

Article X.— A REVISION OF THE LOWER EOCENE WASATCH
AND WIND RIVER FAUNAS.

BY W. D. MATTHEW AND WALTER GRANGER.

PART III.— ORDER CONDYLARTHRA.

FAMILIES PHENACODONTIDÆ AND MENISCOTHERIIDÆ.

BY WALTER GRANGER.

Family PHENACODONTIDÆ Cope, 1881.

Four genera have been commonly placed in this family, *Protogonodon* and *Tetraclænodon* from the Puerco and Torrejon formations, respectively, of the Basal Eocene, and *Phenacodus* and *Ectocion* from the various horizons of the Lower Eocene. Of the genus *Protogonodon* from the Puerco the writer feels that it should be removed from the family, the chief reasons being the lack of anything like a well developed hypocone on the upper molars and the basining of the lower molars. Earl has suggested ¹ its affinities with the ancestral Artiodactyl stem and while the lower molars do resemble very much those of the Bunodont Artiodactyla of the Lower Eocene, yet the premolars are already showing a tendency toward complication as evidenced by the presence of an incipient metaconid on p₄. It seems more probable that *Protogonodon* is a Creodont belonging to either the Oxyclænidæ or Arctocyoniidæ.

If *Protogonodon* be removed from the family, the tooth characters may be defined as follows:

Dental characters of the Phenacodontidæ. First and second upper molars quadrate and consisting of four principal cusps and two intermediates, no marked tendency toward the formation of a metaloph but the conules often uniting with the protocone to form a V; third upper molar always somewhat reduced and differing in outline from the other two molars because of the reduction of the metacone, the hypocone, or both; first and second lower molars composed of four principal cusps, subequal in size, and a prominent

¹ Amer. Nat., 1893, p. 377.

hypoconulid, and usually with small accessory cusps on both the anterior and posterior slopes of the metaconid and on the anterior face of the entoconid; hypoconid and metaconid separated by a valley; last lower molar similar to anterior ones but with the hypoconulid enlarged and produced into a short heel, the tooth being usually the longest and always the narrowest of the lower molars; posterior upper and lower premolars with a strong tendency to become molariform; first lower premolar single-rooted; first

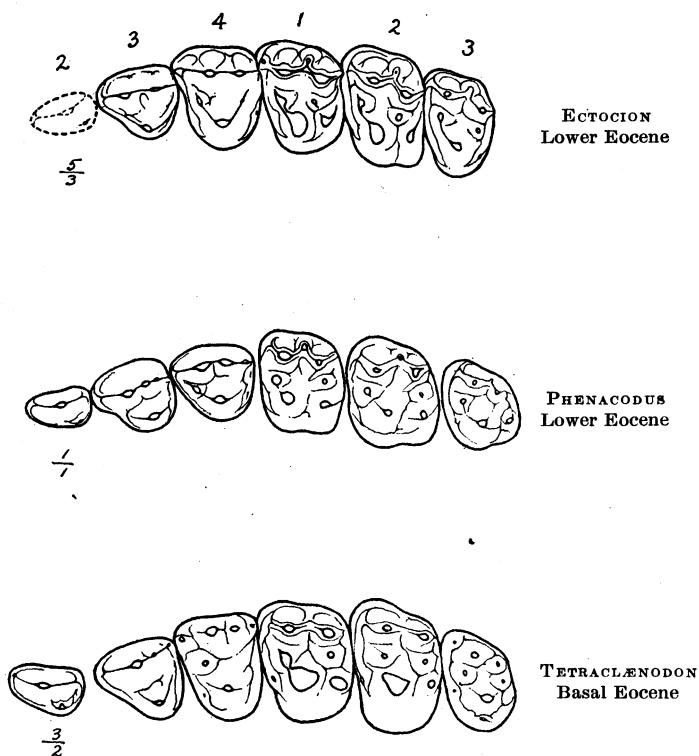


Fig. 1. Outlines of upper cheek-teeth of the three genera of Phenacodontidæ.

upper premolar two-rooted in some forms; canine of moderate size; incisors broad, chisel-edged.

Occurrence. *Tetraclænodon* is confined to the Torrejon¹ where it is the most abundant form, specimens of the genus constituting about one-fifth of the entire collection from this horizon. *Phenacodus* and *Ectocion* range together throughout the Lower Eocene, from the Clark Fork to the Lost

¹ A closely related, possibly identical, genus is found in the Fort Union beds in Montana.

Cabin. In the Clark Fork beds the family predominated to a still greater extent than in the Torrejon, at least three-fourths of the specimens obtained from this horizon being of this family and the collecting was done at various levels and over a considerable areal range. *Phenacodus* is fairly common in the Clark Fork, most abundant in the Gray Bull and fairly common again in the Lysite and Lost Cabin. *Ectocion* is most abundant in the Clark Fork,

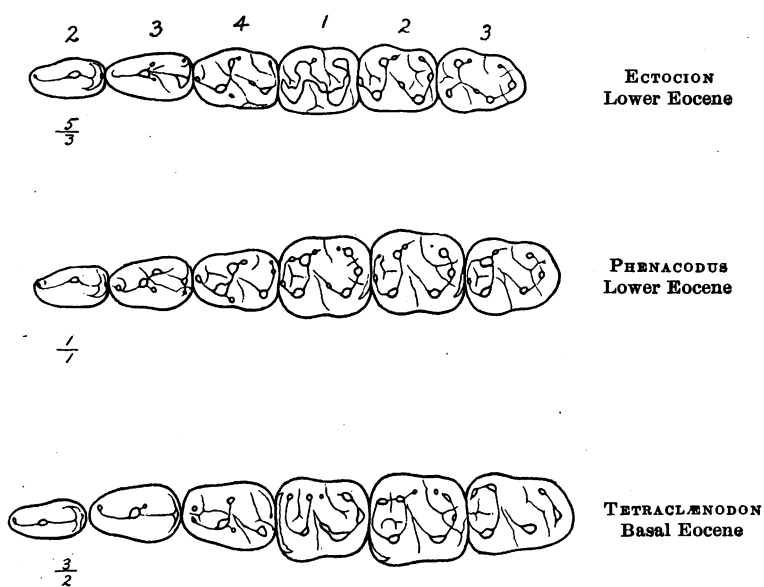


Fig. 2. Outlines of lower cheek-teeth of the three genera of Phenacodontidae.

common in the Gray Bull, absent from the Lysite and rare in the Lost Cabin. In the New Mexico horizons *Ectocion* is absent while *Phenacodus* is rather uncommon in the lower and rare in the upper level.

Key to Genera of Phenacodontidae.

- A. Mesostyle rudimentary or absent.....*Tetraclænodon*.
- B. Mesostyle well developed
 - b. Teeth bunodont, mesostyle and metacone weak on m³, p₁ with entoconid weak or absent, p₂ with low posterior basal cusp. M¹ and m² with metaconule on a line between metacone and hypocone or posterior to it.

Phenacodus.
 - bb. Teeth more or less lophodont, mesostyle and metacone well developed on m³; p₁ with strong entoconid, p₂ with high compressed posterior basal cusp; m¹ and m² with metaconule anterior to a line between metacone and hypocone.....*Ectocion*.

Tetraclænodon Scott, 1892.¹

Protoponia COPE, 1881 (preoccupied).

Euprotoponia COPE, 1893.

Type, *Mioclænus flowerianus* Cope, from the Torrejon formation of New Mexico.

In some respects, particularly in the forward position of metaconules and the semi-isolation of the hypocone, this genus shows rather closer relationships with *Ectocion* than with *Phenacodus*. In the absence of any skeleton material of *Ectocion*, beyond an astragalus and a few fragments, it is, however, not possible to make very satisfactory comparisons.

In his Revision of the Puerco Fauna,² Dr. Matthew recognized two species of the genus, *T. puercensis*, the common form, and *T. minor*, a diminutive species represented by only three specimens. There is a wide range among the specimens referred to *T. puercensis*, not only in size but in minor details of cusp development. This variation is found in *Phenacodus* also, and with a large series of specimens, over 300 of *Tetraclænodon*, it is very difficult to select a set of specific characters which works out satisfactorily. It is now known that *Tetraclænodon* comes from two distinct horizons in the Torrejon and a study of the new material of this genus, in which the level of each specimen is known, may yield some definite systematic results.

Phenacodus Cope, 1873.³

Opisthotomus COPE, 1875.

"*Trispondylus*" COPE, 1884.

?*Eohyus* MARSH, 1894 (genotype only).

Type, *P. primævus* Cope, from the Wasatch⁴ of Evanston, Wyo.

There are now in the American Museum Collection several hundred specimens of this genus, representing all of the Lower Eocene horizons of Wyoming and New Mexico. Together they present a bewildering array with their great variation in size and in the lesser characters of the teeth which in many groups would constitute good specific differences but which here often appear to be only individual. The difficulty is increased by the fact that the group shows little or no evolution throughout its range. The last survivors in the Lost Cabin beds cannot be separated specifically from

¹ Proc. Acad. Nat. Sci. Phila., 1892, p. 299.

² Bull. A. M. N. H., 1897, p. 303.

³ Palæont. Bull., No. 17, p. 3.

⁴ Knight formation of Veatch.

those forms of the same size in the Clark Fork, where the genus makes its first appearance. There are obviously several species, indicated by size

No. 15266
A. M.



P. primævus robustus
(Paratype, Gray Bull beds,
Bighorn basin, Wyo.)

No. 4369
A. M.



P. primævus
(Plesiotype, Cope skeleton,
Gray Bull beds, Bighorn
basin, Wyo.)

No. 15286
A. M.



P. primævus hemiconus
(Topotype, Gray Bull beds,
Bighorn basin, Wyo.)

No. 15761
A. M.



P. intermedius
(Type, Gray Bull beds,
Bighorn basin, Wyo.)

No. 4378
A. M.



P. copei
(Type, Cope skeleton, Gray
Bull beds, Bighorn basin,
Wyo.)

Fig. 3. Upper teeth of species of *Phenacodus*.

and the relative proportions of the teeth, and in one or two cases by pre-molar characters of rather doubtful constancy. An effort has been made to hold as many of the old names and to create as few new ones as possible.

***Phenacodus primævus* Cope, 1873.**

Palæont. Bull., No. 17, 1873, p. 3; 1885, Tert. Vert., p. 435, pll. lviib-lviii.

Syn. *P. omnivorus* COPE, 1874.

P. trilobatus COPE, 1881.

P. nunienus COPE, 1885 (in part).

Type of species and genus, Amer. Mus. Cope Coll. No. 4408, a somewhat worn and weathered last lower molar, from the Knight formation¹ of the Wasatch group, on Bear River, near Evanston, Wyo.

So far as I am aware no other specimens of the genus, than the one



P. voritmani
(Topotype, Lost Cabin
beds, Wind River basin,
Wyo.)



P. brachypternus
(Topotype, Gray Bull
beds, Bighorn, basin,
Wyo.)

Fig. 4. Upper teeth of species of *Phenacodus*.

recorded above, have ever been found in the type locality, and for purposes of comparison it has been necessary to select one of Cope's supplementary types from another region. The splendid skeleton from the Bighorn basin, identified by Cope and very thoroughly described and figured in the Tertiary Vertebrata, offers a most satisfactory plesiotype. The skeleton is from a horizon, the Gray Bull, which is probably a stage lower than the Knight beds but there is almost perfect agreement between the type and the corresponding tooth of the plesiotype, so that, in the absence of more complete material from the type locality, the Bighorn basin skeleton must be considered as identical with the type. In the extensive collection of Phenacodonts, a form may be seen to run through several faunal stages without alteration in specific characters.

P. primævus is the largest and commonest of the species of *Phenacodus*.

¹ See Veatch, 1907, U. S. G. S., Prof. Paper No. 56, p. 92.

Its relative abundance in the different horizons of the Bighorn and Wind River basins is shown in the list of specimens in the Museum collection.

Lost Cabin	2 specimens
Lysite	0 "
Gray Bull	225 "
Sand Coulée	3 "
Clark Fork	35 "



No. 15275
A. M.

P. primævus robustus
(Type, Gray Bull beds,
Bighorn basin, Wyo.)



No. 4369
A. M.

P. primævus
(Plesiotype, Cope skele-
ton, Gray Bull beds, Big-
horn basin, Wyo.)



No. 15286
A. M.

P. primævus hemiconus
(Topotype, Gray Bull
beds, Bighorn basin,
Wyo.)



No. 15761
A. M.

P. intermedius
(Type, Gray Bull beds,
Bighorn basin, Wyo.)



No. 4378
A. M.

P. copei
(Type, Cope skeleton,
Gray Bull beds, Bighorn
basin, Wyo.)

Fig. 5. Lower teeth, crown views, of species of *Phenacodus*.

For the most part the specimens are jaws or jaw fragments, but there are a few crushed or distorted skulls and in three instances an approach toward a skeleton.

The dental structure and osteology of the species has been thoroughly described and figured and there is but little to add. Comparatively few of the referred specimens show as long a p_4 as the plesiotype, or as large a hypocone on the m^3 , but there are minute gradations between the extremes in these characters and they appear to be only individual, as are the differences in the prominence of the various accessory cusps on both molars and premolars and the relative size of the last upper and lower molars.

One of the two specimens from the Lost Cabin, a maxilla (No. 14786) from Alkali Creek, Wind River basin, agrees almost exactly, except for a swelling of the mesostyles, with a similar specimen (No. 16058) from the

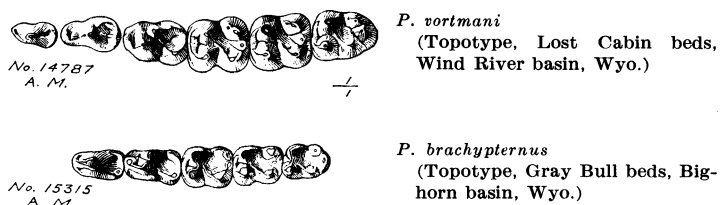


Fig. 6. Lower teeth, crown views, of species of *Phenacodus*.

Clark Fork beds, and both of these are inseparable from the plesiotype from the Gray Bull beds.

Phenacodus nunienus.¹ Under this name Cope described some limb bones which he considered as belonging to the largest species of the genus and which possessed anatomical characters distinct from *P. primævus*. He chose for his descriptions, measurements and figures a humerus and the lower end of a scapula which were found associated with jaws and fragmentary skeleton material belonging to two or more individuals of *P. primævus*, and a skull, jaws and part of skeleton of *Pachyæna ossifraga*. The humerus certainly belongs to the *Pachyæna* specimen and probably also the fragment of scapula. Queerly enough Cope identified and figured² as the humerus of *Pachyæna* a bone which undoubtedly belongs to one of the *Phenacodus* skeletons.

*Phenacodus omnivorus*³ was described by Cope from a last upper molar from the Wasatch of New Mexico, collected in 1874 (Nat. Mus. Coll. No.

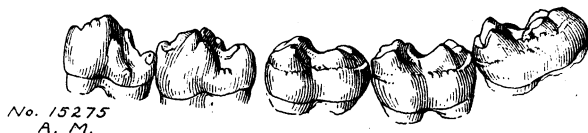
¹ Tertiary Vertebrata, 1885, p. 434, pl. lviig, figs. 7, 8.

² Tertiary Vertebrata, 1885, p. 366, pl. xxiiic, fig. 1.

³ Rep. Foss. Vert. N. Mex., 1874, p. 11.

5382), and which Cope later doubtfully but correctly referred to his *P. primævus*. In a specimen of upper teeth from the same beds, which Cope referred to *P. primævus*, he mistook the second molar for the last, and of course the differences between this tooth and the type of *P. omnivorus* were obvious.

Phenacodus trilobatus Cope¹ was established on a jaw fragment with



No. 15275
A. M.

P. primævus robustus
(Type, Gray Bull
beds, Bighorn ba-
sin, Wyo.)



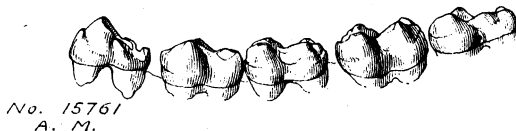
No. 4369
A. M.

P. primævus
(Plesiotype, Cope
skeleton, Gray Bull
beds, Bighorn ba-
sin, Wyo.)



No. 15286
A. M.

*P. primævus hemi-
conus*
(Topotype, Gray
Bull beds, Bighorn
basin, Wyo.)



No. 15761
A. M.

P. intermedius
(Type, Gray Bull
beds, Bighorn ba-
sin, Wyo.)



No. 4378
A. M.

P. copei
(Type, Gray Bull
beds, Bighorn ba-
sin, Wyo.)

Fig. 7. Lower teeth, external views, of species of *Phenacodus*.

¹ Bull. U. S. Geol. and Geogr. Surv., 1881, p. 200.

the three molars (No. 4679), from the Wasatch of the Bighorn basin. Cope differentiated it from *P. primævus* by the presence of accessory cusps on the anterior and posterior slopes of metaconid. In his Tertiary Vertebrata Cope recognized that these characters were merely individual variations.

There is, among the specimens which I have referred to *P. primævus*, a considerable variation in size, relative width, and general robustness of the teeth. And since the specimens showing these variations fall into

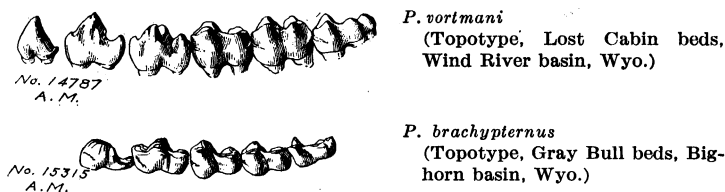


Fig. 8. Lower teeth, external view, of species of *Phenacodus*.

rather well defined groups, it seems well to consider these groups as of subspecific rank, one group being smaller than the plesiotype, the other larger.

***Phenacodus primævus hemiconus* Cope, 1882.**

Phenacodus hemiconus, Proc. Am. Phil. Soc., 1882, p. 179; 1885, Tert. Vert., p. 463, pl. xxve, fig. 16.

Type, Amer. Mus. Cope Coll. No. 4391, a fragment of the upper jaw with the second and third unworn molars; ?Gray Bull beds, Bighorn basin, Wyo., J. L. Wortman, 1881.

The chief distinctions from *P. primævus* pointed out by Cope were the smaller size and the rudimental character of the hypocone and metacone in m^3 . The size of the cusps on this tooth is variable within specific limits and while the individual is somewhat smaller than the type of *P. primævus* yet it seems that it is hardly sufficient to keep it separate as a distinct species. Eleven specimens from the Gray Bull beds and one from the Lost Cabin are referable to this small variety. Of these I select for illustration a topotype consisting of a palate and lower jaws (No. 15286), from the Gray Bull beds, with the third premolar to third molar, above and below, well preserved (Figs. 3, 5, 7). The agreement in size and structural characters with Cope's type are very close.

Phenacodus primævus robustus subsp. nov.

Type, No. 15275, a left ramus with p_3 - m_3 in unworn condition; Gray Bull beds, Bighorn basin, Wyo., Exp. 1910.

Six specimens of *P. primævus* from the Gray Bull have teeth of about the same anteroposterior dimensions as the plesiotype but with greater transverse diameters, giving the teeth a much more robust appearance.

One specimen (No. 15266) shows upper molars and fourth premolar (Fig. 3). Another (No. 4370) has upper and lower jaws, femur, tibia, and lower end of scapula. The limb bones, while not much longer than those of the skeleton of *P. primævus*, are much more massive, the comparative widths across the femoral condyles being 58 and 66 mm. They indicate an animal perhaps two or three inches taller and of at least twice the weight.

Phenacodus intermedius sp. nov.

Type, No. 15761, upper and lower jaws; Gray Bull beds, Five Mile Creek, Bighorn basin, Wyo. Exp. 1911.

About twenty-five specimens from the Gray Bull beds represent a form somewhat smaller than the type of *P. hemiconus* from the same beds and locality. This group seems too small to include in the species *P. primævus*. Comparing the type with the type and topotype of *P. hemiconus*, which form approaches it most nearly in size, there is a greater reduction of the m^3 and a relatively larger p^4 than in *P. hemiconus*. The intermediate cusps of the molars are also less distinct; on m^2 the metaconule is entirely absent. In p_3 the metaconid is placed lower than in *P. hemiconus*.

Paratype, No. 15777, a maxilla supporting all teeth from canine to m^3 , unworn; Gray Bull beds, Shoshone River, Bighorn basin, Wyo. Exp. 1911.

This beautifully preserved specimen (Fig. 9) affords a good supplementary type, since it presents three anterior teeth not preserved in the holotype. The posterior half of the third molar is missing, but otherwise the teeth are perfect. The specimen agrees very closely with the type, except that the metaconule is absent from m^1 instead of m^2 . The canine is large, relatively about the same size as in *P. primævus*; p^1 is shaped like the canine and half the size, p^2 shows a broad outer cusp and posterior internal ledge. There is just a suggestion of two or three cusps on the posterior ridge of the protocone. P^3 presents 5 cusps in line on the outer face; the large protocone, a lower cusp, the tritocone, posterior to the protocone, and a still lower accessory cusp posterior to the tritocone, while at

the posterior and anterior angles of the tooth are tiny cusps produced on the cingulum. The strong conical deuterocone is placed posteriorly, opposite the tritocone, instead of between the protocone and the tritocone as in p^4 . An elevated tip of the cingulum occupies the position of the protoconule in p^3 ; p^4 has the protocone slightly larger than the tritocone and there is a strong protoconule. The p^1 is placed close behind the canine. There is a considerable diastema between p^1 and p^2 and a shorter one between p^2 and p^3 .

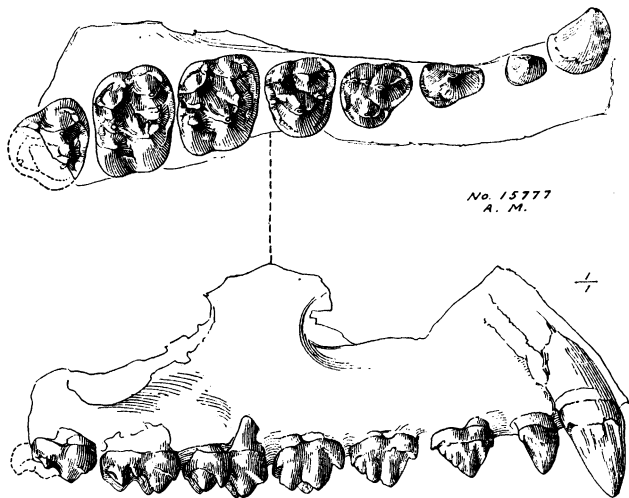


Fig. 9. *Phenacodus intermedius*, crown and external views of unworn maxillary teeth. Paratype, Gray Bull beds, Bighorn basin, Wyoming.

Measurements of paratype, No. 15777.

	mm.
$c-m^3$	73. (approx.)
c ant. post. diam. at base.....	7.8
c tr. " " ".....	6.2
c length, from base of enamel, outside.....	12.7
p^1 long. diam.....	5.
p^1 length, from base of enamel, outside.....	6.3
p^2 long. diam.....	8.
p^2 tr. ".....	5.6

Two badly flattened skulls (Nos 15268 and 15765) have teeth agreeing closely with the type in size and the reduction of metaconules on m^2 , but the skull, as nearly as can be judged in this crushed condition, does not show a corresponding reduction in length for *P. primævus*. The better

preserved one seems to have been nearly as long in the temporal region as *P. primævus* but more slenderly built. A pair of lower jaws (No. 15764) shows an extreme length of approximately 160 mm. as compared with 195 mm. in *P. primævus*.

From the Clark Fork beds are several fragmentary specimens which seem to fall into this group. From the Sand Coulee beds are lower jaw fragments, and from the Lost Cabin some ten or twelve fragmentary specimens are doubtfully referred to this species. Most of these agree in size and in the reduction or absence of metaconules. In Nos. 14794 and 14796 this cusp is absent from both the first and second molars.

Two of these Lost Cabin specimens (Nos. 14784 and 14797) appear to represent either a well marked variety of *P. intermedius* or, more likely, a distinct species. The first specimen consists of jaw fragments with p_2-m_1 ; the second specimen of a first or second lower molar and a p^4 , with which are associated fragmentary limb bones, a calcaneum and astragalus, and parts of both fore feet, one nearly complete. Both of these specimens show a much greater reduction of the premolars than is observed in any specimen of *P. intermedius* from the Gray Bull beds. In No. 14797 the p^4 has the same transverse diameter as the p^4 of the type, but is a much narrower tooth, antero-posteriorly, which coincides with the antero-posterior reduction of the lower premolars of No. 14784.

There is no foot or limb material of *P. intermedius* from the Gray Bull beds for comparison with the Lost Cabin specimen. Compared with the fore foot of *P. primævus* it shows a trifle more slender Mc I but otherwise no differences except in size.

Measurements.

	No. 14797	<i>P. primævus</i>
Mc. III.....	52.5.....	72.
Mc. V.....	28.	36.
Mc. I.....	23.	28. (est.)

The difference in size of the feet is greater than one would expect to find between *P. primævus* and the type of *P. intermedius*. I hesitate to separate these Lost Cabin specimens, because of the lack of comparative material, and because the individual variations in this genus are so great.

From the Sand Coulee beds a specimen consisting of upper and lower jaws (No. 16131) shows in the lower teeth the same reduction of the premolars, but not of p^4 .

From the lower horizon of New Mexico a lower jaw (No. 16246) is intermediate in size between *P. intermedius* and *P. hemiconus*.

Phenacodus vortmani Cope, 1880.

COPE, 1880, Amer. Nat., p. 747 (*Hyracotherium*); 1885, Tert. Vert. p. 433, pl. lviii, fig. 9.

Syn. ?*Phenacodus apternus* COPE, 1882.

Type, Amer. Mus. Cope Coll. No. 4824, a left ramus with the p_4 and a damaged m_1 and the roots of other molars and premolars; Lost Cabin beds, Alkali Creek, Wind River basin, Wyo., J. L. Wortman, 1880.

A very satisfactory topotype is represented by No. 14787, lower jaws with all molars and premolars, unworn, and No. 2983, a maxilla with p^3 - m^3 , unworn (Figs. 4, 6 and 8). The lower jaws were collected in 1909, the maxilla in 1896, both are recorded as coming from the north side of Alkali Creek near its mouth and both are from the same distinctive matrix, a light gray clayey sandstone, in which fossils are rare. The lower teeth fit exactly to the uppers and both show the same slight traces of wear on the first and second molars. It is without much hesitation that I consider them as belonging to one individual.

Distinctive characters, as shown by the topotype, are, aside from the measurements of the teeth, ramus relatively short and deep; p_3 with a well defined anterior basal cusp, fairly well defined external and internal cusps of equal size on the posterior face of the protoconid and an unusually high posterior basal cusp; p_4 without entoconid but with the posterior inner angle developed into a low ridge, forming a shallow basin; p^4 with outer cusps of nearly equal size, inner cusp bent slightly forward and with the cingulum on the posterior side of the tooth developed into a point, which foreshadows the tetartocone; p^3 with large and small outer cusps and large inner cusp, twisted forward away from p^4 and opposite the cleft between the outer cusps.

Occurrence. About 15 specimens from the Lost Cabin are referable to this species, chiefly by size alone since most of the specimens consist of molar teeth only. From the Lysite three specimens agree in size. From the Gray Bull beds five, and one from the lower horizon of New Mexico is doubtfully referred. The reference of all specimens not from the type-horizon, however, is only provisional.

Phenacodus apternus Cope, 1882,¹ from the Gray Bull beds of the Bighorn basin, is based on three fragments of lower jaws, each supporting the three true molars. The species was based principally upon the "oval form of the last inferior molar," a character in which the three cotypes differ as

¹ Palæont. Bull., No. 34, p. 180.

much among themselves as they do from the topotype of *P. vortmani* from which species I cannot distinguish them. The measurements of the molar series are: No. 4390 = 25.7, 4392 = 25. , and 4393 = 25.7 mm., as compared with 25 mm. in the topotype of *P. vortmani*.

***Phenacodus copei* sp. nov.**

Phenacodus vortmani COPE, Tert. Vert. 1885, p. 464, pll. xxix e, xxix f, lvii h, fig. 17 (not *P. vortmani* Cope, 1881); "*Trispondylus*" *vortmani*, 1884, Am. Nat. (foot-note) p. 900 (not *P. vortmani* Cope, 1881).

Type, Amer. Mus. Cope Coll. No. 4378, a nearly complete skeleton; Gray Bull beds, Bighorn basin, Wyo. J. L. Wortman, 1881.

The discovery of excellent supplementary material of *P. vortmani* in the Lost Cabin beds serves to bring out differences between that species and the Gray Bull skeleton which Cope referred to *P. vortmani*. The differences are of specific value, and the distinguishing characters are: $p_3-m_3 = 45$ mm., $m_1-m_3 = 28$ mm., $p^3-m^3 = 37$, $m^{1-3} = 23$; metaconules reduced or absent; p^3 with tritocone very small, deuterocone with a posterior position, opposite the tritocone; p_3 without anterior basal cusp and with low posterior basal cusp; teeth more robust than in *P. vortmani*.

In the type of *P. copei* the last lower molar is not reduced while the last upper molar is very much so. In a referred specimen (No. 15333) the lower molar is the same as in the type but the upper molar is not much reduced. The relative size of this tooth appears to be of little value as a specific character in this genus.

Occurrence. Eleven specimens, chiefly lower jaw fragments, from the Gray Bull beds are referred to this species. From the Lysite there are twenty-five specimens, mostly very fragmentary, and of these only two are from the typical Lysite, the balance being from Buffalo basin where this species is the only one of the genus represented. From the lower horizon of New Mexico two specimens are referable.

From the Sand Coulee beds a single specimen (No. 16125) shows in the third upper premolar the characters of *P. copei* and in the lower those of *P. vortmani*, with which it also agrees in size of teeth.

***Phenacodus brachypternus* Cope, 1882.**

Palæont. Bull., No. 34, 1882, p. 180; 1885, Tert. Vert., p. 433, pl. xxv e, fig. 14.

Type, Amer. Mus. Cope Coll. No. 4396, a left ramus with p_3-m_3 ; Gray Bull beds, Bighorn basin, Wyo. J. L. Wortman, 1881.

Distinctive Characters. $P_3-m_3 = 33$ mm., $m_{1-3} = 20$ mm.; p_4 elongate and narrow with very prominent paraconid, longer and narrower than any of the molars; p_3 with broad low heel and a small accessory cusp high up on anterior ridge of protoconid; ramus rather slender; weak metaconules on m^2 .

Cope founded this species on "three mandibular rami — all displaying the fourth premolar" without specifying a type, but the measurements, most of his characters and the figures were drawn from No. 4396, which is much the most complete and which it seems proper to consider as the type, especially since neither of the other fragments furnishes any characters not found in this one. This is the smallest species of the genus and in some respects the most primitive. The long compressed p_4 and the simple compressed p_3 serve to distinguish it from *P. vortmani*, the next largest species. Most of the specimens show on the fourth premolar a high trenchant hypoconid development and a steep slope down to the inner side of the tooth without much trace of entoconid development. In most of the specimens there is a small accessory cusp in front of and between the protoconid and metaconid on the p_4 . The last upper molar is much reduced in the four specimens in which this tooth is present, while the last lower molar varies from a slight to a marked reduction. In one specimen of badly worn upper and lower teeth (No. 15331) the p^3 is elongate with the inner cusp placed at the extreme postero-internal angle, opposite the posterior outer cusp. It is in the character of this tooth and of the lower premolars that this species is the most primitive of the genus.

Occurrence. Twenty specimens from the Gray Bull beds of the Bighorn basin, and two from the lower horizon of New Mexico are identifiable with this species. Its occurrence in the other horizons has not been noted.

From the upper beds of New Mexico, near Ojo San Jose, is a finely preserved maxilla (Fig. 10) with the canine and all cheek teeth (No. 16249). It is slightly larger than the type of *P. brachypternus* and differs in having the m^3 but slightly reduced and with well developed metacone and mesostyle; p^4 is unusually broad antero-posteriorly and shows a metaconule. The third premolar is elongate and primitive in construction; p^2 is slightly expanded posteriorly and with a small cusp at the postero-external angle; p^1 is double-rooted, a condition not observed in the ten other specimens of *Phenacodus* in which this part



Fig. 10. *Phenacodus* (?) *brachypternus*, upper teeth, crown view. Largo beds, San Juan basin, New Mexico.

of the maxilla is preserved, but it is a character of *Ectocion*, as also is the development of metacone and mesostyle on m^3 , but the p^3 and the m^1 and m^2 are decidedly *Phenacodus* and not *Ectocion*. I hesitate to establish a new species for this single specimen, especially since no identifiable specimen of *P. brachypternus* showing the anterior premolars is present for comparison and the relative size of the m^3 is too variable in this genus, although it appears to be more constant in this species than in others. It is very possible also that the two-rooted condition of the p^1 is not an unvarying character within specific limits.

Measurements of No. 16249.

	mm.
c- m_1	51.
m^2 transverse diameter.....	9.5
m^2 antero-posterior diameter.....	7.
m^3 " ".....	6.
m^3 transverse ".....	8.2
p^3 - m^3	35.
p^3 antero-posterior ".....	7.
p^3 transverse ".....	5.5

Phenacodus astutus (Cope), 1875.

Opisthotomus astutus COPE, 1875, System. Cat. Vert. Eoc. N. Mex., p. 16; *O. astutus* 1877, Ext. Vert. N. Mex., p. 152, pl. xlv, fig. 9.

Type, a first or second lower molar associated with a premolar tooth; from the Wasatch of New Mexico. E. D. Cope, 1874. Type lost.

The molar is, without question, that of a small species of *Phenacodus* but the premolar, which was mistaken by Cope for a last lower molar, and which formed the principal characters of the genus *Opisthotomus*, cannot be identified from the figure with any degree of satisfaction. The closest resemblance, shown in the inner view of the tooth, is to a fourth lower premolar of *Phenacodus* with reduced metaconid. The molar agrees in length, according to Cope's measurements, with the first or second molar of *P. brachypternus* but is slightly broader transversely. The premolar is of a size which might be associated with the molar but shows less wear than would be expected. Cope states that the two teeth were found in close association. Assuming that the association is correct and that no topotype can be selected, it seems best to let this species name stand for this specimen only rather than to refer other types and specimens to it, based on comparison with the molar tooth only.

The measurements of the teeth, as given by Cope, are as follows:

	mm.
Lower molar (?m ₁) — antero-posterior diam.....	6.5
“ “ transverse “	6.
“ premolar (?p ₄) — antero-posterior “	8.5
“ “ transverse “	5.

INCERTÆ SEDIS.

Opisthotomus flagrans Cope, 1875,¹ from the Wasatch of New Mexico, was described at the same time as *O. astutus*. The type, which is lost, is a lower jaw fragment with a single damaged tooth which Cope took to be the last molar. It is an unidentifiable type; the tooth as shown by Cope's figure has a considerable resemblance to the fourth milk molar of *Phenacodus primævus* but not close enough for certain identification.

Phenacodus sulcatus Cope, 1874,² from the Wasatch of New Mexico, was based upon a last upper molar of the left side (Nat. Mus. Coll. No. 1027). The tooth has the outline of a last molar of *Phenacodus* but differs in showing no trace of mesostyle and in having a metaloph developed as well as a protoloph, a character in which it resembles the *Perissodactyla*. The outlines of the tooth, however, together with the much reduced metacone and a rather indistinct hypocone, give the tooth an appearance very much unlike that of *Eohippus* or any other Lower Eocene *Perissodactyl*. The structure of the tooth and a certain peculiar irregularity or unevenness of the enamel surface leads me to think that this type is a malformed tooth of *Phenacodus*. It is about the size of *P. brachypternus*, the smallest species. Measurements are: anteroposterior diameter = 6. mm., transverse diameter = 8.1 mm.

Eohyus distans Marsh, 1894.³ The type of this species and genus is a last upper molar of the left side (Yale Mus. Coll. No. 11889), from the "Coryphodon beds of New Mexico." As the name implies Marsh considered this an Artiodactyl with Suilline affinities. In the same paper he described a second species, *E. robustus*, from the "Lower Eocene of New Mexico," a type which Sinclair has correctly referred⁴ to *Periptychus*, a Torrejon genus. Marsh's drawing of the type of *E. distans* is somewhat misleading. An examination of the specimen shows a facet for the m² which serves to orient the tooth, which gives it a different position in the jaw from that suggested by the drawing. The outline of the tooth is similar

¹ System. Cat. Vert. Eoc. N. Mex., p. 16; Ext. Vert. N. Mex., p. 152, pl. xlv, fig. 8.

² Rep. Vert. Foss. N. Mex., p. 11; 1877, Ext. Vert. N. Mex., p. 179, pl. xlv, fig. 7.

³ Am. Jour. Sci., Vol. XLVIII, p. 259, fig. 1.

⁴ Bull. Am. Mus. 1914, p. 267.

to that of *Phenacodus* and unlike that of any other Wasatch form. The arrangement of the cusps also corresponds with *Phenacodus* in a general way, but the tooth differs in the enlargement of the protoconule and in the more swollen and rounded appearance of all the cusps. The protocone is the largest of the cusps and the metacone and hypocone are reduced and the metaconule and mesostyle are absent. The absence or extreme reduction of mesostyle and metaconule is, however, not rare in the m^3 of *Phenacodus*. I do not have much hesitancy in placing this type as a somewhat abnormal tooth of *Phenacodus*. In size it agrees most closely with the smaller variety of *P. primævus*. Measurements are: tr. = 11.2 mm., antero-post. = 10.2 mm.

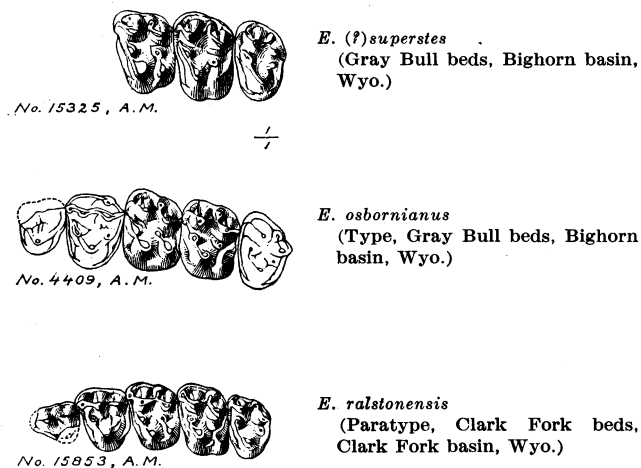


Fig. 11. Upper teeth of species of *Ectocion*.

***Ectocion* Cope, 1882.¹**

Type. *Oligotomus osbornianus* Cope, 1882, from the Wasatch of the Bighorn basin, Wyo.

Cope based this genus upon a single poorly preserved specimen in his collection from the Wasatch of the Bighorn basin. In his Tertiary Vertebrata he placed the genus in the Chalicotheriidae, but suspected its affinities with the Condylarthra to the extent of pointing out its difference from *Tetracænodon* and *Phenacodus*. The forward position of the metaconule, similar to that in *Eohippus*, seems to have been the character which led Cope to consider *Ectocion* a Perissodactyl of a primitive sort, with the metaconule

¹ Amer. Nat., p. 522.

in the proper position for the development of the metaloph. There is, however, the important point that in the numerous specimens now available from several horizons no marked tendency toward the formation of a metaloph is shown. The metaconule is sometimes isolated, often connected with the protocone, and in some cases connected with both the protocone and hypocone forming with the protoconule two Vs, the posterior one opening toward the palate, the anterior one toward the center of the tooth. In only one specimen is the metaconule found connected with the hypocone and separated from the protocone by a deep valley as in *Perissodactyla*, and this individual happens to be from the lowest horizon of the genus and apparently represents merely an isolated example of deviation from the ordinary



E. superstes
(Type, Lost Cabin beds, Wind River basin, Wyo.)



E. osbornianus
(Topotype, Gray Bull beds, Big-horn basin, Wyo.)



E. ralstonensis
(Type, Clark Fork beds, Clark Fork basin, Wyo.)



E. parvus
(Type, Clark Fork beds, Clark Fork basin, Wyo.)

Fig. 12. Lower teeth, crown views, of the species of *Ectocion*.

condition, rather than any distinct phylum. The genus is of interest in this connection as presenting the type of upper molar from which the *Perissodactyl* molars might have been derived.

Additional Characters of Ectocion. Besides the characters given in the Key to Genera there are certain other features which separate this genus from *Phenacodus*. There is usually a metaconule on the p^4 . The m^3 seldom has a hypocone and is a triangular tooth; in *Phenacodus* the hypocone is usually present, although smaller than the protocone. In *Ectocion* the hypoconulid of the lower molars is usually crowded inward toward the entoconid, while in *Phenacodus* this cusp is in the center of the tooth. In *Ectocion* there is a ridge descending anteriorly from the protoconid and passing across to the inner side of the tooth; in *Phenacodus* the ridge is joined in the center

of the tooth by a ridge descending from the metaconid, thus forming a loop in front of the anterior pair of cusps.

Previous to the beginning of the Lower Eocene exploration in 1910 the collection contained but three specimens of the genus — the type, and one other fragment from the Gray Bull beds, and a lower jaw from the Lost Cabin. The collection now numbers over 150 specimens, chiefly jaw fragments and isolated teeth. The genus is confined to the Wyoming horizons. It is most abundant in the Clark Fork, very common in the Sand Coulee and the Gray Bull, absent from the Lysite and represented in the Lost Cabin by a single specimen. In its geological distribution it nearly parallels that of the large *Phenacodus*, *P. primævus*.



No. 233A, A.M.

E. superstes
(Type, Lost Cabin beds, Wind River basin, Wyo.)



No. 16174, A.M.

E. osbornianus
(Topotype, Gray Bull beds, Big-horn basin, Wyo.)



No. 16050, A.M.

E. ralstonensis
(Type, Clark Fork beds, Clark Fork basin, Wyo.)



No. 16080, A.M.

E. parvus
(Type, Clark Fork beds, Clark Fork basin, Wyo.)

Fig. 13. Lower teeth, external views, of the species of *Ectocion*.

A single specimen from the Sand Coulee beds has a few skeleton fragments in association, of these an astragalus is the most important. In general it is intermediate between *Tetraclænodon* and *Phenacodus*. It resembles *Tetraclænodon* in the long neck, in the narrow ectal facet and in having the sustentacular facet broad in the middle and tapering rapidly above and below, the outer line being angular instead of curved as in *Phenacodus*. The astragalus resembles *Phenacodus* in not being flattened and in having no astragalar foramen.¹ The lower end of a radius shows very small facets as in *Phenacodus*. In *Tetraclænodon* these are relatively larger.

The species of *Ectocion* present as difficult a problem as those of *Phena-*

¹ This foramen is usually absent in *Phenacodus* but not always.

(Measurements in millimeters.)

	ps-m ²	m ¹ -s	m ² ant-post. diam.	m ² tr. diam.	m ² ant-post. diam.	m ² tr. diam.	ps-m ³	m ¹ -s	ms ant-post. diam.	ms tr. diam.	ms ant-post. diam.	ms tr. diam.	ps ant-post. diam.	ps tr. diam.
<i>E. superstes</i> sp. nov. Type, No. 233a, Lost Cabin beds, Wind River basin, Wyo.	—	—	—	—	—	—	—	42.5	25.5	7.2	8.7	6.3	8.2	5.4
<i>E. osbornianum</i> Cope. Type, No. 4409, Gray Bull beds, Bighorn basin, Wyo.	—	—	7.5	9.7	—	—	—	—	7.5	6.	—	—	7.5	5.5
<i>E. ———</i> Topotype, No. 16174, Gray Bull beds, Bighorn basin, Wyo.	—	—	—	—	—	—	39.	24.	7.6	6.3	8.5	5.5	7.3	5.5
<i>E. ———</i> No. 16045, Clark Fork beds, Clark Fork basin, Wyo.	32.	19.	6.6	9.6	6.	9.	—	—	—	—	—	—	—	—
<i>E. ralsstonensis</i> sp. nov. Type, No. 16050, Clark Fork beds, Clark Fork basin, Wyo.	—	—	—	—	—	—	32.7 (est.)	19.	6.	5.3	—	—	6.3	4.3
<i>E. ———</i> Paratype, No. 15853, Clark Fork beds, Clark Fork basin, Wyo.	—	17.5	6.5	9.	5.5	8.	—	—	—	—	—	—	—	—
<i>E. ———</i> Paratype, No. 16049, Clark Fork beds, Clark Fork basin, Wyo.	—	—	—	—	—	—	—	19.2	6.2	5.3	7.	4.6	6.3	4.3
<i>E. parvus</i> sp. nov. Type, No. 16080, Clark Fork beds, Clark Fork basin, Wyo.	—	—	—	—	—	—	—	16.2	5.2	4.3	5.5	3.7	—	—

codus. The variations in size are considerable and there are numerous intergradations in relative antero-posterior width of the upper teeth, so that the specimens cannot readily be sorted out into well-defined groups. As in *Phenacodus* practically no progressive premolar development is shown in this genus. At least four species, indicated by size and relative proportions of teeth, are recognizable.

***Ectocion osbornianum* Cope, 1882.**

Oligotomus osbornianus COPE, 1882, Pal. Bull., No. 34, p. 182; *Ectocion*, 1882 (May 20) Amer. Nat., p. 522; *E. osbornianum*, 1885, Tertiary Vertebrata, p. 696, pl. xxve, figs. 1, 10; 1887, Amer. Nat., p. 1061, fig. 25.

Type, Amer. Mus. Cope Coll. No. 4409, upper and lower jaw fragments; Gray Bull beds, Bighorn basin, Wyo. J. L. Wortman, 1881.

Distinctive characters. $P_3-m_3 = 39$, $m_{1-3} = 24.2$; p_3 not longer antero-posteriorly than p_4 , simple, with protoconid and high posterior basal cusp.

I refer to this species about twenty-five specimens from the Gray Bull and about as many each from the Sand Coulee and Clark Fork beds. The widest differences between the specimens so referred is in the relative length and width of the upper molars. The type represents the condition of least antero-posterior compression of the teeth and there are gradual stages between this and a condition where the compression is very marked. The lack of good series of upper and lower teeth in association makes it difficult to determine if more than one species is represented here. The extremes of each condition occur in each horizon although the type with compressed molars is the most prevalent in the lowest beds.

***Ectocion superstes* sp. nov.**

Type, No. 233A, a series of lower teeth, p_3-m_3 , left side, with lower canine; Lost Cabin beds, Wind River basin, Wyo. J. L. Wortman, 1891.

Distinctive Characters. $P_3-m_3 = 42.5$, $m_{1-3} = 25.5$; p_3 longer antero-posteriorly than p_4 and with a tendency for a cusp to split off from the anterior ridge of the protoconid; highly developed entoconid on p_4 .

This type is the only specimen of the genus in the collection coming from a level higher than the Gray Bull, and shows in the premolars a very slight progressiveness over the lower beds forms. The p_4 is rather more molariform in general appearance than in other species, due largely to the reduction of the ridge which curves forward and inward from the protoconid,

To this species I provisionally refer two specimens from the Gray Bull beds (Nos. 15324 and 15325), the former a jaw fragment with molars, the latter a fragment of palate and jaw with upper and lower molars. The lower molars are about equal to those of the type in size and the upper molars show antero-posterior compression. Since the characters of the species are principally in the premolars, this reference to *E. superstes* is made with uncertainty.

Measurements, in millimeters, of upper molars, No. 15325, from the Gray Bull beds: m^3 ant. post. = 6; m^3 tr. = 10.5; m^{1-3} = 21.5; m^2 ant. post. = 7.3; m^2 tr. = 11.5.

***Ectocion ralstonensis* sp. nov.**

Type, No. 16050, lower jaw with p_3 - m_2 and roots of c - p_2 , left side; Clark Fork beds, Head of Big Sand Coulee, Clark Fork basin, Wyo. Exp. 1912.

Paratypes, No. 16049, lower jaw with p_4 - m_3 , and No. 15853, m^{1-3} , left side; both from same locality and horizon as type.

Specific Characters. P_3 - m_3 = 32.7, m_{1-3} = 19, p_3 and p_4 of about equal length; anterior part of jaw shallow, and symphyseal region slender; entoconid on p_4 relatively weak.

Distinguished from *E. osbornianum* by smaller size and relative shallowness and slenderness of ramus. The upper molars do not show the antero-posterior compression seen in some specimens referred to *E. osbornianum* from the same horizon.

The species is abundant in the Clark Fork beds, fairly so in the Sand Coulee beds, while from the Gray Bull I refer several specimens, most of which average a little larger than the type.

Two maxillæ from the Sand Coulee beds show the p^3 , and in both the protocone is placed posteriorly against the p^4 . Supplementary measurements from No. 16124 are: p^3 - m^3 = 29.5, p^4 ant. post. diam. = 5.8, p^4 tr. diam. = 7.4.



Fig. 14. *Ectocion ralstonensis*, lower jaw, external view. Type, Clark Fork beds, Clark Fork basin, Wyoming.

***Ectocion parvus* sp. nov.**

Type, No. 16080, a lower jaw fragment with m_{1-3} , left side; Clark Fork beds, Head of Big Sand Coulee, Clark Fork basin, Wyo. Exp. 1911.

Distinctive Characters. M_{1-3} = 16.2, first and last molar of equal length.

A single specimen from the lowest beds represents a species considerably smaller than *E. ralstonensis* and, hence, the smallest of the genus. In the absence of all teeth but the lower molars the measurements must suffice for specific characters. The first and second molars are much worn but they seem to show rather less crowding inward of the hypoconulids than in the other species. The jaw is much checked but indicates a relatively deeper ramus than in *E. ralstonensis*.

Distribution of Lower Eocene Species of Phenacodontidæ.

	Wyoming					N. Mex.		
	Bighorn & Wind River Basins					Evanston	San Juan Basin	
	Lost Cabin ¹	Lysite	Gray Bull	Sand Coulee	Clark Fork	Knight	Largo	Almagne
<i>Phenacodus</i>								
P. primævus	×		×	×	×	×		×
P. primævus robustus			×					
P. primævus hemiconus	×		×					?
P. intermedius	?		×	×	×			?
P. copei		×	×					×
P. vortmani	×	?	?					?
P. brachypternus			×				?	×
P. astutus								×
<i>Ectocion</i>								
E. osbornianus			×	×	×			
E. superstes	×		?					
E. ralstonensis			×	×	×			
E. parvus					×			

× indicates horizon and locality of type.

Family MENISCOTHERIIDÆ Cope, 1882.

This family of condylarths was established by Cope to include the single genus *Meniscotherium* with skeleton characters more or less like those of the Phenacodontidæ, but with teeth much too highly specialized to allow of its being included in that family. *Meniscotherium* was described by Cope

¹ This is the typical Lost Cabin of the Wind River basin; no Phenacodonts have been found in the Lost Cabin horizon of the Bighorn basin.

in 1874 (*M. chamense*) and was based on a single jaw fragment, with upper molars, found by him during his explorations of the New Mexican Wasatch of that year. A few years later David Baldwin, then collecting for Marsh, obtained from the type locality and horizon the remains of many individuals of this form. Still later Cope secured from Baldwin a large amount of *Meniscotherium* which, judging from its appearance, came from the same "pocket" or bone bed as the Yale material. Both of these collections consisted of badly disorganized skeletons and more or less fragmentary skulls and jaws, all in a hard brick-red matrix. Cope selected from his material two jaw specimens, the largest and the smallest, as types of two additional species (*M. terrærubra* and *M. tapiacitis*) and figured most of the elements of the skeleton except the feet. Marsh from his collection figured a fore and a hind foot under the new name *Hyracops socialis* and created the ordinal name Mesodactyla to include the two genera of Meniscotheriidae. He differentiated *Hyracops* from *Meniscotherium* by the last molar being nearly or quite like the molars, by there being four vertebrae in the sacrum instead of three, and by doubtful and unspecified differences in the feet.

An examination of all of the specimens of this group in the Yale Museum¹ shows no specimens marked as types of *Hyracops* and none which shows generic differences from the *Meniscotherium* types and referred material in the American Museum collection. Two fairly complete fore feet, both with the carpals disarranged and partly obscured by matrix, apparently formed the basis for the figures of the fore foot of *Hyracops*, while a few isolated but well preserved bones of the hind foot seem to have served for the reconstruction of the pes. Compared with the feet of the composite skeleton, assembled from the materials of the Cope Collection,² the pes is very similar. In the fore foot one very important difference is observed; in Marsh's figures of *Hyracops* the magnum is unusually large, the front surface being nearly twice that of the lunar, and it is in articulation with the cuneiform. In the American Museum specimen the magnum is smaller than the lunar and is separated from the cuneiform by the unciform which articulates with the lunar. The centrale is not preserved but its existence in this form is indicated by the

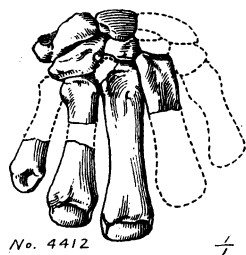


Fig. 15. *Meniscotherium terrærubra*, carpus and metacarpus, seen from the front. From the composite mounted skeleton, No. 4412, in the Amer. Museum.

¹ The writer wishes to express his appreciation of the courtesies extended, in this connection, by Prof. Charles Shuchert of the Yale Museum.

² See Osborn, 1910, *Age of Mammals*, p. 125, fig. 39.

arrangement and facets of the lunar and magnum. In the Yale specimen the centrale is preserved. The relative proportions of the metapodials in both fore and hind feet and the form of the phalanges, including the unguals, are similar to those in the *Hyracops* figures. The differences, indicated in the carpus of the latter, seem to be due to an error in reconstruction rather than to any actual differences in the specimens. I can see no reason for considering *Hyracops* as distinct from *Meniscotherium*.

Meniscotherium Cope, 1874.

Syn. *Hyracops* MARSH, 1892.

Type, *M. chamense*, from the Upper Wasatch of New Mexico.

Both the geological and geographical distribution of this genus, and hence of the family, are unusual and interesting. In New Mexico it first appears in the Upper or Largo beds of the Wasatch and is one of the most abundant forms in this horizon, and serves as an excellent horizon marker. There is no trace of it from the Lower Wasatch horizon of that region,¹ while from the underlying Torrejon and Puerco formations there is no form which might in any way be considered as belonging to this group. The only specimen of the genus which has been previously recorded from outside of this rather restricted New Mexican area is a single individual from the Lost Cabin beds of the Wind River basin, Wyoming, found in 1909.² Two others from the same horizon, one found in 1896, the other in 1909, have recently been discovered in the collection. These specimens while extending the geographical range of the genus considerably do not extend the geological range since the Lost Cabin is considered the equivalent, or nearly so, of the Largo beds. A fourth specimen from Wyoming, collected in 1911, does, however, extend the geological range. This is a lower jaw fragment, with the fourth milk molar and first true molar, from the Clark Fork beds. While it represents a species distinct from the later forms of the Largo and Lost Cabin beds it cannot at present be excluded from the genus *Meniscotherium*, although the discovery of more complete remains may necessitate its removal. The interval between the Clark Fork and the Lost Cabin forms a considerable gap, represented by the Sand Coulee, Gray Bull and Lysite beds, totaling not less than 1300 feet of sediment, in which this genus does not occur, and it is of interest to note in this

¹ Cope has stated that *Meniscotherium* is from the Lower Wasatch beds, but this is an error.

² W. Granger, Bull. A. M. N. H., XXXIII, 1914, p. 206, foot-note.

connection that two other groups of mammals in the Clark Fork, the Limnocyoninæ and the Uintatheriidae, are also absent from these three horizons and reappear, along with *Meniscotherium*, in the Lost Cabin.

We have then the first appearance of the Meniscotheriidae in the base of the Lower Eocene, or the top of the Paleocene, followed by a considerable period during which we get no trace of it; then, at the top of the Lower Eocene it suddenly appears again, in great abundance in the southern or New Mexican area, as a straggler in the northern district, and the family disappears finally, along with the rest of the Condylarthra, before the beginning of the Middle Eocene, or Bridger.

Characters of Meniscotherium: Teeth bunolophoselenodont, m^{1-2} quadrate with four principal cusps and two intermediates, the posterior one of which is confluent with the hypocone and forms a metaloph; the anterior one is crescentic and separated from both protocone and paracone by deep valleys. M^3 triangular, without hypocone; p^4 like m^3 but with outer styles less pronounced. Lower molars double V-shaped with high crests and a prominent recurved metastylid,¹ hypoconulids not developed; m_3 similar to anterior molars; p_3 like molars. Canines relatively small; incisors chisel-edged. Humerus with supracondylar foramen; carpus alternating; a free centrale; unguals long and narrow hoofs, as in *Tetraclænodon*.

The composite skeleton of *Meniscotherium*, mounted in the American Museum collection, shows it to be a short stocky limbed beast with very large broad and deep head. The dorsolumbar formula is placed as 14-7 but it may have been 15-6 as in *Phenacodus*. The sacrum figured by Cope has but three vertebræ but the one used in the mount and one other in the collection have four coössified vertebræ. This variation appears to be no more than an individual or age difference. The skeleton as mounted has the vertebral column too much arched in the lumbar region and the anterior thoracic region is placed too low, which necessitated the reduction of the restored scapula to unreasonable proportions. Such fragments of the shoulder-blade as are preserved indicate that it was not widely different from that of *Phenacodus primævus*.

Considerable *Meniscotherium* material has been obtained by the recent expeditions into the New Mexican Wasatch but there is nothing which adds much to our knowledge of this form.

Three species have been described; of the two species in addition to the genotype, one is distinctly separable, while the other is differentiated by characters which seem to be of only subspecific value.

¹ Absent in m^{1-2} of *M. tapiacitis*.

Key to Species of Meniscotherium (measurements from types).

- A. Strong metastylid on all three lower molars.
 a. $m^{1-3} = 21$ mm.....*M. chamense*.
 aa. $m^{1-3} = 26$ mm.....*M. chamense terrærubræ*.
 B. Metastylid weak on m_3 , absent on anterior molars.
 b. $m^{1-3} = 17$ mm. (est.).....*M. tapiacitis*.

Meniscotherium chamense, Cope 1874.

Report Vert. Fossils N. Mex. p. 8; 1877, Ext. Vert. N. Mex., p. 252, pl. lxvi, fig. 18.

Type, Coll. U. S. Nat. Mus., No. 1093, a fragment of right maxilla with the three molars; from the San Juan basin, N. Mex. E. D. Cope, 1874.

Distinctive Characters. $m^{1-3} = 21$ mm. Metastylids prominent on all three lower molars.

The type is the only specimen of this genus secured by Cope during his exploration of the New Mexican Wasatch in 1874. Subsequently his collector, David Baldwin, obtained remains of a large number of individuals, including nearly all parts of the skeleton. There is but very little association of parts in these specimens and they represent individuals of various ages and show a wide range in size.

A smaller form is represented by a single specimen, the type of *M. tapiacitis*, while of the larger species there are over fifty specimens of portions of skulls, mandibles and jaw fragments. Of these latter the types of *M. chamense* and *M. terrærubræ* represent the small and large extremes and the remaining specimens are all intermediate in size, the majority being closer to *M. terrærubræ*.

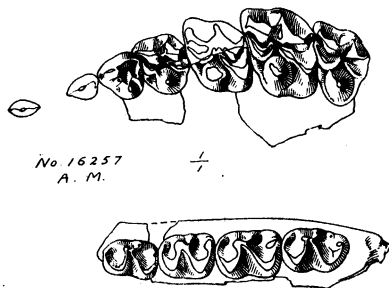


Fig. 16. *Meniscotherium chamense*, upper and lower teeth, crown views. Topotype.

I refer as belonging to *M. chamense* Nos. 16254, 16257, 4438, 4440, all fragments of maxillæ from the type locality. Of these No. 15257 approaches the type most closely ($m^{1-3} = 22$ mm.) and, since it presents both upper and lower teeth, forms a very good topotype (Fig. 16).

From the Lost Cabin beds of Muddy Creek, Wind River basin, Wyo., there is a specimen of *Meniscotherium* found by the Expedition of 1909

(No. 14785).¹ It was found in association with *Lambdotherium*, *Eotitanops borealis* and other characteristic Lost Cabin forms. Fragments of both maxillæ are preserved, one side supporting p^3-m^3 . The teeth measure a little larger than the type of *M. chamense* but I can see no reason for not referring it to this species. On p^4 the mesostyle is rather more sharply defined than on any New Mexican specimen but this is an individual character seemingly, since all stages of development of this style are observed in the New Mexican specimens; some are without trace of it while others have it pronounced but never so highly developed as on the molars. From the typical Lost Cabin beds, on Alkali Creek, are two specimens of lower jaws (Nos. 2972, 14737), both of which are referable to *M. chamense*. The presence of these specimens of *Meniscotherium* in the Lost Cabin beds of Wyoming is a strong point in the correlation of those beds with the upper beds (Largo) of the New Mexican Wasatch.

Measurements of No. 14785 are $p^3-m^3 = 34.5$ mm.; $m^{1-3} = 23.5$ mm.

***Meniscotherium chamense terrærubræ* Cope, 1881.**

Meniscotherium terrærubræ COPE, 1881, Proc. Am. Phil. Soc., xix, p. 493; 1885, Tert. Vert., p. 496, pll. xxv f, figs. 12-14, xxv g.

Syn. *Hyracops Socialis* MARSH, 1892.²

Type, Amer. Mus. Cope Coll. No. 4410, a left maxilla, with p^2-m^3 and a lower jaw fragment with p^4r . in doubtful association; Wasatch of the San Juan basin, N. Mex. D. Baldwin, 1881.

Distinctive characters: $m^{1-3} = 26.5$ mm.; $p^3-m^3 = 37.5$ mm. Lower molars as in *M. chamense*.

Cope differentiated this species from *M. chamense* by size and by the "flattened form of the external faces of the true molars and the absence of the convexity of the external bases of the crown." These differences of form I am not able to make out from the types themselves, although Cope's drawings show them.

The lower jaw fragment associated with the type probably belongs to a smaller individual, judging from other specimens in the collection where the association of upper and lower teeth is beyond question.

I refer to this large form the skull and jaws (No. 4412) used in the composite mounted skeleton, also Nos. 4413, 4417, both of which were figured by Cope in his Tertiary Vertebrata.

¹ W. Granger, *loc. cit.*, p. 206 (*M. terrærubræ*).

² Amer. Journ. Sci., 1892, p. 447, figs. 1, 2.

Meniscotherium tapiacitis Cope, 1882.

Proc. Am. Phil. Soc., XX, 1882, p. 470; 1885, Tert. Vert., p. 506, pl. xxv, fig. 15.

Type, No. 4425, fragmentary lower jaws with p_4 - m_2 r. and p_3 and m_3 ; from the Wasatch of the San Juan basin, "Alto la Zerta", N. Mex. D. Baldwin Coll'r.

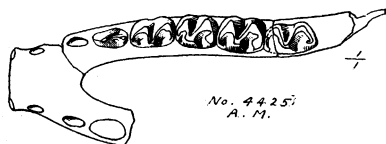


Fig. 17. *Meniscotherium tapiacitis*, lower jaw, crown view. Type specimen.

Distinctive characters: $m^{1-3} = 17$ mm. (est.); lower molars with metastylid slightly developed on m_3 , absent on other molars.

This diminutive species is represented by the type only, and there are no specimens in the collection, except the one described below, which are intermediate in size between it and the type of *M. chamense*.

Meniscotherium(?) priscum sp. nov.

Type, No. 16145, a lower jaw fragment with dm_4 - m_1 left; from the Clark Fork beds, Head of Big Sand Coulee, Clark Fork basin, Wyo. Exp. 1911.



Fig. 18. *Meniscotherium(?) priscum*, fourth milk molar and first true molar, crown and internal views. Type, Clark Fork beds, Clark Fork basin, Wyoming.

Distinctive characters: dm_4 - $m_1 = 11.8$ mm., m_1 ant. post. = 5.5 mm. tr. = 4.5 mm.; prominent metastylid on first molar.

There are no characters in the two teeth present in this specimen to exclude it from the genus *Meniscotherium* but it would not be surprising, considering the low horizon from which it comes, if more complete material forced the establishment of a new genus. It is true that *Phenacodus* and *Ectocion* both run through the same vertical range with very little change, but *Meniscotherium* is a much more specialized form than either of these.

The present species is slightly larger than *M. tapiacitis* and differs from it in having the well developed metastylid; from the larger forms it is readily separable by size.

Distribution of species of Meniscotheriidae.

	Wyoming					N. Mex.	
	Lost Cabin	Lysite	Gray Bull	Sand Coulee	Clark Fork	Largo	Almagre
<i>Meniscotherium</i>							
M. chamense	×					×	
M. chamense terrærubræ						×	
M. tapiacitis						×	
M(?). priscum					×		

× indicates horizon and locality of type.

