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ART. XXVII.—*Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. WORTMAN. With Plate V.

PART I. CARNIVORA.

INTRODUCTION.

IN pursuance of an understanding had with the late Professor Marsh shortly before his death, the writer has recently undertaken the study of the more important materials in the splendid collection of Eocene Mammalia in the Marsh Collection of the Peabody Museum, with the object of presenting a full account of the structure and relationship of those forms, as far as revealed by the remains at present known. This material was derived almost exclusively from the Bridger and Uinta Basins of Wyoming and Utah, but less extensive collections from the Eocene Basin of the San Juan of New Mexico are also included. The first collections of fossils from these localities were gathered in 1870, by the Yale Expedition into the Western Bad Lands, under the enthusiastic leadership of Professor Marsh himself. For four succeeding years, expeditions of a similar character were organized, equipped, and led into the fossil-bearing horizons of the West by this indefatigable student of paleontology, to whom the science is so deeply indebted. Later, for a number of years, Professor Marsh employed regularly trained collectors to search for fossils in the Bad Lands of these basins. The collections resulting from these sources have a richness and significance, perhaps unrivaled by any similar one in the world. The importance of the subject to the student of Mammalogy can scarcely be over-estimated, since these epochs witnessed the beginnings and branching off of many groups destined to play such a prominent part in

succeeding mammalian development. This fact was fully appreciated by Professor Marsh, and he spared neither pains nor expense in making the collections as complete as possible.

In 1871, he issued his first paper descriptive of these discoveries, in this Journal (vol. ii, August, 1871) and in succeeding years many publications in the same Journal were added. A few groups, Dinocerata, Coryphodontia, and Tillodontia, were described and illustrated *in extenso*, but by far the larger part of the collection has either not been studied or only a few specimens described in a brief preliminary way, mostly without illustration. For many years prior to his death, he had fully recognized the importance and desirability of having this subject, which the press of many matters had prevented his undertaking, finally and fully investigated for the sake of the advancement of the science. The Trustees of the Museum have, therefore, generously placed at my disposal this entire collection for study and publication, and it is to be earnestly hoped that the results obtained will prove commensurate with the importance of the undertaking. It is a source of the keenest regret to the author that the investigation could not have been made under the tutorship of the master whose ripe judgment and kindly advice would have proved so helpful and such a tower of strength in the preparation of the work. The subject will be considered group by group, omitting those that have been already fully published. The first of the series deals with the Carnivora, after which the Primates and other orders will follow. A consideration of the relationship of the horizons in which these fossils occur will be reserved for the latter part of the paper.

Part I. Carnivora.

In this group, I mean to include all those forms which are usually classified as the modern Carnivora, together with their extinct representatives commonly arranged under the ordinal group Creodonta. That all the modern Carnivores have arisen from and are directly traceable to what has been formerly known as the Creodonta is now coming to be so well established that from time to time it becomes necessary to modify our ideas of their classification and arrangement. According to the present state of evidence it seems probable that there were at least three if not more points of contact where the two groups actually unite. For this reason the distinction of one from the other becomes a more and more difficult task. I purpose, therefore, in the following treatise to consider the entire series as constituting a single homogeneous order, the origin of which dates back to Pretertiary times, along with the Edentates, Ungulates, and very probably, also, with the Insec-

tivores, Rodents, Primates, etc. There is as yet little or no evidence which throws any light upon their origin, and until the Cretaceous ancestors of the Monodelphs are more certainly known, the problem will of necessity remain obscure.

There appears to be a sort of vague belief that the Carnivora have arisen from the Insectivora, and one frequently hears the expression "Insectivore-creodont ancestors." Now, as a matter of fact, the Insectivora, as we at present know them, are not more primitive than a large majority of the Creodonts; but on the contrary, with very few exceptions, all the living Insectivores are considerably specialized, and even those that do exhibit a more or less generalized structure are far removed from the typical, ideal ancestor of the Carnivores. Nor do the few known fossil Insectivores help us much towards such a belief, for in all of them, as far as we know, the peculiar conformation of the anterior part of the skull is almost as strongly marked as it is in their living representatives. The very general enlargement of the premaxillæ and modification of the incisors, with the reduction or disappearance of the canine, constitute one of the striking osteological peculiarities by means of which they may nearly always be distinguished from any known Creodont or Carnassident.

It would appear from the present trend of the evidence that we shall be compelled eventually to return to the old idea of a direct Marsupial ancestry of all the Monodelphian orders. By this I do not mean to imply that the living Marsupials are these ancestors, for the reason that they have in all probability secondarily acquired a number of modernized features which remove them considerably from the hypothetical progenitors. Their peculiarities in the matter of the replacement of the teeth, the increased number of incisors in the carnivorous and insectivorous forms, and the inflection of the angle of the jaw, we may readily believe to have been acquired, and did not belong to their Mesozoic ancestors. In fact it has already been shown that the increased number of incisors is due to a development and partial retention of a first and second set.

Whatever may be said of the derivation of the other orders, the Mesozoic representatives of the carnivorous Marsupials are not far removed from the hypothetical forms, to which, it seems to me, the present evidence points with no doubtful signs, as the ancestors of the Carnivora. Although we know them from but a few fragments, yet the striking resemblances which these bear to the corresponding parts of the living carnivorous Marsupials, leave little doubt that their structure was very similar. If we subtract from the skeleton of some of the more typical living Marsupial Carnivores, such as the Sarcophiles, Dasyures, Thylacynes, and Opossums, those char-

acters which we may assume are specialized or secondarily acquired, we shall have left an assemblage of primitive features which must have certainly belonged to the ancestors of the Carnivores. These are especially seen in (1) the narrow more or less elongated type of skull, much constricted behind the orbits, (2) the stout, heavy zygomata, (3) the large lachrymal, spreading out upon the face, (4) the prominent sagittal crest terminating in a rather high, overhanging occiput, (5) the relatively large, downwardly projecting paroccipitals, (6) the double condyloid foramen, (7) the peculiar thickening of the posterior border of the palate, (8) the large hatchet-shaped neural spine of the axis, (9) the large size of the lumbar vertebræ as compared with the dorsals, and their tendency in some forms (Opossums) to develop the double tongue and groove articulations, (10) the large deltoid crest and characteristically broad distal end of the humerus, (11) the fusion of the scaphoid and centrale (Opossums, *Myrmecobius*, and Dasyures), (12) the subequal size of ulna and radius, (13) the large size of the lesser trochanter of the femur, (14) the large size of the fibula and its extensive articulation with the proximal surface of the astragalus instead of upon its outside, and (15) the very primitive form of the astragalus. To these may also be added, (16) the small size of the brain, (17) the dorso-lumbar vertebræ formula of 19, and (18) the posterior spreading of the nasals so as to exclude contact between frontals and maxillary in front. With respect to the forms of the teeth, they are with few exceptions primitive.

Now nearly all the foregoing characters are actually possessed in varying degrees by some members of the Creodonta, as far, at least, as we know them; and if the replacement of the dentition were complete instead of partial, and the so-called first molar of the carnivorous Marsupials, which is undoubtedly homologous with a persistent last milk molar of the diphyodont dentition, were replaced by a permanent simpler successor, as is invariably the case where its succession is accomplished, the analogy would then be complete and there would be no difficulties whatever in deriving the Creodonts from this source. In like manner the origin of the Insectivora would be traceable to a form similar to *Myrmecobius*. That the inflection of the angle of the jaw and the partial repression of the second set of teeth were secondarily acquired, is rendered probable from the recent discovery of Matthew* in which it would appear likely that both these characters have been acquired by the Mesonychidæ, among the Creodonts. Just what the Cretaceous Marsupials, when more fully known, will show with respect to these characters cannot now be predicted;

* Bull. Amer. Mus. Nat. Hist., January, 1901.

but we do know that such a type as *Didelphops* Marsh, in its dentition and palate, resembles the living carnivorous Marsupials, and it is to some such type in particular that I would refer the origin of the Creodonta.

The classification herein adopted with respect to the major divisions of the Carnivora is essentially that of Flower and Lyddeker in their work upon the Mammalia, with the exception that I have substituted for their name "Carnivora Vera" the subordinal term Carnassidentia. We shall then have the three suborders,—Creodonta, Carnassidentia, and Pinnipedia, but the difficulties of determining the limits and framing exact and satisfactory definitions for these groups, especially the two former, are just as great when considered as suborders as they are considered as orders. Two main features of their organization have hitherto been used to separate the Creodonts from the higher Carnivora or Carnassidentia, viz: the union of certain elements of the carpus and the modification of particular teeth into a sectorial or carnassial dentition. The relative importance of these two sets of characters in constructing the primary divisions of our classification is of course a matter upon which different opinions are held. Speaking for myself, I am convinced that the tooth characters are of greater moment in making these primary divisions than the union or non-union of certain carpal elements, for the reason that the ununited carpals are undoubtedly expressive of a generalized condition, which applied to all phyletic lines of this series in the early stages of their existence, and cannot, therefore, give the faintest hint of the breaking up into subordinate series. It is, moreover, largely dependent upon time, since later than a given epoch these carpals are united and earlier than this they are free, in any group belonging to the order.

If, on the other hand, we base our primary divisions upon the modifications of the teeth, we have from almost the earliest deposits in which we have knowledge of the remains of this group, many of the various phyla more or less distinctly outlined. Thus, as early as the Torrejon, we find representatives of the Viverravidæ, which not only have the teeth constructed upon the same identical pattern as that of certain living Carnassidentia, but the number is exactly the same. In the succeeding Wasatch, representatives of the modern Canids and Felids appeared, while the various lines of the Creodonta may be said to have been fully established by this time.

The one distinguishing feature of the dentition of the Carnassidentia is found in the fact that the fourth superior premolar and the first inferior molar have been exclusively developed into carnassial teeth. Some of the living representatives, such as the Bears and Raccoons, have largely lost the

more typical structure of these teeth, but the evidence is very strong in favor of their derivation from ancestors in which the carnassials were well developed.* In the Creodonta, on the other hand, if carnassial teeth are developed they are not confined to the fourth superior premolar and the first inferior molar, but usually consist of a varying number of molars in each series. In some of the older types there are no carnassials developed, the molars being intermediate in structure; while in others they are of a pronounced tubercular form. The three suborders would then be divided and defined as follows:

Suborder Creodonta.

Carnassial teeth present or absent; when present, not consisting exclusively of fourth superior premolar and first inferior molar. Scaphoid, lunar, and centrale of the carpus very generally free. Ungual phalanges broad, depressed and fissured, or laterally compressed and pointed. The following families are included: Oxyclænidæ, Arctocyonidæ, Mesonychidæ, Oxyænidæ, and Hyænodontidæ.

Suborder Carnassidentia.

Carnassial teeth present and always consisting of the fourth superior premolar and first inferior molar. Scaphoid, lunar, and centrale of the carpus, very generally united. Ungual phalanges compressed and pointed.

The following families are included: Viverravidæ Viverridæ, Hyænidæ, Protelidæ, Palæonictidæ, Felidæ, Canidæ, Procyonidæ, Ursidæ, and Mustelidæ.

Suborder Pinnipedia.

Limbs modified for progression in the water; no carnassials; scaphoid, lunar, and centrale united. Ungual phalanges greatly modified by enormous development of subungual processes.

Families: Otariidæ, Trichechidæ, Phocidæ.

Suborder Carnassidentia.

Family Canidæ.

The study of the Eocene Canidæ is attended with no little difficulty, owing in large measure to the insufficient and fragmentary materials upon which the types of the respective genera have been based. While fortunately these are not

* Matthew has (loc. cit., p. 17) quite recently discussed the relationship of the Arctocyonidæ, a family of the Creodonta from the Torrejon and Wasatch of this country and Europe, to the modern Bears. Arguing from the structure of the feet and teeth, he believes that they make certain distinctive approaches towards the Ursidæ and may have been ancestral to them. Had he taken the trouble to compare the feet of *Clænodon* with a living Opossum or a Dasyure, he would have found such a striking similarity of structure in every detail, with the possible exception of the astragalus, that he would have concluded that the Arctocyonidæ are much nearer to the Marsupials in these characters than to the Bears.

numerous, yet with such imperfect specimens it is not an easy matter to correctly determine their limits and relationships nor to refer other more complete material to them with certainty and exactness. Any attempt must, therefore, be regarded as tentative to a large extent, at least until such time as the acquisition of more complete specimens will throw additional light upon the structure and organization of the types.

The genera which have been proposed for these dogs are three in number, viz: *Vulpavus*, proposed by Marsh in 1871 upon a first superior molar tooth; *Uintacyon*, proposed by Leidy in 1872 upon an anomalous lower jaw, with the teeth considerably damaged, and *Miacis*, proposed by Cope in 1872 upon a fragment of a lower jaw bearing the penultimate molar. It will be seen, therefore, that in no case is there association of upper and lower teeth in one specimen, so that in the absence of any additional specimens which display characters exactly like the types, the reference of other more or less fragmentary material to them must, at best, be attended with an element of uncertainty.

In the matter of the synonymy of these generic names I have elsewhere expressed the opinion* that the type specimen of Cope's *Miacis* belongs to the same genus as that previously described by Marsh under the name of *Vulpavus;* but in the absence of superior molars in the former, this cannot be demonstrated with absolute certainty. After the study of a much wider range of specimens than were at my disposal when this conclusion was reached, I can see no reason to question the correctness of this view.

Fortunately the relationship of the type species of *Uintacyon* can now be determined with a reasonable degree of certainty and satisfaction. In the present collection a specimen in which there are upper and lower molars associated, shows that it is quite distinct from *Vulpavus*. While the number of superior molars cannot now be stated, they may nevertheless be assumed to be three; this assumption is based upon (1) the relative size of the second molar, the presence of which is indicated by its alveolus, and (2) upon its striking resemblance to the three-molared Oligocene *Daphœnus* series, of which there can be little doubt that it was the forerunner. The main distinction between *Vulpavus* and *Uintacyon* has hitherto been supposed to rest upon the number of superior molars. *Vulpavus* was thought to have but two and *Uintacyon* three, but it now transpires that some of the species of *Vulpavus* have a third molar, and it is no doubt true of all of them; in fact it seems highly improbable that there are any species of Canids in the Bridger which had less than three superior molars. The dis-

* Bull. Amer. Mus. Nat. History, June 21, 1899, p. 110.

tinctions between the two genera are seen in the following characters: in *Vulpavus* the jaw is relatively slender, the heel of the inferior sectorial is comparatively small and basin-shaped, the second and third lower molars have sharp cusps, the main internal cusp of the first superior molar is large, lunate, and connected with the outer cusps by an anterior and posterior ridge upon which intermediates are developed, and there is a postero-internal cusp. In *Uintacyon*, on the other hand, the jaw is thicker and more robust, the heel of the inferior sectorial is small and cutting, the cusps of the succeeding molars are low and obtuse, the main internal cusp of the first superior molar is more conic and connected with the external cusps by a ridge in front only, and there is no posterior internal cusp.

A third group having the jaw characters of *Uintacyon*, as far as known, is represented by a few scattering fragments. In this group the premolars are much reduced in size and the canine is laterally flattened. Members of this latter group are found in the Wind River and Wasatch deposits, which carries them well back towards the base of the Eocene. That they represent a distinct and independent phylum there can be little doubt, and one, moreover, that is known to have left descendants in the succeeding Uinta beds.

If, upon further investigation, it should be found that the scaphoid, lunar, and centrale of the carpus are separate, which is not altogether improbable, the question will then arise as to whether they should be properly classed in the Canidæ or Viverravidæ or whether they should be placed in a distinct family by themselves. According to the previous and perhaps more common acceptation of the limits of the Creodonta they would without doubt be placed in this suborder, but I believe with Schlösser that they stand much nearer to the Carnassidentia and, as I will presently attempt to show, were the immediate progenitors of the two and probably three main branches of the canine phylum. If we range them with *Viverravus* in the Viverravidæ we shall fail to express by such a classification the distinctive and important positions which these two genera hold with respect to the canine and viverrine branches of the Carnassidentia. There now appears to be little doubt that when the evidence is more complete than it is at present, it will be found that the Canidæ and Viverravidæ were derived from a common ancestor. That the separation of these two genera took place, however, previous to the deposition of the Torrejon beds is evidenced by the fact that a species of *Viverravus*, with all the distinctive dental characteristics of this genus, is found therein, and we must therefore look to an earlier date for the

actual convergence of the two groups. If the Viverravidæ were the forerunners of the civets, which appears from present evidence to be exceedingly probable, then the dogs and civets have had a common origin, as has been so frequently insisted upon by Scott.

Vulpavus Marsh.

Vulpes, a fox; and *avus*, a grandfather. Amer, Jour. Sci., 3d ser., vol. xi, p. 124, Aug., 1871. *Miacis* Cope (in part). Paleont., Bull., No. 3, Aug. 7, 1872, p. 2; Proc. Amer. Philos. Soc., p. 470, 1872; Tertiary Vertebrata, 1884, p. 301. *Vulpavus* Wortman and Matthew, Bull. Amer. Mus. Nat. Hist., June, 1899, p. 118.

A group of small dogs limited in their vertical distribution, so far as at present known, to the Bridger Horizon. They are characterized by having the dental formula I. $\frac{3}{3}$, C. $\frac{1}{1}$, Pm. $\frac{4}{4}$, M. $\frac{3}{3}$, with the relative proportions of the lower molars nearly the same as in the modern genus *Canis*. The antero-external angle of the first superior, and to a less degree that of the second superior molar, is drawn out, and produced into more or less of a cutting blade. The external cusps are unequal in size, the anterior being the larger. The hind foot is pentadactyle, the astragalus little grooved, and the femur has a third trochanter. The humerus has a powerful deltoid crest and supinator ridge, and there is a large entepicondylar foramen. The articulations of the lumbar vertebræ are not complex as in some Creodonts but plane as in most Carnivores. The claws are compressed, sharp pointed, and unfissured. The carpus is unknown.

Vulpavus palustris Marsh.

Professor Marsh, in describing the remains upon which this genus and species were primarily established, included a portion of a right superior maxillary, carrying the fourth premolar and the roots of the three succeeding molars. Since this specimen agrees so perfectly in every respect with a species of the genus *Sinopa* Leidy, and differs in such important characters from the accompanying molar, it may be confidently excluded from any further consideration in this connection. The type, figure 1, consists of a first superior molar tooth of the right side, with the antero-external angle missing; otherwise the crown of the tooth is in a perfect state of preservation. The specimen indicates an animal considerably smaller than the common Red Fox with which Professor Marsh compared it in his original description. The composition of the tooth crown, and the arrangement of the component cusps and ridges indubitably stamp it as belonging to a mem-

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FIGURE 1.— *Vulpavus palustris* Marsh; first superior molar; crown view; natural size. (Type.)

ber of the Canidæ, and the name *Vulpavus* was most happily chosen, since it is not only the forerunner of the foxes in name but is so in fact.

Like most of the Canidæ the crown is composed of two principal external cusps, a large lunate internal ridge enclosing a central depression or valley, together with a more internal and posterior ledge-like elevation arising from the cingulum. The external portion of the crown is very different from the corresponding part of this tooth in any of the Miocene, Pliocene, or modern species of dogs, but resembles that of the great majority of the older and contemporary Creodonts. This consists in its external expansion, and the formation of a relatively broad shelf-like area between the external margin of the crown and the two external cusps. Associated with this is the drawing out of the external angles, both anterior and posterior in this species, and the disposition to form cutting blades of these parts of the crown. While the antero-external part of the tooth is broken away in the type specimen, there can be little doubt, from its great similarity in structure to the nearly related species described below, that this angle was present and prominent.

Of the two external cusps, the anterior is by far the larger and more prominent, and as this character appears to be constant in all the species thus far known, it may be taken as of generic significance. The crescentic ridge thickens considerably at its internal angle into a low, stout, more or less trihedral cusp which forms its most prominent part. External to this the ridge is interrupted by two, less prominent, anterior and posterior intermediate cusps situated about midway of the tooth crown on the respective borders which they occupy. The postero-internal cingular cusp is unusually broad and thick for such an early species of the Canidæ, in fact almost equaling in this respect some of the modern species. The summit of this cusp is closely connected with the cingulum which is developed around the entire crown.

The locality of this specimen, which is the only one in the collection, is Grizzly Buttes. This locates it near the base of the horizon; it was found by Professor Marsh.

The following measurements are given:

	mm.
Transverse diameter of posterior part of crown	8
Antero-posterior diameter in middle of crown	4·5

Vulpavus Hargeri sp. nov. (Plate V.)

Two specimens of this species, which include a considerable part of the skeleton, are contained in the collection. From these a fairly accurate knowledge of a large part of the

osteology may be obtained. In one, which is here selected as the type, figures 2 and 3, the larger portion of the anterior moiety of the skull, together with a few fragments of other bones of the skeleton, are preserved, while in the other, parts of the skull, vertebræ, one hind limb complete, parts of fore limb, ribs, etc., are present in more or less perfect condition. There is one other specimen in which there are upper and lower teeth in association, and in this specimen the alveolus for the third superior molar is clearly shown.

Skull and Dentition.—The facial portion of the skull is sufficiently preserved to admit of description; this together with some fragments of the base of the skull and the larger part of the cranial vault serve to give a reasonably accurate idea of the skull. As compared with the Red Fox, the muzzle is shorter and less slender, resembling in this respect the Miocene *Cynodictis gregarius*, with which it agrees fairly well in size. The orbit is relatively larger than in this latter species, holding about the same proportions as that seen in the fox. Its anterior edge lies over the anterior half of the sectorial as in *Cynodictis*, while in the fox the orbit is more posterior. The infra-orbital foramen is larger and occupies its usual position on the side of the face; its posterior edge is a little more posterior than in *Cynodictis*, coinciding with the anterior border of the superior sectorial as in the fox. The skull is much constricted behind the orbits as in *Cynodictis*, in marked contrast with the relatively broad area of this region in the fox. There is a distinct postorbital process present, although it is small as in *Cynodictis*. The lachrymal has the same relative size and proportions in the three genera and is not spread out on the face; there is a small lachrymal tubercle present, which is less conspicuous in *Cynodictis* and absent in the fox. The two converging branches from the postorbital process unite just in front of the postorbital constriction to form a sagittal crest of moderate proportions just as in the case of the Miocene *Cynodictis*. In a large majority if not all the foxes, as is well known, these branches do not unite until near the lambdoidal crest, leaving a large lyrate area in this region of the skull. The development of this lyrate area is no doubt due to a progressive widening of the anterior part of the brain. In all modern species the postorbital constriction is very much less than in either the Miocene or Eocene forms. The zygomatic arches are well developed and display a somewhat greater degree of stoutness than that of *Cynodictis* and the fox.

A portion of a left squamosal exhibiting the glenoid fossa is sufficiently preserved to indicate the existence of an unusually broad postglenoid process; this is divided by a deep notch

into an external and an internal portion of which the external is the larger. The office of this notch, which appears to be a part of a foramen, is not altogether clear, but it is a matter of much interest to note that a similar arrangement is seen in the skull of the carnivorous Marsupials. Placed internal to and close to the edge of the fossa is seen the opening of the foramen ovale, much closer in fact than in any species of dog with which I am acquainted. This condition would seem to indicate a narrow brain case, which would be in keeping with the position of the species in the time scale. The position of the foramen is posterior to the fossa as in the Marsupials, and not anterior or opposite to it as in *Cynodictis* and the modern dogs. Posterior to the glenoid is seen the opening of a rather large postglenoid foramen.

The lower jaw, figure 2, is relatively a little stouter than that of *Cynodictis* and considerably more so than that of the fox; its inferior contour is like that of the typical dogs, being deepest in the region of the inferior sectorial, tapering thence forwards, and more or less curved posteriorly. The symphysis is short, extending to beneath the anterior border of the premolar as in *Cynodictis*. In the fox the symphysis is larger and more extended, reaching backward to beneath the anterior border of the third premolar. The angle is broken away in all the specimens of this species in the collection, but the base indicates that it was present and of apparently the same proportions as in *Cynodictis*. There is an appearance of a slight degree of inflection having been present. The masseteric fossa is relatively large and deep, occupying quite one-third the entire length of the jaw; it has about the same proportions as in *Cynodictis* but is considerably smaller in the fox. The coronoid is much damaged, but there is evidence of its goodly proportions, both as regards breadth and height. The condyle is somewhat heavier and of greater transverse extent than in either the Miocene or recent genera.

With the exception of the last superior molar and the superior incisors, the dentition can be fully described. The canines are of moderate size, more or less oval in cross-section at the base, and well pointed. Of the inferior premolars the first is small, single-rooted, with a somewhat conical crown, and separated from the canine and second premolar by short diastemata. The second has a flattened pointed crown, is implanted by two roots, and separated from the tooth in advance by a diastema. The third and fourth are larger two-rooted teeth with laterally compressed conical crowns having distinct anterior and posterior basal cusps. The third has in addition to these a faintly marked accessory cusp developed upon the posterior border of the crown.

The first molar, or sectorial, bears the unmistakable stamp of an early or primitive condition of this tooth in the Carnassidentia. This is particularly noticeable in the great elevation of the trigon above the heel, in the large size of the internal cusp and the arrangement of the cusps of the trigon in the form of an isosceles triangle, in the obliquity of the principal shear to the axis of the jaw, and the development of a posterior shear. In the sectorial of *Cynodictis* or of a modern dog, the trigon is less elevated, the principal shear is more in

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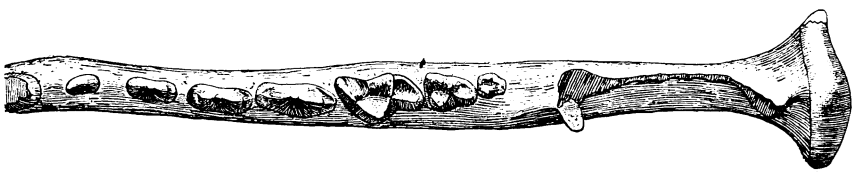

FIGURE 2.—Left lower jaw *Vulpavus Hargeri* Wortman; crown view; one and one-half natural size. (Type.)

line with the jaw axis, the internal cusp of the trigon is reduced, and the posterior shear has practically disappeared. Of the trigon the external or principal cusp is unusually high and prominent; it has a distinctly trihedral form, with the anterior cutting edge but little produced, in marked contrast with that of *Cynodictis* or the fox, in which the whole cusp is laterally flattened and the anterior edge drawn out into a cutting blade. The anterior cusp is prominent and relatively thick; its posterior edge is extended and forms the more important blade of the principal shear. The internal cusp is large and with the principal outer cusp forms a posterior, transverse shear of considerable efficiency, which bites against the anterior edge of the first superior molar. The heel or talon is proportionally small; it is made up of an inner basin-shaped and an outer vertically beveled part, divided from each other by an antero-posterior median ridge, which is terminated behind by a rounded cusp and continued forwards to the base of the trigon. The inner boundary of the basin is furnished by a ridge of moderate proportions which curves around posteriorly to join the median cusp, inclosing between it and the median ridge a concavity. The antero-posterior ridge joins the base of the trigon immediately posterior to and beneath the notch which separates the blades of the posterior or transverse shear. The extent to which this outer beveled portion of the heel is developed varies much in the different species of Canidæ; it has to do apparently with the pushing inwards of the principal external cusps of the first superior molar, for when they have

an internal position the beveled portion is large as in the present species, and when they have an external position the beveled portion is reduced and its position is taken by the basin-shaped part. Taking the present species as one extreme and the modern dogs as the other, the genus *Cynodictis* stands about midway between the two in this respect.

The second molar is a diminished copy of the sectorial with the exception that the trigon is much less in height, and there are less distinctive shears developed among the elements of the trigon. The cusps as well as the heel have approximately the same relations to each other. In *Cynodictis* and the modern dogs this tooth, as well as the succeeding one, has lost all traces of the sectorial structure. The third molar is still more reduced, being relatively as small as in the modern species; the crown, however, still retains traces of the tuberculo-sectorial pattern, although but faintly.

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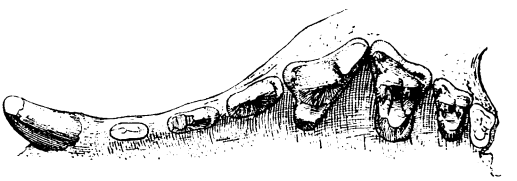


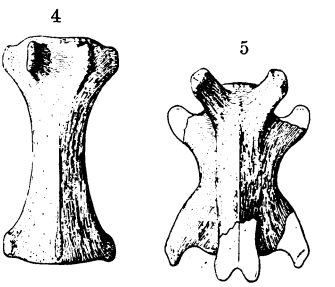
FIGURE 3.—Left upper jaw of *Vulpavus Hargeri* Wortman; crown view; one and one-half natural size. (Type.)

Of the superior dentition, figure 3, the canines are of moderate size and pointed, resembling those of the Miocene *Cynodictis*. The first premolar is a small single-rooted tooth placed close to the base of the canine; a short diastema intervenes between it and the second. The second and third are, as is usual among the Canidæ, two rooted, with laterally flattened, pointed crowns; the third has a posterior basal and accessory cusp like the corresponding tooth in *Cynodictis*. The superior sectorial displays the usual form seen in the Canidæ, although in some respects it is primitive. The two external cusps are large and modified into very efficient shearing blades. At the base of the large antero-external cusp is seen a small tubercle which recalls the structure of the superior sectorial among the carnivorous viverrines. In this latter group, however, it is larger and more distinct, while among the cats and hyænas it has been developed into a powerful third blade. The genus *Ælurodon*, a dog-like mammal from the Loup Fork Miocene of America, likewise exhibits this cusp but in a less degree of development. The internal cusp is unusually large and has an anterior position, displaying about the same proportions as are

observable in *Herpestes* or *Viverriculus*. It is much larger than in the corresponding tooth of either *Cynodictis* or the fox.

The molars display the same generalized characters as those of the type species *V. palustris* already described, and, notwithstanding some minor specific differences, they are undoubtedly indicative of the same genus. The anterior border of the crown of the first molar is relatively much elongated in a transverse direction. The two external cusps, of which the anterior is the larger, are placed well inwards, and a considerable ledge-like area which is broadest in front intervenes between them and the external border. The postero-external angle is more or less rounded, and is not produced into a sharp crest as in the type species *V. palustris*. The large internal cusp is not as lunate in character as in the type species but is more pointed and distinctly separated from the rather large anterior intermediate, the posterior intermediate being small. The postero-internal cusp, which is so highly characteristic of nearly all species of the Canidæ, may be said to be practically absent; a rather strong development of the cingulum marks its position, however, but even this is somewhat variable in the several specimens in which it is shown. The almost total absence of this cusp is in marked contrast with its strong development in the type species. The crown of the second molar is almost an exact copy of that of the first; it is, however, smaller and all the cusps are less distinct. The third molar is not preserved, but its presence is indicated by the alveoli in the two specimens in which it is shown. It was small and vestigial in character.

Vertebræ.—There are comparatively few of the cervical or dorso-lumbar series of vertebræ preserved, so that it is impossible to give an account of either their number or characters. Some fragments of the lumbars, in which the zygapophyses are fairly perfect, indicate that their centra were large as in the early Carnivora and that their articulations were not complex as in many Creodonts. Some well-preserved caudals, figures 4 and 5, show that the tail was large and presumably of good length.



FIGURES 4, 5.—Caudal vertebræ of *Vulpavus Hargeri*: natural size. (Cotype.)

Scapula and Fore Limb.—The head of the scapula presents the same pyriform, cup-shaped glenoid cavity as that seen in

the fox, but the coracoid is larger and more elongate as in *Cynodictis*. The neck is short, the spine rises abruptly, close to the glenoid border, and terminates in an overhanging acromion and metacromion. There is not enough of the bone preserved to indicate the relations of the fossæ with certainty, but they were apparently like those of *Cynodictis* as described by Scott.*

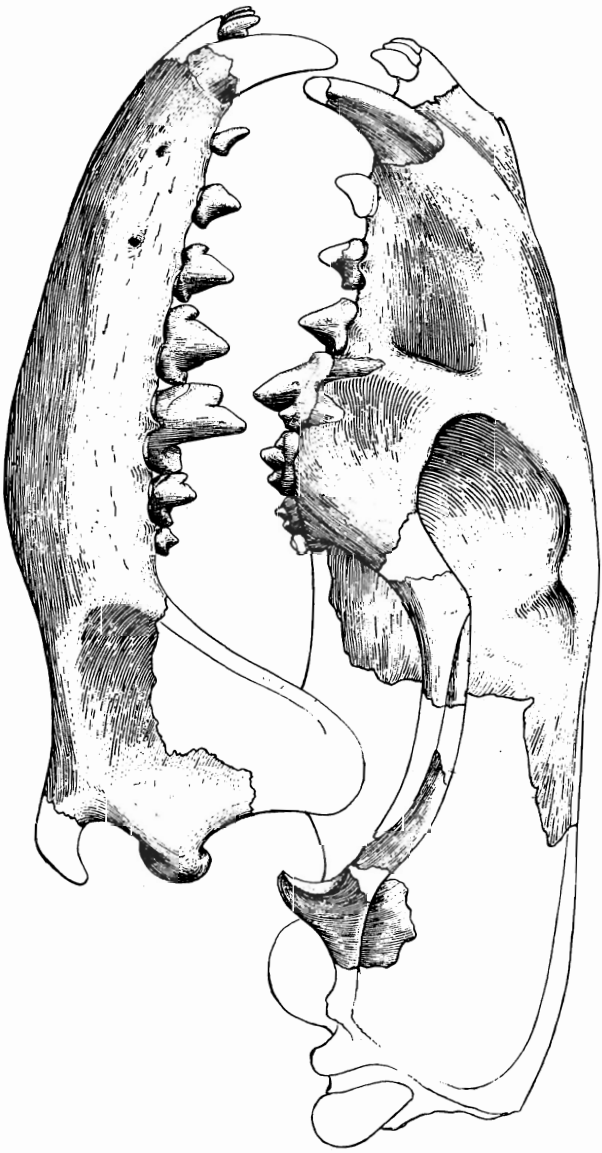
FIGURE 6. — Left radius of *V. Hargeri* Wortman; natural size.

The humerus, figure 9, is broken in the region of its proximal third and does not give the character of the head of the bone. The most conspicuous feature of the shaft is the development on its anterior surface of the very large and prominent deltoid crest, which extends more than half way to the distal end. Associated with this are seen the unusually prominent supinator ridge and internal condyle, all of which serve to give to the bone a combination of characters hitherto completely unknown among the Canidæ. The entepicondylar foramen is present but there is no anconeal perforation. The anconeal and anticubital fossæ are distinct and the articular surface is of unusual transverse extent, as it is in the cats and viverrines, and very different from the modern dogs.

The radius, figure 6, resembles that of the civets much more than of the modern dogs. The shaft is slightly curved and moderately flattened. The head is cup-shaped and subcircular in outline, indicating power of complete pronation and supination; the tubercle for the insertion of the biceps is strong and that for the principal pronator of the fore arm is unusually well developed. The distal end is broken so as to destroy a considerable part of the articular surface for the carpus. Judging from what is preserved of this surface, however, there was apparently no division into separate scaphoid and lunar facets. This would seem to indicate a consolidated scapho-lunar, but this evidence is not altogether reliable.

* Trans. Philos. Soc. Phila., vol. ix, p. 381, 1898.

[To be continued.]



EXPLANATION OF PLATE V.

Skull of *Vulpavus Hargeri* Wortman ; side view ; one and one-half natural size (Type).