Article XXII.—A HORNED RODENT FROM THE COLORADO MIOCENE. WITH A REVISION OF THE MYLAGAULI, BEAVERS, AND HARES OF THE AMERICAN TERTIARY.

By W. D. MATTHEW.

Ceratogaulus rhinocerus, n. g. et sp.

The writer has recently described part of the skull of a *Mylagaulus* from the Colorado Loup Fork beds, found in 1898. A nearly complete skull, with one ramus of the lower jaw, found by Mr. Brown of the Expedition of 1901, indicates a new genus of this family, distinguished by the unique character (for a rodent) of a pair of large connate processes on the nasals resembling the horn-cores of some Ungulata, and giving the skull a profile absurdly like that of a miniature rhinoceros.

The skull is a little larger than that of *Mylagaulus*, and displays considerable modifications, chiefly conditioned by the development of the horn-like processes on the nasals. The muzzle is much wider and tapers forward; the nasals are much wider throughout, and especially in the middle, where they bear the horn-cores. The postorbital processes of the frontal and jugal bones are considerably less prominent and placed farther back, making the orbit larger and more extended anteroposteriorly. The zygomata are deeper. The enlarged molar in the upper jaw differs a little in form, and considerably in the pattern of the crown. The penultimate upper molar appears to be considerably larger in proportion, but is so much damaged in the *Mylagaulus* skull that it cannot be closely compared. The enlarged molar of the lower jaw displays a crown pattern with the usual lakes in three longitudinal rows, instead of four as in *Mylagaulus*. The alveoli of the second and third molars are of nearly equal size, while in *Mylagaulus* the penultimate alveolus is much larger. The type specimen No. 9456, is of nearly the same age as the *Mylagaulus* skull with which it has been compared, the wear of

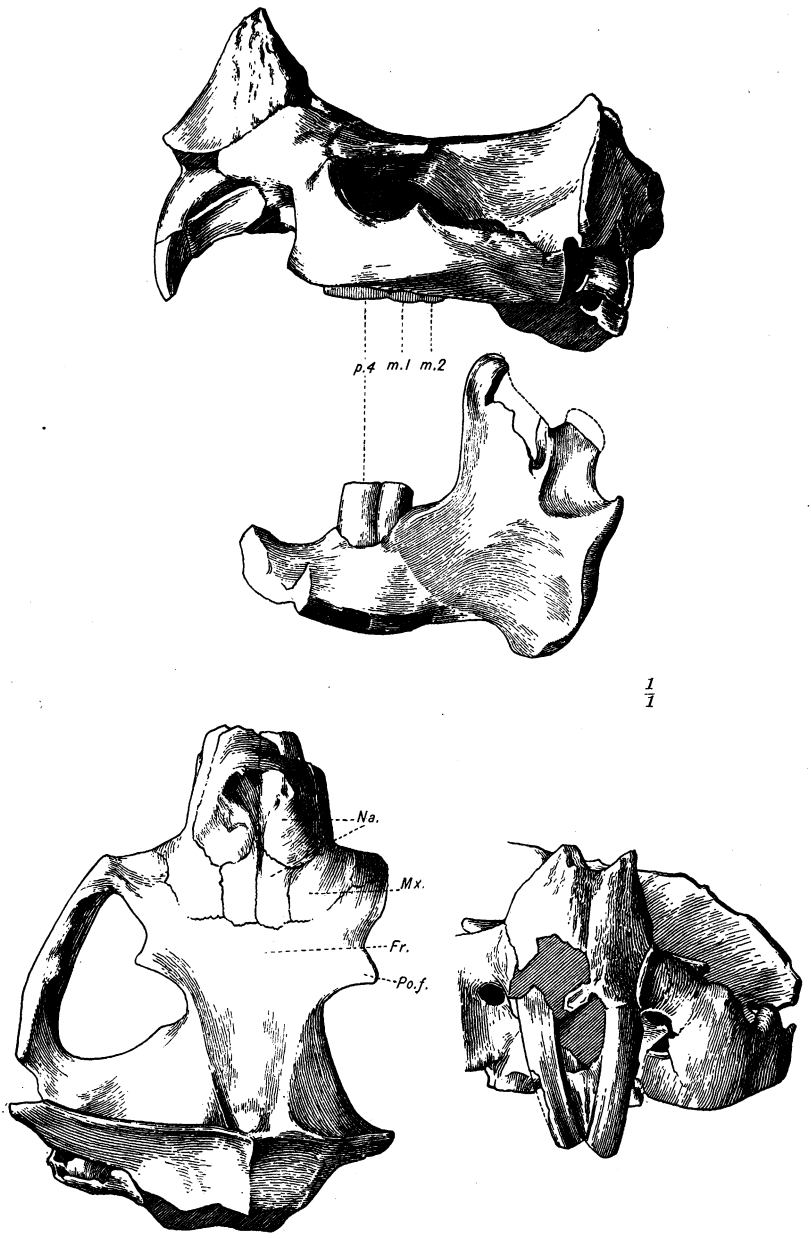


Fig. 1. *Ceratogaulus rhinocerus.* Skull and jaw, natural size. Superior, lateral and anterior views. No. 9456 (type). Loup Fork, (Pawnee Creek Beds) Colorado.

the teeth being slightly less advanced. The distinctions, therefore, cannot be due to age. The horn-like processes might be sexual, although I can find no parallel among the rodents for such a wide divergence between male and female; but the marked distinctions in the teeth and other characters are not likely to be sexual, although in themselves they are not of generic importance.

The height of the horn-cores is about one-fifth the length of the skull, their length a little more, and their conjoined width about one-fourth the skull-length. The longer axis of each process is diagonal, posteroexternal and anterointernal; the conjoined process is subtrigonal, the angles posteroexternal and anterior.

A character so marked as this would seem a good basis for a separate genus. Nevertheless, the resemblance to the skull of *Mylagaulus* obtained in 1898 is considerable in most characters, except in the horn-cores, the position of the postorbital processes, and the pattern of the enlarged grinding teeth.

The occiput is extraordinarily wide and low, its width equalling the entire length of the skull. The postorbital crests do not unite behind; the top of the skull is flat transversely, concave anteroposteriorly, and the occipital surface slopes 30° forward from the condyles to the top of the crest. The zygomatic arches are stout, deepest in front, somewhat wider than the occiput, both postorbital processes (on the frontal and jugal) moderately strong. In both upper and lower jaws the alveoli of two smaller molars are preserved, but no clear indication of a third, behind the enlarged tooth.

Measurements.

Length of skull (condyle estimated)	68 mm.
Width across arches	64
" of occiput	65
Height of horn-core	13
Length " "	17
Conjoined width of horn-cores	19
Width across postorbital processes of frontals	32
Width across postorbital constriction	18
Least depth of zygomatic arch beneath orbit	9

Length of diastema	20 mm.
" " three upper molars (? p^4–m^2)	15
" " enlarged " molar (? p^4)	8
Width of " " " "	6.5
Height of same (root and crown)	12
Estimated length of lower jaw	58
Depth of jaw beneath molars	15
Height " " (angle to tip of coronoid process)	41
Length of enlarged lower molar (? p_4)	10
Width of " " " "	5.5

This remarkable skull has no parallel among the Rodentia. *Haplodontia* most nearly approaches it in width, but the horn-cores and the specialized teeth are unique.

HIND LIMB AND FEET OF MYLAGAULIDÆ.

We know but little as yet of the skeleton of this family. The pelvis was very massive, and beaver-like on a smaller scale, the tail probably not flattened, and the scaphoid and lunar were united. A metacarpal associated with two teeth of *Mylagaulus* shows some remarkable characters. It is nearly as large as the metacarpals of *Castor canadensis* and much stouter. The distal facet is strongly keeled on the inferior surface, in a manner recalling the distal ends of metapodials of *Chalicotherium* or metacarpals of *Dasypus*. The facet is limited superiorly, so that it is not at all reflexed over the superior surface of the metacarpal, but faces entirely inferiorly and distally. The characters of the bone may be taken to indicate the presence of large digging claws on the manus.

I refer also to this family a remarkable specimen in the Cope Collection from the Loup Fork beds of the Republican River, Nebraska, consisting of a nearly complete hind limb and foot, with an ungual phalanx of the fore foot, not associated with any parts of the skull. This specimen combines characters of a Castoromorph rodent, with a resemblance to the modern armadillo so striking that I am unable to state positively that it is not edentate.[1] As nearly as I can judge, however, the ar-

[1] Professor W. B. Scott, whose recent extensive and thorough studies of the Santa Cruzian fauna give especial weight to his authority, has examined this specimen and pronounces it probably rodent and certainly not edentate.

madillo resemblances may be explained as all associated with the development of digging claws, chiefly on the fore foot, and walking on one side of the foot in consequence. The Castoromorph characters, on the other hand, appear to be such as would indicate real relationship, although not close relationship to any living form. From the phalanx just described we have reason to infer that *Mylagaulus* developed large digging claws on the fore foot, and this specimen is of appropriate size and proportions to belong to the *Mylagaulus*. It is found in the same horizon, and could not belong to any other rodent known from those beds, for all the others are quite nearly allied to still existing genera. Edentates have not been found in the Loup Fork,[1] and our specimen shows no resemblance to

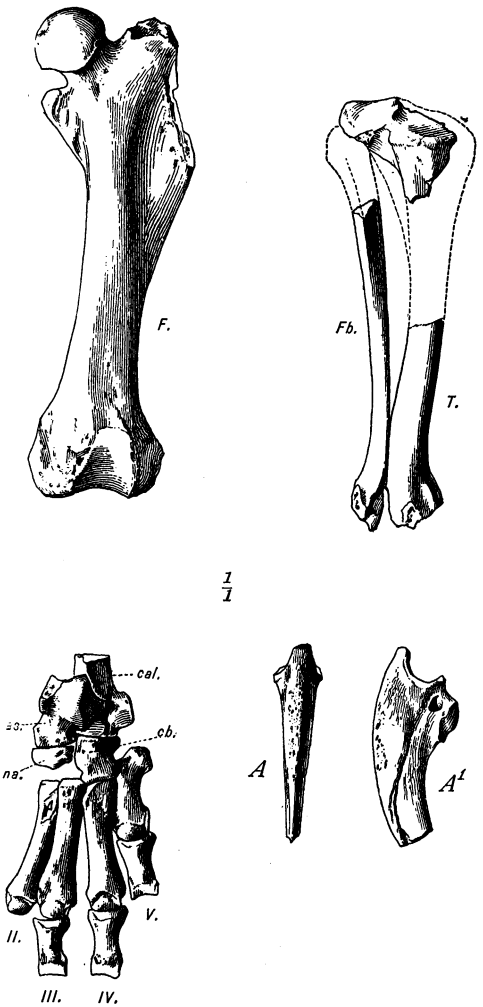


Fig. 2. Mylagaulid, indet. Hind limb bones and claw, natural size: *F*, anterior view of femur; *Fb. T.* posterior view of tibia and fibula; superior view of pes; *A*, *A*,[1] superior and lateral views of ungual phalange of fore foot. No. 8336. Loup Fork, (Republican R. Beds) Kansas.

[1] The supposed exception, *Caryoderma snovianum*, is, according to Williston, a turtle.

any known fossil edentate, the resemblance being only to *Dasypus*, and to a much less extent to *Tatusia*. From this it seems reasonably safe to infer that it is a Mylagaulid, and that this family paralleled the Armadillos in the structure of their feet.

The *femur* (Fig. 2, *F*) is nearly complete; it differs from either beavers or armadillos in the position of the very large and powerful third trochanter, which is placed high up on the shaft, nearly opposite the second trochanter, instead of in the middle of the shaft as is usually the case. The greater and lesser trochanter are much as in *Castor;* the distal condyles are wide and low, and the trochlea short, broad, and shallow.

Most of the *tibia* and *fibula* (Fig. 2, *Fb.*, *T.*) are preserved; the tibia is short and stout, beaver-like at the lower end; the fibula as strong as in *Castor*, separate from the tibia, with a vertical internal facet for the astragalus, but no distal facet, and no contact with the calcaneum. The astragalus (Fig. 2), is quite rodent-like, with moderately broad trochlea defined by sharp keels internally and externally, rather small neck, and broad, flattened head. Metatarsals II to V are present, but the hallux was rudimentary or absent. The second metatarsal is much more slender than the third and fourth, but of about the same length. Mt. V is only three-fifths as long as the others, but fully as stout as mt. III and IV. The phalanges of the first row are rather short, their distal facets wide, not deep, moderately concave from side to side. The size and strength of the metatarsals and proximal phalanges does not appear adequate to bear the very large claw (Fig. 2, *A*, A^1) with which they are associated, and I therefore suppose that it belongs to the fore foot, where the much stouter and more specialized metacarpal, such as has been described as occurring with teeth of *Mylagaulus*, could very ap-

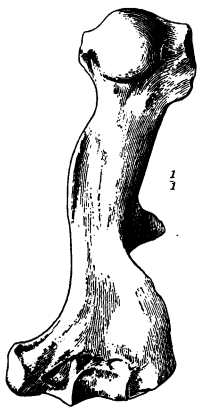


Fig. 3. Humerus of ? *Ceratogaulus*, natural size. No. 9457. Loup Fork (Pawnee Creek Beds), Colorado.

propriately bear it. This claw phalange is long, compressed, the proximal facet very little keeled, the distal end slightly fissured but not symmetrically so, and shows no hood at the base.

The hind foot when set in position on wax shows an unmistakable twist, the external side being bent down distally as if the animal walked on the outside edge of the foot, turning the claws inward underneath. This may serve to explain the short, stout fifth digit, as contrasted with the long, slender second; a proportion seen also in the armadillo and some other modern Edentates.

REVISION OF THE SPECIES.

On comparing the two skulls and three other more fragmentary specimens from Colorado with five specimens of *Mylagauli* from Nebraska in the Cope Collection, it appears that a considerable number of species are represented. On reviewing the description of *Mesogaulus ballensis* Riggs I find that I was in error in identifying it with *Mylagaulus monodon*, but its position can hardly be determined until more is known of the milk dentition and the history of the changes in tooth pattern in this curious family. As far as at present determinable the characters of the known species are:

Mylagaulus monodon *Cope.* Type, a jaw with the enlarged molar and two alveoli posterior to it, from the Loup Fork of the Republican River Valley. A second specimen, a lower tooth from the same locality, referred to it by Professor Cope, is considerably larger. Enamel lakes in four rows. There are seven lakes in the type; nine in the associated specimen. No cement outside external enamel ring.

	No. 8327 (type).	No. 8328
Extreme anteroposterior diam. of molar	? 11.5 mm.	13.5 mm.
transverse " " "	——	6.5
Anteroposterior diam. of grinding surface	10.5	11
Transverse " " " "	6	6

Mylagaulus sesquipedalis *Cope.* Type, an upper molar, No. 8329. Referred specimen a lower molar and incisor and a metacarpal, No. 8330. Both from the same locality as *M.*

monodon. They are much smaller, and the pattern of the enamel lakes simpler and more irregular. Those of the lower tooth are six in number, corresponding in position to the lakes in *M. monodon*, but less elongated, fewer in number, and less regularly arranged. Grinding surface of upper molar regularly oval, with six lakes irregularly arranged.

	No. 8329 (type).	No. 8330
Upper molar, extreme anteroposterior diameter..	10 mm.	
" " transverse.....	5.5	
" anteroposterior diam. of grinding surface.....	8	
" transverse diam. of grinding surface.	5.5	
Lower molar, anteroposterior diam. (estimated)..		8.5
" transverse "		4.5

Mylagaulus (Mesogaulus) ballensis *Riggs.* Type, a lower jaw containing three teeth, from the Deep River beds of Montana. Size of *M. sesquipedalis*, but with only four enamel lakes and, according to Mr. Riggs's drawing, a heavy band of cement surrounding the grinder. Our specimens show nothing like this; several have a thin layer of cement over parts of the outside, but never at the grinding surface, except in a supposed milk-tooth in which the enamel ring does not come up to the grinding surface.

Dimensions, from Riggs's Description.

Anteroposterior diameter of grinder.....	9 mm.
Greatest lateral breadth of "	4.2

Mylagaulus lævis, n. sp.

M. monodon MATTHEW, Mem. Am. Mus. Nat. Hist. I, 1901, 377. Not *M. monodon* Cope.

Type, front half of skull and jaw, pelvis, and other fragments from the Loup Fork of Colorado. Smaller and less robust than *M. monodon*, pattern of lower molar similar, with seven lakes arranged in four rows. Upper molar flattened externally, not regularly oval like that of *M. sesquipedalis*, lakes longer, narrower, and lying more regularly parallel. Nasals smooth.

Dimensions.

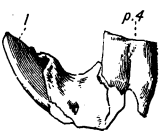
Lower jaw, diameter of enlarged molar, anteroposterior (grinding surface)	9 mm.
Lower jaw, diameter of enlarged molar, transverse (grinding surface)	5
Upper jaw, diam. of enlarged molar, anteroposterior (grinding surface)	9
Upper jaw, diam. of enlarged molar, transverse (grinding surface)	5.8

Ceratogaulus rhinocerus, n. sp.

Generic characters: Nasals bearing a large pair of horn-like processes, closely twinned. *Specific characters:* Size somewhat larger than that of *M. lævis*, less than that of *M. monodon*. Enamel lakes of lower molar simpler, seven in number, arranged in three rows, less regular than those in *M. monodon* or *M. lævis*. Alveoli of last two molars of subequal size. External side of upper grinder flat, internal strongly convex. Second upper grinder larger than third. Muzzle broader than in *M. lævis*, postorbital processes shorter and more posterior.

Dimensions of the Enlarged Grinders.

	Upper.	Lower.
Anteroposterior diameter.	8.7 mm.	9.7mm.
Transverse "	6.5	5.5



Mylagaulus paniensis, n. sp.

Fig. 4. *Mylagaulus paniensis*, part of lower jaw. No. 9361 (type) Loup Fork (Pawnee Creek Beds), Colorado.

A small and simple species indicated by half a lower jaw and a few fragments. There are five enamel lakes, of which the three interior ones are arranged in a row as in *M. ballensis;* and external to these are a large and a small lake, the latter corresponding to the fourth lake of *ballensis*. The tooth is worn well down, while that of *ballensis* appears to be a comparatively young individual, so that the less number of lakes in Mr. Riggs's species can hardly be due to greater age; and on

our specimen is no trace of external cement. This specimen comes from the base of the Loup Fork beds at Courthouse Butte, near Pawnee Buttes, Colorado.

Dimensions, No. 9361.

Anteroposterior diameter of lower molar	7.4 mm.
Transverse " " " "	4
Length of diastema	7
Transverse width of incisor	3
Anteroposterior diameter of incisor	4

CASTORIDÆ.

Steneofiber *Geoffroy.*

The pattern of the molars in this genus is so evanescent that it is almost impossible to make satisfactory comparisons of species on the limited number of specimens available. The essential pattern of the upper teeth consists of a deep internal enamel inflection and three external ones, the anterior and posterior of which quickly become fossettes. In the lower teeth the pattern consists of a simple external and three internal inflections, the anterior and posterior internal inflections soon becoming fossettes. With moderate wear the crown is divided transversely, by the internal and external inflections, into an anterior and a posterior column, united at the base, each column containing a fossette, sometimes more than one. The teeth become broader transversely with wear, and much less in their anteroposterior diameter; the anterior column increases and the posterior one diminishes in size in the upper teeth, while the converse holds true in the lower teeth. The enamel folds become closer, and their direction changes with wear; the internal one in the upper teeth, the external one in the lower, becoming more nearly anteroposterior in direction. The principal inflections in old individuals have become fossettes, while the minor inflections have disappeared. The last molar in young individuals appears small in proportion, because of the small area of the grinding surface; in older individuals it appears larger in proportion. The fourth premolar of

young individuals likewise appears small in proportion to the first and second molars, but reaches its maximum of size earlier than does the third molar.

These observations are based on the American species, which are a rather closely allied group, characteristic of the Oligocene, and more primitive than the European assemblage of species, which are characteristic of the Miocene epoch, and in general larger, longer-toothed, and nearer to the modern branches. The *S. viciacensis* of the Upper Oligocene (St. Gérand-le-Puy) appears to be the nearest to the American group. The distinctions between our species have been based, unfortunately, chiefly on the evanescent pattern of the teeth, not sufficiently considering the great alteration due to a comparatively slight difference in their wear. Seven species have been described, as follows:

1. *S. nebrascensis* Leidy. White River, S. Dakota, skull and jaws.
2. *S. pansus* Cope. Loup Fork, N. Mexico, upper and lower jaws, etc.
3. *S. peninsulatus* Cope. John Day, Oregon, skull.
4. *S. gradatus* Cope. John Day, Oregon, skull.
5. *S. montanus* Scott. White River, Montana, teeth and skeleton fragments.
6. *S. hesperus* Douglas. White River, Montana, lower jaw.
7. *S. complexus* Douglas. White River, Montana, part of skull and jaws.

I have at hand for comparison the types of all the species except the first two, besides three other skulls and some less complete material. I am indebted to the courtesy of Professor Scott and Mr. Douglas for the loan of the type specimens of the species described by them. In revising these species it has been necessary to reject a large part of the distinctions made by their authors, as being merely a matter of different age in the type specimens.

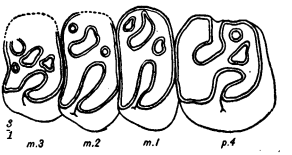


Fig. 5. *Steneofiber nebrascensis.* Upper molars x ⅔. No. 1428. White River (Protoceras Beds), South Dakota.

1. **S. nebrascensis.** I refer here a skull, No. 1428, which, like Leidy's type, comes from the Protoceras beds, and part of a lower jaw, No. 1028*b*, in our

collections. The former is an older animal than Leidy's type, the latter younger. The species appears to be distinguishable by the long, narrow muzzle, small bullæ, sharp sagittal crest, and small brain-case. The postorbital constriction is moderate, the pattern of the teeth rather complicated, two deep fossettes anterior to the external inflection on p^4 remaining in the well-worn teeth of No. 1428.

2. **S. peninsulatus.** Besides the type skull, another skull, less crushed, a skull and jaws, and several parts of jaws, etc., referable to this species, are in the Cope Collection in this museum. It is a more robust species than the last, distinguishable by the large bullæ and probably by the broader muzzle, wide occiput, larger brain-case, and wider sagittal crest. The postorbital constriction is very narrow in the type, but not in the second specimen. The teeth are much like those of *S. nebrascensis*, but the second anterior fossette of p^4 apparently remains longer as a branch from the medial external enamel inflection. The fossette remaining from the posterior external enamel inflection of p^4 has almost disappeared in the type and another specimen, but shows no signs of breaking up into three little fossettes, as it apparently has done in the type of *S. nebrascensis*. The specific validity of these distinctions in the tooth pattern is very questionable; the two sides of a single skull seldom agree at all closely, and this may well be an advanced mutation or subspecies of *S. nebrascensis*, the large bullæ being the clearest distinction.

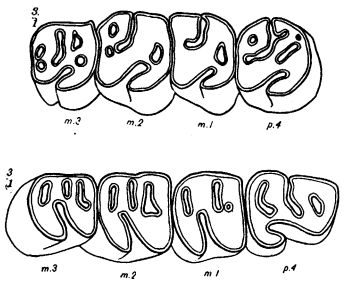


Fig. 6. *Steneofiber peninsulatus.* Upper and lower molars. x ½. Type. No. 6998. John Day (? Diceratherium Beds), Oregon.

3. **S. gradatus.** The type skull, and the palate of a somewhat older individual are in the Cope Collection. It is a smaller animal than the two preceding species, with short, wide muzzle, postorbital constriction moderate, brain-case short and rounded, temporal crests not uniting to form a single

sagittal crest for some distance back of the postorbital constriction. Bullæ of moderate size; grinding series of teeth near together anteriorly, divergent posteriorly. The teeth decrease in size from p^4 to m^3 more than they do in *S. nebrascensis* or *S. peninsulatus;* there is but one fossette anterior to the external enamel inflection on the type, while our referred specimen of *S. nebrascensis* shows two, neither near extinction, although the teeth have attained the same stage of wear. The external enamel inflection has given off a small fossette on the left premolar of the type, but not on the right one; in both type and referred specimen the fossette of the posterior enamel inflection has disappeared.

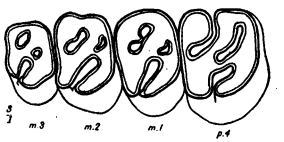


Fig. 7. *Steneofiber gradatus.* Upper molars x $\frac{2}{1}$. Type. No. 7007. John Day (? Diceratherium Beds), Oregon.

4. **S. pansus.** The upper and lower jaws are the only parts of the head known, and I have no certainly referable material to asisst in determination of the characters. Professor Cope's figures indicate an old individual, and apparently that the posterior enamel inflection of the upper teeth was more deeply impressed than in *S. gradatus*, which it resembled in the presence of but one fossette anterior to the median enamel inflection. The form and proportions of the molars, on which Professor Cope relied to distinguish it from other species, are merely a matter of age, as far as any separation from *S. peninsulatus* and *nebrascensis* is concerned. The bullæ are very large, as in *peninsulatus*, which it most nearly approaches as far as known, although presumably distinct, as it is recorded as found at a much higher horizon.

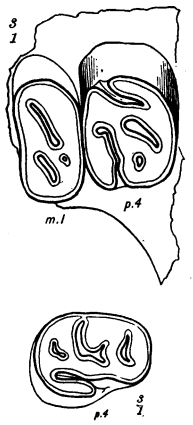


Fig. 8. *Steneofiber montanus.* Upper and lower molars x $\frac{2}{1}$. Type. Lower Beds of Smith Creek, Montana (Lower Miocene).

5. **S. montanus.** Allied to *S. nebrascensis*, but larger, with somewhat longer teeth, and enamel inflections deeper and more complex. The type is an old individual, whence the antero-

posterior direction of the internal upper and external lower enamel inflections, on which Professor Scott largely relies to distinguish the species. Two anterior fossettes are preserved on p^4, while the posterior fossette has already disappeared.

6. **S. hesperus.** Founded on the lower jaw of a young individual which is certainly close to *S. montanus* if not identical; the difference in age prevents any accurate comparison. The size is the same at similar points of wear; the upper incisors are more rounded externally, but the value of this character is doubtful. The depth and complexity of the enamel folds, as nearly as I can judge on the specimens, correspond fairly well.

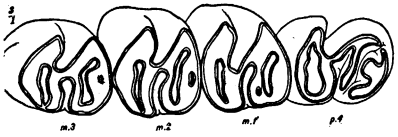


Fig. 9. *Steneofiber hesperus.* Lower molars x ⅔. Type. White River, Montana.

7. **S. complexus.** Founded on the anterior half of the skull and jaws of an animal younger than any of the preceding types, still retaining the milk premolars. The skull has the long, slender muzzle of *S. nebrascensis;* the postorbital constriction is moderate, and the temporal crests do not unite into a sagittal crest, but are separate, as in *S. gradatus*. The difference in wear precludes comparison of the teeth with those of the remaining species; the dimensions of the masseteric scar and coronoid process given by Mr. Douglas as distinguishing characters likewise change with age so much as to be unsafe specific distinctions. The separate temporal crests may constitute a valid specific distinction.

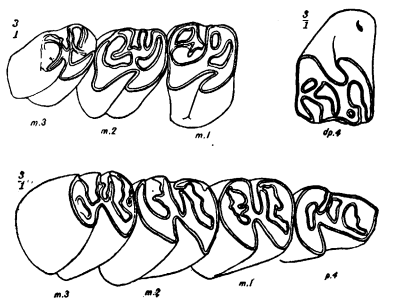


Fig. 10. *Steneofiber complexus.* Upper and lower molars. x ⅔. Type. White River (?), Montana.

Eucastor (*Leidy*) *Allen.*

This genus is represented by a single species found as yet only in the Nebraska Loup Fork. The teeth are considerably

more hypsodont than in the American *Steneofibers;* the molars have but one internal and one external enamel inflection (fossettes in the type specimen). The upper premolar has three external and the lower premolar three internal inflections, as in *Steneofiber* and *Castor*. The position of *Eucastor* is very doubtful; if, indeed, it is a true Castorid at all, it cannot be very nearly allied to either *Castor*, or *Steneofiber*. To this genus and species probably belong, besides the type, parts of two lower jaws in the Cope Collection.

Fig. 11. *Eucastor tortus* Leidy. Lower molars x ¾. No. 8332 (Cope Coll.) Loup Fork (Republican River Beds), Nebraska.

OTHER CASTORIDÆ FROM THE LOUP FORK.

The two isolated teeth which form the type of Leidy's *Hystrix venustus*, if they are really from the Loup Fork, are much more likely to be Castorid than Hystricid, the latter not being likely to occur as far down in the Tertiary of the Western States as the Miocene. Possibly with these species should be associated a broken tooth from the Colorado Loup Fork, of the same size and general proportions and pattern as *H. venustus*. Another isolated tooth from the same beds, No. 9364, represents a species probably undescribed, a little larger than *S. montanus*, more hypsodont and of more complicated pattern. A third specimen is part of a lower jaw with m_2–$_3$, the latter just emerging. This is much more brachydont than *Steneofiber*, although of somewhat the same general pattern, and somewhat smaller than the described species. The style of the teeth suggests *Spalax* rather than any other genus of Rodentia with which I am acquainted.

Fig. 12. *Steneofiber* sp. indesc. Upper premolar x ¾. No. 9364. Loup Fork (Pawnee Creek Beds), Colorado.

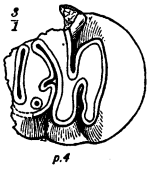


Fig. 13. ? Castorid, indet. x ¾. Loup Fork (Pawnee Creek Beds), Colorado.

Fig. 14. ? Castorid, indet. Last two lower molars x ¾. Loup Fork (Pawnee Creek Beds), Colorado.

LEPORIDÆ.

Palæolagus *Leidy.*

The genus was based on the division of the anterior lower premolar into two columns, instead of three as in *Lepus*. The dentition and characters of the front of the skull and of parts of the skeleton were fully figured and described at length by Professor Cope in his 'Tertiary Vertebrata,' and have been further discussed and revised in recent papers by Dr. Forsyth-Major on the Lagomorpha. We are now enabled to add certain skull characters, not hitherto known.

Palæolagus has a well-developed postfrontal process in all four species, scarcely less than in *Lepus ennisianus*, but much less than in modern Lepores. The angle between basicranial and basifacial axes varies considerably in the different species, but in none is it as great as in the modern species of *Lepus*. The brain is relatively smaller than in *Lepus*. The tooth pattern varies greatly during life; in the young it approximates that of *Lepus*, especially in such species as *L. ennisianus;* in the old animal it becomes much simpler. *P. agapetillus* is the most advanced in tooth, but least in skull, characters; *P. intermedius* most nearly approaches the John Day *Lepus*.

The pattern of the teeth changes greatly in *Palæolagus*, apparently from the superposition of a new pattern (that of *Lepus*) on an older and simpler one. The young individuals show an internal inflection on the upper molars, whose depth and persistence varies in the different species; there is also an external inflection, never deep, but rather persistent, and a median crescent which originates as an anterior marginal inflection on p^2, an anteroexternal one on p^3 (apparently median-external on p^4 and m^1), a postero-

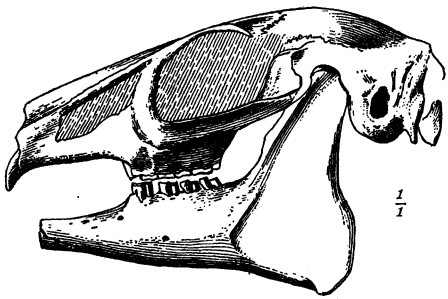


Fig. 15. *Lepus ennisianus.* Cope. Skull and lower jaw natural size. Type specimen No. 7190. John Day, Oregon. Muzzle supplied from another individual.

external one on m^2, and a posterior one on m^3. The median crescent is somewhat less persistent than the internal inflection. Enamel is lacking on the external side of the teeth except in very young animals.

The internal inflection is that which has become deeper and more persistent in *Lepus;* the crescent has disappeared in modern species of *Lepus*, and in the John Day *L. ennisianus* apparently does not persist as long as in *Palæolagus*. The enamel fails on the external side of the upper teeth of *Lepus* except for a little while after they are protruded.

Dr. Forsyth-Major has suggested that the second upper incisor of the Lagomorpha has originated from the posterior cusp of such a tooth as that of *Plesiadapis;* the bifanged tooth splitting in two and the large anterior cusp giving rise to the large incisor of the modern lagomorph. *Palæolagus*, he thinks, might help to verify this theory. But the incisors of *Palæolagus* are quite of modern type. It is to the lower Eocene Rodentia, including the Mixodectidæ, or to the as yet little-known fauna of the Cretaceous, that we must look for light on the method of evolution of their teeth. But Eocene Lagomorpha have not yet been discovered.

Palæolagus approaches most nearly to Forsyth-Major's *Caprolagus* group among modern Leporidæ. These species are less specialized for speed, and in consequence the head is carried lower and more forward, and the basicranial and basifacial axes are at a smaller angle.

Angle between basifacial and basicranial axes in different species of Palæolagus and Lepus.

P. agapetillus	7°
P. intermedius	20°
P. haydeni	22°
L. ennisianus	33°
L. campestris	47°

Palæolagus ? agapetillus *Cope.*

Professor Cope held this species as distinct in 1874, but in 1884 united it with *P. haydeni.* A skull found by our party

in 1898 in the upper levels of the White River beds appears distinct from *P. haydeni*. It is smaller, more narrow and elongated, the muzzle more slender. The anterior half of another skull and several jaws, chiefly or all from the same upper horizon, may be referred here, although they approach *P. haydeni* somewhat more nearly than does the complete skull. The distinctive characters are: slender and narrow muzzle, small teeth, internal median fold of enamel on upper molars more deeply incised and more persistent than in *P. haydeni*. The species appears to be good, on the evidence of some half-dozen specimens referred to it and compared with the very numerous *P. haydeni* specimens in our collections. Whether the type of *P. agapetillus* is properly referred to it, I am unable to decide; but leave it provisionally.

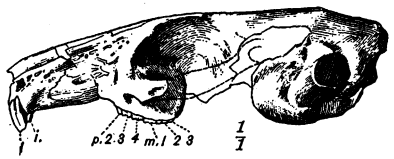


Fig. 16. *Palæolagus ? agapetillus.* Skull, natural size. No. 8704. White River (Martin Cañon Beds), Colorado.

Palæolagus haydeni *Cope.*

Tricium annæ Cope; *Tricium avunculus* Cope; *Tricium leporinum* Cope.

The additional specimens collected by American Museum parties include no complete skull of this species. The best one, No. 9327, shows a skull shorter and wider than *P. agapetillus* or *intermedius*, brain-case rounder than in either, basifacial axis bent down about as in *P. intermedius*, arch heavier than in *Lepus ennisianus*, the jugal a band of uniform width, thickened at the upper and lower margins. Teeth larger than in *P. agapetillus*, less transversely broadened, medial internal furrow less deeply incised or persistent. A scapula, vertebra, and metapodial, associated with this specimen, agree in size with Cope's skeleton material of *P. haydeni*.

Palæolagus intermedius *Matthew.*

Type, a nearly complete skull from the upper levels of the White River, at Castle Rock, Cedar Creek, Col. Associated

type, upper and lower jaws and fragments of skeleton from same level and region.

This skull is much more depressed on the basicranial axis than *P. agapetillus;* it has a long and heavy muzzle, unlike the slender, sharp muzzles of the two preceding species; the teeth are larger than those of *P. haydeni*, but resemble them in pattern; the length of the diastema is equal to that in *P. turgidus*, but the teeth are much smaller, and of more *Lepus*-like pattern; the skeleton appears to be as large as that of *P. turgidus*, and of similar proportions. The postfrontal process is nearly as large as in *Lepus ennisianus;* the muzzle is of the same length as in that species, but heavier; the basifacial axis is somewhat less depressed, and the brain-case is distinctly smaller.

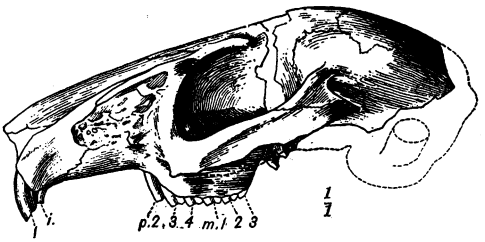


Fig. 17. *Palæolagus intermedius.* Skull, natural size. Type. No. 8722. White River (Martin Cañon Beds), Colorado

Palæolagus turgidus *Cope.*

P. triplex Cope; ? *Tricium paniense* Cope.

Young jaws of this species show a third lobe on the p_4–m_2 and a third lobe on p_3, both of which disappear in the old animal. The jaw on which *P. triplex* was founded appears to be a juvenile stage of *P. turgidus*, in which these characters are very marked. We have no other jaws of the same age; but if the twelve or fourteen examples of lower jaws be arranged according to age (determined by wear on end of p_3) they form a perfect series from *P. triplex* to the type of *P. turgidus*. Cope, in comparing the series, came to the conclusion that the difference between *P. turgidus* and *P. triplex* could not be entirely explained as a matter of age; but the present writer is unable to see sufficient difference to warrant the retention of the species.

Part of a skull, No. 1429*a*, is referred here; it belongs to a very old individual, and the tip of the muzzle and brain-case are missing. It appears to be a short-skulled species, considerably broader but not much longer than *P. intermedius;* the angle of the basifacial axis cannot be determined, and the teeth are very much worn, so that the internal inflection of the enamel has disappeared on the molars, although it persists on pm_4.

Very little additional material of this species has been found by our party, and none that throws any new light on the younger stages of tooth-change, so that Professor Cope's provisional reference of *Tricium paniense* (juvenile *P. turgidus*) cannot be confirmed.

Palæolagus temnodon *Douglas.*

Allied to *P. haydeni* but probably distinct, as it comes from a lower horizon and a widely separate locality.