

Article IX.— A LOWER MIOCENE FAUNA FROM SOUTH DAKOTA.

BY W. D. MATTHEW.

One of the principal desiderata of students of fossil mammals in this country has been the discovery of a fauna which should connect up the latest of the White River with the earliest of the so-called Loup Fork faunæ of the Western Plains. A considerable gap in time separated the two, and the intervening sediments are as a rule very barren, and have yielded but a scanty fauna. This gap is in part filled, in the opinion of most authorities, by the John Day formation of Oregon. But the John Day fauna is much more nearly allied to the White River than to the earliest Loup Fork faunæ, and the geographical separation and different conditions of deposition of this formation from those of the Plains made it uncertain how far its faunal differences from the upper White River might be explained as varying facies of a contemporary fauna rather than indications of later age.

The first intermediate fauna found east of the Rockies was obtained from the beds underlying the Deep River beds (lower Loup Fork) in Montana, and described by Scott in 1893. Prof. Scott regarded it as equivalent to the upper John Day (*Promerycochærus* beds). The exposures however were limited and the fauna a scanty one. In 1901 and subsequent years Hatcher and Peterson conducted a vigorous and successful search on behalf of the Carnegie Museum in the formations overlying the White River in Sioux Co., Nebraska, and in 1905 the great Agate Spring fossil quarry was discovered and worked with extraordinary success. Mr. Hatcher published some geological observations upon these beds in 1902, but his untimely death prevented his sharing in the appreciation of their age and important position in the faunal series, which could only be understood after preparation and study of the specimens was more advanced. The prosecution of this work is now in the able hands of Mr. Peterson, who has already published two important memoirs and several minor papers dealing with this new and interesting fauna.

In 1902 and 1903 the American Museum parties collecting in the Loup Fork of South Dakota, south of White River, made a brief reconnaissance of the beds lying between the Loup Fork and White River formations, and found a few fossils sufficient to indicate their age as Lower Miocene, and the local term of Rosebud beds was proposed by Matthew and Gidley

for this intermediate formation. In 1906, when the work in this region was resumed, Prof. Osborn authorized a thorough search of these rather barren and unpromising beds, in view of the probable importance and interest of whatever fossils might be found in them. The results of the first season's work have fully justified Osborn's decision, the fauna being almost entirely new, and supplying two intermediate stages of evolution between the Oligocene and later Miocene. Although probably nearly equivalent in age to the Agate Springs fauna it presents a very different facies, as far as comparisons have been made. Only a small part of the collection has yet been studied and compared in the museum; for the remainder the determinations are those made by the writer in the field, and are merely approximate and in no case specific. The results already attained, however, seem of sufficient interest to warrant their publication, especially desirable in connection with Prof. Osborn's forthcoming correlation of the mammal faunæ of the American Tertiary and Quaternary.

The western part of the formation attains a thickness estimated at 500 feet on Porcupine Creek, a southern tributary of White River. The base is taken at a heavy white stratum which appears to be identical with the stratum capping the White River formation on Sheep Mountain in the Big Badlands. This stratum can be seen extending interruptedly across the river to Sheep Mountain about twenty miles distant, capping several intervening buttes and projecting points of the underlying formation. The Rosebud beds at the bottom approximate the rather hard clays of the upper *Leptauchenia* beds, but become progressively softer and sandier towards the top, and are capped at Porcupine Butte¹ by a layer of hard quartzitic sandstone. Several white flinty calcareous layers occur in the beds, one of which, about half-way up, was used to divide them into Upper and Lower. The stratification is very variable and inconstant, lenses and beds of soft fine grained sandstone and harder and softer clayey layers alternating with frequent channels filled by sandstones and mud-conglomerates, all very irregular and of limited extent. The hard calcareous layers are more constant. A bed of volcanic ash lies near the top of the formation and there may be a considerable percentage of volcanic material in some of the layers further down. These volcanic ash beds should in theory be of pretty wide extent, and may be of considerable use in the correlation of the scattered exposures on the heads of different creeks — a very difficult matter without their aid.

These beds form the upper part of the series of bluffs south of the White

¹ An isolated butte at the "Bird" head of Porcupine Creek, which is a well known landmark in this neighborhood. It appears to be misplaced or wrongly identified in Darton's usually accurate map.

River on the Pine Ridge and Rosebud Reservations and are exposed in the upper part of the various tributary creeks. The name Arickaree¹ has been applied by Darton to these and various more or less similar formations overlying the White River in the Central Great Plains. In northeastern Colorado the Arickaree beds are known from their fauna to be middle or late Miocene; in the bluffs south of White River in South Dakota they are Lower Miocene — possibly in part Oligocene; for the most part their age is unknown. Hence the term Arickaree, if Darton's connotation of it be accepted, must be used in a broad way — somewhat as Loup Fork has been used by most writers — to signify deposits of similar lithologic character and stratigraphic position, but of quite different age in different parts of the Plains. Terms of more local application and more exact meaning are necessary for palæontologic work, and their wider correlation on faunal grounds will progress hand in hand with determination of their exact position in the general geological scale. By the time we can be sure, for instance, that the Rosebud beds are contemporaneous with the Fort Logan beds of Montana, we will also be sure of their precise position in the Miocene or Oligocene. Continental deposits of fluvial origin are of necessity scattered, discontinuous, and of varying age in different sections, and by their very nature do not admit of the widespread correlations of marine deposits in which uniform conditions and continuous deposits may prevail over wide areas. The exact equivalence of two deposits in separated areas is, when it occurs, a mere coincidence, and for satisfactory comparison of faunas the attempt to extend minor subdivision names over wide areas leads merely to confusion.

Lower Rosebud Fauna.

The following species have thus far been identified from the Lower Rosebud beds:

CARNIVORA.

Nothocyon gregorii sp. nov.

“ *vulpinus* sp. nov.

Mesocyon robustus sp. nov.

Enhydrocyon crassidens sp. nov.

Nimravus sectator sp. nov.

RODENTIA.

Entoptychus formosus sp. nov.

“ *?curtus* sp. nov.

¹ Dr. Hay has called my attention to the fact that the term Arickaree has been previously applied by Cragin to a subdivision of the Cretaceous and should not therefore be used for a Tertiary formation.

Steneofiber ? *pansus* Cope.
 “ *simplicidens* sp. nov.
 “ *sciuroides* sp. nov.
 “ *brachyiceps* sp. nov.
Euhapsis gaulodon sp. nov.
Meniscomys sp.
Lepus sp.

PERISSODACTYLA.

Parahippus sp.
Anchitherium sp.
Diceratherium sp. div.

ARTIODACTYLA.

Elotherium sp.
Eporeodon sp. div.
 ?*Mesoreodon* sp.
Promerycochærus sp. div.
Leptauchenia sp.
Hypertragulus ordinatus sp. nov.

Upper Rosebud Fauna.

The fauna of the Upper Rosebud is almost entirely distinct, few species passing through.

CARNIVORA.

Cynodesmus thomsoni sp. nov.
 “ *minor* sp. nov.
Megalictis ferox gen. et sp. nov.
Oligobunis lepidus sp. nov.

INSECTIVORA.

Arctoryctes terrenus gen. et sp. nov.¹

RODENTIA.

Heteromyid gen. indet.
Entoptychus curtus sp. nov.
 “ ?*formosus* sp. nov.
Lepus macrocephalus sp. nov.
 “ *primigenius* sp. nov.

PERISSODACTYLA.

Parahippus
 “
Diceratherium

¹ Chrysochlorid, gen. indet., Matthew, Science, N. S., Vol. XXIV, p. 786, Dec. 14, 1906.

ARTIODACTYLA.

Desmathyus pinensis gen. et sp. nov.

Merychys sp. nov.

Merycochoerus sp.

?*Miolabis* sp.

Blastomeryx advena sp. nov.

COMPARISON WITH AMERICAN OLIGOCENE AND MIOCENE FAUNAE.

The Rosebud fauna is very clearly related to the John Day. The great majority of the species in the lower Rosebud and many of those of the upper beds can be referred to John Day genera but show, whenever adequate comparison can be made, a very considerable advance upon the species of the John Day. The rest of the species show a sufficient advance upon John Day or White River species for generic distinction, but the entire fauna is an outgrowth of the Oligocene (White River and John Day) faunæ and contains no new (immigrant) elements, with the single exception of *Blastomeryx*. Comparison with the Middle and Upper Miocene faunæ is more difficult on account of our imperfect knowledge of so many of the species. For the most part they appear to be a further outgrowth of the Rosebud fauna, but contain several new elements which cannot be derived from this source. The most prominent of these are the Proboscidea, the Pecora (modernized ruminants), the Protohippinæ¹ (horses with long-crowned cemented teeth and reduced lateral metapodials but retaining a vestigial pollex), and probably certain phyla among the Carnivora (*Lutrinæ*, etc.). Aside from these foreign elements of the later Miocene, the Rosebud fauna presents two stages in the evolution of the Miocene fauna, fairly intermediate between the John Day and the Deep River-Pawnee Creek. A considerable number of the genera of the Upper Rosebud are found in the Deep River or Pawnee Creek beds; the remainder are sufficiently more primitive for generic separation or represent phyla that have not survived. If the John Day represents the Upper Oligocene of Europe and the Deep River-Pawnee Creek the Middle Miocene, the Rosebud represents an earlier and a later phase of the Lower Miocene. Stratigraphically it appears to be continuous with the White River formation, and I do not think there is any considerable break between them. But the fauna is much closer to that of the John Day than to the highest known White River fauna (Protoceras beds). There is, however, a considerable thickness of barren clays (Upper Leptauchenia beds) overlying the fossiliferous Pro-

¹ Gidley, unpublished.

toceras beds, and it is probable that these barren clays, in which hardly anything but *Leptauchenia* has been found, represent the John Day or Upper Oligocene stage. The difference in thickness is rather startling, the John Day being 1800 feet thick while the Upper *Leptauchenia* beds are about 100 feet. But the John Day is a volcanic ash and tuff formation, probably of comparatively rapid deposition, while the deposition of the Oligocene and Miocene series on the Central Plains was in most places comparatively slow, measured by the faunal change from one level to another, and this is especially true where it is composed exclusively of very fine clays.

The discovery of these intermediate stages will enable us to clear up the relations of most of the Oligocene and Upper Miocene genera and to trace the descent of the various phyla and subphyla much more exactly than has hitherto been possible. The more elaborate studies and extensive collections of the past few years in the American Tertiaries have shown that the simple phyletic series, based upon more fragmentary and imperfect data than are now available, are true only in a general and approximate way. Recent phylogenetic study has tended quite as much to negative as to positive results — to break up accepted phyla as much as to reinforce them by more complete knowledge of the morphology of the genera. It is peculiarly satisfactory therefore to find a fauna which is intermediate between two stages hitherto disconnected, and enables us to perceive the exact relationships between genera which could until now be connected only in a general or provisional way. The preliminary results here presented are very incomplete, and various additions and modifications may be needed when the collections are more completely prepared and studied. But some relations are already tolerably clear.

Among the Carnivora, the Rosebud species referred to *Nothocyon*, *Mesocyon* and *Cynodesmus* bridge the gap between these genera, those from the lower beds being somewhat nearer the earlier forms, while the upper beds species are closer to the more advanced type of *Cynodesmus*. Their dentition is very like that of modern Canidæ, in brain and foot structure they are very different, and much nearer to the Oligocene Canidæ. The aberrant Oligocene Canid *Enhydrocyon*, and *Oligobunis*, which is more probably a Musteline, survived into the Lower Miocene.

With *Oligobunis* is found in the Upper Rosebud a larger and more advanced genus of Mustelines which bridges the gap between the primitive Mustelidæ of the Oligocene and the modernized forms of the later Miocene and more recent formations. The *Dinictis* phylum of Machærodonts appears in the Rosebud beds, with the dental formula reduced to that of *Hoplophoneus* and *Machærodus* but retaining the characteristic proportions of jaw and teeth of *Dinictis*. It may be provisionally referred to *Nimravus*,

but is a larger and more advanced species than any known from the John Day beds.

The discovery of a Chrysochlorid mole is a very interesting one. I have elsewhere¹ pointed out its importance in palæogeography.

The Rodents are well represented in this fauna, by a series of skulls and parts of skeletons. The John Day genus *Entoptychus* continues through the formation with species approaching *Thomomys* in some respects, but in others somewhat nearer the Heteromyidæ. The Oligocene genus *Steneofiber* branches out into a number of divergent species, which are almost generically distinct. From one of these the Upper Miocene (*Eucastor*) *Dipoides* may be descended; the others probably are not continued. The European *Steneofiber* is, according to Schlosser, directly ancestral to the modern beaver, through the Upper Miocene *Chalicomys*. But the structure of skull and skeleton is scarcely known in *Chalicomys*, and Schlosser's argument is as usual founded principally upon the structure of the teeth. His statement, however positively expressed, can only be accepted provisionally, since, as Peterson has shown, the Steneofibers of this country at least, were animals of rather specialized fossorial habits, and the trend of their evolution in America is certainly not in the direction of the modern beavers. It is quite possible, however, that from the Oligocene Steneofibers have descended *Castor* in Europe, *Dipoides* and *Mylagaulus* in America, the last through some form related to *Euhapsis*.

The Hares are represented in the Rosebud fauna by species which cannot be separated from the modern genus *Lepus*, although the tooth pattern is more primitive in many minute details. The feet are as modern as the teeth, and present no distinctions of generic importance although in many minutiae they retain vestiges of a more primitive construction.

The Equidæ are represented in this fauna only by species of the Mesohippinæ (with short-crowned uncemented teeth, lateral toes typically reaching the ground, but no vestige left of the pollex). The genus *Parahippus* occurs in the upper beds, and in the lower beds are *Mesohippus* and a transitional form between the two. These forms do not appear to be directly ancestral to *Merychippus* and the other Protohippinæ, in which the vestigial pollex is retained, although it is lost even in the Middle Eocene *Orohippus*. The Protohippinæ are probably an immigrant group, appearing first in the Middle Miocene. The Mesohippinæ continue along with them through the Middle and Upper Miocene in the genera *Parahippus*, *Hypohippus*, and *Archæohippus*, to which the Rosebud species afford an excellent transitional series from *Mesohippus* and *Miohippus* of the Oligocene.

¹ 'Science,' loc. cit.

The *Parahippus* of the upper Rosebud has the lateral digits more reduced than in *Neohipparion*, and we may yet find species of this genus completely monodactyl, paralleling the direct line of descent of the modern horse, and more advanced in foot structure while more primitive in teeth.

Rhinoceroses are not common in the Rosebud beds on Porcupine Creek, only two skulls having been found. They have been provisionally referred to *Diceratherium*, with which they appeared in the field to agree. If this reference is confirmed, and no intermediate forms turn up later, we may conclude, as Osborn has already suggested, that the *Aphelops-Teleoceras* group of Rhinoceroses were of Old World origin and not derived from the rhinoceroses of the American Oligocene.

The Tapirs are indicated only by a single lower molar, which adds nothing to our knowledge of their development.

The Oligocene genus *Elotherium* persists into the Lower Rosebud. In the Upper Rosebud the true peccaries are represented by an intermediate stage between the Oligocene *Perchaerus* (*Thinohyus*) and the more specialized genera of the later Tertiary.

The camels are represented by two or more species, apparently of the genus *Miolabis*, as seen in the field, and not far from *M. transmontanus* of the Mascall beds in Oregon. They have short-crowned teeth, upper incisors unreduced, and separate metapodials, and differ chiefly in size from the John Day camels. In the Middle Miocene of the Plains the camels have long-crowned teeth; some have separate, others united metapodials, and the upper incisors 1 and 2 are generally present though often reduced in size. In the Upper Miocene the teeth are long-crowned, the upper incisors absent, the metapodials united.

Oreodonts are very abundant in the Rosebud. *Promerycochærus* is very common in the lower beds, and there are various smaller Oreodonts with short-crowned teeth probably referable to *Mesoreodon* and *Eporeodon*. *Leptauchenia* is found only in the lower levels of the Lower Rosebud beds. In the Upper Rosebud *Promerycochærus* is replaced by *Merycochærus* and the smaller Oreodonts by *Merychyus*, a primitive species allied to *M. arena-rum* Cope.

The smaller ruminants are represented in the Lower Rosebud by *Hypertragulus*, an advanced species as compared with the John Day or White River types; and odd teeth and jaw fragments indicate other small ruminants of this family. In the Upper Rosebud the Hypertragulidæ have disappeared and their place is taken by *Blastomeryx*, the most primitive of the Merycodontinæ. This is a true Pecoran and the earliest from this country. It has the characteristic form of the cannon bones of fore and hind foot, the distal metapodial keels extending over the superior surface of

the articulation, and various other distinctive features to which no approximation is made in any of the older American ruminants. It must be regarded therefore as a forerunner of the several immigrant types of the Middle Miocene already referred to.

COMPARISON WITH THE LOWER MIOCENE OF NORTHWESTERN NEBRASKA.

The collections made for the Carnegie Museum by Hatcher and Peterson at the headwaters of the Niobrara River are chiefly or entirely of Lower Miocene age, as Peterson's recent studies have shown. The exact correlation of the several faunal levels with those of the Rosebud is not yet advisable. It is quite probable that many species will be found common to both regions, but as far as published results and comparison of prepared material have shown, the faunæ have less in common than one would expect, and perhaps represent somewhat different facies. The present indications are that they cover about the same geological time.

COMPARISONS WITH EUROPEAN FAUNÆ.

The three principal faunæ with which the Rosebud can be compared are:

¹ St. Gerand-le-Puy,	Upper Oligocene
² Orleanais	Lower Miocene
³ Sansan	Middle Miocene

These are the faunæ taken by Osborn as typical of these three Tertiary stages.

Close comparisons can be made in but few instances with any of the European faunæ, and for the most part we must depend upon the greater or less degree of approach to modern types for correlation. Where any close comparisons can be made, it usually means that a phylum developed in one region has extended its range to others, and we expect to find it more advanced in its original home than in its later range, and least advanced in the regions most remote from its place of origin.

1. ST. GERAND.—Comparison with the St. Gerand fauna gives the following data:

The European Lagomyidæ correspond to the American Leporidæ, but *Titanomys* of St. Gerand is much more primitive than *Lepus* of the Upper Rosebud, corresponding in its stage of molar development to the earliest *Palæolagus* (*P. brachyodon*, *temnodon*) of the Lower White River.

Steneofiber viciacensis of St. Gerand is less specialized than the *Steneofiber* of the Lower Rosebud, corresponding more nearly with the John Day species in its stage of development.

Potamotherium, *Proailurus*, and *Amphicyon lemanensis* are comparatively modernized; *Plesictis*, *Amphictis*, "*Herpestes*" *lemanensis*, and *Palæogale mustelina*, are primitive survivals, related to the Phosphorite fauna, and equivalent in development to the White River and John Day carnivora, much more archaic than anything in the Rosebud. *Cephalogale* appears to be quite nearly related in dentition to *Cynodesmus thomsoni* (infra), judging from Filhol's figures of *C. brevirostris*.

Cænotherium in the St. Gerand fauna takes the place of the American Hypertragulidæ, which are characteristic of the White River and John Day, although one or more species survived into the Lower Rosebud. *Hyotherium* compares with *Perchærus* of the White River and *Thinohyus* of the John Day, but is decidedly more primitive than the Rosebud species referred to *Thinohyus*. *Dremotherium* of St. Gerand is a primitive stage of the Pecora which first appear in this country in the much more advanced *Blastomeryx* of the Upper Rosebud. An exact comparison, however, of *Dremotherium* and *Amphitragalus* with *Blastomeryx* is not practicable, the phylogeny of the Pecora being far from clear.¹

From the above data it would appear that the St. Gerand fauna is on the whole decidedly more ancient than either of the Rosebud faunæ and more nearly equivalent to the John Day.

2. ORLEANAIS.—The data for comparison with this formation are not very satisfactory. The carnivora and rodentia are of no especial value for the purpose, except *Chalicomys*, which may be compared with the specialized Steneofibers of the Rosebud as an equivalent but divergent outgrowth from the primitive Steneofibers of the Oligocene, and *Myolagus*, which is nearly as modernized as the Rosebud *Lepus*. Proboscidea first appear in the Orleansais beds while in America they first appear in the Deep River; as this group has been shown to be of African origin its earlier appearance in the European than American Miocene would be expected. On the other hand the Equidæ are more advanced in the Rosebud, *Parahippus* being a step beyond *Anchitherium*; and as this group appears to be of American origin, we should expect to find it more advanced in American formations than in their European equivalents. *Listriodon*, and *Sus palæochærus* might be regarded as more modernized than the Rosebud peccary, *Hyotherium chæroides* hardly as much. *Teleoceras aurelianensis* compares with *Aphelops* of the Deep River (Pawnee Creek) formation and is probably a more advanced type than the Rosebud rhinoceroses.

¹ I am unable to accept Schlosser's view that the Pecora are in part (Sivatheriinae Cephalophinae, Gazellinae) derived from the American Hypertragulidæ (including *Protoceras*) in part (Giraffinae, Cervidæ, and the remaining Bovidæ) of European ancestry. Their characteristic and unique foot structure is not approached by any of the American Eocene or Oligocene ruminants but appears suddenly, and fully developed, in the Miocene of this country. It is very probable that the group is rather of Asiatic than European origin and its outlying members only are represented in the late Eocene and Oligocene of Europe so that the direct phylogeny is still unknown. But the group of Pecora appears to be a natural one and of Palæarctic origin.

Altogether the Orleanais fauna may be regarded as a near equivalent of the Rosebud, more advanced in groups of Old World origin, more primitive in groups of New World origin, but lacking in closely related types.

3. SANSAN.— This fauna appears distinctly more modernized than the Rosebud, and compares fairly well with the Deep River and Pawnee Creek fauna. *Amphicyon* and the *Chalicotheres* attain much larger size, the rhinoceroses are larger and more advanced, *Palæomeryx* and allied genera appear, and all the more primitive ruminants have disappeared. In all these respects it is decidedly later than the Rosebud. The horses remain primitive and there is little opportunity for comparison in the rodents and most of the carnivora.

The above comparisons indicate that the Rosebud faunæ are later than the Upper Oligocene, and earlier than the Middle Miocene of the European standard. Their position is thereby fixed as Lower Miocene, the Lower and Upper Rosebud representing an earlier and a later stage.

DESCRIPTIONS OF NEW SPECIES.

The only parts of the collection at present accessible for study are the Carnivora, Rodentia, Equidæ, and a few of the smaller Artiodactyla. The Equidæ, although fragmentary, afford some interesting data on the phylogeny of the family which will be presented by Professor Osborn in another contribution.

CARNIVORA.

Canidæ and Mustelidæ are well represented, but Felidæ appear to be rare, as only a single lower jaw was found by our party. Procyonidæ should also be included in this fauna, as the skeleton of *Phlaocyon* from the Martin Cañon beds in Colorado is from a horizon approximately equivalent. I have elsewhere shown the relationship of *Phlaocyon* to the modern *Procyon*, to which it appears to be approximately although not exactly ancestral, and it will appear in the course of the following descriptions that the nearest comparisons among modern Canidæ with those of the Oligocene and Miocene of this country, are to be found among the Neotropical and Oriental species. It is not clear whether this is the case among the Mustelidæ — the new genus *Megalictis*, described below, and probably also *Elurocyon* Peterson, compare best with the Oriental and African genus *Mellivora*; but for the most part the modern Mustelidæ are a Holarctic group with few southern representatives and those closely allied to the typical forms, while the Oligocene and Miocene representatives of the family in America are mostly imperfectly known, primitive in dentition,

and their exact relationship to any surviving types has not been determined. The relationship to modern Neotropical and Oriental faunæ is equally apparent in other groups of the Middle Tertiary faunæ of the Western States, as the Tapirs, Peccaries, and Camels, and perhaps among the Deer. It is not true of the Rodentia, which seem to have either adapted themselves to changing environment without migration, or to have become extinct.

CANIDÆ.

The resemblance of the various species of upper Oligocene and Lower Miocene Canidæ to one or another of the species now inhabiting South America is a very significant fact. The nearest comparisons among modern dogs in details of structure of the teeth, as well as in proportions and structure of the skull are always to be found in South American or Oriental species rather than among the wolves, jackals, and true foxes which constitute the typical group of Canidæ. None of the John Day or Rosebud species are quite typical in dentition — all are more or less aberrant, and their peculiarities are paralleled by one or another of the various aberrant Canidæ of the Neotropical and Oriental regions. The dentition of *Nothocyon lemur* and *latidens* can best be compared with that of *Canis parvidens* or *urostictus*, of *N. gregorii*, *geismarianus* and *vulpinus* with *C. azara*, *magellanicus*, etc., of *Cynodesmus thomsoni* and *minor* with *C. cancrivorus*, etc., of the *Enhydrocyon-Temnocyon* group with *Icticyon* and *Cyon*. There are several aberrant types of modern Canidæ in the African continent (*Otocyon*, *Lycaon*, *Canis zerda*) but there is no suggestion among our Tertiary Canidæ of any especial relationship to these.

All the modern Canidæ are separated from the Middle Tertiary genera by the much larger brain and more specialized feet, and these features are about equally developed in the typical and aberrant groups. The amount of difference in these respects between the Oligocene or Lower Miocene genera and any recent dogs much exceeds the differences *inter se* among the two groups. But they are obviously characters of specialization and may be supposed to have proceeded at an equivalent rate in races already distinct in the Middle Tertiary. The Upper Miocene and Pliocene Canidæ which should exhibit intermediate stages, are very imperfectly known, and it seems premature to attempt any detailed phyletic connections, except in the very aberrant genera. *Cyon* and probably *Icticyon* are pretty clearly derivable from the John Day *Temnocyon*, the characters of skull and skeleton confirming those of the teeth. The more typical South American Canidæ cannot so safely be connected in detail, but in general may be said to be the nearest living representatives of the Middle Tertiary *Nothocyon*.

and *Cynodesmus*. *Mesocyon* is slightly off the line in the direction of *Temnocyon* although much nearer to the typical group.

The accepted classification of the extinct Canidæ divides them into three subfamilies, Caninæ, Simocyoninæ, and Amphicyoninæ. The genera grouped under Simocyoninæ by von Zittel in his classic textbook do not, however, form a natural group. As Dr. J. C. Merriam has recently observed in his very discriminating and suggestive remarks upon the carnivora of the John Day "The continuance of their definite arrangement in one subfamily will serve only to cover up certain weak places in our phylogenies and ultimately to impede the progress of knowledge." In this opinion I entirely agree, and believe that the genera *Cephalogale*, *Simocyon*, *Oligobunis*, *Enhydrocyon*, and *Hyænocyon* are in no respect a natural group. *Oligobunis*, as is shown later in this paper, is probably a Musteline, and has no resemblance in either form or proportions of the teeth to the remaining genera. *Enhydrocyon* and *Hyænocyon* are closely related, probably not separable generically, and with Merriam's new genus *Philotrox* appear to be more nearly allied to *Temnocyon* and through this genus to *Cyon*, than to the typical Canidæ. *Cephalogale* appears to belong rather to the typical Canidæ, with basin talonids, well developed metaconids, conules present on the upper molars, etc. The only atypical characters, judging from Filhol's figures, appear to be the short robust skull, large subquadrate molars and crowded and slightly reduced premolars, characters seen in a less degree in *Cynodesmus*, especially *C. thomsoni* (infra). Dr. Schlosser regards the genus as ancestral to the Ursidæ, but even if this view were accepted, the genus is so close to the typical Oligocene Canidæ that it should be associated with them.¹

The character of the molar heels appears to be a very constant feature among the Canidæ, and may be of prime value in the arrangement of the fossil genera if it proves to accord with the more important but less generally available characters of the basicranial region and of the feet. In nearly all the modern Canidæ the heel of the carnassial is composed of two equal cusps (hypoconid and entoconid) with a more or less clearly defined basin between. The trigonid of the second molar is also bicuspid and the heel basin-shaped. These features are shown in *Cynodesmus*, *Nothocyon*, *Ælurodon*, *Cynodon*, *Cynodictis*, *Cephalogale*, and various other extinct genera. In *Cyon* and *Icticyon*, *Lycaon*, *Temnocyon*, *Ischyrocyon*, *Enhydrocyon*, *Simocyon*, and less completely in *Daphænus*, *Amphicyon*, *Dino-*

¹ It appears to the writer to be obviously improper to separate two closely allied genera or species because they are destined to give rise in the future to two distinct families, in the opinion of the investigator. So far as nomenclature and classification are based upon the facts of structural resemblance or difference, they are permanent, but the attempt to make families, genera, or species correspond with hypothetical phyla is not simply misleading but destructive of any approach to uniformity or permanency of arrangement.

cyon, and *Mesocyon*, the carnassial heel and the trigonid and heel of m_2 are each composed of a single trenchant ridge, the hypoconids being crested and submedian, the entoconids vestigial or absent, and the metaconid reduced or absent upon m_2 , and upon m_1 as well in the first five genera. The upper molars show corresponding differences. In the first group the conules and inner shelf are well developed giving a comparatively flat tuberculate crushing surface. In the second group the conules and inner shelf are mostly reduced or absent, giving a deeply concave crushing surface corresponding to the convexity in the lower molars.

Whatever the value of these characters of the molars may prove to be they do not give an adequate basis for subfamily division of the Canidæ, nor does it appear to the writer that there are any such well marked distinctions among them at any epoch of their evolution as to warrant subfamily division. On the contrary they appear to be a rather homogeneous group, and the diversity among them is by no means comparable to that which exists among the Mustelidæ. It is possible to disentangle and trace out several different phyla more or less accurately, but to give these phyla a subfamily distinction would be misleading.

Nothocyon *Matthew.*

The more typical Canidæ of the John Day fall into two closely allied genera, *Mesocyon* (= *Hypotemnodon*, or "*Temnocyon*" *coryphæus* and *josephi*) and *Nothocyon* ("*Galecynus*" *geismarianus*, *lemur* and *latidens*). The former genus includes larger forms with the sectorial dentition better developed and tubercular dentition smaller; the latter, smaller species with reduced sectorial and larger tubercular dentition, large eyes and large bullæ. In both genera the shear of the carnassials is largely transverse, although somewhat less so than in the White River Canidæ.

The next stage in the evolution of typical Canidæ is shown in *Cynodesmus* of the Fort Logan beds of Montana, in which the dentition approximates that of the microdont forms of modern Canidæ, while the brain and, as we are now able to add, the feet, retain more nearly the primitive structure of the Oligocene dogs. The carnassial shear has become nearly anteroposterior and the subordinate transverse shear has disappeared.

The typical Canidæ of the Rosebud beds are intermediate between the John Day genera and *Cynodesmus*, but those of the Lower Rosebud are nearer to *Nothocyon* and *Mesocyon*, and those of the upper beds to *Cynodesmus*, and are referred accordingly.

Nothocyon gregorii sp. nov.

The type (No. 12879) is a skull with parts of the jaws and fragments of limb bones from the lower beds, found by Mr. W. K. Gregory of the Museum Expedition of 1906. It is a little smaller than the skull figured by Cope (Tert. Vert., pl. LXX, fig. 2) as *Galecynus geismarianus*; the orbits are proportionately larger and closer together, the postorbital processes stronger, there is hardly any sagittal crest, the postorbital constriction is

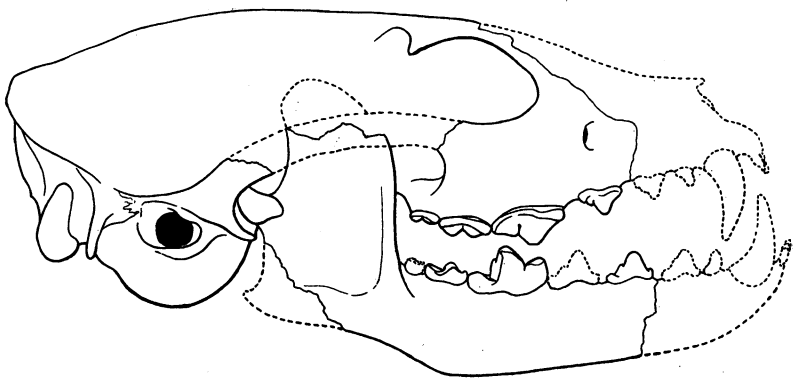


Fig. 1. *Nothocyon gregorii*. Skull, natural size. Type specimen.

narrower, the bullæ are larger and closer together, the paroccipital process more closely united with them and its tip directed downward instead of partly backward as in the John Day species. The premolars are smaller, the upper carnassial has a more longitudinal shear and its antero-external angle is less rounded. The lower teeth show corresponding differences so far as they are preserved.

Nothocyon vulpinus sp. nov.

Type, a lower jaw with parts of upper jaw, fore and hind limb bones and other fragments, No. 12883, from the Lower Rosebud beds. The species is a little larger than *N. gregorii*, the jaw longer and more slender, premolars larger, considerably spaced. The dental formula is $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{3}{3}$. Third lower molar two-rooted. The carnassial is larger and more elongate than in *N. geismarianus*, the premolars spaced, the molars more compressed. The limb bones compare closely in size and proportions with *N. geismarianus* but show a somewhat greater degree of modernization throughout. The humerus is long and slender, supinator and deltoid ridges low, entepicondylar foramen present. The ulna, including the olecranon, is as long as the humerus. The radial shaft is stouter than the ulnar shaft

towards the distal end, but they have about the same stoutness in the proximal half. The head of the radius is round-oval, and its distal end has lost

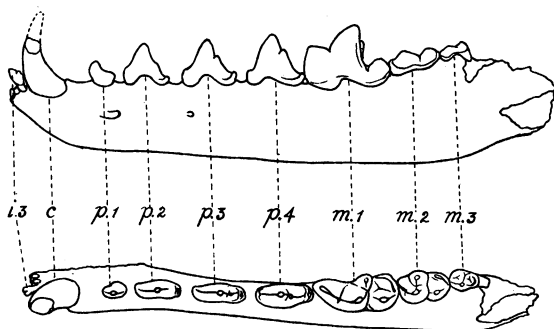


Fig. 2. *Nothocyon vulpinus*, lower jaw, external and superior views, natural size. Type specimen.

the triangular outline characteristic of early carnivora. The fibular shaft is still moderately strong. The astragalus has a rather deep, narrow trochlea and no astragalar foramen.

	Measurements.	mm.
Length of lower dentition	60.
" " premolar "	27.5
" " true molars	22.4
Diameters of m_1 , anteroposterior	11.8
" " " transverse	4.8
Diameter of m_2 , anteroposterior 6.9; transverse	4.
Humerus, length	98.3
" diameter of head	22.8
" " " distal end	21.7
Ulna, length	100.
" diameter of olecranon	12.5
Radius, length	82.
" diameter of head	9.3
" diameter of distal end (transverse)	15.
Fibula, diameter of shaft	3.
Tibia " " "	8.
Astragalus, length	18.2
" width of trochlea	6.8
Calcaneum, length	28.5

Nothocyon, sp. div. innom.

A lower jaw, and parts of the upper and lower jaws of a second individual and probably other fragmentary specimens indicate a third species about as large as *N. gregorii* but with longer jaw, larger sectorials and

smaller tubercular teeth. A fourth species, approaching *N. latidens* in size and characters, is indicated by part of a lower jaw with the carnassial preserved. It seems undesirable to name these species until more complete specimens are obtained.

Mesocyon robustus sp. nov.

Type No. 12884, lower jaws with complete dentition, from the Lower Rosebud. A less complete jaw is referred to the species.

The species is about the size of *M. josephi* Cope from the John Day, smaller than *M. coryphaeus*. The premolar region is robust and deep,

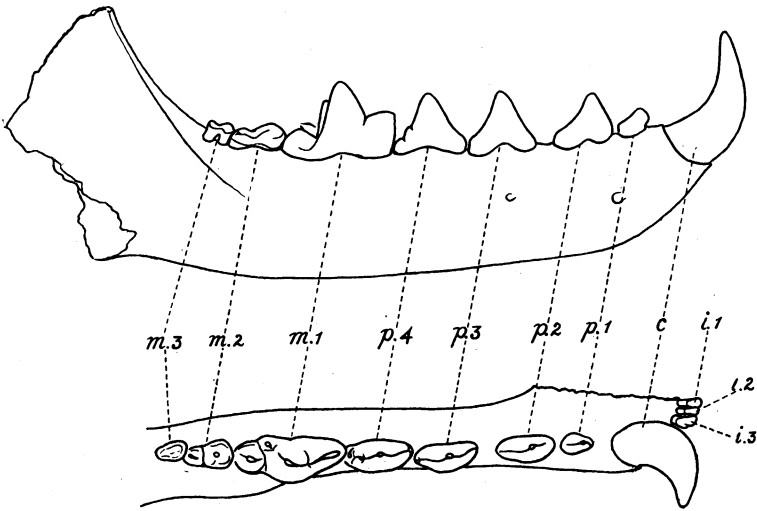


Fig. 3. *Mesocyon robustus*, lower jaw, external and superior views, natural size. Type specimen.

the premolars of moderate size and spaced. The heel of the sectorial tooth is trenchant with slight entoconid ridge; the tubercular teeth are also partly trenchant instead of fully tubercular as in *M. coryphaeus*. The third molar is present on one side of the jaw, but absent on the other, indicating that this tooth is variable. The canines are much more robust than in *Nothocyon*.

	Measurements.	mm.
Length of lower dentition	. . . . .	72.7
“ “ premolar “	. . . . .	33.5
“ “ true molars 1-3	. . . . .	24.2
Diameters of m ₁ , anteroposterior	14.9; transverse	6.2
“ “ m ₂ “	6.2; “	4.4
Depth of jaw beneath m ₁	. . . . .	6.

Cynodesmus Scott.

From Prof. Scott's figures and description, the type species of this genus is somewhat more modernized in dentition than the species here referred to it. They agree with it, however, in having the jaw somewhat reduced in length and the rather small premolars closely set, while in *Nothocyon* and *Mesocyon* they are spaced and the jaw is slender and of less depth. The larger and more predaceous dogs at this stage of evolution are represented by the so-called "*Canis*" *brachypus* Cope of the Laramie Peak beds. This species is in some respects more primitive than *Cynodesmus thoöides*, notably in the more transverse carnassial shear and backwardly directed paroccipital process; but the feet are somewhat more modernized than in the Rosebud species referred to Scott's genus; the metapodials are more compressed and elongate and the retractility of the claws has been lost. The brain-case is evidently of small capacity, and although no trace of the structure of the brain is preserved we may infer from the size that it was not more advanced.

Cynodesmus thomsoni sp. nov.

The type is a finely preserved skull and jaws, with the fore part of the

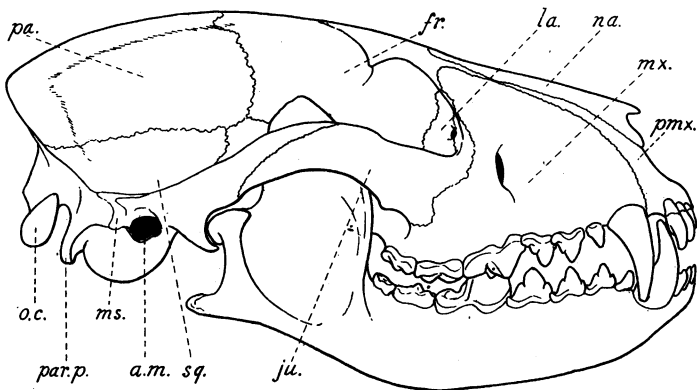


Fig. 4. *Cynodesmus thomsoni*. Side view of skull and jaws, two-thirds natural size. Type specimen. *a. m.*, auditory meatus; *fr.*, frontal bone; *ju.*, jugal; *la.*, lachrymal bone with foramen; *ms.*, mastoid process; *mx.*, maxillary; *na.*, nasal; *o. c.*, occipital condyle; *pa.*, parietal bone; *par. p.*, paroccipital process; *pmx.*, premaxilla; *sq.*, squamosal bone.

skeleton, from the Upper Rosebud beds, found by Albert Thomson of the Museum party of 1906.

The species is smaller than *C. thoöides* and of a less predaceous type, with shorter muzzle, smaller sectorial and relatively larger tubercular teeth

The premolars and carnassials are about one fourth smaller, while the tubercular teeth are of nearly the same size as in the type. The sagittal crest varies from an eighth to a quarter of an inch in height and the occipital crest is correspondingly developed. The bullæ are of moderate size, and the paroccipital much closer to them than in *C. thobides*, projecting downward at the tip. The direction of the carnassial shear agrees nearly with the type species.

Among modern Canidæ, *Canis cancrivorus* affords the nearest comparison with *Cynodesmus thomsoni*. The size and general proportions of the skull are much the same, except for the shorter and heavier muzzle, larger teeth and more powerful jaws of *C. thomsoni*, and its very much smaller brain-case with consequent development of sagittal and occipital crests. The postorbital constriction is hardly more than half as wide and the posterior nares narrow and deep. The zygomata and postglenoid processes

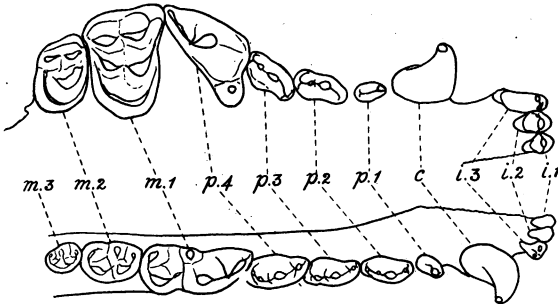


Fig. 5. *Cynodesmus thomsoni*, crown view of upper and lower teeth, natural size. Type specimen.

are much heavier, the pterygoids larger with hamular processes much more prominent, the jaw deeper with much broader coronoid processes, wider condyles, and masseteric fossa correspondingly wide and deep. The bullæ are slightly larger and the basisphenoid not so wide, but otherwise the basicranial bones and foramina are very like those in the modern species. I^3 is larger, with strong lateral cusp; the canines are longer and more robust; the premolars somewhat larger, more robust, and close-set, the accessory cusps well developed; the carnassials are slightly longer and much more robust, the shear somewhat more transverse; the inner half of the upper molars and the heels of the lower molars are much broader.

The fore foot is widely different from that of modern Canidæ, intermediate between *Cynodesmus brachypus* and the Oligocene Canidæ. The carpus has not the compact structure and relative height of the modern dogs, but in composition and proportions resembles the primitive type of *Cynodictis*. The metacarpals are not at all appressed and but little elongate;

Mc. I is somewhat more reduced, but not more than in the modern *Mustela pennanti*, much less than in *Viverra*, and far less than in any modern Canidæ. The phalanges are short, as in the dogs; in most Mustelidæ and Viverridæ they are relatively long. The penultimate phalanx shows the asymmetric excavated upper surface of the shaft indicating that the claws were partly retractile, but somewhat less so than in the Oligocene dogs. The ungual is narrow and compressed with a slight hood at the base. In *Cynodesmus brachypus* the retractility of the claws has been lost, and the metacarpals are longer and more appressed, though far less so than in *Canis*; the pollex is not known.

A fragmentary skull with parts of the lower jaw (No. 12875) indicates a smaller variety or distinct species nearly related to *C. thomsoni*, and other fragmentary specimens are referred here provisionally. In one of them (No. 12876) the hind leg with part of the foot is preserved and shows a comparatively strong fibula, the shaft scarcely if at all reduced beyond what is seen in *Daphænus* and *Cynodictis*. The first metatarsal indicates a complete digit fairly well developed but considerably smaller than in the White River dogs.

The construction and proportions of fore and hind feet in this species nearly resemble those of *Phlaocyon* as figured by Matthew¹ but the animal was of larger size and the limbs more elongate.

		Measurements.	mm.
Length of skull	.	.	132.7
Width " " at zygomata	.	.	81.
Width of postorbital constriction	.	.	18.4
" " brain-case	.	.	46.
Length of upper dentition (left side)	.	.	68.5
" " lower "	.	.	67.2
" " upper premolars	.	.	31.
" " upper true molars	.	.	16.
" " lower premolars	.	.	26.8
" " true molars	.	.	26.9
Diameter of p ₄ , anteroposterior 13;	transverse	.	8.
" " m ¹ " 10.5;	"	.	13.7
" " m ² " 5;	"	.	6.4
" " m ₁ " 14.5;	"	.	6.8
" " m ₂ " 7.5;	"	.	5.5
Length of jaw, incisors to condyles, 104.5; depth beneath m ₁	.	.	17.9
Width of proximal end of metacarpus	.	.	24.
Length of first metacarpal	.	.	17.
" " fifth "	.	.	30.
" " first phalanx	.	.	18.
" " second "	.	.	10.
" " third "	.	.	12.

¹ Mem. Amer. Mus. Nat. Hist., Vol. I, pl. vii, p.

Cynodesmus minor sp. nov.

A second smaller species from the Upper Rosebud is represented by the upper and lower jaws (No. 12877, type), by a separate lower jaw (No. 12878), and other fragmentary specimens. It is about two thirds (lineal) as large as *C. thomsoni*, and has a shorter carnassial with larger internal cusp, relatively larger tubercular teeth, especially m^2 , and the lower premolars are longer and not so high.

Measurements of type.						mm.
Diameters of p^4 , anteroposterior	8.7;	transverse	.	.	.	5.7
" " m^1 "	7;	"	.	.	.	9.2
" " m^2 "	5;	"	.	.	.	8.
" " m_1 "	9.6;	"	.	.	.	4.1
" " p_4 "	7.	"	.	.	.	3.2
" " p_3 "	6;	"	.	.	.	2.6
" " p_2 "	4.9;	"	.	.	.	2.

Enhydrocyon Cope.

The characters of this genus and of *Hyænocyon* have been much confused by careless diagnosis and improper transference of types. The following corrections are necessary in order to clear up the status of the two genera.

1. The type of *Enhydrocyon stenocephalus*, No. 1 of Cope's original description,¹ Am. Mus. No. 6902, consists of fragments of upper and lower jaws with unworn teeth, the premolars not completely protruded. A finely preserved skull with teeth much worn and defective, No. 6901, was used as paratype. The type specimen shows that there were probably but three upper premolars, that m_2 was present, the heel of m_1 and trigonid of m_2 trenchant. The paratype has a tooth formula of I^3, C^1, P^3, M^2 . The teeth in the type appear to be considerably larger and the premolars, more obliquely set and crowded than in the paratype; this difference however may be individual or due to age.
2. The type of *Hyænocyon* is *Enhydrocyon basilatus* Cope,² based upon a lower jaw, No. 6904. Cope subsequently referred to it an upper jaw, No. 6905, and defined the genus³ on these two specimens as having a dentition of P^3_4, M^1_1 . This was corrected afterwards⁴ to P^3_3, M^1_1 , and still later the upper jaw was separated as the type of *Hyænocyon sectorius*.⁵

¹ Bull. U. S. G. S. Terrs., Vol. V, No. 1, p. 56, Feb. 28, 1879.
² Loc. cit. p. 57.
³ Palæont. Bull., No. 31, p. 3, Dec. 24, 1879.
⁴ Amer. Nat., 1881, p. 497, May 19.
⁵ Amer. Nat., 1882, p. 246.

3. By clearing away the matrix from the type of *H. sectorius* it appears that Cope was mistaken in supposing m^2 to be absent, as the alveoli of its roots are certainly present. It has therefore the same dental formula as *Enhydrocyon*, to which it is in all other respects closely allied. In the lower jaw, type of *H. basillatus*, m_2 appears to be absent, at least on one side, but I suspect from the appearance of the specimen that this is a mere abnormality. The validity of the genus *Hyænocyon* is therefore very questionable, as there are no material differences in the form of the teeth to distinguish it generically from *Enhydrocyon*.

The above mentioned specimens from the John Day constitute all that has hitherto been known of this aberrant group of Canidæ.

***Enhydrocyon crassidens* sp. nov.**

The type, No. 12886, consists of a complete skull and jaws with a considerable part of the skeleton, found by Mr. Thomson in the Lower Rose-

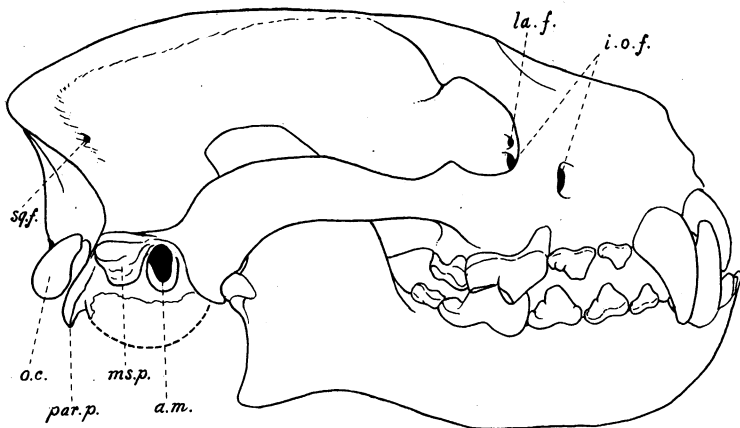


Fig. 6. *Enhydrocyon crassidens*, side view of skull and jaws, one half natural size. Type specimen, *a. m.*, auditory meatus; *la. f.*, lachrymal foramen; *i. o. f.*, infraorbital foramen; *ms. p.*, mastoid process; *o. c.*, occipital condyle; *par. p.*, paroccipital process; *sq. f.*, postparietal foramen.

bud bed. The species is somewhat larger than *E. stenocephalus*, the pre-molars simpler, the molar heel more reduced, and m_2^3 smaller. The skull is a little more robust throughout, the brain-case considerably larger. The second upper molar is minute on one side, absent on the other; m_2 is small but not so much reduced as the corresponding upper tooth. The size is about the same as in *E. (Hyænocyon) sectorius*, the m^2 more reduced, p^3 with broader heel but less robust protocone, and p^2 set obliquely but in the opposite direction from the corresponding tooth in *sectorius*, its anterior end

lying inside instead of outside the canine. The Rosebud species is smaller and less robust than *E. (Hyænocyon) basilatus*, and the anterior premolars are less massive. The fragmentary nature of the types of the John Day species precludes any further comparison, but *E. crassidens* is quite clearly distinct from the referred skull of *E. stenocephalus* and more advanced in several respects.

The basicranial region agrees with that of *E. stenocephalus*. It is of moderate width; the bullæ are large, longitudinally oval; the auditory meatus is open, without ossified tube, the septum of the bulla little developed. The condylar foramen lies close behind the posterior lacerate foramen, in front of the crest connecting the base of the paroccipital process with the condyle. The carotid canal is not clearly recognizable. The

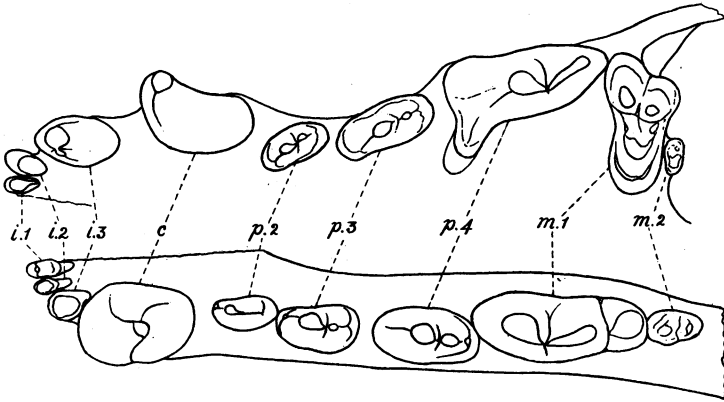


Fig. 7. *Enhydrocyon crassidens*, crown views of upper and lower teeth, natural size. Type specimen.

foramen lacerum medius is large, and the foramen ovale lies close outside of it. The postglenoid foramen is of moderate size. The alisphenoid canal is moderately long. The paroccipital process is close to the bulla at the base, and projects beyond it backward and downward in a rather long trihedral spine. The mastoid processes are well defined but not very large, and project moderately. The parts of the skeleton preserved are the first eight vertebræ, pelvis, fore and hind limb bones, astragalus and calcaneum.

The cervical vertebræ indicate a rather short neck, comparing rather with *Daphænus* in length than with any modern Canidæ. The fore limb bones are as large as in *D. vetus*, but the hind limb bones are considerably shorter and smaller. The deltoid crest of the humerus and the lower extremity of the ulna are more reduced, the head of the radius reduced on

the side next the ulnar facet. The shaft of the femur is straighter and more rounded in section; the patellar trochlea is very peculiar, short, rather wide and shallow, and almost distal in its position, while the condyles face inferiorly instead of distal-inferior. This peculiar conformation may be in part due to a vertical crushing of the bone, but not wholly so. It is paralleled to some extent in the hyænas, also in connection with small hind limbs and large fore limbs, and may indicate a similar pose of the skeleton. The tibia is much shorter than in *Daphænus*, cnemial crest more oblique and relatively higher. The astragalus is much more modernized than in *Daphænus*, the inner crest much more built out, higher and sharper, and there is no trace of the astragalar foramen, which is present although vestigial in *Daphænus*. The calcaneal heel is considerably reduced in length.

The characters of the skeleton confirm Professor Cope's view of the affinities of *Enhydrocyon*, derived from study of the teeth and skull, but not his suggestion of aquatic habitat. It is an aberrant type of the Canidæ without marked relationship to any other family. Its nearest relative among the Canidæ is probably *Temnocyon* of the John Day, which has also the heel of m_1 and trigonid and heel of m_2 trenchant instead of basin shaped, upper molars without intermediate cusps and deeply concave transversely, and relatively small m_3^2 . But in *Temnocyon* the premolars are large and compressed, in *Enhydrocyon* they are small and robust and $p\frac{1}{2}$ absent. The modern genera *Cyon* and *Icticyon* are probably representatives of this group of Canidæ but derivable from *Temnocyon*. *Enhydrocyon* is an extinct branch. The group is connected with the typical Canidæ by such types as *Mesocyon*. All these and perhaps also some of the so-called Amphicyons of this country may be derived in a general way from *Daphænus* of the White River, more nearly than from *Cynodictis*. The more typical group of dogs, on the other hand, leading through *Nothocyon* and *Cynodesmus* into the modern *Canis*, *Vulpes*, etc., may preferably be derived from *Cynodictis*.

Such derivations are at the best approximate, and a more extended knowledge of the fossil Canidæ, may, and probably will, show the way to a closer approximation to the true phylogeny than can now be made

Measurements of Type.

	mm.
Length of skull, incisors to condyles	181.
Breadth of skull across zygomatic arches	110.
Width of postorbital constriction	28.
Height of occiput	54.
Width of palate and teeth	58.
“ “ condyles	28.
Length of upper dentition (left side)	89.

	mm.
Width of six incisors	25.
Diameters of canine, anteroposterior 13.2; transverse	9.2
“ “ P ₂ “ 9.6; “	6.3
“ “ P ₃ “ 14; “	6.8
“ “ P ₄ “ 22.2; “	13.
“ “ m ₁ “ 10.5; “	17.
“ “ m ₂ “ 3; “	4.5
Length of lower jaw, incisors to condyles	139.
“ “ “ dentition (left side)	88.
Diameters of canine, anteroposterior 12; transverse	10.5
“ “ P ₂ “ 8; “	5.5
“ “ P ₃ “ 10.2; “	6.5
“ “ P ₄ “ 13.6; “	7.8
“ “ m ₁ “ 23; “	9.5
“ “ m ₂ “ 7.6; “	5.3
Depth of jaw beneath m ₁	22.5
Length of humerus 153; diam. of distal end	38.5
“ “ radius 114; “ “ “ “	25.
“ “ femur 143; “ “ “ “	38.
“ “ tibia 139; “ “ “ “	23.
Length of astragalus 30.; width of trochlea	13.

MUSTELIDÆ.

Oligobunis Cope.

Cope described this genus as an aberrant member of the Canidæ, ancestral to *Icticyon*, and this reference has not hitherto been questioned. A re-examination of the type of *O. crassivultus* leads me to believe that it is more nearly related to the primitive Mustelidæ of the Oligocene and Miocene and should be transferred to that family. The type, Am. Mus. No. 6903, consists of the lower jaws and anterior part of the skull, from the John Day formation, and the principal diagnostic characters are as follows:

Dental formula, $I_{\frac{3}{3}}, C_{\frac{1}{1}}, P_{\frac{4-3}{4}}, M_{\frac{2}{2}}$. The jaws and muzzle are short and heavy and their general proportions rather musteloid than cynoid, the muzzle lacking the constriction in front of the carnassials common to most of the Canidæ, especially the early members. The canines are short and stout, the premolars rather small, massive, and simple, without accessory cusps except on p₄. The antero-internal cusp of p₄ is well developed and, as in the later Mustelidæ, but to a less degree, constricted off from the rest of the tooth. M¹ is reduced antero-posteriorly and much extended transversely, the paracone nearly median, metacone vestigial and parastyle much extended, protocone compressed, and, as in all primitive Mustelines, it lacks the broad flange characteristic of the modern Mustelidæ. M² is very

small, transversely oval and lies behind the inner part of m^1 [the tooth was covered by matrix at the time of Prof. Cope's description and supposed by him to be absent.] The lower carnassial has a well developed metaconid and rather large heel with external crested hypoconid and broad slightly concave inner slope without entoconid. This form of heel is characteristic of most Mustelidæ; *Amphicyon* shows the nearest approach to it among the Canidæ with which I am acquainted, but in this genus the entoconid is developed as a low crest. M_2 is small, oval, tubercular, with low protoconid, metaconid and hypoconid of about equal height and somewhat marginal position. [Cope incorrectly described this tooth as composed of two trenchant cusps one behind the other, as in *Temnocyon*]. As in other primitive Mustelidæ the carnassial blades are separated by a distinct notch and the inner part of the upper tubercular lacks the broad flange found in all modern members of the family. The basicranial region is unknown but probably it would, as in *Bunælorus*, *Plesictis*, *Amphictis*, etc., show a large inflated bulla.

***Oligobunis lepidus* sp. nov.**

This species is much smaller than the type, and the teeth and jaws much less massive. But the form and cusp composition of the teeth,

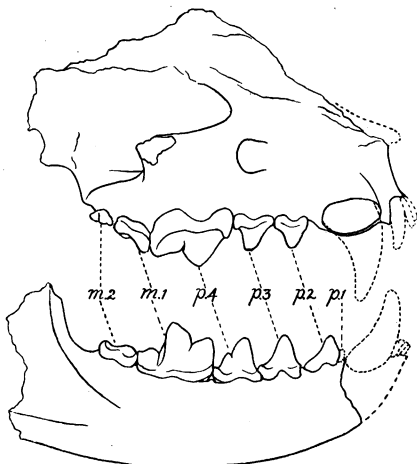


Fig. 8. *Oligobunis lepidus*, external view of upper and lower jaws, natural size. Upper jaw, No. 12866; lower jaw, No. 12867.

and proportions of jaws and muzzle are otherwise very similar to the John Day species, although somewhat more advanced in the direction of modern Mustelidæ. The premolars are more characteristically musteloid, short, high, simple, and close set. The inner cusp of p^4 is somewhat larger and more clearly separated from the rest of the tooth. M_2 is somewhat smaller and of more oval shape, its three cusps more marginal, and the vestiges of its primitive tuberculo-sectorial form more completely obliterated. The sectorial blades of the carnassial are separated by a notch, and

there is no flange on the protocone of m^1 .

The type, No. 12865, is a damaged anterior part of the skull with lower jaw. A second specimen, No. 12866, shows the upper molars, which are

not preserved on the type. This specimen appears to be a distinct variety or species, the teeth being more robust throughout, the skull larger and wider and p^1 absent. A lower jaw, No. 12867, is referable to this more robust form, and shows corresponding differences in the teeth, p_1 being very minute. Another lower jaw, No. 12868, agrees with the type except for its larger size. In the absence of more material for comparison I do not think it advisable to distinguish these as separate species.

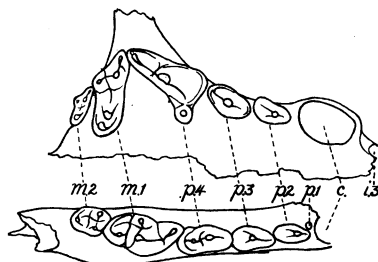


Fig. 9. *Oligobunis lepidus*, crown views of upper and lower teeth, natural size. Upper teeth, No. 12866; lower teeth, No. 12867.

Measurements.

	12865 Type	12866 var. <i>robustior</i>	12867	12868
Length of upper dentition ($i1-2$ and m^2 estimated)	36.			
Length of upper dentition exclusive of incisors		37.3		
Length of upper premolars	20.3	23.3		
Transverse diameter of lateral incisor	2.5			
Height of crown " " "	4.7			
Anteroposterior diameter of canine alveolus	5.4	7.7		
" " " p^2	4.0	5.		
" " " p^3	5.0	6.2		
" " " p^4	9.3	11.1		
Transverse " " p^4	6.8	7.3		
Anteroposterior " " m^1		5.0		
Transverse " " m^1		11.0		
Anteroposterior " " m^2		2.3		
Transverse " " m^2		5.		
Length of lower teeth, premolars and molars	30.4		31.4	32.
Length of lower premolars	16.9		17.3	18.3
" " " molars	13.9		14.9	14.5
Anteroposterior diameter of p_1	2.3			2.3
" " " p_2			4.9	4.2
" " " p_3			6.0	5.4
" " " p_4	5.7		6.5	6.2
" " " m_1	8.7		10.1	9.9
Transverse " " m_1	4.6		5.0	5.0
Anteroposterior " " m_2	5.0		5.2	4.8
Transverse " " m_2	3.7		4.0	3.7
Depth of jaw beneath m_1	10.0		12.0	11.0

Megaliectis gen. nov.

This name is given to a very large musteline allied to *Mellivora* and *Gulo* but retaining many characters of the primitive Mustelidæ in greater or less degree.

Teeth transitional between *Oligobunis* and *Gulo* or *Mellivora*. Molars $\frac{3}{2}$, the second molar much reduced, oval and flat-topped. Antero-internal cusp of p^4 strong and well separated. M^1 extended transversely, the inner shelf moderately developed, less than in any modern Mustelidæ, more than in any of the Oligocene genera. M_1 without metaconid.

Skull short, wide, massive, extremely high in frontal region, zygomatic arch stout, sagittal and occipital crests heavy and rather high, occipital region low and wide, basicranial region broad, bullæ small, inflated, flat-

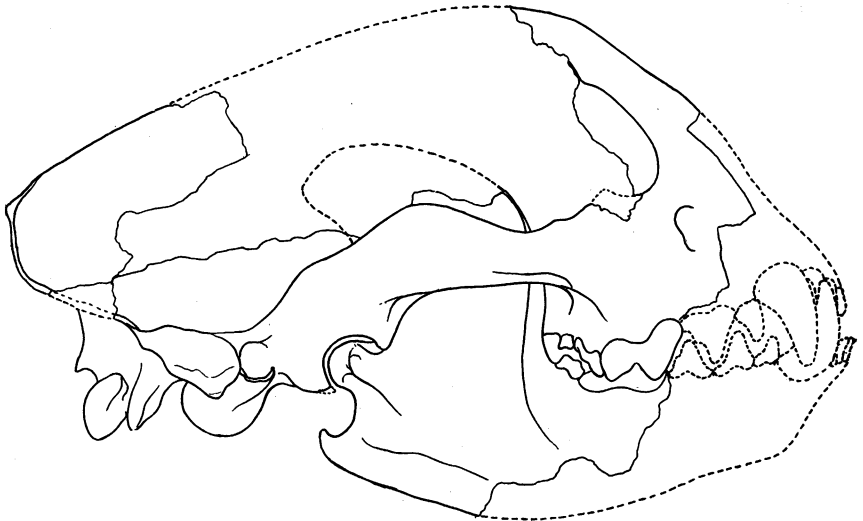


Fig. 10. *Megalictis ferox*, outline restoration of skull and jaws, side view, one half natural size. The full lines show the parts preserved in the type specimen.

tened marginally, auditory meatus long, flattened tubular. Mastoid processes stout, projecting laterally, paroccipital processes short, stout, spatulate, projecting backwards and partly downwards, well separated from bulla. Lower jaw short, deep, with wide condyles and broad coronoid process.

Ribs long, not flattened, lumbar vertebræ relatively short and small, caudals indicating a long and powerful tail. Limbs short and stout, feet plantigrade, short and spreading, five-toed, the pollex somewhat and hallux considerably reduced, phalanges short, claws large, non-retractile, little curved and not compressed, hooded at the base.

The above characters indicate an animal which may best be described as a gigantic wolverene, equalling a jaguar or a black bear in size, but in

proportions more like the ratel. The extremely high frontal region gives a peculiar aspect to the skull, suggesting *Cynælurus*. The limbs and feet are decidedly shorter than in the wolverene, somewhat longer than in the ratel. The single claw-phalanx known indicates some degree of fossorial specialization, less than in the ratel, more than in the wolverene. The teeth indicate an animal fully as predaceous as the wolverene but the skeleton points to more fossorial habits.

***Megalictis ferox* sp. nov.**

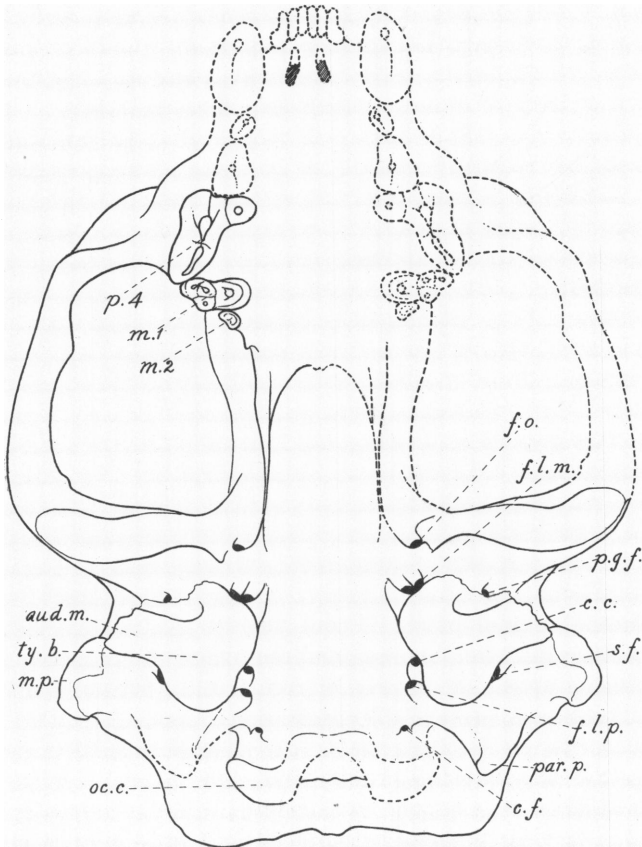


Fig. 11. *Megalictis ferox*, skull, inferior view, one half natural size. Type specimen. *Aud. m.*, auditory meatus; *c. c.*, carotid canal; *c. f.*, condylar foramen; *f. l. m.*, foramen lacerum medius; *f. l. p.*, foramen lacerum posterius; *f. o.*, foramen ovale; *m. p.*, mastoid process; *par. p.*, paroccipital process; *p. g. f.*, postglenoid foramen; *s. f.*, stylomastoid foramen; *ty. b.*, tympanic bulla.

The type, No. 12880, is a fragmentary skull and jaw, with parts of the fore limb and foot bones. A second specimen, No. 12881, includes limb and foot bones, ribs, and vertebræ. Both are from the Upper Rosebud beds and agree exactly in size and in the corresponding parts of limb and foot bones preserved. Between the two we are able to obtain a fair idea of the principal characters of the skeleton.

The more important features have already been given under the generic description. The skull has to an exaggerated degree the characteristic broad form, with short wide arches, short muzzle, broad basicranial region, seen in the large Mustelidæ, and differs from the comparatively narrow elongate skull of *Amphicyon* and the Canidæ. The form and position of the mastoid and paroccipital processes, and the arrangement of the basicranial foramina are also Mustelid, and the bulla shows in an incipient

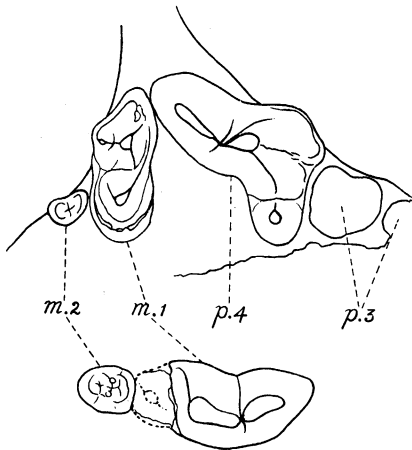


Fig. 12. *Megalictis ferox*, crown views of upper and lower teeth, natural size. Type specimen.

stage the flattening characteristic of this family. The large size of the animal and its comparatively small brain capacity cause the sagittal and occipital crests to be much more developed than in modern mustelines, more as in *Amphicyon*. The jaws and teeth anterior to the carnassials are unfortunately not preserved except for the root of p^4 , and a part of the canine alveolus, but the contour of the facial bones enables us to restore the outlines with a fair degree of accuracy. The skull when found was in fragments more or

less displaced but well preserved and uncrushed. The fragments were pieced together by Mr. Thomson and the writer with especial care, and the remarkable height of the frontal region and other peculiar characters cannot be ascribed to error in the preparation. The bullæ are intermediate between the simple inflated cynoid type of the Oligocene Mustelidæ and the flattened form characteristic of most modern members of the family. They are flattened at the borders and the auditory meatus is long and partly flattened. *Taxidea* displays a somewhat similar intermediate condition. The alisphenoid canal is absent. The foramen ovale lies close to the inner margin of the glenoid articulation. The carotid canal is large and situated close in front of the posterior lacerate

foramen. The condylar foramen is posterior in position, at some distance behind the foramen lacerum posterius. The postglenoid foramen is of moderate size. The primitive form and position of the paroccipital processes is equally characteristic of the family to which *Megalictis* belongs. In the Canidæ they become slender, directed downward and closely approximate to the bulla; in the Viverridæ and Felidæ they become thin flat plates enveloping the back of the bulla. The stout, widely separated, projecting mastoid processes are as in the larger Mustelidæ, contrasting with their moderate development in Canidæ, Viverridæ or Felidæ.

The teeth retain the molar formula of *Oligobunis*, *Amphictis*, etc., but m_2 have become vestigial, and the form of the carnassials and of m^1 is partly modernized. P^4 comes nearest to *Mellivora* in form; m^1 is most like that of *Gulo*; the longitudinal shear of m_1 and absence of metaconid is seen in both genera and distinguishes *Megalictis* from *Oligobunis* in which the shear is more oblique and metaconid well developed.

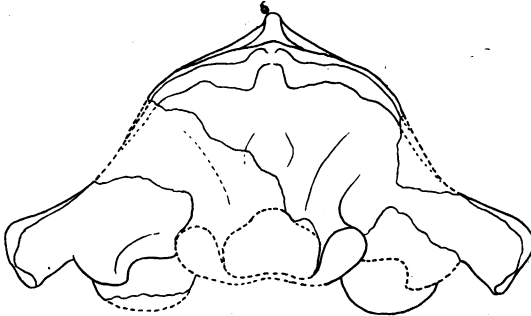


Fig. 13. *Megalictis ferox*, back view of skull, one half natural size. Type specimen.

With the fragmentary skull and jaws of the type specimen were found the greater part of the scapula, ulna, radius, and metacarpals I, II, and III complete but the characters of the skeleton are principally derived from the second specimen, No. 12881. This individual includes the humerus, tibia, and parts of other limb bones, all the metapodials except the pollex, a few carpals and phalanges, thirteen vertebræ, various ribs more or less complete, two sternal segments, and an os penis.

The humerus, radius and ulna are of about the same size as in *Amphicyon lemanense* but more robust; they are not so short as in *Mellivora*. The femur has a broad flat trochlea and the small patella is nearly as wide as it is long. The tibia and fibula are hardly more than half the size of those attributed to *A. lemanense* by Filhol, and are much like those of *Mellivora* but longer in proportion. The proportions of the metapodials are much

as in the ratel; they agree in size and robustness with *A. lemanense* as figured by Schlosser, but the hallux is much more reduced, and mt II of larger size, paired with mt V. The phalanges of the first row are more slender than in *A. lemanense* or in *Mellivora*. In *Gulo* the feet are much

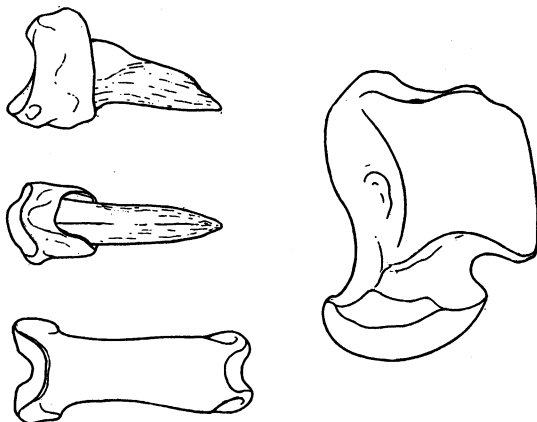


Fig. 14. *Megalictis ferox*. Astragalus, proximal and ungual phalanx, natural size. No. 12881.

more elongate, especially the phalanges, their proportions being much as in the smaller Mustelines. The single ungual phalanx preserved is quite

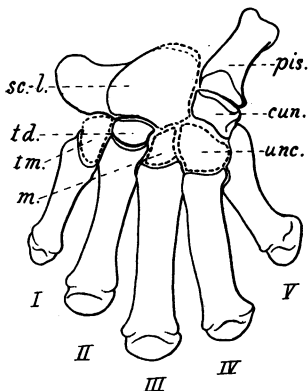


Fig. 15. *Megalictis ferox*. Left fore foot, one-half natural size. No. 12881. Metacarpals I and II from No. 12880.

unlike the compressed form seen in the bears, and intermediate in character between the unguals of the manus and of the pes in *Mellivora*. The astragalus is wider than in *Amphicyon*, the trochlea shallow, and limited in its backward extension, the astragalar foramen distinct, the neck of moderate length and the head somewhat flattened. It differs from *Daphænus* in the more vertical position of the fibular facet, the trochlear crests parallel instead of divergent anteriorly, reduction of the postero-inferior process behind the trochlea, and other characters of modernization. The proportions and character of the metapodials are not unlike those of *Daphænus* but also more modernized; the unguals differ

widely and are not retractile.

The atlas vertebra, an anterior dorsal and parts of two others, two

posterior dorsals, four lumbar and three caudals are preserved in the second specimen, besides about a dozen ribs more or less complete. The relatively short, weak lumbar and long ribs indicate a short thick barrel as in *Mellivora*, instead of the long sinuous body of the weasels generally. *Gulo* is intermediate in this respect but more like the typical weasels. The anterior dorsal spines are rather short, expanded at the tip. The posterior dorsal and anterior lumbar zygapophyses are strongly convex and concave, but in the posterior lumbar they are flattened out assuming the form of cervical zygapophyses, and giving an unusual flexibility to the posterior lumbar region. The anterior caudal indicates a tail moderately large at the root, but the great length of the posterior caudals preserved shows that the distal portion was elongate and stout.

The ribs are all of round-oval section in the shaft, with none of the flattening observed in modern Canidae and many other carnivora. They are relatively long, and moderately stout. The segments of the sternum resemble those of *Mellivora* in form. The os penis is large, the shaft of subquadrate section enlarged at the butt, considerably curved upwards, reduced in diameter and channelled above toward the distal end. The tip is incomplete but apparently was recurved downward.

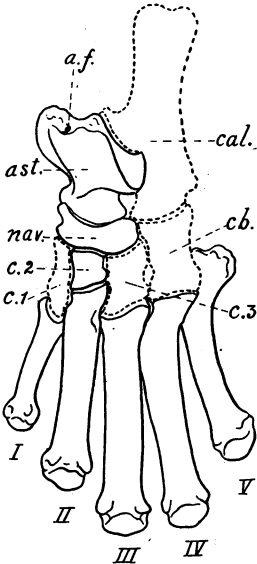


Fig. 16. *Megalictis ferox*. Left hind foot, one-half natural size. No. 12881.

Measurements.

	Type Specimen, No. 12880.	mm.
Length of skull, estimated		210.
Width at arches		164.
“ “ mastoid processes		140.
“ across bullae		83.
Distance from m ² to glenoid fossa		56.
Transverse diameter of bulla inflated portion		20.
Diameters of p ⁴ , anteroposterior 24.3; transverse		18.7
“ “ m ¹ “ 8.1; “		19.5
“ “ m ² “ 5.5; “		5.5
“ “ m ₁ “ 23; “		11.
“ “ m ₂ “ 7.3; “		6.2
Transverse length of condyle of lower jaw		49.
Width of coronoid process at base		42.

					mm.
Metacarpal I,	length 36.7,	diameter of shaft	.	.	6.5
"	II	51.8	"	"	9.1
"	III	57.6	"	"	9.2

Paratype, No. 12881.

Humerus,	length 189;	diameter of proximal end	.	.	53.
"	diameter of distal end	.	.	.	59.5
Tibia,	length, 172;	diameter of proximal end	.	.	49.
"	diameter of distal end	.	.	.	33.
Patella,	length 28.5;	breadth	.	.	24.1
Astragalus,	length 36;	width of trochlea	.	.	16.
Metacarpal III	length 55.3;	diameter of shaft	.	.	10.
"	IV	53.6	"	"	10.5
"	V	41.2	"	"	9.5
Length of a proximal phalanx	31.;	diameter of shaft	.	.	8.5
Length of an ungual phalanx	28.;	width of proximal end	.	.	10.5
Transverse diameter of distal end of radius	.	.	.	.	36.
Metatarsal .I	length 38.5;	diameter of shaft	.	.	5.5
"	II	56;	"	"	8.8
"	III	63;	"	"	9.8
"	IV	64 (est.);	"	"	9.7
"	V	55;	"	"	9.
Atlas,	length, 44.3;	breadth	.	.	89.
Anterior dorsal,	length of centrum 24;	height to top of spine	.	.	75.
Posterior dorsal	length of centrum 28;	width of centrum	.	.	28.
Anterior lumbar	" " 28.5;	" " "	.	.	30.
Posterior	" " 35;	" " "	.	.	30.
Anterior caudal	" " 20.5;	" " "	.	.	18.5
Posterior caudal	" " 39;	" " "	.	.	11.6
Posterior caudal	" " 39;	" " "	.	.	11.6
Length of the longest rib preserved complete	¹	.	.	.	181.
Diameter of shaft of above rib	.	.	.	.	9.
Length of portion of os penis preserved	.	.	.	.	154.

Restoration of the skull.—The accompanying outline restorations of the skull (Figs. 10, 11, 13) of *Megalictis ferox* call for some explanation in regard to the restored parts. The extreme height of the forehead is not due to crushing nor to any error in restoration, the frontal bones and right maxilla being fairly complete and uncrushed. The maxilla is complete to the premaxillary suture as far down as the upper part of the canine alveolus, which appears on the inside of the bone. It is thus possible to determine the approximate position of the canine and the space behind it for the premolars without much margin of error. From the extremely short space between the roots of p^3 and the supposed position of the canine, it appeared

¹ Chord measurement.

probable that p^1 was absent and p^2 small and crowded. The size of the canine and incisors is conjectural, but the outlines of the front of the skull continued forward from the parts preserved, cannot be very far from correct, although the front teeth may have been more robust and more crowded than they are represented. The outlines of the anterior part of the lower jaw were drawn to correspond with the muzzle outlines, and the depth and robustness will be correspondingly greater if the front teeth are more robust. The back of the skull is sufficiently complete on one side or the other to render the outlines certain except in the parietal region. The basicranial region is not conjectural except a part of the border of the foramen magnum; elsewhere the base of the skull is perfectly preserved upon one side or the other as far forward as the carnassial. As the skull is completely uncrushed I do not think there is any possibility of considerable error except in the front teeth and the anterior part of the lower jaw.

*Comparison with *Ælurocyon* Peterson.*—After the description and figures of *Megalictis* were completed I was led to suspect that it might be identical with a large fossil musteline described by Mr. Peterson in a memoir of the Carnegie Museum now in press. Through the courtesy of Mr. Peterson I have been enabled to make comparison between the type of this genus and the type of *Megalictis*. The two are undoubtedly nearly allied, but there are several distinctions which I regard as of generic importance. The tubercular teeth are almost identical in the two; the upper carnassial in *Ælurocyon* is more elongate and has an antero-external basal cusp not present in *Megalictis*. The third upper premolar is evidently of quite different proportions so far as can be judged from the roots of that tooth preserved in *Megalictis*. The distance from the orbit to the premaxillary border is twice as great in *Ælurocyon*, allowing a much wider space for the premolars, which are three in number, while in *Megalictis* the space behind the canine (as judged from the course of the premaxillary border of the maxilla and from the part of the canine alveolus which is preserved) is so small that there can hardly have been more than two premolars between C^1 and p^4 , and these smaller and more crowded than in *Ælurocyon*.

The outline of the skull is very different in the two genera. In *Ælurocyon* the muzzle is of moderate length and the frontals not nearly so high as in *Megalictis*, in which the muzzle is extremely short. The peculiar abrupt forehead of our genus is not due to crushing, and although the *Ælurocyon* skull is considerably crushed, it is quite clear that it lacked this peculiar feature and was much more elongate. The arch in *Megalictis* is much broader and heavier, the glenoid articulation and condyle nearly twice as wide. The length of the two skulls appears to have been about

the same. The basicranial region in *Ælurocyon* is not well enough preserved to make any exact comparison but does not appear to have been by any means so wide as in *Megalictis*.

I believe there can be no question of the generic distinctness of the two, nor that both belong to a group of Mustelines of which *Mellivora* and *Gulo* are the nearest living allies. *Mellivorodon* from the Siwalik beds also belongs to this group.

FELIDÆ.

Nimravus sectator sp. nov.

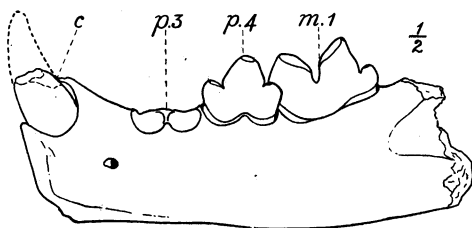


Fig. 17. *Nimravus sectator*. Outside view of type lower jaw, one half natural size.

The only felid specimen in the collection is a lower jaw clearly referable to the *Dinictis* group of sabre-tooth cats (*Dinictis*, *Nimravus*, *Ailurictis*) and provisionally referred to *Nimravus*. The species is larger and more robust than any of those from the John Day, and the flange of the jaw is reduced to a mere angulation, as in *Ailurictis*; there are two premolars of subequal size; the carnassial has the distinct heel and deep notch between paraconid and protoconid opening into a horizontal valley, and there is no trace left of the second molar. The post-canine diastema is unusually short.

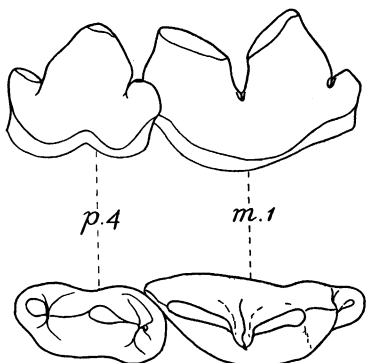


Fig. 18. *Nimravus sectator*. Outside and crown views of lower teeth, natural size. Type specimen.

This species may on better knowledge prove generically distinct from *Nimravus* and more or less directly ancestral to "*Machærodus*" *catocopsis* of the Upper Miocene, which species I judge belongs to the *Dinictis* group and not to the true *Machærodi*.

Measurements of Type.¹

mm.

Length of dentition, canine to m ¹	93.3
Length of post-canine diastema	16.
Diameters of alveolus of p ³ anteropost, 17; transv.	7.
Diameters of p ⁴ , anteroposterior, 20.2; transverse	9.6
“ “ m ¹ “ 28.5; “	11.6
Depth of jaw in front of p ³	29.
“ “ “ behind m ¹	4.3

RODENTIA.

CASTORIDÆ.

Steneofiber E. Geoffroy.

This genus is abundant in the Lower Rosebud but has not been found in the upper beds. The species referred to it include a wide range of variation and should probably be divided into several distinct genera or subgenera. This, however, is best reserved until a larger series of skulls is accessible. The species from this formation, as well as those from the Harrison beds to the southwest, described by Peterson, appear to be more advanced and specialized than those of the John Day, which again show a distinct advance on the White River species. The Lower Miocene species are more numerous and include a wider range of divergence in size and proportions, and their teeth have longer crowns and in general a tendency to reduce the inflections to one principal external and one internal in the upper molars, one principal internal and one external in the lower; also to reduce the last molar. This appears to be an approximation to the *Dipoides* (*Eucastor*) pattern, in which the minor inflections have disappeared, the teeth are very hypsodont (?rootless) and the last molar reduced (said to be absent in *Sigmogomphius*). It is not unlikely that *Dipoides* (Upper Miocene) is descended from one of the Lower Miocene species of *Steneofiber*, among which *S. simplicidens* (infra) most nearly fulfills the required conditions. The skull of *Dipoides* has not yet been found unless *Sigmogomphius* Merriam be referable to this genus.

I have not been able to positively identify *S. barbouri* or *S. fossor* Peterson among our specimens, but some of the incomplete skulls and jaws may be referable to these species. The following appear to be clearly distinct:

Steneofiber simplicidens sp. nov.

Type, a skull, No. 12900, from the Lower Rosebud, found by W. D. Matthew.

Size intermediate between *S. barbouri* and *S. fossor*. Skull comparatively long and narrow, muzzle long and heavy. Sagittal crest moderate.

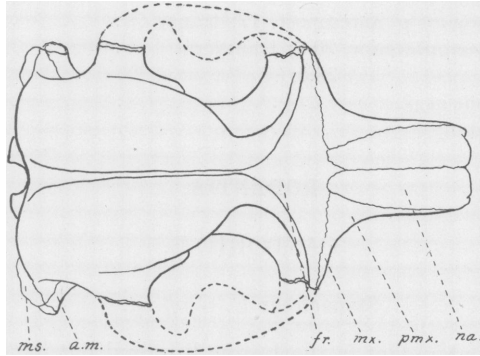


Fig. 19. *Steneofiber simplicidens*. Skull, top view, natural size. Type specimen. A. m., auditory meatus; fr., frontal bone; ms., mastoid; mx., maxillary; na., nasal; pmx., premaxillary bone.

Braincase and occiput not so wide as in the other species, except *S. nebrascensis*; bullæ rather small, intermediate between *nebrascensis* and the

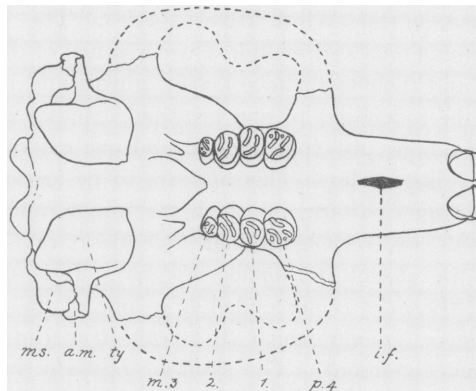


Fig. 20. *Steneofiber simplicidens*. Skull, base view, natural size. Type specimen. A. m., auditory meatus; i. f., incisive foramen; ms., mastoid exposure; ty., tympanic bulla.

later forms. Incisors broad, diastema long, molars with long crowns, of rounded outline and simple pattern, the accessory external inflections having disappeared in the moderately worn tooth. Third molar much reduced.

Measurements.	mm.
Length of skull (incisors to condyles)	61.
Width of muzzle	13.
“ “ postorbital constriction	9.
“ “ occiput	34.5
Transverse diameter of bulla (excluding meatus)	7.
“ “ “ incisor	4.
Length of diastema	20.5
Anteroposterior length of grinding teeth	12.5
Diameters of p ⁴ , anteroposterior 3.7; transverse	4.1
“ “ m ¹ “ 3.4; “	4.2
“ “ m ² “ 3.2; “	4.1
“ “ m ³ “ 2.3; “	2.8
Measurements taken at grinding surface.	

Steneofiber sciuroides sp. nov.

Type, a skull, No. 12901, from the Lower Rosebud beds, found by W. D. Matthew. The species is about the size of *S. barbouri*, with shorter and wider skull, well rounded cranium without traces of postorbital or sagittal crests, and apparently a very low occipital crest. The nasals, occipital and basicranial bones are missing, so that complete comparisons cannot be made. The postorbital constriction is wider than in *S. barbouri*, the tooth rows less divergent posteriorly, the posterior nares open further forward, the jugal is deeper and the zygomatic process of the maxilla is nearly vertical, while in the other *Steneofibers* it slopes strongly forward superiorly. The full, capacious cranium, short, sharply defined muzzle, and very wide arches give this species a peculiar aspect. The teeth are much like those of *S. barbouri*.

Measurements.	mm.
Approximate length of skull, incisor to interparietal	51.
Width of skull across arches	46.
Width of muzzle	12.3
“ “ postorbital constriction	12.
Depth of zygoma	10.6
Width of palate at p ⁴	5.
“ “ m ³	5.9
Length of diastema	15.
Anteroposterior length of p ⁴ -m ³	
Diameters of p ⁴ , anteroposterior 3.6; transverse	3.3
“ “ m ¹ “ 2.9; “	3.4
“ “ m ² “ 2.9; “	3.4
“ “ m ³ “ 2.8; “	3.
Diameters taken at grinding surface.	

Steneofiber brachyiceps sp. nov.

Type, a skull and jaws and fore limb bones, No. 12902, from the Lower Rosebud beds, found by Albert Thomson. The skull is as wide as that of *S. fossor*, but considerably shorter, with shorter muzzle, deeper jugal, well marked postorbital process on frontal as well as on jugal, shorter and deeper jaw, fore limb bones proportionately larger and more robust. The under side of the skull is not seen in its present state of preparation, nor the upper side of the jaws; the upper teeth appear to be unusually wide, but this may be due to wear.

	Measurements.	mm.
Length of skull (approximate)	58.
Width at arches	49.
Width of muzzle	14.
“ “ postorbital constriction	9.6
“ “ occiput	43.
Depth of arch	16.
Length of lower jaw	46.
Depth beneath first molar	12.5
Extreme depth at coronoid process	33.4
Length of humerus	42
Transverse diameter at distal end	15.2
Anteroposterior diameter at head	8.7
Length of radius approximate	31.

Steneofiber ? pansus Cope.

Several skulls, parts of skulls, and lower jaws agree with the skull referred by Matthew and Gidley to this species. This skull, No. 10818, was found in a more easterly exposure of the Rosebud beds. The species appears to be common in the lower Rosebud. It is of the size of *S. barbouri* but is distinguished by its greater width, shorter muzzle and deeper zygomata. It was figured and described by Matthew and Gidley in Bull. Amer. Mus. Nat. Hist., 1904, pp. 257-260.

Euhapsis gaulodon sp. nov.

Type, a skull and lower jaws, No. 12897, from the Lower Rosebud beds, found by W. D. Matthew.

The species is distinguished from *E. platyceps* Peterson by its considerably greater length of skull. The arches are badly preserved, but do not appear to have been so wide or massive as in the type; the occiput has about the same width but considerably greater length, the muzzle is longer,

the sagittal crest widens a little in advance of the occiput into a broad raised area reaching forward to the postorbital constriction. The forward slope

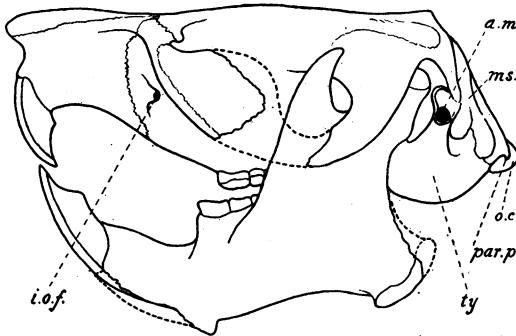


Fig. 21. *Euhapsis gaulodon*. Skull, side view, natural size. Type specimen. *A. m.*, auditory meatus; *i. o. f.*, infraorbital foramen; *ms.*, mastoid exposure; *o. c.*, occipital condyle; *par. p.*, paroccipital process; *ty.*, tympanic bulla.

of the occiput is conspicuous, as in the type. The teeth are all present and their general appearance confirms Peterson's suggestion of the *Mylagaulid*

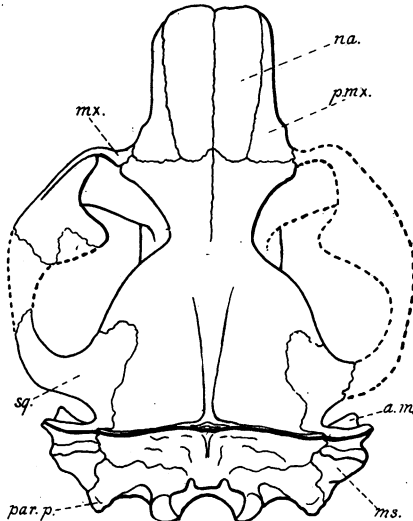


Fig. 22. *Euhapsis gaulodon*. Skull, top view, natural size. Type specimen. *A. m.*, auditory meatus; *ms.*, mastoid exposure; *mx.*, maxilla; *na.*, nasal; *par. p.*, paroccipital process; *pmx.*, premaxilla; *sq.*, squamosal bone.

affinities of this rodent. The relationship to *Steneofiber* is equally clear, the pattern being almost identical. It may be approximately although

not exactly ancestral to *Mylogaulus*, but a considerable change in the tooth proportions and pattern would be necessary to convert it into that genus.

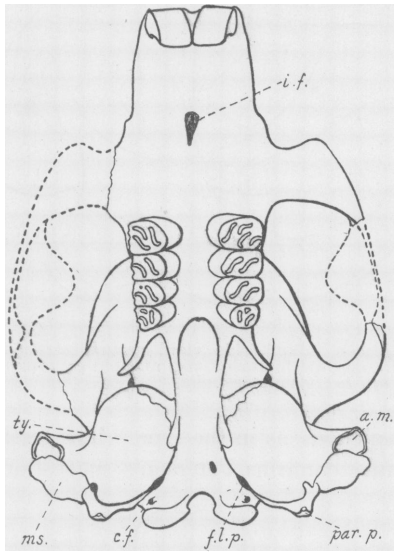


Fig. 23. *Euhapsis gaulodon*. Skull, base view, natural size. Type specimen. A. m. auditory meatus; c. f., condylar foramen; f. l. p., foramen lacerum posterius; i. f., incisive foramen; ms., mastoid exposure; par. p., paroccipital process; ty., tympanic bulla.

Measurements.		mm.
Length of skull, incisors to condyles	. . . . .	68.
“ “ “ nasals to occiput	. . . . .	56.5
Width of muzzle	. . . . .	13.7
“ “ postorbital constriction	. . . . .	11.
“ “ occiput including mastoids	. . . . .	40.
Slant height of occiput including condyles	. . . . .	25.3
Length of bulla (between stylomastoid and med. lac. foramina)	. . . . .	15.
Width “ “ (“ postglenoid and carotid “ )	. . . . .	12.
Length of upper dentition p ⁴ -m ³.	. . . . .	13.7
Diameters of p ⁴ , anteroposterior 3.8; transverse	. . . . .	5.3
“ “ m ³ “ 3; “	. . . . .	3.5
Width of incisor	. . . . .	4.1
Length of diastema between i and p ⁴	. . . . .	23.
Vertical height of occiput including tympanic bullæ	. . . . .	25.

GEOMYIDÆ.

Entoptychus Cope.

This genus has hitherto been known only from the John Day formation. It is rather common in the Rosebud beds, two well marked species being easily recognizable among our specimens. In both of these the skull is proportionately shorter than in any of the John Day species, with wider muzzle and greater development of the mastoid swelling. These, with various minor differences, while not of generic importance, are perhaps significant as indicating a trend of development somewhat in the direction of the modern *Heteromys*, although at the same time these species come nearer to *Thomomys* than do the types of the genus. The molars are rooted, and by definition these species should be referred to *Pleurolicus*, if the latter be regarded as a valid genus. But the distinction between the two genera is more nominal than real.

Entoptychus and *Pleurolicus* were referred by Prof. Cope to the Geomyidæ (Sacomysidæ), in which family the Heteromyidæ were then included. *Entoptychus* was described as with rootless teeth, *Pleurolicus* being distinguished by the rooted teeth. Cope called attention to their relationships to *Heteromys* on the one hand, to *Thomomys* and *Geomys* on the other. Scott, in describing the Uinta genus *Protoptychus* regarded it as ancestral to the Dipodidæ and *Entoptychus* and *Pleurolicus* as ancestral to the Geomyidæ. He emphasized the close relationship of Geomyidæ, Heteromyidæ and Dipodidæ, and concluded that the small development of the mastoid in some of the modern forms is due to degradation. Palmer in his Catalogue of the Genera of Rodents regards *Entoptychus* and *Pleurolicus* as Heteromyidæ, the former with doubt.

Entoptychus and *Pleurolicus* appear to be much nearer to the Geomyidæ, especially to *Thomomys*, than to any of the Heteromyidæ. The heavy, solid skull, with prolonged postorbital constriction, broad, long cylindrical muzzle, nasals not projecting beyond incisors, tubular meatus, moderately developed squamosal, wide incisors, long-crowned molars, and numerous minor features, ally them with the pocket gophers and separate them widely from the pocket-mice, even from *Heteromys*, which is the nearest of the modern Heteromyidæ. Unfortunately we know nothing of the skeleton of *Entoptychus*, and until the genus is proved to be fossorial or otherwise, we cannot be certain of its exact relationship to the modern genera of Geomyidæ. But on present evidence it should certainly be placed in this family. The ancestral types of the Heteromyidæ will perhaps be found in the imperfectly known Oligocene genera *Adjidaumo* (*Gymnopty-*

chus), and *Heliscomys*, and in still more fragmentary remains from the Miocene provisionally referred to *Heteromys*. The relationships of all these are conjectural until more complete specimens are found. It is probable that the common ancestry of Geomyidæ, Heteromyidæ, and Dipodidæ will be found in the group of Middle Eocene (Bridger) genera described from fragmentary material by Marsh and Leidy under the names of *Sciuravus*, *Mysops*, *Taxymys*, *Tillomys*, and *Colonomys*. The American Museum collections of 1903–1906 contain a fine series of specimens, including skulls and skeletons, of small rodents belonging to this group, and the preliminary studies now being made of them by Dr. F. B. Loomis will no doubt throw much light upon the origin of this group of the Rodentia.

***Entoptychus formosus* sp. nov.**

Size equalling that of the smaller species of the John Day formation, but with broader muzzle, mastoid swelling larger, and numerous minor differences. Skull of moderate proportions, about as in *Thomomys*, but

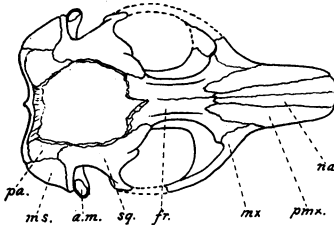


Fig. 24.



Fig. 25.

Fig. 24. *Entoptychus formosus*. Skull, top view, natural size. Type specimen. Lettering as in Figs. 19 and 22.

Fig. 25. *Entoptychus formosus*. Skull, side view, natural size. Type specimen. As., alisphenoid bone; i. o. f., infraorbital foramen; ms., mastoid bone; mx., maxilla; o. c., occipital condyle; pmx., premaxilla; sq., squamosal bone; ty., tympanic bulla.

with smaller brain-case, narrower and somewhat longer postorbital constriction, arches less expanded anteriorly, postorbital, sagittal and occipital crests better developed. Bullæ somewhat smaller than in *Thomomys*, more like those of *Heteromys*. Mastoid swelling more than in *Thomomys*, less than in *Heteromys*. Nasals not prolonged forward as in Heteromyidæ, like those of Geomyidæ but reaching further backward. Postorbital constriction long and narrow, postorbital ridges prominent, uniting at a short distance behind the constriction into a low sagittal crest and separating again before reaching the occiput so as to enclose with the occipital crest a triangular raised area as wide as the interorbital space. The attachment of the masseter muscle is defined above by a sharp crest on the upper edge

of the arch, which is carried forward as a prominent ridge to and beyond the anterior border of the maxilla at the junction of the lateral and superior surfaces of the muzzle. This crest is more prominent than in the John Day *Entoptychi* or in *Thomomys*, more as in *Heteromys*.

Incisors of moderate width and slightly convex on the outer surface. Molars and premolars like those of the John Day *Entoptychi*, the crowns very long, but with closed roots in old age.

The type is a nearly perfect skull, No. 12887, found by Mr. Thomson in the Upper Rosebud beds. Other skulls and lower jaws are referred to this species.

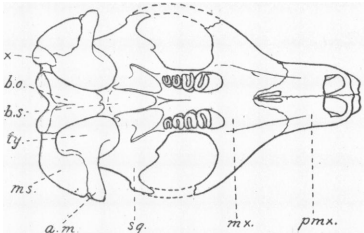


Fig. 26. *Entoptychus formosus*. Skull, base view, natural size. Type specimen. *a. m.*, auditory meatus; *b. o.*, basi-occipital; *b. s.*, basisphenoid; *ms.*, mastoid; *mx.*, maxillary; *pmx.*, premaxillary; *sq.*, squamosal bone; *ty.*, tympanic bulla; *x.*, a small accessory bone overlapping the mastoid and occipital at their junction with the tympanic.

Measurements.					mm.
Length of skull (incisors to condyles)	.	.	.	.	40.1
Width across arches (estimated)	.	.	.	.	24.
“ “ mastoids, behind auditory meatus	.	.	.	.	22.1
Height of occiput	.	.	.	.	11.3
Width of postorbital constriction	.	.	.	.	5.6
Height at “ “ (including molars)	.	.	.	.	15.3
Width of muzzle at middle of nasals	.	.	.	.	9.
Width of incisor	.	.	.	.	2 1
Length of diastema	.	.	.	.	12.8
Length of grinding teeth p ⁴ -m ³ at alveolar border	.	.	.	.	8.3
Width of palate at p ⁴ (exclusive of teeth)	.	.	.	.	2.2
“ “ “ “ m ³ ( “ “ “ )	.	.	.	.	3.8
Length of auditory meatus	.	.	.	.	4.5
Transverse diameter of bulla	.	.	.	.	5.
Diameter of p ⁴ , anteroposterior 2. ; transverse	.	.	.	.	2.5
“ “ m ¹ “ 1.5; “	.	.	.	.	2.3
“ “ m ² “ 1.3; “	.	.	.	.	2.
“ “ m ³ “ 1.5; “	.	.	.	.	1.6

Entoptychus curtus sp. nov.

Size a little less than *E. formosus*, muzzle somewhat shorter, postorbital constriction much shorter and somewhat wider, without postorbital crests; sagittal crest low and narrow, extending forward to the posterior part of the postorbital constriction, triangular area at junction of sagittal and postorbital crests minute. Teeth as in the preceding species but p₄ slightly larger.

Type, No. 12890, a skull from the Upper Rosebud beds, found by Mr. Gregory. Other specimens from the Upper and Lower beds are referred to this species.

	Measurements.	mm.
Length of skull, incisor to condyle	39.
Width behind auditory meatus	22.8
Height of occiput	11.
“ at postorbital constriction (including molars)	13.4
Width of muzzle at middle of nasals	8.4
“ “ postorbital constriction	6.5
Length of diastema	13.1
Length of p^4 - m^3 at alveolar border	8.
Diameter of p^4 (No. 128.91), longitudinal 2.3; transverse	2.6
“ “ m^1 “ 1.8; “	2.3
“ “ m^2 “ 1.4; “	2.
“ “ m^3 “ 1.5; “	1.7

The measurements are from the type except as noted.

HETEROMYIDÆ.

A lower jaw from the Upper Rosebud beds indicate what is probably an undescribed genus of this family. The teeth are very like those of *Heteromys*, but the posterior lobe of m_3 is larger and the anterior lobe of p_4 smaller in proportion. The size is considerably larger than any of the modern species of this genus, the diastema longer, and the incisor directed more forward. The coronoid process is less reduced, and the prominence at its base on the external side of the jaw is much more pronounced. In this and several other respects the conformation of the jaw approaches that of *Pleurolicus*, but the incisors have the narrow rounded form of the Heteromyidæ. It probably indicates an intermediate genus which cannot at present be adequately defined.

A second much smaller Heteromyid is indicated by a part of the lower jaw with p_4 - m_1 preserved. The premolar is proportionately small, as in the larger species.

LEPORIDÆ.

Lepus macrocephalus sp. nov.

This species belongs to the primitive group represented by *L. ennisianus* of the John Day, intermediate between *Palæolagus* and the typical modern hares. The type specimen, No. 12910, consists of a lower jaw with fore and hind feet of both sides and parts of the limbs, etc. It is a more robust and considerably larger species than *L. ennisianus*, and like it has three

columns on the outer side of p_2 , but the furrow between the two anterior columns shallow as compared with modern *Lepus*. The last molar is much reduced, as in *Palæolagus*. The jaw is short, deep, and heavy, equalling *L. campestris* in size but with shorter diastema.

The limb bones and feet are much smaller than in *L. campestris*, nearer to *L. virginianus* in size and proportions. It is of interest to observe that in the elongation and specialization of the limbs and feet the Lower Miocene Leporidae, in this species at least, were practically as far advanced as any of their modern descendants. Vestiges of the former primitive five-toed short-footed conditions appear more clearly than in the modern hares, and there are also accessory ossicles on the dorsal surface of the proximal ends of mc. II and III and of mt. II, presumably associated with peculiar conditions of the carpal and tarsal extensor tendons, which require further study for their explanation. But in proportions and in character of the articulations the podials, metapodials, and phalanges, and what can be seen of the limb bones, compare nearly with the typical *Lepus*, and would place the species in this genus rather than in the short-limbed group of modern Leporidae (*Sylvilagus*, *Caprolagus*, etc.).

It is remarkable that palæontology has thrown so little light upon the relations of the Lagomorpha to the remaining Rodentia. No Eocene Rodents show any approximation to this group; they appear suddenly in the Oligocene, already abundant and highly specialized, the Leporidae in North America, the Ochotonidae Lagomyidae in Europe, and have changed comparatively little from that epoch to modern times. Judging from their rate of evolution these two closely related families must have diverged during the Eocene, and the splitting off of the Lagomorpha from the main rodent stock must date well back in the Cretaceous. From the entire absence of related forms in the Eocene of Europe, the two Americas and Africa, it is fair to assume that they did not develop upon any of these continents; they are undoubtedly a northern type, and Asia appears the most probable place of origin.

Measurements. (Type of *L. macrocephalus*.)

	mm.
Length of lower dentition p_2 - m_3	15.7
" " diastema of lower jaw	15.
Depth of jaw beneath p_4	13.
Length of mc I 5.5; diam. distal end	2.5
" " " II 20.1; " " "	3.7
" " " III 22.9; " " "	3.6
" " " V 12.5; " " "	3.8
Length of proximal phalanx, digit II	10.5
" " " " " III	11.3
" " " " " V	10.5

									mm.
Length of middle phalanx, digit V	.	.	.	.	.	.	.	.	6.2
" " ungual " forefoot	.	.	.	.	.	.	.	.	9.
Length of calcaneum	.	.	.	.	.	.	.	.	24.9
Length of mt. II 42.3; diam. distal end	.	.	.	.	.	.	.	.	4.5
" " " III 43.; " " "	.	.	.	.	.	.	.	.	4.5
" " " IV 41.6; " " "	.	.	.	.	.	.	.	.	4.7
" " " V 37.; " " "	.	.	.	.	.	.	.	.	4.7
Length of a proximal phalanx (III or IV)	.	.	.	.	.	.	.	.	18.6
" " median " "	.	.	.	.	.	.	.	.	8.8
" " ungual " "	.	.	.	.	.	.	.	.	10.
Total length of manus	.	.	.	.	.	.	.	.	52.2
" " pes	.	.	.	.	.	.	.	.	109.

Lepus primigenius sp. nov.

A second smaller species of similar type to *L. macrocephalus* is indicated by a single lower jaw, No. 12911. The teeth are like those of the larger species except in size, the jaw is not so deep and the diastema proportionately longer, although short in comparison with most of the modern Lepores.

DICOTYLIDÆ (TAGASSUIDÆ).

The Suidæ, Elotheriidae and Dicotylidae are apparently derived from a common Eocene ancestry and the Dicotyline group is first clearly distinguishable from the others in the Oligocene *Perchærus*. The skeleton of this genus is unknown; the skull differs from modern peccaries chiefly in the small braincase, simple premolars, full Eutherian dentition and simple round bulla without cancellous tissue. In all upper Miocene, Pliocene, Pleistocene, and recent species the upper incisors are reduced to two, the premolars are more or less completely molariform, p_1 is absent, the bullæ are filled with cancellous tissue, and the brain is of much larger size. These characters are common to *Dicotyles*, *Platygonus*, *Mylohyus*, and *Prosthennops*, and each of these genera shows various divergent specializations in addition to the common progressive characters.¹

The Lower Miocene peccaries are intermediate in the progressive characters common to all the genera, and might be ancestral to any or all of them. Peterson has described and figured a species from the Harrison beds of Nebraska under the name of *Thinohyus siouxensis*. The typical *Thinohyus* is from the Oligocene (John Day) and neither Peterson nor Sinclair make any attempt to distinguish it from the previously described *Perchærus* of the White River. Skulls of *Perchærus* in the American Mu-

¹ See Matthew and Gidley, Bull. A. M. N. H., 1904, p. 265.

seum show the two to be very closely related, and I do not know of any valid generic distinctions. "*Thinohyus*" *siouxensis* is, however, distinguished from *Perchærus* and the typical *Thinohyus* by the following characters: (1) Lateral incisors reduced, median incisors enlarged. (2) P_1 absent. (3) Bullæ filled with cancellous tissue.

A nearly related species from the Rosebud shows in addition to these characters some degree of premolar complication. It appears therefore, as Mr. Peterson has already suggested, that *T. siouxensis* should be separated from the Oligocene species, as a distinct subgenus at least, and this is more clearly evident in the Rosebud species, which may be regarded as generically distinct.

Desmathyus gen. nov.

This genus is designed to include peccaries with three upper incisors but the lateral incisor reduced or vestigial and the median enlarged, the first lower premolar absent, premolars beginning to be molariform, bullæ filled with cancellous tissue. Proportions of skull much as in *Perchærus* (*Thinohyus*) and *Dicotyles*, but braincase much smaller than in the modern genus. In *Perchærus* the incisors are of equal size and the dentition complete, the premolars simple and the bulla not cancellous. In all the later genera there are but two incisors; in *Dicotyles* the median one is enlarged, in *Prosthennops* and *Mylohyus* both are vestigial, and the muzzle elongate. In *Platygonus* the crowns of the teeth are higher and crested transversely. In *Prosthennops*, *Mylohyus*, and *Dicotyles* the premolars are more completely molariform.

As type of the genus I take the species described below, and refer to it "*T.*" *siouxensis* as a primitive marginal form transitional from *Perchærus*.

Desmathyus *pinensis* sp. nov.

Type, a skull and part of lower jaw from the upper Rosebud, No. 12936, found by W. D. Matthew. Two other skulls, one with lower jaws complete, the other with lower teeth only, and a lower jaw with fragments of the skull are referred to the species. All are from the same horizon and locality.

The species is distinguished from *D. siouxensis* by greater reduction of i^3 and enlargement of i^1 ; p^1 two-rooted, close to p^2 and separated from c^1 by a diastema; premolars broader and p^3 with well developed deuterocone and posterior heel; skull larger and proportionately broader, especially in the muzzle. The lower jaw is deeper and less angulate beneath the

symphysis; the fourth premolar in the type has a crest representing the entoconid, but in all the referred specimens the entoconid is a distinct cusp. In *D. siouxensis* it is not present.

Measurements. (Type specimen, No. 12936.)		mm.
Skull, length from incisors to occiput		310.
“ “ “ “ “ condyles		270.
“ width at zygomata		141.
Muzzle, width at canines		70.6
“ “ across postorbital processes		107.
Occiput height		108.7
Upper dentition, length		166.6
Palate, width across m^2		71.2
Diameters of i^1 , anteroposterior 12; transverse		15.
“ “ i^2 “ 9; “		8.2
“ “ i^3 “ 5.2; “		4.8
“ “ c^1 “ 17; “		11.
“ “ p^{1-4} , length		48.4
“ “ m^{1-3} , “		60.3
Length from canine to m_2 , lower jaw		106.7
“ of three lower premolars		38.
Lower jaw depth beneath m_1		41.5
Skull No. 12938.		
Length from incisors to occiput		337.

HYPERTRAGULIDÆ.

Hypertragulus ordinatus sp. nov.

Larger than the type of the genus (*H. calcaratus*), about equal in size to *H. hesperius* Hay from the John Day. Distinguished from either species by the closing of the diastema between p_2 and p_3 and great reduction of the diastema between c_1 and p_1 in the lower jaw. The length of the diastema between (the caniniform) p_1 and p_2 is increased, so that the general proportions of the jaw are about the same. Molar crowns more hypsodont than in *H. hesperius*, about as in *H. calcaratus*. P_1 and p_2 are shorter and proportionately higher than in the John Day species, but less reduced than in the White River species.

Two or more undescribed species of *Hypertragulus* are indicated by fragmentary material in our collections from the White River, and at least one from the John Day. In one of the White River species the anterior diastema is closed, a fact that Prof. Cope had evidently observed, as he had given the fragments an appropriate manuscript name. But the diastema between p_2 and p_3 is found in every Oligocene specimen that I have seen; its disappearance may therefore be a mark of progress of the genus.

The type, No. 13011, is a complete lower jaw from the Lower Rosebud beds of Porcupine Creek. The genus is represented by various fragmentary specimens, probably of this species, all from the lower beds. In the Upper Rosebud it is replaced by *Blastomeryx*. The specific name refers to the compact ranking of the teeth resulting from closure of the lesser diastemata.

ANTILOCAPRIDÆ.

MERYCODONTINÆ.

Blastomeryx Cope.

True ruminants (Pecora) are common in the Middle and Upper Miocene of this country, but are not found in the Oligocene. We have found no trace of them in the Lower Rosebud fauna but in the Upper Rosebud are two species referable to *Blastomeryx* Cope, a Middle and Upper Miocene genus nearly related to *Merycodus* Leidy but with more brachyodont teeth.

This genus is evidently an immigrant type, and the only member of the fauna not derivable from the White River and John Day faunæ. The manus and pes are typically pecoran and in no respect transitional from any of the Hypertragulidæ of the Oligocene.

Blastomeryx advena sp. nov.

The type is a lower jaw, No. 13014, which agrees quite nearly with *B. gemmifer* of the Pawnee Creek beds but is considerably smaller. A second lower jaw, No. 13016, with a few skeleton bones, indicates a larger variety or distinct species. A third specimen No. 13015, with a considerable part of the skeleton but no skull parts, probably belongs to this genus. It shows the structure of manus and pes almost identical with that of *B. gemmifer*.

