present memoir, the number of vertebræ in the spinal column of two species of *Cynocephalus,* ar recorded by Flower, viz, three specimens of "*G. volans*" and one specimen of "*G. philippinensis.*" This second exhibits, if correct, some remarkable variations in this part of the skeleton.

Flower discovered 7 cervical vertebræ in all four of the specimens he examined, while he found 13 thoracic in two "*G. volans;*" 14 in another; and 14 in "*G. philippinensis.*" Still more remarkable is the record he left with respect to the lumbar vertebræ present in this animal, for in "*G. volans*" these ranged 5, 6, and 8, while in the specimen of "*G. philippinensis*" there were 6 of these vertebræ. Coming to the sacrals, he claims to have found 5 in two of "*G. volans,*" 4 in another, and 4 in "*G. philippinensis.*"

As *Cynocephalus* has a long slender tail, we are not greatly surprised at any variation that may occur there, especially as some of these vertebræ may be lost for one reason or another, and at the best they are likely to vary somewhat in this division of the column. Flower found in "*G. volans*" 14+, 15, and 17 caudal vertebræ, and 17+ in the specimen of "*G. philippinensis*" he examined. Taking his total count for the vertebral column it stands thus: "*G. volans*" 45+, 45, and 50, and for his specimen of "*G. philippinensis*" 48+. In other words no two specimens, without regard to species, were in agreement in this particular.

Upon careful count, the three specimens here being examined show the following for the number of vertebræ in the spine:

Number of vertebræ in Cynocephalus.

Specimens.	Cervical.	Thoracic.	Lumbar.	Sacral.	Caudal.	Total.
Professor Steere No. 1	7	13	9	3	19+	51+
Bureau of Science No. 2	7	13	8	3	18+	49+
Bureau of Science No. 3	7	13	7	4	16+	47+

If by a + in his account of the number of caudal vertebræ present Flower meant that certain terminal caudals were missing, no such meaning is here intended to be conveyed. In the above table a + does not mean that the skeleton with respect to the number of caudal vertebræ is imperfect in any of the specimens examined, but that the skeleton of the tail is finished off distally by an apparently rudimentary vertebra which lacks the posterior moiety. The truth of this has been confirmed in my specimens by the use of the microscope. For example, caudal vertebræ 11 to 15 in specimen number 2, very much resemble, upon a casual glance, some of the joints of the manus or pes, with a shaft and articular extremities. Now the minute terminal vertebra of the tail in specimen number 2 (and in others) if compared with a phalangeal joint, appears to have been broken in two at the middle of the shaft, or at a point that in reality is the middle of the centrum of the vertebra. The + stands for this "nib" or rudimentary terminal caudal vertebra in my specimens, and as such is entitled to recognition in the total count. (See figure 17, plate V.)

From an examination then of six individuals, three of Flower and three here, it may be stated with certainty that the number of vertebræ in the spinal column of *Cynocephalus,* irrespective of species, is markedly variable, after we pass the 7 cervicals, which are invariably present in all specimens. There may be 13 or 14 thoracic vertebræ (bearing ribs); from 5 to 9 lumber vertebræ; from 3 to 5 sacrals, or those that fuse together to form the "sacrum;" and, finally, from 14 to 19 caudals, which in most cases possess in addition (a +) a rudimentary one at the termination of the tail series.

Throughout the class Mammalia, even including man, the number of caudal vertebræ present in any particular species is subject to considerable variation. This becomes less and less the case as we pass from the tail to the cervical division of the spine, where with but very few exceptions 7 is the rule. *Manatus* among the Sirenia has but 6 cervical vertebræ; which is also the case with *Cholœpus* among the Edentates, while in the same group (Edentata) *Bradypus* possesses 9. At the present writing no other exception to this rule is known to me in the class.

The count may be made to vary, too, by the number we elect to represent the pelvic sacrum. In *Cynocephalus* as in other mammals, man included, the number varies also with the number that fuse together to form the sacrum. Where they have thus coössified, the bones so united have been here considered as sacral vertebræ; 3 in two instances; 4 in another. In man they vary from 4 to 6.

All these facts led Flower[15] to state that—

> It must never be forgotten that although the division of the vertebral column into distinct regions is convenient for descriptive purposes, at the contiguous extremities of the regions the characters of the vertebræ of one region are apt to blend into those of the next, either normally or as peculiarities of individual skeletons.

---

[15] Osteology of the Mammalia, 78.

In describing the spinal column in any mammal it has been the rule of the present writer to consider all those vertebræ between the skull and the first one in the chain, proceeding backward, that bears a pair of true, free ribs, as cervical vertebræ; all those bearing a pair of true, free ribs, as dorsal or thoracic vertebræ; all those between these last and where they coössify to form the "pelvic sacrum," as lumbar vertebræ; all those fusing together between the ilia of the pelvis, as sacral vertebræ; and all the rest to the end of the column, or chain, as caudal vertebræ. This rule has been here applied to *Cynocephalus*. (Figures of vertebræ will be found upon Plates II to V of the present memoir, that is figures 7, 8, 10, 11, 12, 13, 14, and 17.)

In describing the spinal column of the insectivore here being considered, the specimen furnished by Steere has been selected; constant references, however, will be made to the others, designating them as 2 and 3, respectively, as already indicated.

There is nothing especially unusual in the vertebral column of *Cynocephalus*, as it is strictly mammalian in character, with all of the vertebræ reduced to their simplest forms for an insectivorous animal. Even in the matter of number these bones may agree with others among the Insectivora, as in the case of the common European mole (*Talpa europæa*), which has in its vertebral column 7 cervical, 13 thoracic, 6 lumbar, 5 sacral, and 11 caudal vertebræ, the tail simply being somewhat longer in *Cynocephalus*.

Viewed in its entirety in the latter it is to be noted that the atlas is by far the largest vertebra in the chain; the axis is the next in size and is considerably smaller, being about equal in bulk to the last lumbar. The succeeding five cervical, and the first dorsal are all large vertebræ, which very gradually decrease in size as we approach the dorsal region of the spine. From the second dorsal to the seventh inclusive the vertebræ continue gradually to diminish in size; except the terminal caudals, the seventh dorsal is about the smallest one in the column; beyond the seventh dorsal the vertebræ gradually increase again, become much larger and of different character in the lumbar region, and terminate with the largest one of all, which articulates with the anterior vertebra of the pelvic sacrum. The first lumbar bears considerable resemblance to the last dorsal, but is distinguished by not supporting a pair of facets for ribs.

The vertebræ composing the sacrum fuse very solidly, but the lines of demarcation between the central and the neural spines are always more or less distinguishable, more so in some specimens (1 and 3) than in others (2). The first caudal vertebra, which is free, resembles the last sacral, and the same may be said of the second, third, and fourth caudals, although the resemblance becomes gradually less evident as we proceed toward the end of the tail. This dissimilarity continues to increase rather rapidly, although never abruptly, as we follow the caudal series to its termination, each succeeding vertebra having its various apophyses disappear, becoming lengthened and much simpler in character, straight and subcylindrical, and with interarticulations of the most primitive kind. As we come to the last four or five caudals they gradually shorten again, being in this region represented by mere delicate straight rods, with slightly enlarged articular ends, and finally terminate in a minute osseous tip, the smallest vertebra in the entire series, hardly worthy of the name (figure 17).

No neural spine occurs upon the atlas vertebra, although a very prominent one, arising from the entire length of the neural arch is to be found upon the axis. Its superior border is convex from before, backward. The neural spine in the remaining five cervicals is very markedly reduced in size, in each bone being represented by a mere stumpy process. In the first dorsal it starts to increase again, being situated posteriorly and directed backward. It then gradually increases in size; becomes nearly vertical, quadrilateral in outline, and almost imperceptibly dwarfs once more to include the eighth dorsal, when again its proportions increase, and this continues as we pass through the lumbar region. In the mid-series of the vertebræ in this latter locality in the Steere specimen, the neural spine is a very conspicuous feature of the bone, being lofty, quadrilateral in outline, and with a thickened superior border; it extends the entire length of the neural arch, being about one-half the size on the last lumbar vertebra. In other individuals these neural spines are not nearly so conspicuous (figure 17) as the ones just described (figure 7, Plate II).

Neural spines are always present upon the sacrum, but here by fusion they constitute a single plate of bone, being individualized only by the thickened superior borders (figure 8). This plate is not so high posteriorly as it is in front, while at the same time it extends the entire length of the sacral neural arch.

On the leading caudal vertebra we find a fairly well-developed neural spine of about the same size as the one on the last dorsal vertebra. It is centrally situated. This is the case with the next two succeeding caudals, but in these the neural spine is becoming aborted, while in the fourth caudal it may be only just evident, to entirely disappear in the vertebra next following, and not be produced again for the balance of the vertebral elements in the skeleton of the caudal appendage.

A mere mesial raised line represents the hæmal process or hæmapophysis, in the axis and the third cervical vertebra; for the rest of the column no such structure is present, while the caudal vertebræ appear to be entirely lacking in chevron bones. These last are found in many mammals, as, for example, among marsupials, the Edentata, Cetaceæ, many rodents, carnivores, and even in some Insectivora, as *Rhynchocyon*, where, according to Flower, they "are well developed and bifid." [16]

---

[16] Osteology of the Mammalia (1885), 73.

Returning to the atlas (figure 10) we find, in addition to characters already ascribed to it, that it possesses upon its anterior aspect the usual two, extensive, cup-shaped facets intended for the condyles at the back of the cranium. They face forward and inward in about equal proportions, and are completely out of view when the vertebra is regarded from directly above. The neural canal is short and cylindrical, being covered by the broad neural arch above, but very slightly so protected ventrally. Each apophysial, transverse, lateral expansion is twice pierced by foramina; the anterior ones are for the vertebral arteries and suboccipital nerves, the other pair, entering the neural canal at its sides, are for the vertebral arteries. On the posterior floor of the neural canal, the articular surface for the odontoid process of the axis and the entire fore part of the latter bone, save its neural spine, are continuous, thus affording very considerable play between the two bones. The under sides of the nearly horizontal, lateral, apophysial plates of the atlas are decidedly concave, with the mesial, almost entirely aborted, hypophysial tubercle standing between them behind.

This ventral surface of the atlas is bounded in front by a deep concave articular border with the concavity directed backward. A similar border with thickened edge forms the posterior boundary; its concavity, which is not so profound, is directed forward. Between the nearest points of these two concave borders in the middle line, the separating isthmus of bone measures only a few millimeters. The margins of the lateral edges of this vertebra are sharp and convex outward.

Passing next to the axis, or second cervical vertebra, it is to be noted that its odontoid process is but fairly well produced, being bluntly triangular in form, considerably compressed from above, downward, and together with the rest of the articular surface on that aspect of the bone, projecting entirely beyond the neural spine above it. This is by no means always the case in mammals, for among certain Felidæ and Canidæ it may be observed that the anterior projection of the neural spine in this vertebra overhangs the odontoid process. There are no prezygapophyses, while the postzygapophyses are much aborted, the elliptical articular facets, which they support in other vertebræ being represented, one on either side, by similar surfaces situated beneath the neural laminæ. They project beyond the small and vertically much compressed centrum, which presents, posteriorly, a rather large facet for the third vertebra. (Plate III, figure 11.) The transverse processes are moderate in size, triangular in outline, and much compressed in the vertical direction. No foramen for the passage of the vertebral artery, on either side, is to be found in the axis, while the cylindrical neural canal is much smaller than it is in the atlas. In fact it has about the same caliber and form throughout the cervical series as it has in the axis now being considered.

The remaining five cervicals are all very much alike, and we find each of them perforated upon either side, in the longitudinal direction, by the foramen for the vertebral artery. In each the centrum is much compressed from above, downward, which results in giving the articular facet at either end a transverse elliptical form, the concave one being behind, the convex one in front. The prezygapophyses are quite individualized and project directly forward beyond the centra and the neural arch. Postzygapophyses practically agree with what has been described for the axis. All these vertebræ have a broad, compressed appearance with their flat ventral aspects quadrilateral in outline. Small and stumpy in the third cervical, the transverse processes become gradually more conspicuous to include the seventh, or last cervical, where they are produced both forward and backward from a broad common pedicle.

Among the leading dorsal vertebræ the centra are much compressed as we found them in the cervicals, but they gradually become more cylindrical in form to the close of the series. Reniform in outline, the articular facets at either end have their concave edges upward.

Greatly reduced in size and caliber throughout the dorsal region, the neural canal is slightly compressed from above, downward, in the first few dorsals, finally to become cylindrical among the ultimate ones. This continues to be the case through the lumbar vertebræ, until we arrive at the last lumbar, where the canal is very much compressed from above, downward, and with this form passes through the sacrum and the first four caudal vertebræ. On the fourth caudal the spinal cord receives its last and very scant osseous protection, passing through a delicate little arch on the superior aspect of the bone, posteriorly.

Among all the dorsal vertebræ the diapophyses, or transverse processes, are short and thick, and in all cases project directly outward from their bases. At their nether extremities we note the usual facets for the tubercles of the ribs articulated with them at these points. The capitular facets for the heads of the ribs are shared in each case throughout the dorsal series by two vertebræ, by which is meant that one-half of the facet (a demifacet) is on the centrum of one vertebra and the other half on the side of the centrum of the vertebra next following it. No exception to this rule has been met with in the three specimens examined. Zygapophysial processes here present their usual mammalian characters, the postzygapophyses only becoming differentiated as true processes in the last few bones of this region.

The intervertebral foramina for the entire spinal column are formed about as they are throughout the mammalian series, including man. They are large in the cervical region, very much smaller in the dorsal section, and increase in size again in the lumbar where they are longitudinally slit-like, and are found in each case between the centrum and the long, backwardly directed, spiny anapophysis on either side, at the posterior end of the vertebra (figure 7).

These anapophysial processes of the lumbar vertebræ, where present, are quite characteristic. Each one on either side forms a deep notch with the postzygapophysis next to it on the same vertebra. Into this notch, when the bones of the spine are normally articulated, fits the prezygapophysis (of that side) of the next succeeding vertebra, the combination making a very close interlocking articulation, which, when taken altogether for the six leading lumbars, accounts for the remarkable fixity and stability of this part of the column in *Cynocephalus.* In the last two lumbar vertebræ these anapophysial processes are entirely aborted, as are the transverse processes in the first two lumbars. After that, however, these diapophyses begin to appear again, being represented by thin, quadrilateral, horizontal plates of bone of good proportions. They are thick and strong in the last lumbar, and claw-shaped in the three that precede it with the apices of the claws directed to the front. (Plate IV, figure 13.) Metapophyses of a very rudimentary type are also to be seen in the mid-lumbar vertebræ; in any case the most of the projection belongs in reality to the anterior zygapophysis, an exception being found in the last lumbar vertebra, where these processes are much better defined and rather more prominent.

In Steere's specimen the sacrum is a very solid bone, composed of three vertebræ thoroughly fused together. The leading one has double the bulk of the last, while the middle one is massive anteriorly and slopes away behind (Plate IV, figure 14). Anteriorly, the first sacral presents the usual facets, processes, and surfaces to articulate with those on the hinder aspect of the last lumbar. So, too, the posterior face of the third sacral is similarly modified in order to meet the requirements of an articulation with the anterior face of the first caudal vertebra. Laterally, the entire mass of the first sacral and the anterior moiety of the second, are enlarged, thickened, and curved ventrad to support on their outer aspect a large, subelliptical, articular surface for the ilium of the same side. This surface looks upward and outward, and the major axis of the ellipse is in line with the longitudinal axis of the spinal column, being parallel to the long axis of the ilium when the bones are normally articulated. There are two pairs of foramina on the ventral surface of the sacrum for the exit of the anterior roots of the spinal nerves. Similar pairs of foramina, for the posterior roots, occur on the dorsal aspect of the bone directly opposite these; then the foramina for the pairs of roots of the spinal nerves both anterior and posterior to these are only completed when the last lumbar and first caudal vertebræ are in position and duly articulated in the column, being represented only by shallow notches in front and behind when we study the sacrum as a single bone.

Considerable compression in the vertical direction is noticed in the first four caudal vertebræ. The fifth is rather stocky, after which they commence to elongate and lose their apophyses and the other usual vertebral characters of the bones in the fore part of the column. The lateral processes, especially, are developed in the first four caudals, most so in the third and fourth, where they are extensive horizontal plates with circular limiting borders. Zygapophysial processes are well developed in the leading caudals, particularly the prezygapophyses, which subsequently, as we pass down the skeleton of the tail, become a pair of rounded tubercles situated side by side on the supero-anterior aspect of the bone. These persist in a number of vertebræ as we pass toward the end of the tail.

On the ventral aspect of the skeleton of this part of the vertebral chain in Steere's specimen, between the sixth and seventh and the seventh and eighth vertebræ, and situated directly over the intervertebral articulations, we note a pair of minute ossicles, ellipsoidal in form, and placed side by side, at an interval of about one millimeter. They are perfectly free and are held in place by delicate ligaments. Possibly similar pairs may be found posteriorly between a few more vertebræ, but after that they surely disappear altogether. These last have evidently been lost in the specimen, and it is fair to presume that these ossicles probably represent rudimentary chevron bones.

Flower,[17] under the Insectivora, makes no mention of the ribs and sternum, although he lightly touches upon them for *Talpa, Sorex, Erinaceus,* and *Rhynchocyon.*

Viewed as a whole the osseus framework of the thorax in *Cynocephalus* is quite in keeping with what we meet with in this part of the skeleton in any average mammal, being decidedly more so than in *Talpa,* although the mole and the colugo each possess 13 pairs of ribs.

The chest capacity of *Cynocephalus* is considerable, notwithstanding the fact that it is much contracted anteriorly, where it is bounded by the first pair of ribs, the first dorsal vertebra, and the presternum. From this region it gradually, though very uniformly, expands to the plane of its posterior termination, where it has an average transverse diameter of 6 centimeters.

Owing to the greater size of the leading dorsal vertebræ and to the small dimensions of the ribs themselves the first three pairs of ribs have, upon either side, greater intervals between them than any other members of the series. These ribs are somewhat roundish in form, although exhibiting a disposition to flatten at their vertebral ends as we pass backward. In the fourth pair this flattening associated with an increased width is pronounced, and from thence on is continued to include the last pair. This accounts for the decrease in the width of the intercostal spaces after passing the third pair of ribs, so that each intercostal space is about equal to the ribs that bound it. There is very little difference in the width of the ribs from the fifth to the thirteenth pair, inclusive,

---

[17] Osteology of the Mammalia, 94–96.

and each one is nearly as wide at its sternal end, where it is joined by a costal rib, as it is at its angle. Those forming the first pair are the shortest in the series; the sixth, seventh, and eighth pairs are of about equal length and are, at the same time, the longest ones of all.

Seven of the leading pairs of ribs are joined to the sternum through the intervention of costal ribs; in the eighth pair the costal ribs are very long and attenuated, and lack but very little of meeting the distal extremity of the mesosternum. After this they rapidly shorten, the ninth, tenth, and sometimes the eleventh articulating in sequence with each other's lower borders; the twelfth and thirteenth are thus joined by a ligamentous membrane only, and are practically floating costal ribs. (Figure 17.) The first pair of costals are the shortest of all that unite the vertebral ribs with the anterior end of the presternum, occupying facets, one upon either side, just behind where the clavicles articulate. Like all the others they are curved, the concavity of the curvature looking forward. From the first to the last, or seventh, pair of costals this curvature continues, although it is here principally, indeed, almost entirely confined to the outer third of the bone, especially in the last two or three pairs. They become progressively longer as we pass backward, and all seem to be composed of true bone, although a little elementary in character. The distal pairs of costals are still more cartilaginous, but there is evidence of osseous tissue in all of them. At their sternal ends they articulate upon facets situated *between* the joints of the presternum and mesosternum, the sixth and the seventh articulating at the distal end of the posterior joint of the mesosternum. None of the costals ever articulates with the xiphisternum.

All the thoracic ribs articulate with the dorsal vertebræ in the way usual among mammals and they present the common characters of these bones. They are somewhat narrower in some specimens (1) than in others (2, 3), but wide or narrow, any single rib in mid-series varies but little in its own width from angle to costal articulation. All present the usual curvature, although here it involves almost the entire continuity of the bone and is most pronounced dorsad.

If we select a "true rib" of the eighth pair as an example we find that its capitulum is well developed; the elliptical double facet is rather large and placed longitudinally on the bone. The "neck" is but moderately constricted; the "tubercle" is but feebly pronounced, and owing to the short transverse process of the dorsal vertebra, is quite close to the capitulum. The "angle" is but very faintly indicated, and is entirely absent in the last three pairs of true ribs. As in the rest of the series, the "body" of the twelfth rib is very flat with rather sharp anterior and posterior borders. These last in Steere's specimen are far more rounded. Posteriorly and at the same time dorsad, there is a faint groove running down the border of this rib. It harbors in life the intercostal vessels and nerve, while its borders give attachment to the internal and external intercostal muscles.

A very shallow concavity, or pit, occupying the ventral end of all the true ribs, is intended for articulation with the outer extremity of the corresponding costal rib.

Between the head and tubercle in most of the true ribs of this animal we meet with a single nutrient foramen, usually upon the posterior aspect of the bone. It is extremely minute in some of the ribs and varies somewhat in locality.

Cynocephalus possesses an ordinary and rather stout sternum, the parts consisting of spongy bone overlaid by an extremely thin outer covering of compact tissue. As usual in most mammals it is divided into the presternum (manubrium), the mesosternum (gladiolus, etc.), and the xiphisternum (ensiform cartilage, or xiphoid appendage, etc.). Sometimes the parts of the mesosternum are designated as sternebræ, the whole being frequently called the "breast bone." (Figure 17.)

The presternum is here short and trihedral in form, with its blunt third angle situated mesially, and articulating in life with the anterior end of the first sternebra of the mesosternum. Its outer anterior angles are for articulation with the first pair of costal ribs. The sharper anteromesial angle has, running between it and the distal end of the bone, a low mesial raised crest which stands between the lateral aspects of this joint of the sternum. Dorsally it is flat, while anteriorly the triangular surface is very moderately concaved. Its longitudinal diameter averages about 8 millimeters, and it is scarcely any wider at its widest part in front.[18]

Passing to the mesosternum we find it composed of four sternebræ closely resembling one another in form, and differing but little in the matter of size. They are vertically compressed, smooth bones, narrower at their middle than at their extremities, and in life articulate with each other in the manner usual among mammals. They average about 4 millimeters in width, and rather more in length, the anterior one being 5 millimeters long and the third or longest one about 8 millimeters long. They present the usual facets at their anterior and posterior angles for articulation with the costal ribs.

The xiphisternum varies considerably in form, although it may be described as a cartilaginous appendage, about as long as the third sternebra. Occasionally it appears to be in two bits, one behind the other, the anterior one exhibiting a very faint disposition to ossify. Viewing the thorax from in front, it will be noticed that in most specimens the

---

[18] The presternum in *Cynocephalus* is entirely different from that bone as we find it in the mole (*Talpa europæa*), as will be seen by examining Flower's figure of the latter. Osteology of the Mammalia, figure 34.

sternal ends of the seventh pair of costal ribs articulate with each other in the mesial line, and at the same time with the distal end of the last sternebra. The xiphisternum is united to the mesosternum at the dorsal aspect of this triple articulation; this is an unusual arrangement among mammals, possibly not existing in any other known species. It is entirely different in *Talpa,* and very probably in other insectivores.

In the articulated skeleton the xiphisternum is about opposite the tenth dorsal vertebra, and the entire sternum has an average length of 4.5 centimenters.

[*To be concluded.*]

ILLUSTRATIONS.

Plate A.

Skeleton of a flying lemur. By permission. Reduced. From the mounted specimen in the collection of the United States National Museum.

Plate I.

Fig. 1. Basal aspect of the skull of *Cynocephalus;* lower mandible removed, and a few teeth missing. Adult. Very slightly enlarged. Specimen from Professor J. B. Steere.

2. Left lateral view of the skull of *Cynocephalus*, with lower mandible articulated *in situ*, and the dental armature complete. Hyoidean apparatus removed. About adult. Very slightly enlarged, and in same proportion as figure 1. A specimen from the Bureau of Science, Manila, P. I.

Plate II.

Fig. 3. Superior aspect of skull of *Cynocephalus*, lower mandible removed. Same specimen as shown in figure 1 of Plate I. Exact natural size.

4. Lower mandible of *Cynocephalus* seen upon direct superior view. Dental armature complete. This jaw belongs to the skull shown in figure 3. Exact size of the specimen.

5. Left scapula of *Cynocephalus* seen upon direct ventral view, and natural size. The absence of the superior angle, and the foraminal vacuities in the blade are normal. The rounded superior angle of the right scapula in this specimen is perfect. The bone belonged to the same individual from which the skull and mandible were taken shown in figures 3 and 4.

6. Left femur of *Cynocephalus* seen upon anterior view and slightly enlarged. Note the almost entire absence of the pit for the ligamentum teres. From the same specimen as figures 3, 4, and 5.

7. Lumbar vertebræ of *Cynocephalus*, being the third to the seventh, inclusive, and seen upon left lateral aspect. Natural size; from the same specimen as the other bones in this plate.

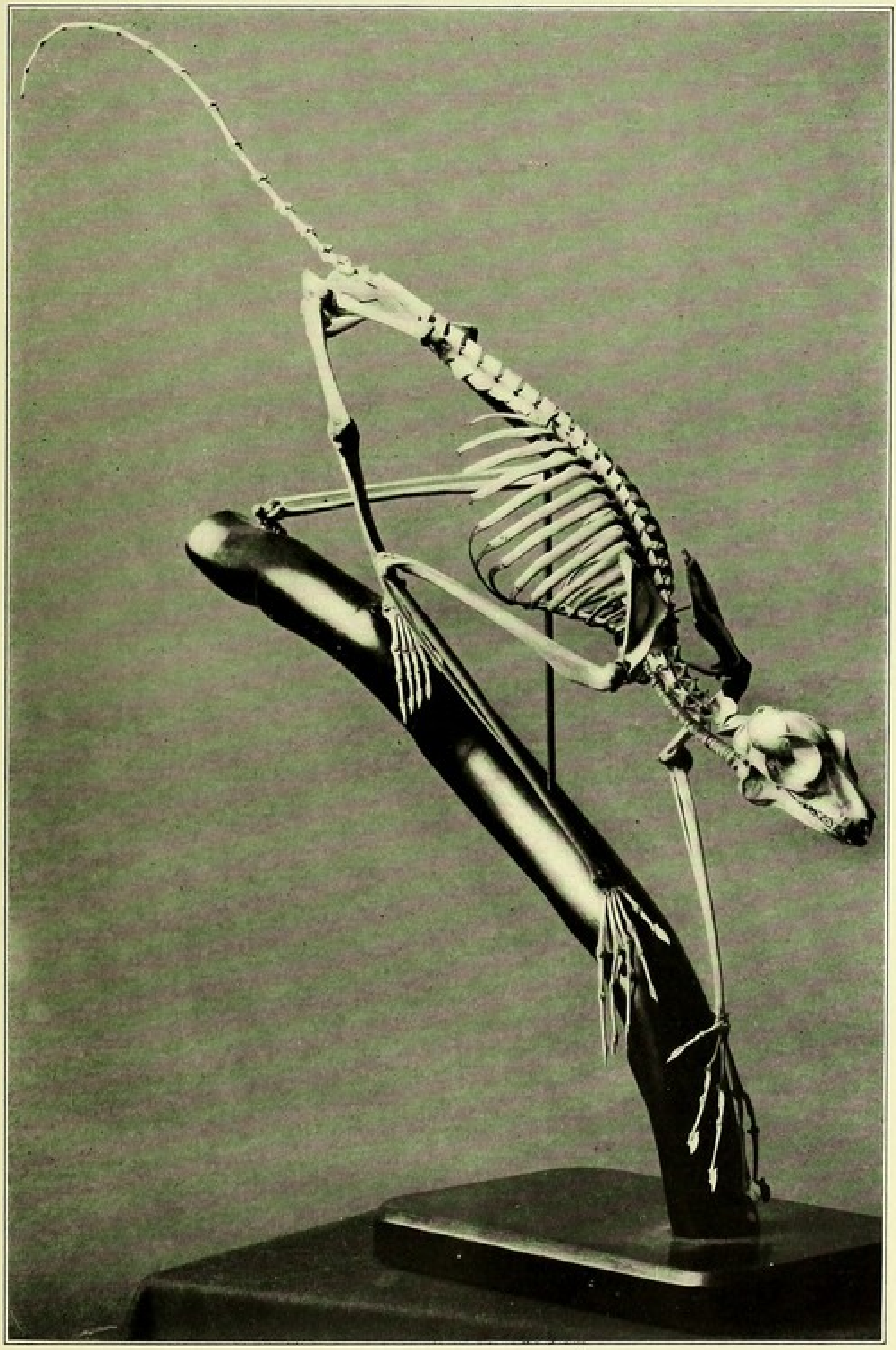

PLATE A.

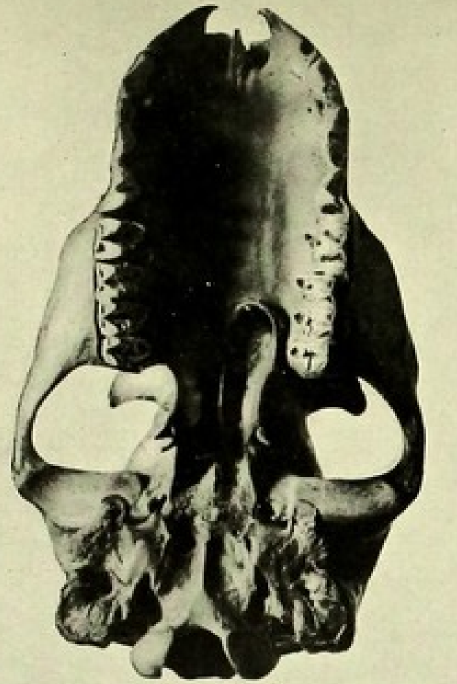

Fig. 1.

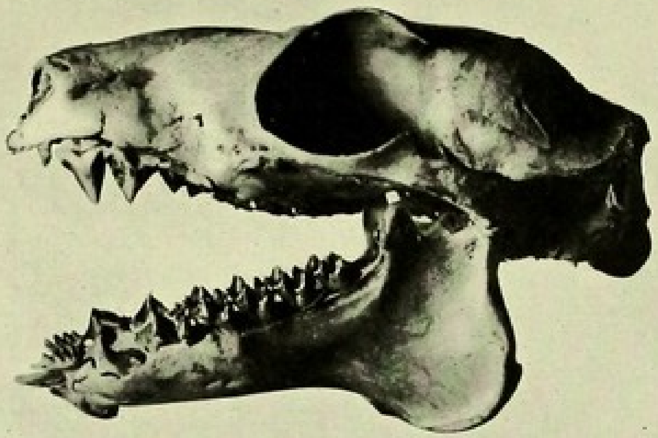

Fig. 2.

PLATE I.

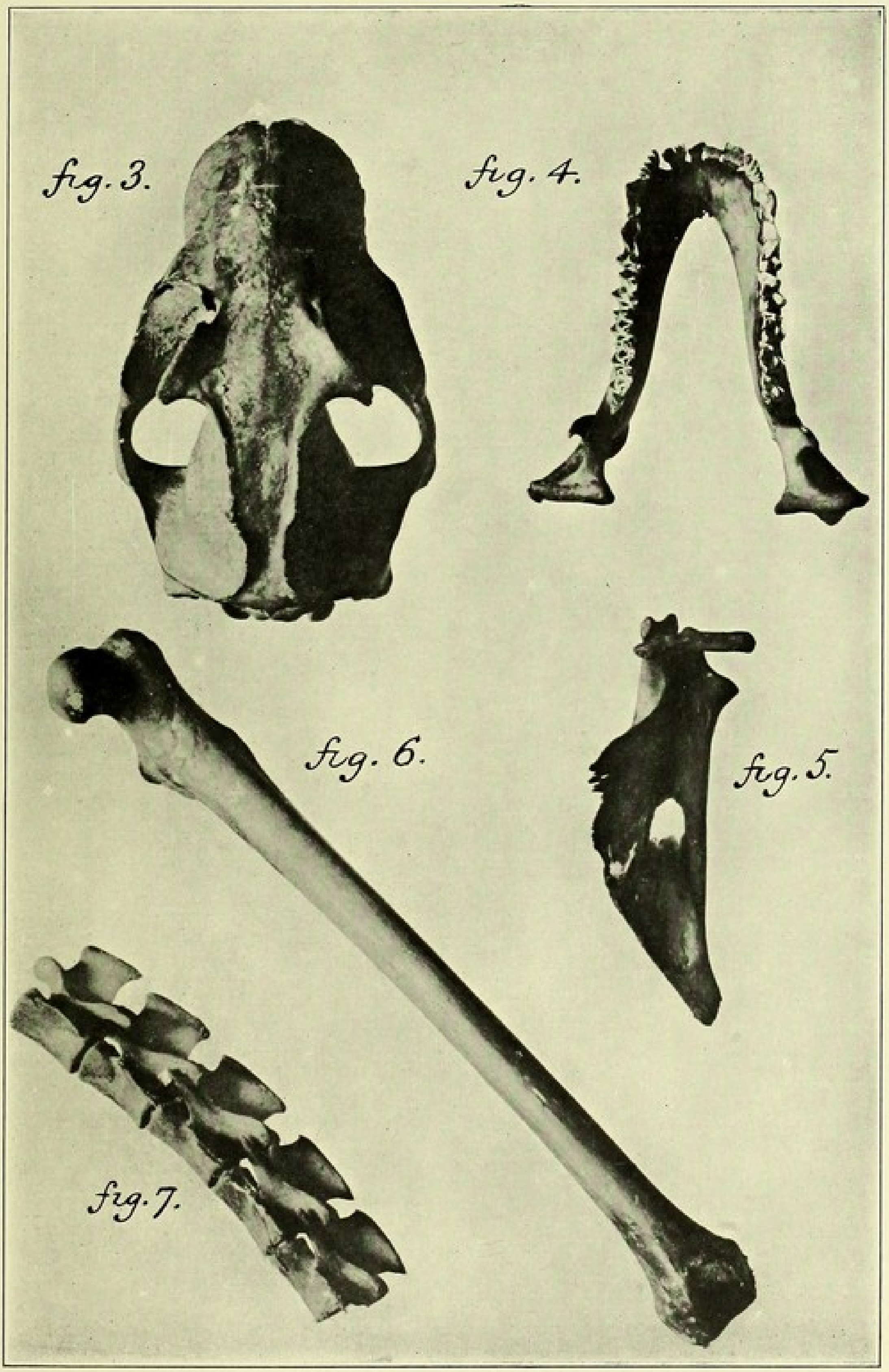

PLATE II.

THE PHILIPPINE JOURNAL OF SCIENCE,
D. General Biology, Ethnology and Anthropology.
Vol. VI, No. 4, August, 1911.

THE SKELETON IN THE FLYING LEMURS, GALEOPTERIDÆ.

By R. W. SHUFELDT.
(*Washington, D. C.*)

(*Concluded.*)

THE SHOULDER GIRDLE.

Comparative anatomists have observed great differences in the morphology of the shoulder girdle among the various representatives of the Insectivora, not finding this structure alike in any two families of the order. *Cynocephalus* has the two bones composing it, the clavicle and the scapula, remarkably well developed and in full proportions for the size of the animal.

Making the usual articulations with the sternum and the scapula, we find the clavicle to be a large, strong bone. Its extremities are enlarged to support the articulatory facets. The shaft is stout with its continuity of nearly uniform caliber, and presents two curvatures. About two-thirds of its mesial length offers the least apparent curvature, being slightly and uniformly bent so as to present the concavity to the front; the remaining third of the bone makes a very decided curve to arrive at its scapular articulation. This part of its shaft is somewhat anteroposteriorly flattened, or rather compressed, being nearly flat behind and concave in both directions anteriorly. In the normally articulated skeleton, this curvature allows the clavicle to pass over the prominent coracoid process of the scapula, and brings its outer extremity in articulation with the external process of the two apophyses which finish off the upper end of the acromion process of the scapula. In one of the specimens from the Bureau of Science (2) the clavicle has a length of 3.6 centimeters while it is only 3.4 centimeters in the Steere specimen, and 3.5 centimeters in the remaining individual (3). Therefore it averages 3.5 centimeters in length, and is about as long as one of the thirteenth pair of true, or vertebral, ribs of the skeleton to which it belongs.

It is somewhat remarkable that the scapula in some specimens of *Cynocephalus* does not fully ossify; this lack of ossification occurs in the so-called "blade" of the bone (Plate II, figure 5 (1): see explanation of plates), while in others it is very complete and rather thick (2, 3). Again, the scapula in different individuals is prone to vary in some of its characters, but to no greater extent than we find among a series of human scapulæ chosen from adults of the same sex and race. One of the skeletons sent by McGregor (2) has the scapula thoroughly ossified, quite perfect, and presenting all the characters of the bone as they occur in our subject. It is here seen to be a distinctly triangular bone with all its parts highly developed.

Facing upward and inward, the glenoid cavity is rather extensive; the concavity is pear-shaped in outline, and the small end extends upon the base of the coracoid process. From the glenoid cavity to the inferior angle we have the external or axillary border, which here presents a notable departure from mammalian scapulæ generally in being broad and flat for almost its entire length to the lower point of the bone. This flat border is of uniform width to its termination, that is about 4 millimeters, and appears as if it had been formed by bending that much of the blade of the bone abruptly, at a right angle toward the spine, thus creating a deep "infraspinous fossa," but adding nothing to the ventral aspect of the bone. The vertebral or internal border is not as long as the axillary one, and its margin is only very slightly thickened for its entire length. The two borders make an angle of 30° with each other, and the angle thus formed, or the inferior angle of the scapula, is here rounded off rather than acute; the sizable bit of the apex, evidently formed from the usual independent center of ossification, has not yet united with the blade of the bone.[19] The superior border, extending from the inner base of the coracoid process to the angle which in anthropotomy is known as the "superior angle," is here sharp and uniformly concave throughout its length. The superior angle is about a right angle and is rounded as in most mammalian scapulæ. The superior border is only about one-half as long as the axillary one; the vertebral border stands between the two in this respect. A suprascapular notch hardly exists in the superior border near the coracoid process; indeed, although the greatest concavity of the border here is where it usually occurs, no such break in its continuity is to be distinguished. At its narrowest part the neck of the scapula measures just 1 centimeter, and likewise this is the thickest part of the bone antero-posteriorly, it being about 0.5 centimeter just within the glenoid cavity.

---

[19] This indicates that the animal was still in a subadult stage when killed. Complete union has taken place in the other two specimens (1 and 3) from which we conclude that they are more advanced in age. In the human species it is not until the sixteenth year that this epiphysis unites with the rest of the scapula at this point.

Smooth and quite level, the subscapular fossa on the venter of the bone exhibits hardly any muscular ridges, the only one of any prominence being a mere indication of such extending from the neck to a mid-point on the vertebral border. Even this may be absent from some specimens.

The coracoid process is represented by a straight, somewhat flattened rod of bone, that may attain a length of nearly 1.5 centimeters. It is extensively attached to a raised base or pedicle at the junction of its inner and middle thirds. This gives rise to a long and a short process, the first assisting in the formation of the articulation for the humerus, and the inner and shorter one for ligamentous attachment. Its longitudinal axis makes an angle with the long axis of the acromion process of about 60°, and an angle of about one-half as many degrees with the plane of the scapular blade. Thus it will be seen that the coracoid is not bifurcated as stated by Flower [20] but simply produced both ways from its base, in the same straight line.

Very conspicuously developed, the spine on the dorsum of the scapula commences superiorly or, perhaps, what may be called externally, beyond the glenoid cavity. Here it supports a large acromion process and a metacromion; this is followed by a somewhat flattened pedicle to the scapular neck, and from there on it becomes a thin lamina of bone which gradually slopes away to a point near the middle of the vertebral border. This osseous partition creates the supraspinous and infraspinous fossæ, which are thus thoroughly defined. The latter is about twice the size of the former, and lengthwise is bounded by the aforesaid spine on the one hand and by the raised axillary, described above, on the other. The scapula makes the usual articulations with the humerus and clavicle, and has attached to it, either by origin or insertion, a number of important muscles and ligaments.

THE PELVIS.

Beyond a few unimportant individual variations, the pelves (Plate III, figure 8; Plate IV, figure 14, and Plate V, figure 17) of the three specimens of *Cynocephalus* at hand present the same characters for description. On the other hand this part of the skeleton differs widely in its morphology among the Insectivora as a group, being long in some, short in others, while in such genera as *Sorex, Talpa,* and *Chrysochloris* a wide interval separates the pubic bones at the mesial line below, where they usually unite.

When submitted to ordinary maceration in water the two ossa innominata readily part company with the sacrum and with each other. This happened in the case of the Steere specimen here shown in figures 8 and 14. One of the most striking features of the pelvis in *Cynocephalus*

---

[20] Osteology of the Mammalia, 253.

is its unusual length as compared with its width; the former being about 8.7 centimeters and the latter 4.3 centimeters taken opposite the acetabulæ.

Its articular surface for the sacrum is upon the inner side of the ilium about 1.7 centimeters from the "crest," and covers an area of a little more than 1 centimeter in length. Dorsally, this area projects as an elongated, sharp crest; otherwise it is entirely confined to the surface of the ilium proper and is faintly divided into two facets, a long posterior or dorsal one, and a shorter oval one, parallel to and in close contact with it.

Flower has stated that in "*Galeopithecus*" the symphysis pubis "is long, as in the Carnivora, and becomes ankylosed."[21] He is certainly in error in this statement for in all the specimens before me the symphysis pubis is reduced to the merest contact of the bones, the area being very small, and ankylosis never results. (See figure 14.) As he states, the symphysis is long in most Carnivora, and this can be easily verified by examining the pelvis of any of the Felidæ.

In the articulated skeleton of *Cynocephalus* the preacetabular portions of the ilia are nearly parallel to each other and lie in a subtransverse plane that makes but a slight angle with the longitudinal axis of the lumbar and sacral vertebræ. The anterior presacral portions of the ilia are directed upward, forward, and outward; the free extremities, which are slightly enlarged and rounded, are about opposite the neural spines of the vertebræ. Thus it will be observed that all the preacetabular portion of the pelvis affords but very slight protection to the contained abdominal viscera; it does afford protection to some extent laterally, and in conjunction with the sacrum and leading caudal vertebræ, to a greater extent dorsally.

It remains to say of the preacetabular part of an ilium that it is sigmoid in form, and for the most part subcylindrical, although exhibiting slight longitudinal flatness dorsally, mesially, and externally. This rod-like part of the ilium gradually expands as it comes to the acetabulum which it assists in forming. The latter is large, being over 1 centimeter in diameter, and presents all the usual mammalian characters. Its cotyloid notch is wide and rather deep; the cotyloid articular ring is well developed; while the bone at the bottom of the cavity is often very thin and always translucent. As usual, it is formed by the three pelvic bones, the ilium, the ischium, and the pubes, the sutures among which have become entirely obliterated within the cotyloid cavity. In fact the only sutural line that persists throughout the life of the individual among any of the three pelvic bones is the one between the rami of the ischium and pubes. It is very distinct in all specimens at hand, and probably is invariably present. (Figure 14.)

[21] Osteology of the Mammalia, 320.

The postacetabular portion of the pelvis is triangular in outline, the acetabulum occupying one angle, the symphysis pubis another, and the remaining one being at the tuberosity of the ischium, the last two being rounded off. Upon its mesial aspect this part of the bone is uniformly and moderately concave throughout, and entirely unmarked by elevations or depressions. It encloses the very large, oval, obturator foramen, the larger end of which is formed by the ischiopubic rami, where its margin is sharp and clean cut, it being thicker and more rounded for the remainder of the curve of this vacuity.

Externally the surface of the postacetabular part of the pelvis is likewise smooth, with its convexity corresponding to the concavity of the mesial aspect. But one muscular line marks it, and that the usual one, halfway between the obturator foramen and the tuberosity of the ischium, indicating the limitations of the areas where arise certain important muscles of the thigh, or more exactly, of the posterior femoral and adjacent regions.

The external borders bounding this postacetabular portion of the pelvis are rounded, smooth, and continuous for the pectineal line, continuous and slightly thickened for the ramal line, and considerably thickened where formed dorsally by the ischium. The ischium presents two prominent tubercles just without the rami of the cotyloid cavity. They are separated by a shallow valley or notch, and the anterior one has generally been designated as the "spine of the ischium," at least, it has been so-called in the human skeleton, where it affords surface for the origin of the gemellus superior muscle, the gemellus inferior arising from the other tuberosity. These muscles among the lower mammalia are generally known as the gemellus anterior and gemellus posterior, owing to the direction of the longitudinal axis of the body.

THE SKELETON OF THE PECTORAL LIMB.

Both pairs of limbs in *Cynocephalus* are fully and powerfully developed, and they present many points of considerable interest. In writing upon the subject of "the adaptive changes which take place in the segments of the limbs proper in various animals," Flower [22] has said:

> In what may be considered the first stage of modification each segment of the limb is simply bent upon the one above it. The proximal segments (humerus and femur) remain unchanged in position, the dorsal surface still looking upwards, and the ventral surface downwards, the middle segment is bent downwards, so that its ventral surface faces inwards and its dorsal surface outwards; and the joints between these segments (elbow and knee) form prominent angular projections.
>
> The third segment being bent to a greater or less degree, in the opposite direction to the middle one, retains much of its primitive position, the dorsal surface being directed upwards and the ends of the digits pointing outwards. The relations of the pre-axial and post-axial borders of the limb are unchanged. No

---

[22] Osteology of the Mammalia (1885), 365, 366.

mammal habitually carries its limbs in this position, although the climbing *Galeopithecus* and the Sloths are not far from it. It is, however, very nearly the normal position of some Reptiles, especially the Tortoises, although it is ill adapted for anything but a very slow and clumsy mode of progression.

In *Cynocephalus* the humerus makes the usual articulations with the scapula proximally, and the radius and ulna distally, that are seen among mammals generally. These articulations are in all cases extensive and the joints very perfect anatomically.

The left humerus of the colugo (figure 15) offers the following points for examination, some of which are better seen in the right humerus (figure 16) from the same skeleton, this being due to the different positions in which the bones were photographed. Its characters, including its length and to some extent its size, vary somewhat in various individuals. It is considerably shorter than the ulna or the radius; in man it is the longest bone of the arm.

Viewed in its entirety, upon either its direct inner or outer aspect, the humerus is seen to possess for its continuity the true "sigmoid curve." This curve starts at the head and terminates with the trochlear extremity. Ignoring the prominent ridges its shaft is for the most part subcylindrical in form, the principal departure being at the distal end which is expanded to support the trochleæ for the bones of the antibrachium. It is uniformly smooth, and pierced by an oblique, nutrient foramen situated about 2 centimeters distad of the articular part of the head, on the posterior aspect.

The very conspicuously elevated deltoid ridge with its thickened edge extends down the shaft, on its anterior aspect, for about one-third of its length. It commences at the head and slopes away rather abruptly distally. Its nearly straight free margin is almost parallel to the shaft's long axis, its sides being smooth. On the other hand the supinator ridge is low, sharp, and thin, extending from the external condyle almost to a middle point of the shaft, following accurately the lower sigmoidal curvature of the latter, where it is gradually lost.

Among mammals we rarely meet with the humerus possessing a more perfect head than it does in *Cynocephalus,* in which genus it is almost a complete and entirely smooth hemisphere. For the most part its articular surface is distinctly differentiated by its circular limiting line and surrounding shallow groove or neck, the major part of which is seen on posterior view. It reminds one of the humeral head of anthropotomy and surmounts the shaft in a very similar manner (figure 15). Upon either side of it the greater and lesser tuberosities are well developed, the comparatively deep bicipital groove passing the latter down the shaft and the side of the deltoid ridge.

At the distal extremity of the bone, posteriorly, the olecranon fossa is very deep and markedly defined. Its osseous base is thin, and may be perforated by a minute foramen. The internal and external condyles are large, and pitted for the origin of certain muscles upon either side. Above the internal condyle, anteriorly, there exists a delicate span of bone of no great length. It passes, as a gently curved arch from the condyle, obliquely toward the center of the shaft in a proximal direction forming the supracondyloid foramen (figure 15), which gives passage and protection to the median nerve and brachial artery. Where high division of the brachial occurs, the nerve only, as a rule, passes under it, but may be accompanied by the ulnar-interosseous artery.

The distal points of the trochlea and capitellum lie in the same horizontal plane to which the axis of the shaft is perpendicular. Each constitutes a prominent tuberosity separated distally by a well-marked valley. Both in front and behind they rise to the same transverse line on the shaft, ceasing at the distal boundary of the olecranon fossa posteriorly, and at the rather shallow depression intended for the ulna anteriorly. The smaller tuberosity is flat upon its internal aspect, while the capitellum for the radius is fully double the size with a roundly convex articular surface. The average extreme length of the humerus is about 10.2 centimeters.

Judging from the material at hand it would appear that when the bones of the arm are normally articulated they admit of extreme flexion to a far greater degree than they do of extreme extension, that is, extension to the extent of bringing the long axis of the shaft of the humerus and the ulna into one and the same straight line.

The radius is a very strong and nearly straight bone with enlarged extremities and subcylindrical smooth shaft. It has an average extreme length of 12.2 centimeters, or two centimeters greater than the humerus. (Plate III, figure 9.) At its proximal end, the tuberosity for the insertion of the tendon of the biceps, is represented by a short longitudinal crest, terminating in a groove near which we usually discover the opening of a small nutrient foramen. Above the tuberosity the bone is somewhat constricted to form the neck of the radius and the latter is surmounted by the head of the bone. The head is large, oval in outline, and at its summit exists the rather deep concavity for articulation with the capitellum of the humerus, while its marginal articulatory surface for the ulna is about 2 millimeters deep. The outer lower third, or more, of the shaft is flattened, forming a surface to which the distal fourth of the ulna is firmly attached by ligament. Anteriorly, on its expanded part at this extremity, we note the five conspicuous longitudinal grooves intended for the passage of the extensor tendons as they go to the hand. A sharp, peg-like, styloid process projects forward at the outer side of the bone, but does not extend beyond the border over which the extensor tendons pass. Internal to this process is a deep, elliptical, transverse facet for articulation with the first row of bones of the wrist or carpus. The interosseous space existing between the articulated ulna and radius is long and narrow. From a study of the various articulations of the antibrachium it would appear that during life the power of pronation and supination must be somewhat limited.

A very considerable amount of atrophy marks the development of the ulna of *Cynocephalus*. To some slight extend this involves the head of the bone, but is far more evident in the shaft. (Plate III, figure 9.)

On the whole the ulna is very straight from one extremity to the other, straighter distally than represented in figure 9, where some curvature is shown due to long maceration and subsequent drying. It has an average length of 12.1 centimeters, or is practically of the same length as its companion in the antibrachium; it holds a postaxial position with respect to the latter in the normally articulated skeleton. Among other mammals, where the ulna is fully developed, it is a much longer bone than the radius, due principally to its extension at the elbow. This is the case in man, in the Felidæ, and in many other mammals.

In the subject here under consideration the shaft of the ulna below the head is considerably compressed from side to side and longitudinally grooved for some little distance on its radial aspect, thus giving rise to a sharp margin for the attachment of the interosseous membrane. From its coronoid process to its distal apex the shaft contracts very gradually and uniformly, and where the lateral flattening ceases it becomes more or less compressed in the opposite direction, a condition which continues to its distal end. On its outer surface this flatness is continuous from one end of the bone to the other. In human osteology this outer surface is described as the posterior surface of the ulna.[23]

Distally, the ulna is carried finally to a very sharp apex, or point, which in the articulated skeleton is found just above the styloid process of the radius. This point, together with the lower fourth of the bone, is closely applied to the shaft of the radius and is held there by a firm ligamentous attachment. That it ever actually ankyloses with the radius is very much to be doubted, as ordinary maceration is quite sufficient to separate the two completely.

Proximally, the greater sigmoid cavity is circularly concave and not very wide, although withal of good size; it is overarched by the olecranon, which is here concave on its summit, uniformly thick from before, backward, and pretty well fills the deep olecranon fossa of the humerus when the limb is fully extended. There is not the slightest evidence of any longitudinal division of the greater sigmoid cavity by a raised central ridge as in man and other mammals.

Both the lesser sigmoid cavity and the coronoid process are well developed, the former being but very slightly concaved with its limiting margin sharp and circular in outline. On the radial aspect of the head

---

[23] Gray's Anatomy (1870), fig. 158.

a deep notch marks the boundary between the two sigmoid cavities, while on the opposite side the limiting border is continuous and distinctly circular in outline (figure 9). It is unnecessary to add that such an ulna as *Cynocephalus* possesses takes no part in the carpal articulation.

The bones of the arm and forearm vary among the Insectivora to a very marked degree; as, for example, among the hedgehogs, moles, and shrews; and it is said that the ulna in *Macroscelides* and *Petrodromus* is atrophied distally as in the colugo, but whether in these animals it coössifies with the radius at that end may be open to question.

According to Flower:

> Among the insectivora, the scaphoid and lunar (in the carpus) coalesce in *Galeopithecus*, *Tupaia*, *Centetes*, *Solenodon*, *Erinaceus*, and *Gymnura*, but in most of the other forms these bones are distinct. A distinct os centrale is found in all except *Galeopithecus*, *Potamogale*, *Chrysochloris*, and *Sorex*.[24]

A very careful microscopical examination of two wrists, or carpi, in two different specimens of the material at hand, proves beyond all question that this statement, in so far as *Cynocephalus* is concerned, is quite incorrect. All of the eight usual bones of the carpus are to be found in this animal. They are especially well developed in the manus of Steere's specimen, the one from the right pectoral limb having been very carefully examined by me under a high-power lens. There are four bones in the proximal, and an equal number in the distal row.

Commencing at the inner end of the proximal row (ulnar side) we find the pisiform to be represented by a rather large, elongate ossicle that has a facet upon its mesial aspect merging with another distally, the first articulating with the cuneiform, and the latter with the unciform, as in the Felidæ and probably other mammals. Cuneiform, one-third larger than pisiform, is of an irregular cuboidal shape, with a small facet for pisiform, and a larger one for unciform and semilunar, the latter being much concaved.

The semilunar is larger than any three of the other carpal bones taken together, and is the only one of the wrist that articulates with the former. This it does with its large semi-ellipsoidal facet on its proximal aspect, intended for the articulation at the distal end of the radius. Its outer extremity also has a rather large, nearly circular, facet with which the scaphoid articulates. Distally, the bone presents a raised, ridgelike, longitudinal articulation for the trapezium; this is separated by a deep groove from a larger, central, likewise longitudinal, raised facet which articulates with trapezoid and os magnum. More internally it offers a small articular surface to the unciform. Thus it will be seen that the semilunar articulates with no fewer than seven bones, viz: radius, cuneiform.

---

[24] Osteology of the Mammalia (1885), 289. This authority's description of the hand in the insectivores will hardly apply with accuracy to the colugo which is unusually large.

unciform, magnum, trapezoid, trapezium, and scaphoid. Scaphoid is a small compressed bone, but is larger than pisiform; it has but a single articular facet covering its entire mesial aspect that articulates with a similar facet on semilunar. It is connected with the trapezium by ligament only.[25]

Trapezium of the distal row is only exceeded in size by the unciform. It is of an irregular cuboidal shape, with articular facets for the proximal end of pollex metacarpal, trapezoid, and lunar. Above it, attached by ligament only, we find the scaphoid, while mesially it presents a small facet to the proximal end of index metacarpus.

Having very nearly the same form and size, either being parallelepipedal with respect to the former, the trapezoid and os magnum articulate with each other and both with semilunar. Trapezoid also articulates with the metacarpus of index digit, as os magnum does with the same bone of the middle finger.

Unciform is a cube of irregular shape, the last carpal in the distal row on the ulnar side, that articulates with lunar, cuneiform, and the metacarpus of minimus digit, and the inner side of the base of the metacarpus of the fourth phalanx. Its palmar process is but feebly developed.

The manus of *Cynocephalus* is large in proportion to the size of the animal, and exhibits in its skeletal morphology the chief uses to which it is put, that is, being fitted to serve the purposes of climbing rather than of prehension. It is especially long and rather narrow, being armed distally with very efficient and powerfully hooked claws. It is a pentadactyl member with a short pollex and four elongated digits. All the phalanges composing these digits present the usual characters seen among ordinary small mammals. Their shafts are very nearly straight and quite cylindrical, while their distal extremities, or heads, support the usual double trochleæ for articulation with the phalanx next beyond them in each instance. The base of each of these long bones is larger than its head and also presents an articular facet, which is oval and concave to receive the head of the phalanx next behind it. The ungual, or distal, joints are entirely different and will be described further on. The metacarpus consists of five bones; distally they articulate with the five proximal phalanges of the digits and at their other ends with the carpus in a manner already pointed out. Pollex metacarpal is very considerably shorter than any of the others; index and minimus metacarpals

---

[25] In describing this bone as the scaphoid, the fact is known to me that among rodents there are many wherein the scaphoid and lunar unite to form a single bone; and further that a special ossicle, which has been described as occurring on the radical side of the wrist, is of very considerable size in *Castor*. It has also been said that in the beaver the scaphoid and lunar fuse to form one bone. Notwithstanding these statements it is contended here that the scaphoid is present in *Cynocephalus*, though embryology may disprove it, and two centers of ossification may be shown to exist in the bone here described as semilunar.

come next in length and nearly equal each other in this respect. Medius and annulus metacarpals are also of equal length and larger than any of the other bones of this part of the hand. Pollex metacarpal is the stoutest of them all and is about 1.6 centimeters long; minimus is also stout and has a length of about 2.8 centimeters, while that of index is 5 millimeters shorter. The shafts of the middle and ring, or the medius and annulus, metacarpals are rather more slender, and each is nearly 3 centimeters long. These metacarpal bones are slightly curved palmad and like the phalanges, nearly parallel and very close to each other when the member is at rest. Pollex has one short (1.5 centimeters), stout phalangeal joint and an ungual joint; all the other digits have three each including the ungual joints. Index is the shortest finger, minimus next, with medius and annulus of about equal length. Not including the terminal joint, annulus has a length of about 4 centimeters.

The ungual joints are all very much of the same form and size; the largest being on pollex, index, and the next two digits, the smallest on the little finger. Any one of them is very deep from dorsal to palmar border, the latter being slightly concave, and the former powerfully convex and a little jagged distally. From side to side one of these thoroughly ossified joints is uniformly compressed to extreme thinness, while its proximal border is somewhat thickened for the articular facet and for tendinal insertions. At the postero-dorsal angle there is a very small, concave, circular process for the insertion of the extensor tendon; palmad to this is a large concave facet divided by a median longitudinal ridge. This concavity is twice as deep as it is wide, and its surrounding border is raised above the general surface. Palmad to this again, at the postero-palmar angle, there is another very small process for the insertion of the flexor tendon, while above this, beneath the lower border of the mid-articular facet, are two minute foramina, side by side in the transverse line. They lead into the bone and appear to be nutrient foramina.

The horny theca, fitting as a claw over one of these ungual joints, is also powerfully compressed from side to side, and in form, with its very sharp apex, resembles upon lateral view the upper bill of one of the smaller typical falcons.

On the palmar aspect, beneath the articular joints of the metacarpals and phalangeal bones, we observe in the case of each digit a pair of sesamoids. These have the form of small compressed ellipsoids, the largest ones being in the proximal tier of bones, whereas in the case of the smaller pairs beyond, they are placed side by side in the transverse line.

Distally, the sesamoids are very minute and may be absent in the index digit, between its first and second phalanx. They do not occur, apparently, beneath the ungual joints at all. These sesamoids occur in the hands and feet of other mammals, as certain carnivora, and even in the tendons running to the toes on the plantar aspect of the foot in man.

THE SKELETON OF THE PELVIC LIMB.

Proportionately, the pelvic limb of *Cynocephalus* is not as powerfully developed as is the pectoral limb, though there seem to be exceptions to this general rule. In Steere's specimen, for example, the long bones of the posterior limbs are fully as well developed as are the corresponding ones in the anterior extremities. However, pes always seems to be weaker and somewhat smaller than manus, and this is also evidenced in the skeleton of these parts.

In the matter of proportions there are very marked differences in the pelvic limbs of the three skeletons at hand. These differences may be due to the fact that they came from different species, or if from the same species, it may be due to differences in age or even sex. In any event the Steere specimen was a much bigger animal than either of the McGregor specimens, and one of the latter (3) is larger than the other (2), though the characters throughout agree.

Two of the femora, selected as examples, show how marked these differences are; for instance, the right femur of the Steere skeleton has an extreme length of 12.3 centimeters, as compared with the extreme length of the femur in the smaller of the two individuals from the Bureau of Science, which is only 11.1 centimeters. Then in the matter of actual size the two bones are also in proportion to this difference in length, the shaft of the femur in the first case being fully one-third larger than in the second case.

The description of the pelvic limb here given is from the right side of the skeleton in Steere's specimen, with occasional reference to the other two individuals.

The femur (Plate II, figure 6), possesses a stout, straight, cylindrical shaft, which is so smooth that even linea aspera is scarcely indicated upon it. The proximal extremity of the bone presents an elegant, smooth, hemispherical head, in fact so globular is it that it approaches the sphere. This head is marked by no pit for the ligamentum teres; its boundary is sharply defined in front; less so behind, where the articular surface encroaches slightly upon the summit of the shaft of the bone. The axis of the head and neck makes an obtuse angle with the axis of the shaft, thus bringing the head above the latter's summit. Conspicuous and rough, the great trochanter curves slightly to the front, thus making the neck of the bone very distinct behind it and the caput femuris. Minute nutrient foramina may occur in this locality. On the postero-external aspect of the great trochanter there is a well-marked pit, the so-called trochanteric fossa, within which certain muscles are inserted.

Situated internally and at the same time posteriorly, and about 1 centimeter below the head, there arises the lesser trochanter, sometimes called the tibial trochanter. It is bluntly triangular in form, and arises from a substantial base. On the opposite side of the shaft, that is, on its external border, and rather lower, there is still another and smaller process, which is the third trochanter. Between these two projections on the posterior aspect of the bone, the shaft is very smooth and particularly flat. No spiral line joins the greater and lesser trochanters on the anterior surface of the bone, while posteriorly, the trochanteric line is very feebly pronounced in the corresponding locality. Both these lines, or intertrochanteric ridges, are very noticeable in the femora of many other mammals, man included.

At the distal end of the shaft the two condyles are strong and thick. They are almost exactly of the same size and neither one is lower on the shaft than the other, as is sometimes the case among mammals where the inner condyle is the lower of the two.

The smooth, convex, articular surfaces seen posteriorly on these condyles are practically of exactly the same size, and they terminate in the same transverse planes, both above and below. Between them is a deep, sharply defined, intercondyloid notch, that terminates abruptly at the lowest plane of the bone and superiorly in a similar manner on a flat surface named in anthropotomy the popliteal space. Again, either the internal or external condyle exhibits upon its outer surface a distinct pit, or depression, wherein certain muscles arise or are inserted. One is about as well marked as the other, as are the tuberosities that occur, one in each case, above them. The one on the outer condyle is the outer tuberosity, and the other the inner tuberosity. Anteriorly, the intercondyloid space is of a nearly quadrilateral outline; it is smooth, slightly narrower above than below, gently concave from side to side, and roundly convex in the longitudinal direction with respect to the axis of the shaft. This surface is shown in figure 6.

The patella is poorly developed in *Cynocephalus*. It may, or may not, be completely performed in bone, and there is reason to believe that in young specimens it will always be found in cartilage or at the best in very elementary osseous tissue. When in bone it is not large, though it extends from a point opposite the center of one condyle to a point opposite the center of the other, being parallelogramatic in outline, with the long sides transverse. Anteriorly, the patella is convex from above, downward, and correspondingly concave posteriorly. The tendon in which this sesamoid is embedded, the quadriceps extensor, is very tough and strong and is inserted on the free anterior border of the head of the tibia.

The tibia is the longest bone in the skeleton of this animal; it is, however, by no means the stoutest, being exceeded in this respect by both the humerus and the femur. Proximally the tibia has a shaft the caliber of which about equals that of the femoral shaft at the junction of its upper and middle thirds, but as we pass to the distal end this caliber gradually diminishes until just before arriving at the lower end of the bone. The shaft, likewise, exhibits a curvature from one extremity to the other, the greatest amount being at its middle; the entire convexity is on the outer side. The shaft of the tibia in most mammals is triangular in section, but in *Cynocephalus* it is quite quadrilateral, especially where its caliber is at its minimum. A shallow longitudinal groove marks its outer aspect, being best seen along the middle third; otherwise the bone, or rather its continuity, is devoid of any particular characters.

The proximal end, or what is known as the head of the bone, is expanded and nearly as big as the distal end of the femur. This expansion gives rise to two lateral eminences, the tuberosities of the tibia. They support superiorly the two smooth concavities with which the condyles of the femur articulate in life. In extent they are of about equal size, and between them toward the back of the bone is a low, pointed process, the spinous process of the tibia. A slight notch occurs in the posterior border bounding the tibial head which has received the name of the popliteal notch, and to it the posterior crucial ligament is attached. On the outer side of the head there occurs a flat, subcircular, articular facet intended for the head of the fibula. It is of no great size. Posteriorly, the boundary of the head somewhat overhangs or extends beyond the shaft, which is here broad, flat, and smooth.

The enlarged distal end of the tibia is not more than one-half the bulk of the proximal extremity, and it has a form to fulfill a variety of purposes. Chief among these are its articulation with one of the bones of the metacarpus, its articulation with the fibula, for the passage of tendons of certain muscles, and for ligamentous attachment. At its inner side it is prolonged distally into a prominent process which is the internal malleolus. Just above this there is a deep, oblique groove, its lower opening being in front. In life this groove gives passage to the tendons of the flexer longus digitorum and the tibialis posticus muscles. There is a small, rough, inconspicuous facet on the outer side of this distal end of the bone with which the lower end of the fibula articulates. The extreme inferior surface of this extremity is given over entirely to a broad, spindle-shaped, articulate concavity which in life articulates with the astragalus; internally this is carried slightly up the shaft, or at least upon the back of this end of the bone. In front this extremity is convex from side to side and very smooth; over it in life glide the extensor tendons.

The fibula is very nearly as long as the tibia, being exceeded only by the internal malleolus of the latter. On the whole it is the most slender long-bone in the skeleton and, for its length, the straightest. Some specimens have the proximal moiety reduced to extreme slenderness while the head of the bone at that end, which makes a feeble articulation with the tibia, is always reduced to a mere semiellipsoidal nib, only a few millimeters long, flattened on its inner articular aspect, and convex on its outer. The shaft is smooth, compressed from within, outward, and very gradually increases in caliber toward its malleolar extremity. In one specimen (3) this bone is deeply and longitudinally grooved for the entire upper one-third of its tibial aspect.

Bulbous in shape, its distal end forms the external malleolus, being obliquely truncate from above, downward, and outward; the inner surface is given over to the facets for articulation with the tibia and the astragalus of the foot. Above this is a distinct little process for ligamentous attachment. There is another, but larger, tubercle on its outer aspect. Ligaments of the ankle are also attached at a few other points; in fact, the most important function of this bone in *Cynocephalus* is to assist in completing this very essential joint.

Pes contains the same number of metatarsals as manus contains metacarpals, and the toes the same number of phalanges as we find in the hand; that is, three joints in all the toes with but two in hallux.

The study of the foot of *Cynocephalus* is wonderfully interesting. Owing to the unusual way the member has been used and ontogenetically evolved, it has the appearance, on first sight, of having been dislocated. The articulatory part of the astragalus which articulates with the tibia, and to some extent the bone itself, has rotated inward and to a degree forward, so that the longitudinal axis of this long and narrow foot makes a varying angle with the continuity of the shafts of the bones of the leg. This angle in the vertical plane may range all the way from 120° through a right angle to an acute one of 70°, according to the manner in which the animal holds its foot. The member possesses also a certain amount of motion either backward and forward, when the limb is held away from the body, or inward and outward, when it is brought near the latter and the effort is made to move the foot in those directions.

Flower [26] states, and it is true, that "The bones of the tarsus of mammals present fewer diversities of number and arrangement than those of the carpus." *Cynocephalus* offers no exception to this rule.

There are seven bones in the tarsus of the colugo, namely the astragalus, the os calcis or calcaneum, the scaphoid or navicular, the three cuneiforms (internal, middle, and external), and the cuboid. This enumeration does not take into consideration the presence of several important sesamoids which will be noticed farther on.

The astragalus of all the tarsal bones is next in size to the os calcis, the latter being the largest bone of the foot. In man this bone receives

---

[26] Osteology of the Mammalia, 340. Many works have been examined in this connection, and the literature of the subject is very extensive, but it would appear that no author as yet has produced sufficient evidence to warrant any radical change in the nomenclature of the tarsal bones, or to set aside their homologies as they have long been given in standard treatises on anatomy.

the weight of the body in standing and walking, transmitted to it from the tibia, and to a very slight degree the fibula. Quadrupeds have this weight variously divided, while in *Cynocephalus* it appears that this tibio-tarsal joint sees its chief use as an enarthrodial articulation. Usually the very irregularly-shaped astragalus is described as having a head, a neck, and a body, and such divisions are easily made out. When duly articulated, the head projects to the front in line with the scaphoid, the cuneiform bones, and the first and second toes. Anteriorly the head has a large, smooth, convex facet which articulates with a concavity in the scaphoid and a surface on the antero-superior aspect of the os calcis.[27] The latter encroaches upon the surface of the neck beneath. The neck is somewhat compressed from above downward (here really from side to side), and is wider in the opposite direction. The entire upper part of the body is occupied by an elegant, smooth, convex facet for articulation with the two bones of the leg. This articular surface is carried over upon the sides of the astragalus, and here the malleoli of the aforesaid bones articulate, as is the case with nearly all mammals. Fibula gets the smaller share, a little less than one-half of this articulation. Posteriorly and beneath we note a well-marked groove, which in life gives passage to the tendon of the flexor longus hallucis muscle. On the sides there are pits for the attachment of ligaments. At the center of the bone, on the side next to the os calcis in articulation, there is an irregular concavity; this is on the neck, while posterior to it on the body there is an elliptical facet for a similar one on the calcaneum. No muscle either arises from, or is inserted upon, the astragalus, and as pointed out above the astragalus articulates with four bones: tibia, fibula, calcaneum, and scaphoid.

The os calcis or calcaneum, is longer, narrower, and larger than the astragalus; the latter projects just a trifle more to the front, while the former exceeds it in length behind. Altogether the bone is very irregular in form and has the tendons of a number of muscles and ligaments attached to it, or arising from it. Os calcis is the tarsal that forms the skeletal part of the heel and here we find this posterior extension to be a distinct semi-ellipsoidal projection, subvertically placed upon the body of the bone. This is generally called its tuberosity, and upon it is inserted the tendo Achillis. Beyond it, the body of the bone is somewhat constricted and compressed from side to side. Mesially, it throws out a conspicuous triangular process, the upper side of which articulates with the under side of the neck of the astragalus. A similar, rather smaller,

---

[27] In assigning directions, and the directions in which surfaces look or face, for the sake of convenience, it is assumed that the animal stands on the ground as do ordinary quadrupeds, otherwise it would be very difficult to appreciate the relations of the tarsus to the rest of the skeleton, and the most unusual position in which the foot is held with respect to the surface upon which the animal is traveling.

apophysis, occurs on the outer aspect of the bone just posterior to the cuboidal articulation; this is intended for muscular insertion.

Anteriorly, the face of the os calcis is entirely given over to a concavo-convex articular facet for the cuboid, which presents a peculiarity, in that it is conically hollowed on the planter border; into this fits a pea-like articular process on the cuboid. On the under, or planter, side of this the two bones are firmly lashed together by a broad tough ligament. There would appear to be some special cause for the development of a joint such as this, but the cause is not apparent. Internal to the cuboid articulation there is a small facet for the scaphoid. When the two tarsal bones thus far described are articulated, and we view them from what is really the outer side, we note that the plantar aspect of the neck of the astragalus is oblique and arches over a similar groove on the calcaneum, the two forming a foraminal passage through which we can look. In the recent state this is filled up by the calcaneo-astragaloid interosseous ligament, and is present in nearly all ordinary mammals.

The cuboid in *Cynocephalus* is really more or less cuboidal in form; its posterior articular face has already been described. It is also articular in front where its slightly concave surface is divided by a ridge into two, for the fourth and fifth metatarsals. There is a strong oblique groove on its plantar surface, and this lodges the tendon of the peroneus longus muscle. On its mesial aspect the cuboid makes an extensive articulation with the scaphoid, and also the external cuneiform. Thus it articulates with four bones: calcaneum, scaphoid, and the fourth and fifth metatarsals.

Os naviculare, or scaphoid, is rather larger than the cuboid and its posterior articulation is somewhat remarkable, for it not only articulates with the head of the astragalus, but on its plantar aspect on the margin of this articulation, it sends back a distinct process the side of which articulates with the os calcis, and upon which the plantar surface of a part of the head of the astragalus rests. This process has a notch on its outer side. Anteriorly, it has facets to articulate with the three cuneiform bones. These are all more or less cuboidal in form, differing a little in the matter of size, and each articulates anteriorly with the base of a metatarsal. The internal cuneiform is the largest and joins the hallux metatarsal; it extends farthest to the front; the middle one is the smallest, and the external one is between the two in point of size.

The three middle metatarsals very closely resemble the corresponding bones in the hand, while in the foot a peculiarity is seen in hallux metatarsal in that it has a conspicuous, rounded process erected on the dorsal aspect of its extreme distal end. The articular surface in front is carried upon this, affording the joint next beyond an unusual amount of backward play in the vertical plane.

The metatarsal of the little toe is almost as stout as, and considerably longer than, hallux metatarsal, and as in many other mammals it developes a process proximad that projects from the side of the foot. This is the tuberosity of the fifth metatarsal; in man and probably in many other mammals the peroneus brevis muscle is attached to it.

The distal phalanges as well as the greatly compressed ungual joints, closely resemble those of manus and consequently require no special description.

At the side of the foot, a short distance back of the hallux metatarsal and apparently encased in the lateral ligaments in that locality, there is a large, flat, quadrilateral sesamoid. It is on the tibial side of the tarsus and rests, flatwise, on the scaphoid and internal cuneiform bones. Baur took this to be the rudimentary tarsale tibiale in which he was doubtless mistaken, as it is sesamoidal in all its characters.[28]

It would appear that no special name has as yet been bestowed upon this bone, so it might conveniently be known as the tarsal sesamoid.

There are other sesamoids in the sole of this foot, and they agree in all particulars with the corresponding ones in the hand. We see them, proximad, just within the tarsophalangeal articulations, a pair back of each joint, and very much smaller pairs in the row of joints beyond. Occasionally specimens are found having a few very small sesamoids in the sole of pes, and in the partly cleaned skeleton the palmar surface of the process projecting backward from the scaphoid may easily be mistaken for one, as it is exposed there and has the same elliptical form.

No tendon of any of the muscles in *Cynocephalus* has been found to ossify, nor have there been, beyond the rings of the trachea, any other ossifications met with in this animal.

So much then for the osteolgy of *Cynocephalus*, the caguan, the aberrant insectivore of certain islands of the Indian Archipelago, which we know is certainly no lemur.

THE HYOID ARCHES AND THE LARYNX.

As stated above the specimens here described lacked the hyoid arches and the trachea. This I communicated to Mr. McGregor by letter and in due time received the following reply from him.

> I have, unanswered, your letters of October last and of January of this year [1909.] I am glad to know that you have a paper on *Galeopithecus* roughed out and I will hope to be on hand to see it copied and to read the proof for it. I regret that the specimens sent you were incomplete. They were prepared in the field by my assistant at a time when we had a great press of other work and you know what that is in a hot climate. I am fortunate in having on hand a pickled specimen of the lemur from Basilan, doubtless the same species

---

[28] *Amer. Nat.* (1885), **19**, 349. This bone has also been discovered to exist in *Hyrax*, the duckbill, certain Rodentia, and in some of the Edentates.

> as the Bohol specimen, and I will forward the entire head and neck of this in hope that you may be able to dig out the hyoid from it. It has been long in formalin so that the bones may have softened a bit or perhaps hopelessly so, at any rate I think it worth while to forward in case it will complete your description.
>
> If you have already mailed your manuscript you can write out the hyoid matter and send to me with indication where to insert, etc., and I will see that it is properly placed in your manuscript.

Toward the latter part of April, 1909, I received by mail the above mentioned head and found it to be a specimen of the kind described by Mr. McGregor and in a very satisfactory condition for dissection. I have carefully dissected the hyoidean apparatus, the larynx, and about an inch of the trachea (all that came with it) of this specimen.

I have compared all the parts with the corresponding ones of a domestic cat as figured by Mivart, and with several other species of the Carnivora, bats, etc. Upon the whole it agrees pretty well with the first-named animal, except in the matter of the tympanohyal, and it was Flower[29] who said:

> The hyoid [in the Insectivora] is formed generally like that of the Carnivora, with three complete extracranial ossifications in the anterior arch, a tranversely extended basihyal, and tolerably long, stout, flattened thyrohyals, sometimes ankylosed with the basihyal.

The tympanohyal in *Cynocephalus,* if it exists at all, is very small and coössifies with certain bones at the base of the skull between the periotic and tympanic elements in the neighborhood of the stylomastoid foramen.

Neither Dobson nor Flower, I believe, ever described the hyoid or the ossifications of *Cynocephalus,* and in fact up to the present time I have not met with any observations of any kind upon this part of the skeleton of the flying lemur.

The specimen at hand is from a fully adult animal and probably ossification in the parts has gone as far as it ever goes in this species, though in individuals attaining an unusual age it may be carried somewhat further.

The anterior cornu has a length of 1.5 centimeters, and the posterior cornu has a length of 6 millimeters, while the average height of the laryngeal box is 7 millimeters, and its width about the same, the former including the crinoid cartilage.

So much of the windpipe as remained with this specimen is composed of vertically narrow, closely adjusted rings. These rings are not large; they are transversely elliptical, performed in elementary bone, and while thinner posteriorly they appear to unite in bone in the medio-vertical line; the first few superior rings certainly do. All the parts usually found in the larynx among the higher vertebrates are present, but it is only in the case of the anterior thyroid alæ that firm ossification is

---

[29] Osteology of the Mammalia, 176.

observed; all the other elements remain in cartilage and these, apart from the cricoid, fuse more or less together.

The hyoidean apparatus rests directly upon the top of the larynx and it is only the limbs of the anterior cornua, including the epihyals and stylohyals, that stand out independently; these project posteriorly. Each thyrohyal is broadly paddle-shaped, the blade being in front and directly articulating on either side with basihyal. They only connect with the superior cornu of the thyroid by means of cartilaginous extensions. Parallelogramic in outline, the basihyal is nearly flat, being but very slightly concave from side to side posteriorly, and correspondingly convex in the same direction in front. The stylohyals are entirely in cartilage and rudimentary, while both the epihyals and ceratohyals are in bone, each being represented by extremely delicate little rods, making feeble articulations with each other upon either side, and with the basihyal anteriorly.

It will be of interest to mention, incidently, that *Cynocephalus* has a very large thick tongue, finely serrated on the thin edge of its semicircular, anterior margin. The roof of the mouth is peculiarly corrugated in curious, transverse, zigzag lines, and these being raised leave strong similar impressions on the superior surface of the tongue. This last may be of a post-mortem nature and may not exist during life.

NOTES ON THE OSTEOLOGICAL MATERIAL REPRESENTING THE GALEOPTERIDÆ IN THE COLLECTIONS OF THE UNITED STATES NATIONAL MUSEUM.

After the typewritten copy of this memoir had been forwarded to me by Mr. McGregor for revision and had received my careful reading, it occurred to me that the value of the memoir would be greatly enhanced if certain parts of it were read by such an eminent writer on mammalogy as Mr. Gerrit S. Miller, jr., curator of the division of mammals in the United States National Museum. Mr. Miller at the time was in Europe, and did not return to Washington until the early part of September, 1910. On the first of the following month I took the material I had described, together with the typewritten manuscript to Mr. Miller at the Museum, and after taking up some of the points in the latter, he advised me to make a thorough comparison of the skeletons and skulls of my own collection with those of the far more extensive collection of the Galeopteridæ belonging to the United States National Museum, together with a series of skulls of flying lemurs loaned him by the Bureau of Science. Mr. Miller informed me that all the species of these animals belonging to the Malayan fauna were now contained in the genus *Galeopterus,* and that the Philippine species *volans* was of the genus *Cynocephalus.*

There are a number of Malayan species and perhaps subspecies, but the skins and osteological material of the Philippine forms were as yet not sufficiently extensive in the National Museum collections to differentiate them. In addition to the above-mentioned material, Mr. Miller placed at my disposal a particularly fine and perfect mounted skeleton of an unidentified Malayan form of flying lemur belonging to the National Museum. This specimen was photographed for me by Professor T. W. Smillie, chief of the photographic division of the National Museum, and the reproduction of this photograph illustrates the present memoir as a frontispiece. It is particularly valuable as showing the skeleton in one of these animals with all the bones, even including the hyoid and trachea, normally articulated. There is listed in the following tables all of the osteological material (October 1, 1910) representing the flying lemurs in the collection of the United States National Museum, which I have compared and studied. The scientific name given is the name on the label attached to the specimen. Such information likewise applies to the locality, sex, and name of collector given. In some instances the condition of the specimen is added.

Skulls of Cynocephalus from the Philippine Islands, United States National Museum collection.

U. S. Nat. Mus. number.	Original number.	Name.	Locality.	Sex, age, etc.	Collector.
144663	6145	*Cyanocephalus volans.*	Catagun, Mindanao.	Adult ♂; broken, incomplete.	E. A. Mearns.
144662	6046	do	Basilan Island Isabela.	Adult ♂	Do.
144660	6036	do	do	do	Do.
144659	6034	do	do	do	Do.
123422		Colugo.	Pantar, Mindanao.	Not given; adult, perfect.	Not given.
144655	6027	*Cyanocephalus volans.*	Basilan Island, Isabela.	Adult ♀	E. A. Mearns.
144657	6030	do	do	Broken up; adult ♂	E. A. Mearns, 1906.
144656	6028	do	do	Adult ♀; perfect	E. A. Mearns.
144658	6033	do	do	Adult ♀	Do.
144661	6038	do	do	Juvenile ♀	Do.

Skulls of Cynocephalus from the Philippine Islands, Bureau of Science collection.

Original number.	Name.	Locality.	Sex, age, etc.	Collector.
105	Not given	P. B. S.	Adult ♂	R. C. McGregor.
111	do	Bohol	Not given	Do.
108	do	do	Adult ♀	Do.
104	do	do	Adult ♂	Do.
106	do	do	do	Do.

Two skeletons of Malayan species. United States National Museum.

U. S. Nat. Mus. number.	Name.	Locality.	Sex, etc.	Collector.
49640	*Galeopterus sp.?*	Pulo, Bintang	Adult ♀	(?)
154600	do	Mount Salak, Tandak	Juvenile, complete	O. Bryant, 1909, Java Expn.

Skulls of Malayan species, United States National Museum.

U. S. Nat. Mus. number.	Original number.	Name.	Locality.	Sex, age, etc.	Collector.
122841	2454	*Galeopithecus*	Malacca Strait, G. Karimon Island.	♀ adult	W. L. Abbott.
144373	5089	do	Rhio Arch., Pulo Jombol.	do	Do.
144372	5088	do	do	♂ adult; full of shot holes.	Do.
144377	5095	do	do	♀ adult	Do.
123035	2616	*Galeopithecus sp.?*	E. Sumatra, Pulo Bakong.	♂ subadult	Do.
123086	2700	do	E. Sumatra, Pulo Penuba.	♀ adult; broken	W. L. Abbott, 1903.
123088	2717	do	do	do	Do.
123087	2701	do	do	♀ adult; perfect	Do.
123069	2676	do	E. Sumatra, Pulo Sebang.	♂ adult	Do.
112427	1000	*Galeopithecus aoris*	S. China Sea, Pulo Aor.	do	W. L. Abbott, 1901.
104600	463	*G. gracilis*	Natuna Islands, Sirhassen.	do	Do.
104447	154	*G. pumilus*	Butang Islands, Pulo Adang.	♂ juvenile; perfect	W. L. Abbott, 1899.
121748	2235	*G. saturatus*	Batu Islands, Tana Bala.	♂ adult; perfect	W. L. Abbott, 1903.
121749	2277	do	do	♂ adult; badly shot up.	Do.
121747	2216	do	do	♂ adult; perfect	Do.
115605	1884	*G. volans*	Rhio Arch., Pulo Bintang.	♀ adult; perfect	W. L. Abbott, 1902.
143327	4704	*Cyanocephalus sp.? (Galeopterus).*	E. Sumatra, Pulo Rupat.	(?)	W. L. Abbott, 1906.
143325	4696	*Galeopterus sp.? (Cyanocephalus.)*	do	♀ adult; good	Do.
114376	1460	*Galeopithecus tuancus.*	Banjak Islands, Pulo Tuangu.	♂ adult	W. L. Abbott, 1902.
121853	2353	*Galeopithecus saturatus (Galeopterus).*	Batu Islands, Pulo Pince.	do	W. L. Abbott, 1903.
121854	2364	do	do	do	Do.
3780 3940	--------	*Galeopithecus volans.*	Singapore, Malay Peninsula.	Not given	Explor. Exped.

Skulls of Malayan species, United States National Museum—Continued.

U. S. Nat. Mus. number.	Original number.	Name.	Locality.	Sex, age, etc.	Collector.
3785 3946		*Galeopithecus volans.*	Singapore, Malay Peninsula.	Not given	Explor. Exped.
3784 3945		do	do	do	Do.
122766		*Galeopithecus sp.?*	Malay Peninsula, Pinic.	do	W. L. Abbott. Parietals dented, killed with blow.
115493	1838	*G. volans*	Rumpin R., Pahang.	♂ adult	W. L. Abbott, July, 1902.
122888	2521	*Galeopithecus*	E. Sumatra, Pulo Kundur.	♀ adult; mandible broken.	W. L. Abbott, July, 1903.
49693		*G. volans*	E. Sumatra, Pulo Kundur.	♀ adult; perfect	W. L. Abbott, 1903.
86786		do	Trong, Lower Siam.	do	W. L. Abbott, 1899.
84420		do	do	do	W. L. Abbott, Mar. 5, 1897.
84421		do	do	♀ young; somewhat broken.	W. L. Abbott, Mar. 4, 1897.
86787		do	do	Sex not given; young.	W. L. Abbott, Mar. 4, 1899.
83276		do	do	♂ subadult	W. L. Abbott, Mar. 1, 1896.
151887	5701	*Galeopithecus sp.?*	Pulo Sebuku	♂ adult	W. L. Abbott, 1897.

Skull.—Taking the series as a whole (Malayan and Philippines) and viewing the skull from above there are a number of points of difference worthy of notice, and these apart from the matters of sex and age. On this view any Philippine Islands specimen can be distinguished at once from any of the Malayan forms by the character of the naso-maxillary arch, taken transversely from alveolar process of one side to the one on the opposite side and including all the region anterior to the orbits. In the Philippine forms this is very broad and rounded; the nasals more or less lying in the same surface; while on transverse section here the line of the curve is circular. In the Malayan forms this region is narrower; as a rule, more acute, and the nasals more in evidence, and raised above the general surface for their entire lengths. In old individuals these bones in all forms (Malayan and Philippines) fuse completely with the bones they articulate with in the face.

In the Malayan forms the superior produced arches of the orbital peripheries are more elevated and, as a rule, much broader than they are in any of the Philippine forms. In all species, the orbital cavity is strikingly circular in outline, with the plane of its margin looking forward, outward, and slightly upward; its cavity, everything else being equal, being markedly greater in the Malayan species than it is in any of the specimens from the Philippine Islands, at least one-third larger on comparing skulls of equal size. (As 144655 ♀ Basilan Island and 84420 ♀ Trong, Lower Siam.) This character is constant and eminently distinguishing.

One of the most interesting characters on this superior view of the skull is the variation in the extent of the area of the temporal fossæ, and the fact as to whether or not they meet in the median line posteriorly, and to what extent, if they do meet. This character I have carefully examined in the 52 skulls at hand belonging to the National Museum and the Bureau of Science, and in the few skulls of my own collection. On any specimen the surface of one of the temporal fossæ, selecting either side, may be more or less rough. In all forms these areas are very distinctly defined, with the limiting boundary line more or less raised. Now in no Malayan form of flying lemur do the temporal fossæ at all approach each other posteriorly: the interval often being nearly one centimeter in adult skulls of either sex. This appears to be the case with the young of *Cynocephalus* (number 144661 ♀) and still more marked in the young of *Galeopterus*.

Among the Philippine forms this character varies, though in none of them do the temporal fossæ ever approach each other anywhere as closely as in any of the Malayan forms.

Referring to the numbers in the above tables for the specimens and their localities the following are found to be the intervals between these fossæ. In number 144663 it could not be determined as the skull is too much broken up. Of all the skulls from the Philippines the contact is most extensive in number 144655 where the internal margins of the fossæ come in contact for one centimeter, their common borders forming a distinct crest, which extends posteriorly to the occipital crest. In numbers 123422 and 144656, where it is about equal, it is less extensive, the medium crest is less pronounced and does not extend to the occipital crest. The contact is slightly less in number 144658. In numbers 144657 and 144659 there is an interval of one millimeter, and in number 144660 about two millimeters. The greatest interval is seen in skull number 106 where it is equal to the interval in the Steere specimen in my own collection, that is five millimeters; it is slightly less in number 108, and still less in 105 and 111, the interval still being from one to two millimeters. As a rule, then, the approach of the temporal fossæ, posteriorly, is likely to be far more extensive in Basilan specimens than in those from Bohol; in the latter they are rarely, if ever, in actual contact.

Turning to the base of the cranium we find the palatal region, or roof of the mouth, comparatively broader and much more in front in the Philippine specimens than in any of the Malayan species; the tympanic bullæ are much better developed and have thinner walls in the latter than in any of the skulls from the Philippines. Posteriorly, we find that the form of the occipital area varies to some extent, though as a rule it is lower and more rounded superiorly in skulls of *Cynocephalus* than in any of the others. In the Malayan skulls it tends to become more lofty and oblong in outline, its width averaging nearly double its height.

In *Cynocephalus* the mandible is as a rule, in specimens of the same age and sex, a considerably stronger and deeper bone than in any of the Malayan species. (Compare numbers 121749 and 168.)

Mr. Gerrit Miller has pointed out to me the fact that the milk teeth in Philippine forms (*volans*) more or less resemble the permanent teeth in any of the Malayan species. This is well seen in two skulls prepared for the purpose, namely, number 121854 ♂ (Malayan) and number 105 ♂ from Bohol. To compare all the dental characters would require too much space here. They vary in the two genera and in old age wear down considerably.

Trunk skeleton.—Passing to the trunk skeleton it is to be noted that apart from the fact that all flying lemurs possess 7 cervical vertebræ, and as a rule 13 dorsals, they may vary very decidedly in the number of the lumbar vertebræ, as the following table tends to show.

Vertebræ in Galeopteridæ.

Specimen.	Number of vertebræ.		
	Cervical.	Dorsal.	Lumbar.
McGregor specimen in personal collection	7	13	7
No. 49640, National Museum, ad. ♀	7	[a]13	6
No. 154600, National Museum, juv.	7	13	5

[a] The 13th supports a pair of free ribs.

Moreover, the characters of some of the vertebræ are different, as for instance, in the atlas. In *Galeopterus* (number 49640) this bone is nearly square in outline, and possesses a fairly well developed neural spine, situated anteriorly. There is no evidence whatever of such a spine in the atlas of *Cynocephalus,* in which genus this vertebra is very much wider transversely than it is longitudinally. The transverse processes of the lumber vertebræ in *Galeopterus* (number 49640) are strongly developed, in every case springing from the entire side of the centrum, and are directed outward and forward. They are much smaller in the Steere specimen (*Cynocephalus*), and in the specimens of this genus sent by McGregor from the Philippines they are nearly entirely absent. Some unimportant differences are seen in the sacral and caudal vertebræ of the specimens here under consideration and, everything else being equal, the ilia of the pelvis in *Cynocephalus* are longer than in the Malayan species.

Limbs.—The comparison of the bones of the limbs, although made with care, need not be entered upon to any extent in the matter of description. In the main the long bones are very much slenderer in *Galeopterus* (number 49640) than they are in the specimen of *Cynocephalus* collected by Steere, while they vary very little in their lengths. This is especially well seen in the humeri and in the femora.

In the forearm of *Galeopterus* the radius and ulna still remain distinct in the adult, though the ligamentous union is very close, and in very old animals it is just possible that coössification may take place distally between these two bones. It is fair to presume that for this character Owen, Huxley, and Flower examined old adult specimens of some Malayan flying lemur in the collection of the British Museum or at the Royal College of Surgeons and that without forcing maceration far enough to separate the bones, they came to the conclusion that osseous union had taken place between the radius and ulna distally. Mr. Gerrit Miller was kind enough to examine this character with me, and even went so far as to macerate for several days the forearms of the old *Galeopterus* and the young one in the National Museum collection, and became convinced of the above facts as here set forth.

The scapulæ and clavicles of these two genera are quite similar, and in animals of the same age the differences are scarcely noticeable.

ILLUSTRATIONS.

(From photographs by the author.)

PLATE III.

FIG. 8. Left lateral view of the pelvis of *Cynocephalus*, natural size, and from the same adult specimen which supplied the bones shown in figures 3 to 7. The leading vertebra shown in this figure is the last or eighth lumbar vertebra.

9. Antero-external aspect of the left radius and ulna of *Cynocephalus;* slightly enlarged and from the same specimen as before, figures 3 to 8. This figure shows the ligamentous attachment of the ulna to the radius. The bones are somewhat pulled apart at their proximal extremities.

10. Ventral view of the first cervical (atlas) vertebra of *Cynocephalus*, adult, natural size and from the same specimen, figures 3 to 9. This is a direct view and the extremity of the bone that articulates with the skull is faced toward the top of the plate.

11. Direct left lateral aspect of the second cervical (axis) vertebra of *Cynocephalus*. From the same specimen from which the other bones were obtained, figures 3 to 10.

12. Direct ventral view of the five caudal vertebræ of *Cynocephalus* (being the fourth to the eighth inclusive), natural size and from the same specimen, figures 3 to 11. When articulated in the skeleton the first three of these vertebræ are between the pelvic bones, the distal extremity of the third being exactly opposite the posterior ischio-iliac border.

PLATE IV.

FIG. 13. Lumbar vertebræ of *Cynocephalus*, being the third to the seventh inclusive and seen upon direct dorsal view. Slightly reduced and the same bones as those shown in figure 7 of Plate II. The seventh lumbar is toward the top of the plate.

14. Direct ventral view of the pelvis of *Cynocephalus;* slightly reduced and the same bone as shown in figure 8 of Plate III. The vertebra in front of the sacrum is the eighth lumbar.

15. Outer aspect of the left humerus of *Cynocephalus*, very slightly enlarged. At the distal end the supracondyloid foramen is partly in view. From same specimen as before, figures 3 to 14.

16. Right humerus of *Cynocephalus;* direct view of posterior surface, and the bone very slightly enlarged. From the same skeleton from which the the one in figure 15 was taken.

PLATE V.

FIG. 17. Right lateral view of the trunk skeleton of *Cynocephalus*, reduced about one-third. Skull removed. This is from one of the skeletons sent from the Bureau of Science. Some of the dried ligaments have not been removed, especially in the cervical region. Spinal column complete. The skull of this specimen is shown in figure 2 of Plate I.

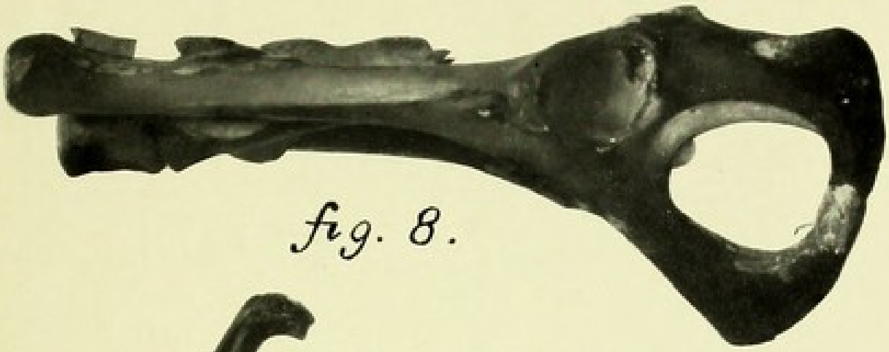

fig. 8.

fig. 9.

fig. 10.

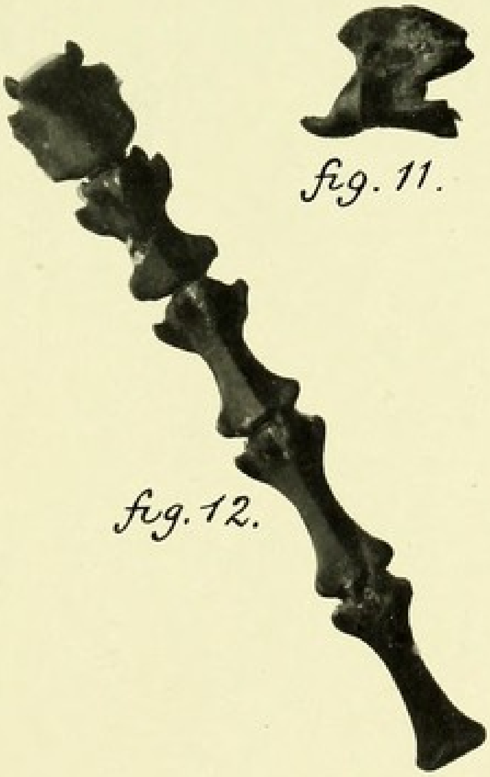

fig. 11.

fig. 12.

PLATE III.

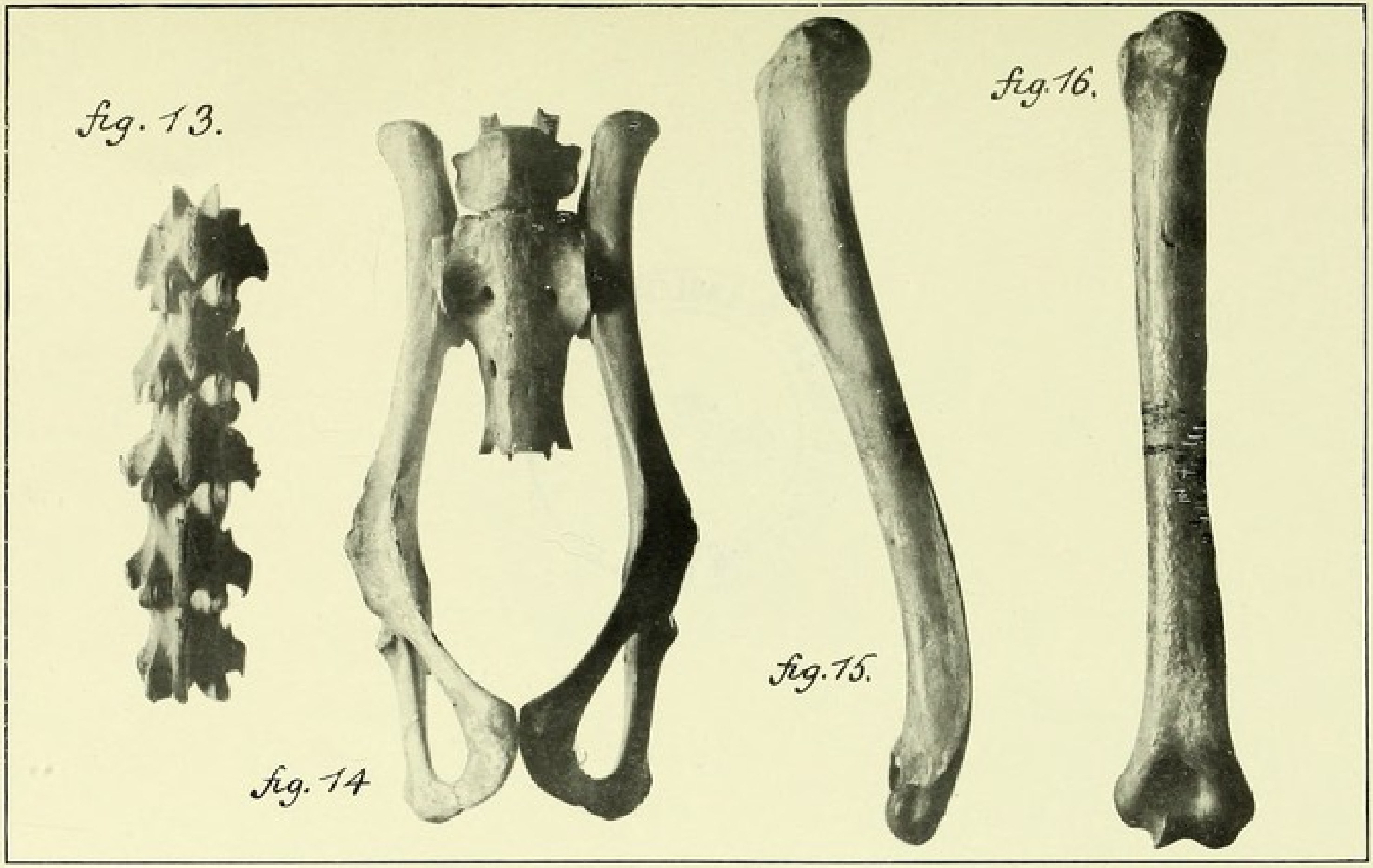

PLATE IV.

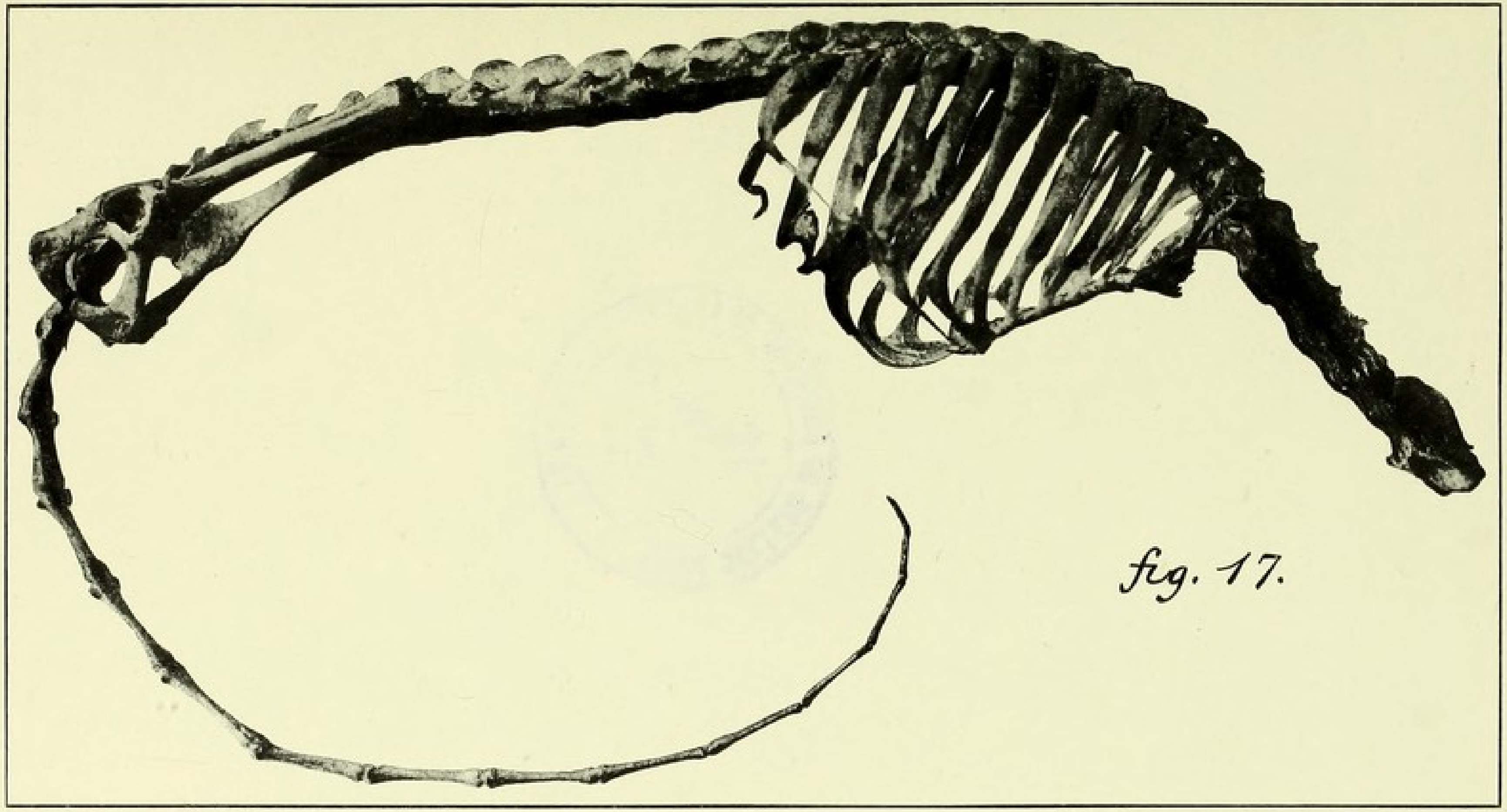

fig. 17.

PLATE V.

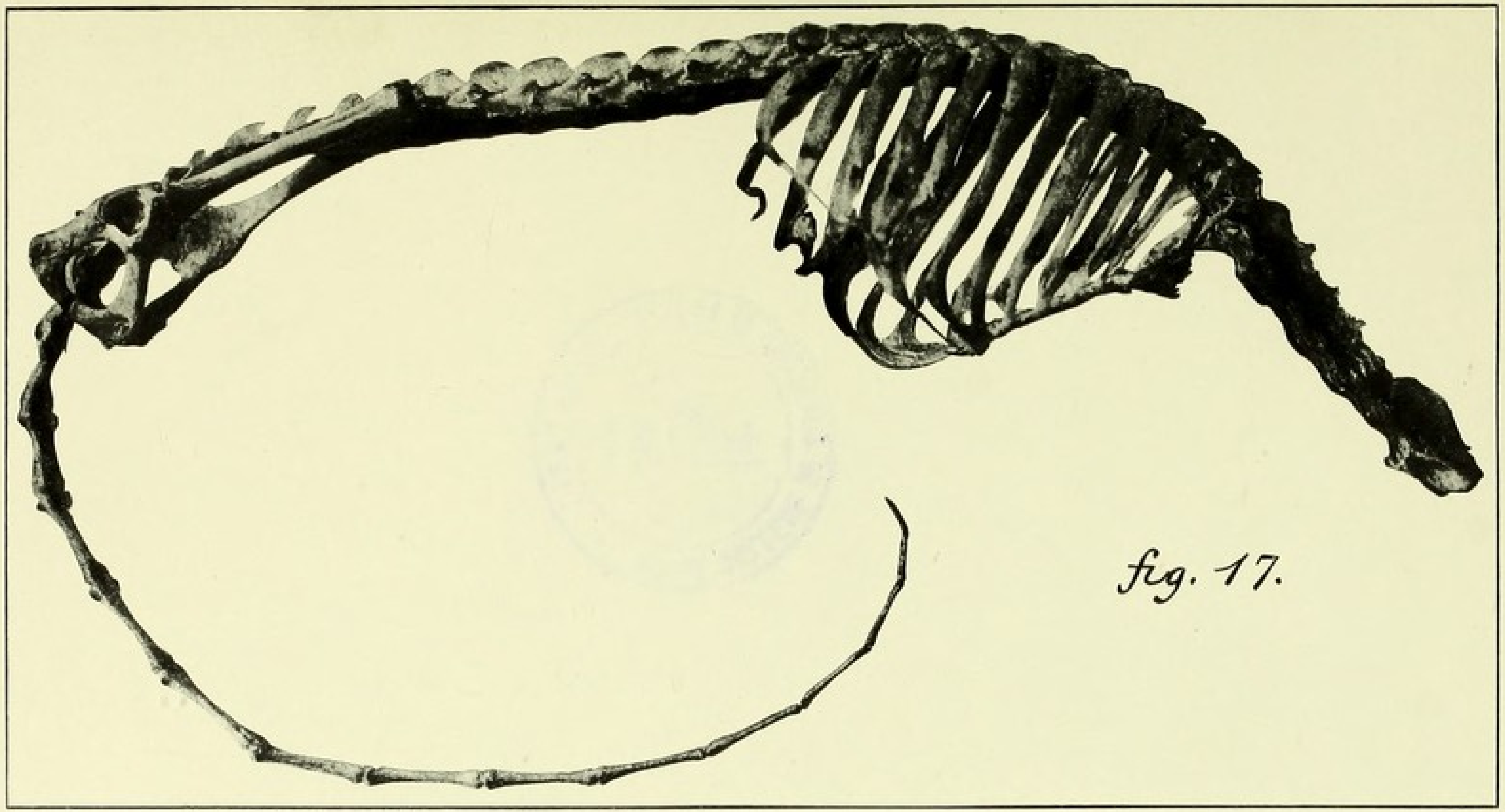

fig. 17.

PLATE V.