

Article XXII.—A REVISION OF THE PUERCO FAUNA.

By W. D. MATTHEW.

The Basal Eocene Fauna of New Mexico, as described by the late Prof. E. D. Cope in numerous papers between 1881 and 1888, contained ninety-one species of mammals, to which three were added by Prof. H. F. Osborn and Mr. Charles Earle in their article on the Puerco in 1895. Many of these were based on extremely fragmentary material, and in comparatively few has much been recorded of the skeletal structure. The primitive unspecialized character of the fauna has made it very difficult to determine the ordinal position and relationship of the different species, the dental characters being often misleading.

The original collections made by Mr. David Baldwin and described by Prof. Cope were purchased by the American Museum in 1895. In 1892 and 1896 important collections in this field were made by the Museum Expeditions in charge of Dr. J. L. Wortman. The addition of a large amount of new material to the earlier collections, the careful comparison of all the known material, and the appreciation of the fact that the faunas of the upper and lower beds had not a species in common, made a thorough revision of the fauna advisable. For this purpose the entire collection was placed in my hands by the Curator, Professor Osborn, to whose kindness I also owe convenient access to the scattered literature of the subject, and many valuable suggestions. The past year has been given to this work. The original intention was to publish a joint paper with Dr. Wortman, but he found that lack of time would prevent the completion of his part of the paper, and he has very generously handed over his results to me, confining himself to an article on the stratigraphy of the beds, besides the paper already published on the Edentata (Ganodonta).¹

This revision has consisted largely in the re-arrangement of the species and reduction of their number. The more perfect mate-

¹ Bull. Am. Mus. Nat. Hist., 1897, pp. 59-110.

rial at hand shows that several of the species described were based on a misapprehension of the characters of imperfect specimens, and that others are varieties not yet sufficiently distinct for specific separation. In no case, however, have I abandoned a species already described without definite evidence to prove that it is invalid; in the absence of such evidence species have been retained whose validity is doubtful.

It must be remembered that all the species of the upper beds come from a single thin stratum, those of the lower beds from two strata only.¹ Not a fragment has been found except in these layers, aggregating only a few feet in thickness. The varying forms of the upper beds were therefore strictly contemporaneous; we have in no case records of successive varieties. The same may be said of the lower beds, if we leave out the specimens from the lowest stratum. Variation in a species, therefore, does not represent successive phases of development of a race, but it does show precisely what characters were plastic at the time, and thus indicates in what points we may expect the successors of a species to differ from it.

The most important point brought forward in this paper is the entire distinctness of the species of the upper and lower beds. Cope in 1888 gave a list of twenty species peculiar to the lower beds. Osborn and Earle in 1895 gave a complete list of the fauna, correctly designating the horizon of thirty-six out of ninety-three species, and noted the important points in the vertical distribution as then known. But it was not until the complete records kept by the American Museum field parties afforded a secure working basis, that it was possible to demonstrate that the upper and lower beds contained two absolutely distinct faunas. They have not a species in common,² and in no case does a genus pass through without serious modifications of at least subgeneric value. Of fifteen families of the upper beds only eight are represented in the lower. The two faunas are as different as in any two successive Eocene formations. It becomes necessary to adopt a new name to designate one of these two, and Dr. Wortman proposes

¹ See Bull. Am. Mus. Nat. Hist., 1895, p. 2, and also Dr. Wortman's forthcoming paper on the Torrejon formation.

² One or two apparent exceptions are probably due to imperfect knowledge of the species in question or to incorrect records.

to call the upper beds the Torrejon formation, retaining the name Puerco for the lower. The reasons for this change will be more fully set forth in his article.

COMPOSITION OF THE FAUNA.

The Puerco-Torrejon faunas are composed of the following elements :

1. The Mesozoic group of Multituberculates culminates in the Puerco and dies out in the Torrejon, true Rodents coming in to take its place.

2. The main body of the fauna is composed of the primitive types from which sprang the Ungulates on the one hand, the later Creodonts and Carnivores on the other. In the Puerco these two divisions are hardly distinguishable ; in the Torrejon they are clearly separable although still closely allied, and the subdivisions of each group are foreshadowed. But it must not be supposed that we have here the direct ancestors of all the later types ; on the contrary there are comparatively few forms even in the Wasatch, that are descended from known Basal Eocene species, and these are not the persistent types. It is clear that a large addition to the fauna must be made before we will come across the direct ancestors of most of the modern Ungulata. The Basal Eocene Carnivores and Ungulates were evolving into types corresponding to the modern differentiation, but to a large extent analogous only and not ancestral.

For such primitive Carnivores the term *Creodonta* is universally used. For the corresponding group of primitive Ungulates the term *Condylarthra* will here be used, making it nearly equivalent to the hypothetical *Protungulata*.¹

3. A few more specialized lines may be separated from this main group. The *Edentata* are already well advanced in their differentiation. The *Amblypoda* and *Rodents* are just beginning, but clearly recognizable. A fourth type is allied to the *Primates*.

Table I shows the scope of the fauna and its relation to the later ones.

¹ See note at end of this article.

TABLE I.

	EOCENE.						Oligocene.	Miocene.	Pliocene.	Pleistocene and Recent.
	Puerco.	Torrejon.	Wasatch.	Wind River.	Bridger.	Uinta.				
MULTITUBERCVLATA...										
{ Polymastodontinæ.....	X									
{ Plagiolacinae.....	X	X								
Bolodontidæ.....		X								
PRIMATES.....										
Anaptomorphidæ.....	?X	X		X	X					
Hypsodontidæ.....		X	X	X	X					
Microsyopidæ.....				X	X	X				
RODENTIA.....										
Mixodectidæ.....		X								
Ischorymyidæ.....			X	X	X	X	X			
EDENTATA.....										
Stylinodontidæ.....	X	X	X	X	X		(Ground Sloths).			
Conoryctidæ.....	X	X								
CREODONTA.....							(Carnivora).			
Oxyclænidæ.....	X	X								
Triisodontidæ.....	X	X								
Arctocytonidæ.....	?X	X	X							(?Ursidæ).
Mesonychidæ.....		X	X	X	X	X				
Proviverridæ.....		X	X	X	X					
Miacidæ.....		X	X	X	X	X				(?Canidæ).
Oxyænidæ.....			X	X ¹						
Hyænodontidæ.....						X	X			
Palæonictidæ.....			X	X	X					(?Felidæ).
CONDYLARTHRA.....							(Specialized Ungulates).			
Phenacodontidæ.....	X	X	X	X						
Mioclænidæ.....	X	X	X							(?Artiodactyla).
Periptychidæ.....	X	X								
Meniscotheriidæ.....			X							
AMBLYPODA.....										
Pantolambdæ.....		X								

¹ Lower Huerfano. See OSBORN, Bull. Am. Mus. Nat. Hist., 1897, p. 247.

The difference between the Puerco and Torrejon faunas appears to be mainly in the poverty of the former in families. This, however, is not due to any scarcity of specimens or of species, as is shown in Table II. It points to a large immigration at the beginning of the Torrejon. Another considerable immigration must have taken place before the beginning of the Wasatch.

TABLE II.
LIST OF SPECIES.

PUERCO.	No. of specimens determined.	TORREJON.	No. of specimens determined.
MULTITUBERCULATA.			
PLAGIAULACIDÆ.			
<i>Polymastodontinæ.</i>			
Catopsalis foliatus Cope.....	1	Polymastodon fissidens Cope..	1
Polymastodon taöensis Cope....	27	(Recorded as coming from	
“ attenuatus Cope....	9	the upper beds.)	
“ selenodus O. & E.	1		
<i>Plagiaulacinæ.</i>			
Neoplagiaulax, sp. ?	1	Neoplagiaulax molestus Cope..	1
“ americanus Cope.	4	Ptilodus mediævus Cope.....	10
		“ trovessartianus Cope..	3
BOLODONTIDÆ.			
		Chirox plicatus Cope.....	2
PRIMATES.			
? ANAPTOMORPHIDÆ.			
		Indrodon malaris Cope	4
RODENTIA.			
MIXODECTIDÆ.			
		Mixodectes pungens Cope....	9
		“ crassiusculus Cope.	4
CREODONTA.			
OXYCLÆNIDÆ.			
Oxycænus cuspidatus Cope ...	9	Chriacus pelvidens Cope.....	11
“ simplex Cope ...	1	“ baldwini Cope.....	6
Protochriacus priscus Cope.....	17	“ truncatus Cope.....	10
“ attenuatus O. & E.	2	“ schlosserianus Cope..	1
“ hyattianus Cope... 5		Tricentes crassicolliidens	1
		“ subtrigonus.....	87
? PROVIVERRIDÆ.			
		Deltatherium fundaminis Cope.	28
TRIISODONTIDÆ.			
Triisodon quivirensis Cope....	1	Sarcothraustes antiquus Cope..	6
“ heilprinianus Cope....	28	“ sp. indesc	1
“ gaudrianus Cope.....	4	Goniacodon levisanus Cope....	16
		Microclænodon assurgens Cope.	3
MESONYCHIDÆ.			
		Dissacus navajovius Cope.....	13
		“ saurognathus Wortman.	5

TABLE II.—*Continued.*

<i>PUERCO.</i>	No. of specimens determined.	<i>TORREJON.</i>	No. of specimens determined
ARCTOCYONIDÆ.			
? <i>Clænodon protogonioides Cope.</i>	1	<i>Clænodon protogonioides Cope.</i>	5
		“ <i>ferox Cope.</i>	14
		“ <i>corrugatus Cope.</i>	13
MIACIDÆ.			
		<i>Didymictis haydenianus Cope.</i>	16
		“ <i>cf. leptomytus Cope.</i>	2
INCERTÆ SEDIS.			
<i>Carcinodon filholianus Cope.</i>	1		
<i>Oxyacodon apiculatus O. & E.</i>	6		
“ <i>agapetillus Cope.</i>	5		
		<i>Pentacodon inversus Cope.</i>	2
CONDYLARTHRA.			
PHENACODONTIDÆ.			
<i>Protogonodon pentacus Cope.</i>	20	<i>Euprotogonia puerensis Cope.</i>	189
“ <i>stenognathus.</i>	4	“ <i>minor.</i>	3
PERIPTYCHIDÆ.			
<i>Ectoconus ditrigonus Cope.</i>	45	<i>Periptychus rhabdodon Cope.</i>	157
<i>Periptychus coarctatus Cope.</i>	27	“ <i>carinidens Cope.</i>	25
<i>Anisonchus gillianus Cope.</i>	22	<i>Anisonchus sectorius Cope.</i>	35
<i>Hemithlæus kowalevskianus Cope.</i>	38		
<i>Conacodon entoconus Cope.</i>	27		
“ <i>cophater Cope.</i>	5	<i>Haploconus lineatus Cope.</i>	66
		“ <i>corniculatus Cope.</i>	19
MIOCLÆNIDÆ.			
		<i>Mioclænus turgidus Cope.</i>	68
		“ <i>lydekkerianus Cope.</i>	1
<i>Mioclænus turgidunculus Cope.</i>	5	“ <i>lemuroides.</i>	16
		“ <i>inæquidens Cope.</i>	5
		“ <i>acolytus Cope.</i>	17
? <i>Protoselene opisthacus Cope.</i>	1	<i>Protoselene opisthacus Cope.</i>	14
AMBLYPODA.			
PANTOLAMBIDÆ.			
		<i>Pantolambda bathmodon Cope.</i>	17
		“ <i>cavirictus Cope.</i>	11
EDENTATA.			
STYLINODONTIDÆ.			
<i>Hemiganus otariidens Cope.</i>	2	<i>Psittacotherium multifragum Cope.</i>	17
CONORYCTIDÆ.			
<i>Onychodectes tisonensis Cope.</i>	11	<i>Conoryctes comma Cope.</i>	13
“ <i>rarus O. & E.</i>	1		
Total number of determined specimens.	331	Total number of determined specimens.	945
Total number of species.	31.	Total number of species.	44.

MULTITUBERCULATA.

The distribution of the species of this group is peculiar. The large *Polymastodon* is common in the lower beds, but only one specimen is recorded as from the Torrejon, while *Ptilodus* and *Chirox*, the smallest and most primitive genera, occur only in the upper beds, and the intermediate *Neoplagiaulax* is found in both horizons.

PRIMATES.

Osborn and Earle have placed in this order the Chriacidæ, besides *Mixodectes* and *Indrodon*, which Cope considered of Primate affinities (Prosimiæ). The Chriacidæ seem more nearly Creodont in their affinities, as Cope and Scott considered them, and *Mixodectes* is probably a Rodent. *Indrodon* is shown by the skeleton described in 1895 to have Primate affinities though a generalized type. Yet its upper molars are curiously like those believed to belong to *Mixodectes*, showing how unreliable tooth-characters may be in this fauna.

? RODENTIA.

Mixodectes Cope.

COPE, Proc. Am. Phil. Soc. 1882-3, 559; Tert. Vert. p. 240; SCHLOSSER, Affen, Lemuren, u. s. w. pp. 40, 49 (Sep.-Abd. aus Beit. z. Pal. Ost.-Ung. Bd. VI).

The discovery of some skeleton fragments in good association with a lower jaw of *Mixodectes pungens* makes it probable that this genus should be removed from the Primates and placed as an extremely primitive Rodent. *Microsyops* may perhaps go with it, but this is extremely doubtful, as the type of its lower molars is much more primitive and persistently so, and in several other respects different from *Mixodectes*.

The skeleton fragments in question include a well-preserved astragalus, which is wide, thin, sharply keeled, without astragalar foramen, and with moderately long neck and wide flat head. The

ectal astragalo-calcaneal facet is large, triangular and not strongly concave, the sustentacular is much smaller and oval, not confluent with the distal facet. The trochlea is wide, and continued back obliquely to the underside of the astragalus.

The shape of the astragalus and all the details of its facets sustain a close comparison with that of *Plesiarctomys* of the Wasatch. The absence of the foramen is an unusual character for a Basal Eocene mammal; it is seen also in *Onychodectes*. There are fragments of the limb-bones preserved, which indicate a long hind leg.

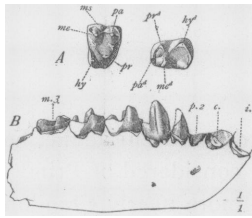


Fig. 1. — *Mixodectes pungens* Cope. Natural size. A, upper and lower molar, No. 2385. B, lower jaw, type specimen, No. 3081.

Another specimen shows the character of the enlarged lower front tooth, which is not yet chisel-shaped, although approaching that form. It is long and slender, caniniform, the crown completely invested with enamel which extends but a little further down on

the outside than the inside. The long axis of a section across the root of the tooth is antero-posterior, and this part is flattened on the inner side. The crown, however, is twisted around so as to have the long axis more nearly transverse, the flattening of the inner side disappearing. This seems to be a trace of its original incisive (spatulate) character; it is difficult to see why such a peculiar shape should develop in a canine. The position and character of the smaller tooth behind it strengthens this supposition; it is more on the outside of the jaw than a premolar should be, is oval and rather long-rooted. This is probably the canine, the first premolar being absent; the front tooth is then one of the incisors, and the dental formula is $\frac{1 \cdot 1 \cdot 3 \cdot 3}{1 \cdot 1 \cdot 3 \cdot 3}$.

The second premolar is very small, one-rooted; the third is small, two-rooted, with high cusp and small heel, and is often set somewhat transversely in the jaw. The fourth is large with strong heel, and high cusp in front and minute antero-internal cusplet or cingulum. The anterior position of the main cusp is characteristic.

The molars have four high cusps, the paraconid being reduced to an anterior ridge rising to the protoconid. The third molar

has also a strong hypoconulid; the position of this cusp is usually nearly behind the entoconid instead of median. The cusps are more peripheral than is usual, their outer surface rising nearly vertically from the side of the crown instead of sloping inward.

Associated with a lower jaw of *Mixodectes* is an upper molar of appropriate size which may belong to it. This tooth has high cusps, moderately strong spur-like hypocone, minute para- and mesostyle and no intermediates. In shape and character of the cones it strongly resembles *Indrodon*, but is much larger than *I. malaris*.

The strong resemblance of the astragalus of *Mixodectes* to those of the sciromorph Rodents is in harmony with the indications of the teeth, which show progress towards a type with scalpriform incisors and four molariform teeth in the lower jaw, short-crowned with peripheral cusps. Such a type is *Plesiarctomys*, but to place the Torrejon *Mixodectes* as directly ancestral to this Wasatch genus would involve a greater change than we should expect during the interval. It is better to place it as a sciromorph Rodent of the most primitive type. It has hitherto been considered a Primate,¹ and in the line of ancestry of *Chiromys*. But the astragalus is quite unlike that of the contemporary Primates, and still more different from *Chiromys*. The dental characters, except for the single doubtfully associated upper molar, indicate affinity rather to the Rodents than any of the early Primates.

CREODONTA.

OXCLÆNIDÆ Scott.

This family includes a number of genera whose characters as far as known seem to place them on the border line between Creodonts and Lemurs. Scott remarks: "The genera associated to form this family are known almost entirely from the dentition, and their relationship with each other, even their ordinal posi-

¹ Cope, Tert. Vert., p. 241; Schlosser, Affen, Lemuren, u. s. w., pp. 40, 49.

tion, is very obscure, the teeth being of that generalized and primitive character to which all mammalian types of dentition converge as we trace them back in time."¹ Osborn and Earle place the group, except *Oxycænus*, among the Primates. The positive evidence of Primate relationship, aside from the merely primitive characters, is not very convincing, the strongest point being the character of the upper molars in *Chriacus*. Against this we may place the long slender jaw, characteristic of the family, with spaced premolars, strong canines and no tendency to a reduced dentition. The resemblance in dental structure to the Creodont *Deltatherium* must not be overlooked. The little that is known of the skeletal characters is equally unsatisfactory. A femur associated with *C. baldwini* is of moderate length with well developed trochanters, and compares with *Didymictis* rather closely. An imperfect astragalus with the type of *C. schlosserianus*, described in 1888 by Prof. Cope, is somewhat like that of *Indrodon*, but is more keeled and the ectal calcaneal facet much wider. The resemblance is chiefly in the lack of specialization, and is therefore untrustworthy.

The type genus, *Oxycænus*, shows a considerable resemblance to the Triisodontidæ, and perhaps should be included with them. In this case the remaining genera, *Chriacus*, *Protochriacus* and *Tricentes*, will be united under Osborn and Earle's family Chriacidæ.

Protochriacus Scott.

SYN. *Loxolophus* COPE, 1885, SCOTT, 1892.

Dentition: I.₅, C.₁, P.₄, M.₃. Upper molars tritubercular with hypocone little developed and no protostyle. Lower molars broad and low approaching the *Protogonodon* type; p₃ and p₄ with rudimentary dentocene. Intermediates minute or absent on upper molars.

Cope's *Loxolophus adapinus* was founded on a crushed specimen of his *Chriacus hyattianus*. The distinctions so far as made were based on error, and Scott's name, *Protochriacus*, is therefore preferred. The type is *P. priscus* Cope; another species, *P. attenuatus*, was described by Osborn and Earle, and a third, *P. hyattianus* Cope is probably referable, although the premolars are unknown. Scott's second species, *P. simplex* Cope, is, as

¹ Trans. Phila. Acad. Nat. Sci., 1892.

remarked by Osborn and Earle, widely different from *P. priscus*, and may perhaps be provisionally placed under *Oxycænus*. All the above species are from the lower beds or true Puerco.

Protochriacus priscus (Cope).

Chriacus priscus COPE, Trans. Am. Phil. Soc. 1888, p. 337, fig. 6; (*Protochriacus*) SCOTT, Proc. Phila. Acad. 1892, 296; OSBORN & EARLE, Bull. A. M. N. H. 1895, p. 22.

Dimensions: $M^{1-3}=.0185$; $m_{1-3}=.0133$ (type, No. 3108); $i_1-m_3=.055$ (No. 803).

The lower teeth of *P. priscus* are remarkably like those of *Protogonodon*; the upper teeth are entirely different from those referred to that genus, and are much like those of *Tricentes*, except that the cusps are more angulate.

Protochriacus attenuatus Osborn & Earle.

Bull. Am. Mus. Nat. Hist. 1895, p. 22.

This species is much smaller than *P. priscus*, which it otherwise closely resembles. The teeth are not so wide, the paraconid is more internal, the notch between protoconid and entoconid deeper. It is doubtful whether the third molar described by Osborn and Earle belongs to the species; it does not seem to be the same individual. Length, $m_{1-3} .0108$ (type, No. 790).

Protochriacus hyattianus (Cope).

Chriacus hyattianus COPE, Am. Nat. 1885, 385; Trans. Am. Phil. Soc. 1888, 336; (*Loxolophus*) SCOTT, Proc. Phila. Acad. 1892, 297; *Loxolophus adapinus* COPE, Am. Nat. 1885, 386.

The type specimen (No. 3121) is crushed transversely, as is also the type of *Loxolophus adapinus* (No. 3134). A third specimen (No. 931) which I refer to this species, gives the outline of the upper molars more satisfactorily. The species is smaller than *P. priscus* and m^3 much more reduced. The lower molars (No. 3124) show a corresponding reduction of m_3 . In the absence of any knowledge of the premolars the position of the species is

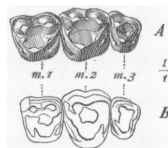


Fig. 2.—*Protochriacus hyattianus* Cope. A, upper molars of left side, crown view, distorted by transverse pressure. Type specimen No. 3121. B, outline of upper molars of left side. No. 931. Both natural size.

provisional; it may belong to *Protogonodon*. Satisfactory distinctions from *P. attenuatus* are lacking, except in the characters of the last molar tooth whose reference to the latter species, as above noted, is doubtful.

Length, m^{1-3} , .016; m_{1-2} , .011.

Tricentes Cope.¹

Dentition: I. $\frac{1}{1}$, C. $\frac{1}{1}$, P. $\frac{3}{3}$, M. $\frac{3}{3}$. Hypocone moderate, no protostyle, very rudimental deutocone, or none, on p^3 and p_4 . Cusps conical and blunted. Canines well developed in both jaws, incisors small or reduced. A considerable diastema behind the upper and lower canines, which are short and directed nearly vertically.

Tricentes differs from *Protochriacus* in the more conical form of the cusps, the loss of the first premolar and close setting of the remaining ones, and the reduction of the paraconid. From *Chriacus* it differs in the simpler premolars, less development of hypocone, absence of $pm_{\frac{1}{1}}$, canines vertical instead of projecting forward, and in the much less trenchant and more rounded molar cusps.

Tricentes subtrigonus (Cope).

Mioclenus subtrigonus COPE, Proc. Am. Phil. Soc. 1881, 491; 1882-3, 555; Tert. Vert. p. 338, pl. lviii, fig. 5, and xxiv, fig. 4; Am. Nat. 1881, 490; Trans. Am. Phil. Soc. 1888, 321; (*Tricentes*) Proc. Am. Phil. Soc. 1883-4, 315; SCOTT, Proc. Phil. Acad. 1892, 297.

Mioclenus bucculentus COPE, Proc. Am. Phil. Soc. 1882-3, 555; Tert. Vert. p. 341, pl. xxiv, fig. 10; (*Tricentes*) Proc. Am. Phil. Soc. 1883-4, 316; Trans. Am. Phil. Soc. 1888, 303; OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 24.

Phenacodus zuniensis COPE, Proc. Am. Phil. Soc. 1881, 492; Tert. Vert. 491, pl. lviii, fig. 10; (*Protogonia*) Trans. Am. Phil. Soc. 1888, 359 (in part). Not *P. zuniensis*, Am. Phil. Soc. 1881, 180.²

Chriacus baldwini COPE, Trans. Am. Phil. Soc. 1888, 340 (part). Not previous references.

Upper canines straight, rather short, directed downwards, strongly striate longitudinally, somewhat ridged posteriorly, with a considerable diastema behind. Second premolar two-rooted, high and trenchant, without cingulum. Third and fourth three-rooted, with strong cingulum all around the base, the fourth with large deutocone. Molars with strong enveloping cingulum,

¹ Proc. Am. Phil. Soc., 1883-4, 315.

² Recorded from the Wasatch Beds; but the specimens were afterwards referred by Prof. Cope to *Hyopsodus* (*H. powellianus* Cope).

except sometimes on inner side of protocone. M^1 and m^2 , subquadrate, with small hypocone, m^3 triangular. Intermediates not large, but distinct.

Lower canines with sharply curved root of round oval section, the cusp directed upward, not at all forward, and having a considerable diastema behind. Second, third and fourth premolars of nearly equal size, but successively wider and less trenchant, the third and fourth with cingulum around the base, developed into a small heel on the fourth. Lower molars with much reduced paracoid and an external cingulum more or less obsolete.

The second upper and lower molars are considerably larger than the first; the third is somewhat variable in size and shape, the upper one considerably smaller than the second, the lower never larger.

The premolar and molar cusps are marked by a characteristic interrupted striation or wrinkling longitudinal to the cusp; this is partly worn off on old individuals, but very distinct on unworn teeth.

Measurements, $m^1 \cdot 2 = .017$, No. 2399; $c - m_3 = .0455$, No. 4001. Lower diastema, .008.

This is a very abundant form, represented by over eighty specimens in our collections. It shows a considerable range of variation in size, in the comparative width of the teeth, in the length and shape of the last lower molar, and in the relative size of the second molar above and below. The cingulum is sometimes discontinuous around the internal face of the protocone in one or more of the upper molars. Normally there are but three premolars above and below; this condition is conclusively shown in four upper and fourteen lower jaws; three lower jaws have a minute pit which may have held in the young a vestigial first premolar; one jaw (figured by Cope) shows apparently the root of a well-developed first premolar.

On the above variations two species have been separated from the typical form. A careful comparison of all the material shows that neither of them is valid.

Tricentes bucculentus was described originally from a fragment of upper jaw with $p^4 - m^2$, in which m^2 is unusually large. Subsequently specimens were referred to it showing the loss of p^1 , and

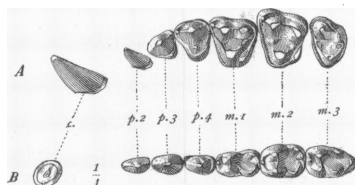


Fig. 3.—*Tricentes subtrigonus* Cope. Natural size. *A*, upper teeth of left side, crown view; No. 2399. *B*, lower teeth of left side, crown view; No. 4001.

the genus was separated from *Mioclanus* on this ground. There is no evidence in the type specimens as to whether either *M. subtrigonus* or *T. bucculentus* lacked the first premolar. Only one specimen is known to have p_1 present, and as this specimen is in all other respects like the rest, the extra premolar is probably abnormal. This leaves as a distinction between *bucculentus* and *subtrigonus* only the comparative size of the upper molars, a character quite variable in this group, and not of specific value. The type and all but two of the other specimens referred to *Protonia zuniensis* Cope belong here, as is stated under the discussion of that species.

The surface of the teeth is corrugated in a characteristic manner, which, with the rounded, blunt-pointed cusps, make it easy to recognize a single tooth. Old or weather-worn specimens sometimes have this nearly obsolete, but in the young individuals it is very strong. It is somewhat like the surface corrugation of the teeth of *Hyracotherium* and *Systemodon*, but more constant. It appears on the premolars of *Protochriacus*, but is hardly noticeable on the molars.

Tricentes crassicollidens Cope.

Proc. Am. Phil. Soc. 1883-4, 315; Trans. Am. Phil. Soc. 1888, 304.—SCOTT, Proc. Phila. Acad. 1892, 297.

This species is the type of the genus, but is represented only by a very much damaged skull, which shows a similar dentition to *T. subtrigonus* so far as it can be determined. In absence of more satisfactory specimens the placing of *T. subtrigonus* as congeneric with this species must remain provisional.

Measurements, $m^{1-3} = .015$.

Chriacus Cope.¹

Dentition: $I.1$, $C.1$, $P.4$, $M.3$. First and second upper molars with strong spur-like hypocone projecting inwards and backwards, and smaller protostyle on m^2 , giving them a quadrate outline with concave sides. Intermediates small. Cusps higher than in the two preceding genera, trigonid more raised. Paraconid somewhat reduced, p^3 and p_4 with well-developed deutercone in the larger species.

¹ Proc. Am. Phil. Soc. 1883, 313.

The number of species belonging here is doubtful. Among the larger forms two appear fairly distinct, and there are two or three small ones not easily separated.

Chriacus pelvidens (Cope).

Lipodectes pelvidens COPE, Am. Nat. 1881, 1019; (*Chriacus*) Proc. Am. Phil.

Soc. 1883-4, 313 (part); (*Pelycodus*) Tert. Vert. p. 225 (part).

Chriacus stenops COPE, Trans. Am. Phil. Soc. 1888, p. 341; SCOTT, Proc. Phila. Acad. 1892, p. 295.

Chriacus baldwini OSBORN and EARLE, Bull. Am. Mus. Nat. Hist. 1895, 21.

Third upper molar not reduced, being as wide transversely as the second. Lower jaw long and slender; canines strong, rather long, oval in section, projecting forward, striate longitudinally. First lower premolar one-rooted, second two-rooted, both spaced in front and behind. Third and fourth premolars considerably larger than the second, fourth with well-developed deutoconid.

Measurements: $M^{1-2} = .018$ (No. 2384); $c-m_3 = .056$, $p_2-4 = .018$, $m_{1-3} = .0225$ (No. 2378.) Transverse diameter $m^2 = .0093$, $m^3 = .0095$ (No. 2384).

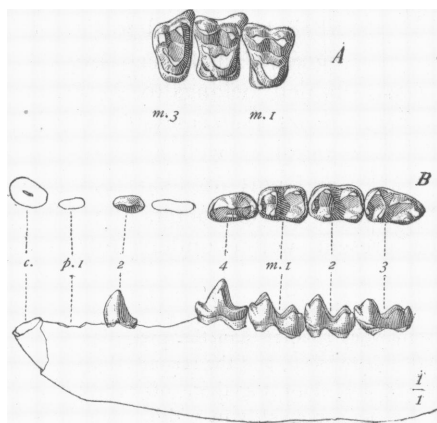


Fig. 4. *Chriacus pelvidens* Cope. Nat. size. A, upper molars of right side, No. 2384, crown view. B, lower teeth, crown view, No. 2379. C, lower jaw from within, No. 2379.

The type of Cope's *C. pelvidens* appears to be a larger species than specimens later referred to it, and is probably identical with *C. stenops* Cope. The remaining specimens referred to *pelvidens* by Cope I am unable to distinguish from his *C. baldwini*. Sev-
[November, 1897.]

eral specimens obtained by the Expedition of 1896 fill out our knowledge to some extent.

Chriacus baldwini (Cope).

Deltatherium baldwini COPE, Proc. Am. Phil. Soc. 1882-3, 463; Tert. Vert. p. 282, pl. xxiiid, fig. 12; *Chriacus baldwini*, Trans. Am. Phil. Soc. 1888, 340 (part).

Pelycodus pelvidens COPE, Tert. Vert. p. 225 (all specimens except type), pl. xxiiid, figs. 7 and 8; (*Chriacus*) Proc. Am. Phil. Soc. 1883-4, p. 314 (part). Not *Lipodectus pelvidens*, Am. Nat. 1881, 1019.

There is much confusion about this species. The original type (No. 3114) is a part of a lower jaw containing two premolars and a molariform tooth. Prof. Cope describes these as the third and fourth premolars and the first true molar, but comparison with various other specimens shows that they are the second and third premolars and fourth milk molar. In 1888 he referred to *C. baldwini* a lower jaw which belongs to *Tricentes subtrigonus* (No. 3993) as well as jaws and part of a skeleton (No. 3115) which show the characters of *C. baldwini* as the present writer understands them.



Fig. 5.—*Chriacus baldwini* Cope. Upper molars and last premolar of left side, crown view. No. 3115. Nat. size.



Fig. 6.—*Chriacus baldwini* Cope. Posterior view of femur $\times \frac{3}{2}$. No. 3115.

C. baldwini is somewhat smaller than the preceding species, the last molar is reduced, and the second, third and fourth premolars are close together, of nearly uniform height, increasing successively in width. The deutoconid on p_4 is small. The fourth milk molar in the type is smaller than the first true molar, but composed of the same elements, the paraconid more reduced, the other cusps too much worn for exact comparison.

Measurements: $M^{1-2} = .018$ (molars displaced); $m_{1-3} = .022$ (molars displaced, No. 3100). Transverse diameter $m^2 = .0082$, $m^3 = .0071$ (No 3099).

***Chriacus truncatus* Cope.**

Proc. Am. Phil. Soc. 1883-4, p. 315; Trans. Am. Phil. Soc. 1888, 336, fig. 9.

This species is a close copy of *C. baldwini* on a smaller scale, the length of the three upper molars being only .014. There is some variation in size, but not much, among the five or six specimens referred here. The lower teeth are not known.



Fig. 7.—*Chriacus truncatus* Cope Upper teeth of right side, crown view. Type specimen, No. 3101. Nat. size.

***Chriacus schlosserianus* Cope.**

Trans. Am. Phil. Soc. 1888, p. 338; (*Epichriacus*) SCOTT, Proc. Phila. Acad. 1892, 296.

The only distinctions from *C. truncatus* are the absence of prostyle and less prominence of hypocone on m^2 and the comparatively greater transverse width of m^3 . These are of somewhat doubtful specific value. The fourth lower premolar is badly preserved in the type specimen; Scott describes it as "having all the elements of a true molar, though not fully developed," and founds a new genus on it. The writer is not able to see any essential difference from the usual type of p_4 in *Chriacus* which is not accounted for by the crushing and displacement which the tooth has undergone. The anterior cingular cusp (paraconid) which is always present in the Chriacidae, is well developed in all the species of *Chriacus*, and in *C. schlosserianus* does not materially differ from the larger species, so far as can be judged from the imperfect specimen. A jaw (No. 3915a) containing a perfect fourth premolar and the three true molars, and not otherwise distinguishable from the type of *C. schlosserianus*, shows a normal *Chriacus* p_4 with deuterconid reduced apparently by wear, and paraconid as a basal cingular cusp of the same proportional size and form as in *C. pelvidens*. This specimen might of course

equally well be referred to *C. truncatus*, if the latter be distinct from *C. schlosserianus*.

With the type of *C. schlosserianus* are some fragments of skeleton, already fully described by Prof. Cope. These are not sufficient to decide the relationship; there does not seem to be anything distinctively primate about them as distinguished from what we should expect to find in an early type of Creodont.

Oxyclænus (Cope) Scott.

"The anterior premolars form simple, compressed and trenchant cones; on p^4 there is also a well-developed deutercone. The molars are simply tritubercular, with small, erect and acute cusps. . . . The para- and metacones arise close to the outer side of the crown. . . . The protocone is the largest of the elements. There is no distinct hypocone, merely a thickening of the cingulum at that point, which is most marked in m^3 . Minute but very distinct proto- and metaconules are present. M^3 is very much reduced in size, and more oval than triangular in shape, but preserves all the cusps."¹

Under this genus are included two or three species of doubtful family relations, being intermediate between the Chriacidæ and Triisodontidæ. They are small forms with a trigon like *Chriacus*, but with somewhat more rounded cusps. The type is *O. cuspidatus* Cope, represented by one specimen whose horizon is not recorded. A closely allied or identical species is represented by most of the specimens referred by Osborn and Earle to *Protochriacus simplex*. A third species represented by the type specimen only of *C. simplex* Cope can be placed here only provisionally, the premolars being unknown.

Oxyclænus cuspidatus Cope.

Mioclænus (Oxyclænus) cuspidatus COPE, Proc. Am. Phil. Soc. 1883-4, 312; Trans. Am. Phil. Soc. 1888, 321. (*Oxyclænus*) SCOTT, Proc. Phila. Acad. 1892, 295.

? *Protochriacus simplex* OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 23. Not *P. simplex* of Cope and Scott.

Most of the specimens referred by Osborn and Earle to *Protochriacus simplex* are of a form closely allied to or identical with this

¹ Scott, Proc. Phila. Acad., 1892, 295.

species. The true *O. simplex* Cope is much smaller and differs considerably in the upper molars. The upper teeth of these individuals are the same in character as the type except that the hypocone is rather more developed and the metacone is not pushed inwards. Their third molar is unknown. Fourth upper premolar with high sharp *pr.* somewhat ridged behind and usually rounded in front, and sharp well separated *de.* Third considerably smaller, with protocone ridged in front and behind and no *de.* Molars subquadrate, with round rather high cusps, and small hypocone on m^2 , reduced to a wide cingulum on m^1 . Paracone and metacone connected by a low narrow ridge. Intermediates very small. The third molar is reduced sub-oval and three-cusped in the type. Lower molars with high trigon, well developed paraconid, and deep basin heel partly closed by the entoconid, which is not very well separated from the hypoconulid. Last molar varying in size in different specimens.

Oxycænus simplex (Cope).

Chriacus simplex COPE, Proc. Am. Phil. Soc. 1883-4, 314; Trans. Am. Phil. Soc. 1888, 336; (*Protochriacus*) SCOTT, Proc. Phila. Acad. 1892, 296. Not *P. simplex* of O. & E.

This is a very small species, much smaller than *O. cuspidatus*, but the molar teeth are of about the same type, except m^2 , which is wider and more trigonal. In the absence of any knowledge of the premolars it is placed here provisionally.



Fig. 8.—*Oxycænus simplex* Cope. Upper molars of right side, crown view. Type specimen, No. 3107. Natural size.

TRIISODONTIDÆ Scott.

"Superior molars with low massive cusps, but sometimes having a well-developed hypocone on m^2 ; trigonid much higher than talon, but not forming a shearing blade; paraconid reduced; premolars high and acute."¹

Fourth lower premolar large, with strong bicuspid talonid, second and third premolars small. Jaw symphysis deep and short. Tarsus (in *T. heilprinianus*) non-serial, having an astragalo-cuboid facet.

¹ Scott, Proc. Phil. Acad., 1892, 294.

The Triisodonts are not very far removed from the Mesonychidæ, and were apparently undergoing a somewhat similar cusp degeneration, although it had not progressed so far. The molars are much wider transversely, and the difference in size between the third and fourth premolar is characteristic of the group. The following genera are recognized by Prof. Scott :

1. *Triisodon* Cope. Type, *T. quivirensis*, from the Puerco Beds.
2. *Goniacodon* Cope. Type, *G. levisanus*, from the Torrejon.
3. *Sarcothraustes* Cope. Type, *S. antiquus*, from the Torrejon.
4. *Microclænodon* Scott. Type, *M. assurgens*.

The last genus can be placed here only provisionally, as it is known from a single last lower molar with shattered outlines of the two preceding molars of the same specimen. A review of all the material of this group results in a considerable reduction of the number of species. *Triisodon biculminatus*, *Goniacodon* (*Triisodon*, *Mio-clænus*) *rusticus*, *Sarcothraustes coryphæus*, *S. bathygnathus* and *S. crassiscuspis* Cope appear to be all identical with *T. heilprinianus*, differing only in the depth of the jaw and wear of the teeth. Better material of *Goniacodon gaudrianus* Cope shows it to belong to *Triisodon*. *Sarcothraustes conidens* Cope is identical with *S. antiquus*. None of the genera as at present defined are found in both Puerco and Torrejon Beds. I believe, however, that *Sarcothraustes* was the successor of *Triisodon*, which it resembles. The short deep jaw and extraordinary wear of the teeth, characteristic of the family, indicate probably similar habits to those of the Palæonictidæ of Lower and Middle Eocene time.

***Triisodon* Cope.¹**

Prof. Cope's original generic diagnosis is : " Derived from the lower jaw. Probably only three premolars. True molars alike, consisting of three anterior cusps and a heel. The cusps are relatively small and the heel large. Of the former the internal is much smaller than the external and the anterior is rudimentary, being merely a projection of the cingulum. The cutting edges of the large external cusp are obtuse. The heel is basin-shaped and its posterior border is divided into tubercles, of which the external is a large cusp. The fourth

¹ Am. Nat., 1881, 667.

premolar has no anterior inner tubercle, so that the anterior part of the crown consists of a compressed cutting cusp. The heel has two well-developed posterior cusps. The third premolar has a similar principal trenchant cusp, but a smaller heel. Canines large."

The present arrangement of species requires some modification of this definition. The characters are supplemented in large part from the other species.

Dentition: I. $\frac{1}{3}$, C. $\frac{1}{1}$, P. $\frac{4}{4}$, M. $\frac{3}{3}$. Second upper premolar two-rooted, third and fourth three-rooted, with well defined deutocone. Upper molars wide transversely, subquadrate, with weak hypocone on m¹⁻². Second and third lower premolars small with simple minute talonids, fourth large with strong bicuspid talonid, the outer cusp larger. Lower molars with moderately high trigon, the protoconid and metaconid of nearly equal size, paraconid lower and placed partly in front of metaconid.

There are three very distinct species, but no sufficient evidence of more. All are from the lower or true Puerco Beds.

***Triisodon quivirensis* Cope.**

Triisodon quivirensis COPE, Am. Nat. 1881, 667; Proc. Am. Phil. Soc. 1881, 485; Tert. Vert. p. 270, Pl. xxvc, fig. 2; SCOTT, Proc. Phila. Acad. 1892, 301.

***Triisodon heilprinianus* Cope.**

Triisodon heilprinianus COPE, Proc. Am. Phil. Soc. 1882-3, 193 (Dec. 1881); Tert. Vert. p. 273, Pl. xxiiid, fig. 11; SCOTT, Proc. Acad. Phila. 1892, 301; (*Mioclenus*) COPE, Trans. Am. Phil. Soc. 1888, 321.

Triisodon rusticus COPE, Proc. Am. Phil. Soc. 1883-4, 310; (*Mioclenus*) COPE, Trans. Am. Phil. Soc. 1888, 321; (*Goniacodon*) SCOTT, Proc. Phila. Acad. 1892, 302.

Conoryctes crassiscuspis COPE, Proc. Am. Phil. Soc. 1882-3, 468; Tert. Vert. p. 201, Pl. xxiie, fig. 6; (*Mioclenus*) Trans. Am. Phil. Soc. 1888, 323; (*Sarcothraustes*) SCOTT, Proc. Phil. Acad. 1892, 303.

Sarcothraustes coryphaeus COPE, Am. Nat. 1885, 386; SCOTT, Proc. Phila. Acad. 1892, 303; OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 29; (*Mioclenus*) COPE, Trans. Am. Phil. Soc. 1888, 323.

Mioclenus bathygnathus COPE, Trans. Am. Phil. Soc. 1888, 320; (*Sarcothraustes*) SCOTT, Proc. Phila. Acad. 1892, 303.

Triisodon biculminatus COPE, Trans. Am. Phil. Soc. 1888, 343; SCOTT, Proc. Phila. Acad. 1892, 301; OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, p. 28, fig. 7.

This species is the most abundant Creodont of the lower beds, and is represented by about thirty specimens in our collections. Its appearance varies greatly with the age of the specimen, as the

wear on the teeth is great, and in old individuals the jaw becomes remarkably large and deep. The first three species here included were founded on very imperfect types which cannot be separated except by differences in the wear of the teeth from the more complete types of *Miocænus coryphæus* and *M. bathygnathus*. The type specimen of *M. coryphæus* proves to be the same individual as No. 770 of the Amer. Mus. Coll. 1892; we are thus enabled to supplement former descriptions to some extent. *Miocænus bathygnathus*, as Osborn and Earle have already observed, is founded on the lower jaw of an older specimen with teeth more worn and deeper jaw than the type of *M. coryphæus*. The type of *Triisodon biculminatus* is a very young individual with the last molar not emerged and m_{1-2} completely unworn; a second specimen referred to this species by Osborn and Earle is also young, with teeth unworn and shallow jaw. In none of these can any distinctions of specific value be detected; the apparent difference is almost entirely due to the age of the individual. The further description given here is mainly from the type specimen of *M. coryphæus* Cope, from which the previously-described *M. heilpridianus* cannot be distinguished.

Dentition: I. $\frac{1}{1}$, C. $\frac{1}{1}$, P. $\frac{4}{4}$, M. $\frac{3}{3}$.

Canines of moderate size and round oval section, the upper one larger, directed downward and forward, not lateral. Upper premolars four, the first one-rooted, the second two-rooted, the third and fourth three-rooted with internal cusp and strong cingulum with cusps developed at the anterior and posterior corners. The characters of the remaining teeth are given by Cope.¹

Specimen 773a contains part of limb and a few foot bones, among which is a complete cuboid which shows a considerable astragalar facet about the same in proportion as in *Dissacus*. The limbs are somewhat shorter than those of *D. saurognathus* and about one-fourth smaller.

***Triisodon gaudrianus* (Cope).**

Miocænus (*Sarcothraustes*) *gaudrianus* COPE, Trans. Am. Phil. Soc. 1888, 326; (*Goniacodon*) SCOTT, Proc. Phila. Acad. 1892, 302.

To this species we refer, besides the type described by Cope, another individual, No. 4029, which includes the last four upper

¹ Trans. Am. Phil. Soc., 1888, 323.

molars somewhat damaged, most of the lower jaw, and fragments of the skeleton. This enables us to fix the species in the genus *Triisodon* rather than in *Goniacodon*, where it was placed by Prof. Scott.

There are three small incisors in the lower jaw ; the canines are rather small and nearly round in section. The third upper premolar is three-rooted, the crown is not preserved. The molars are quadrate, remarkably wide transversely with strong external cingula; the cusps very like those of *T. heilprinianus*. The third lower premolar is small, the fourth large with high round protoconid and strong talon whose cusps are unfortunately broken off. The last lower molar is not reduced; the last upper one is narrowed antero-posteriorly, but not reduced transversely.

The reasons for placing this species in *Triisodon* rather than *Goniacodon* are: the transverse width of the teeth as compared to their length; quadrate shape of the first two upper molars, form and size of the last molar. The lower jaw fragment of the type specimen is too imperfect to show the character of the inferior molars, and p^3 is not preserved, although from the transverse width of the roots we may suspect that it had an internal cusp.

The comparative size of the three species of *Triisodon* is shown by the measurements given below.

<i>T. quivirensis.</i>	<i>T. heilprinianus.</i>	<i>T. gaudrianus.</i>
p^3-m^3.....	.052	.034
$m^1-\bar{a}$.....	.031	.022
m^2 transv.....	.0155	.013
" antero-post.....	.0107	.0085
m^3 transv.....	.0150	.011
" antero-post.....	.0084	.0058
p_3-m_3.....	.062	.043
$m_1-\bar{a}$.....	.038	.027
m_3.....	.0135	.0095
$m_1-\bar{a}$..... .031 } Type	.0255	.0185
p_4..... .019 } No. 3352	.013	.0095

No. 3181

No. 3177

No. 4029

Goniacodon Cope.

COPE, Trans. Am. Phil. Soc. 1888, 321. (Subgenus.)

SCOTT, Proc. Phila. Acad. 1892, 301. (Genus.)

Miocænus levisanus is designated by Cope as the type species of *Goniacodon*. The other species referred here by Cope and Scott I remove to other genera. As thus limited the genus must be re-defined.

Family characters given above. Generic distinction especially in the upper molars which are much less quadrate than in *Triisodon*, m^3 reduced and m^1 as large or larger than m^2 , instead of smaller. The third upper premolar is three-rooted without well-developed deutercone. The paraconid is perhaps somewhat smaller than in *Triisodon*, and the proto- and metaconid higher and more equal in size. The position of the paraconid is not entirely constant, but it is usually submedian on m_1 , internal on m_3 , as in *Triisodon*. The third lower molar is reduced. A character observed in two specimens, and perhaps a constant one, is the position of the mental foramen underneath the second premolar instead of between the third and fourth. This is associated with the short deep symphyseal part of the jaw. The symphysis is ovate and widest behind, extending back to beneath the third premolar, while in *Triisodon* it is widest anteriorly and pointed behind.

Goniacodon levisanus (Cope).

Triisodon levisanus COPE, Proc. Am. Phil. Soc. 1882-3, p. 546; Tert. Vert. p. 273, Pl. xxivf, fig. 3; (*Mioclanus*) Trans. Am. Phil. Soc. 1888, 321; (*Goniacodon*) SCOTT, Proc. Phila. Acad. 1892, 301.

A well-preserved lower jaw found by the American Museum Expedition of 1896 has the last two molars and roots of all the other teeth except incisors. The large lower canines were placed rather close together, so that the incisors must have been quite small in size if not reduced in number. Four premolars without any considerable diastema, the last much larger than the rest. The third molar is scarcely more than half as long or as wide as the second. The jaw is very deep in front, the width under the second molar being carried forward to the posterior part of the symphysis under p_2 .

The third upper and lower molars are much reduced in this species, and have the cusps very low.

Sarcothraustes Cope.

Proc. Am. Phil. Soc. 1882-3, p. 193 (Dec. 1881).

The type of this genus is *S. antiquus* Cope, with which I identify *Triisodon conidens* Cope, both from the Torrejon Beds.

This genus shows a marked approach to the Mesonychidæ in certain characters as compared with *Triisodon*.

The prominent cusps on the teeth are enlarged and simplified, the cingula and accessory cusps obsolescent; this change is carried furthest on the posterior molars. But the width of the upper molars is retained, and the heel of the lower molars is wide and bicuspid.

Sarcotbraustes is strictly a Torrejon genus, and may be considered the successor of *Triisodon*; if so, we have a case of degeneration parallel to that seen in the Mesonychidæ, but not leading into them, the tendency being to a dentition with upper molars of great transverse width and broad-heeled lower molars, the last premolar becoming molariform, and the anterior ones small and simple.

Sarcotbraustes antiquus Cope.

Sarcotbraustes antiquus COPE, Proc. Am. Phil. Soc. 1882-3 (read Dec. 1881), p. 193; Tertiary Vertebrata, p. 347, Pl. xxiv^d, figs. 19-22; SCOTT, Proc. Phila. Acad. 1892, 303; OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 29; (*Mioclanus*) COPE, Trans. Am. Phil. Soc. 1888, 320. *Triisodon condens* COPE, Proc. Phila. Acad. 1882, 297; Tert. Vert. p. 274, Pl. xxiii^d, figs. 9-10; (*Diacodon*) Am. Nat. 1884, 350; (*Mioclanus*) Trans. Am. Phil. Soc. 1888, p. 321.

In this species the paracone is larger than the metacone, while the protocone is much enlarged at the expense of the accessory cusps around it. The hypocone has disappeared except on m^1 , where a small remnant still holds out. On m^1 the paracone is scarcely larger than the metacone, on m^2 the difference is considerable, while on m^3 the metacone is very small. The great transverse width of the molars is the most prominent distinction from the Mesonychidæ. P^3 and p^4 have deuterocones. In the lower jaw corresponding differences from *Triisodon* are seen. The protocone is larger than the other cusps of the trigon, progressively larger on the succeeding molars till on m_3 the pa^d and me^d are vestigial. In the heel the entoconid is not lost, but two high rounded cusps arise, internal and external.

The above characters are taken from the type and another specimen of *S. condens* Cope. In the type specimen of *S. antiquus* the lower premolars are seen to be similar in character to those of *Triisodon*; the fourth large with strong bicuspid heel, the three anterior ones small and not spaced, front of jaw deep and canine of moderate size.

The type of *S. antiquus* is the anterior part of a lower jaw with the premolars, and a fragment of upper jaw with the second true

molar and root of the third, besides fragments of the skull and skeleton figured by Cope. The type of *S. conidens* consists of the upper jaw with p^3-m^3 , and lower jaw with m_1-3 . A third specimen consists of the last four upper teeth of both sides, very finely preserved. These three specimens show no differences in such parts as they have in common, and there seems to be no reason for considering the two species as distinct. A smaller species is clearly indicated by two upper molars (No. 3190); but in the absence of more evidence from other specimens it seems inadvisable to name it.

MESONYCHIDÆ.

The three genera of this family are fairly well known, and if they stand in direct descent, form a marked example of cusp simplification. The known species cannot be placed in direct line on account of the last upper molar, which is much reduced in both species of *Dissacus*, of full size in both species of *Pachyæna* and absent in *Mesonyx*. The three genera are, however, very closely related, and as Osborn and Earle remark, the transition stage between *Dissacus* and *Mesonyx* would be some as yet undiscovered species of *Pachyæna*.

Dissacus navajovius Cope.

Dissacus navajovius COPE, Am. Nat. 1881, 1019; Proc. Am. Phil. Soc. 1881, 484; Tert. Vert. p. 344, 741, Pl. xxivg, figs. 3, 4; Trans. Am. Phil. Soc. 1888, 344.

Dissacus carnifex COPE, Am. Nat. 1882, 834; Tert. Vert. 1885, 345; Trans. Am. Phil. Soc. 1888, 304. Not *D. carnifex* of Osborn & Earle, 1895.

This smaller species of *Dissacus* is represented by thirteen specimens, one of which includes considerable parts of the skeleton, and has been fully described by Prof. Cope. *D. carnifex* Cope was separated on the longer and deeper jaw and the presence of an anterior cusp on the fourth lower premolar. As to the last character, a comparison of the two types shows the difference to be very small—the premolar has a cingulum in front, developing a rudimentary cusp in both individuals. Other specimens show some variation—in no case is it well developed, as it

is in the species described below. The teeth of the type specimen of *D. carnifex* are not larger than those of *D. navajovius*, although they are spaced apart a little; they are otherwise precisely similar, the depth of the jaw and slight spacing of the teeth being the only distinctions. These are individual differences, due chiefly to age; other specimens are intermediate between the two types. The specimens referred to *D. carnifex* in the Puerco paper of 1895 are a much larger species, *D. saurognathus*.

The tooth which Cope describes in the Tert. Vert. as the third upper molar is the second, as shown by specimen No. 3357, the third molar being much reduced.

Dissacus saurognathus Wortman.

Dissacus saurognathus WORTMAN, Catal. Fourth Ann. Exhib. N. Y. Acad. Sci. (name only); *D. carnifex* OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, p. 30, figs. 8 and 9.

The type of this species is a complete left ramus of the lower jaw, No. 2454, found by Mr. Brown of the American Museum Expedition of 1896. To the same species belong the teeth and skeletons, Nos. 776 and 777, described in 1895 as *D. carnifex*. It differs from *D. navajovius* in size, being about twice as large, in the presence of a second internal cusp (the postero-intermediate according to Osborn and Earle) on the fourth upper premolar, and a well-developed anterior cusp on the fourth lower premolar. The metaconid on m_1 is vestigial or absent; on m_2 and m_3 it is well defined, as is the case in *D. navajovius*. The fourth upper premolar cusp may be a variable character; it is present in *D. navajovius*, but very minute.

The skeleton has been quite fully described by Osborn and Earle. A complete humerus referred to this species has a well-developed greater tuberosity, but the lesser is very small. The shaft is less cylindrical than in the bear, the deltoid ridge more prominent and extending somewhat further down. The entepicondyle is prominent, the entepicondylar foramen large, the olecranal fossa much more open than in the bear. The proportion of the jaw and skeleton are about as in *Pachyana*, the head of

these animals being, as also in *Hyænodon*,¹ disproportionately large. Compared with the bear the disproportion is extreme, the jaw of *D. saurognathus* being one and four-fifths as large as that of the black bear, while the limb-bones average only five-sixths as long, and are not very differently proportioned. This species was of nearly the size of *Pachyæna ossifraga* of the Wasatch, and is the largest known Creodont from the Basal Eocene.

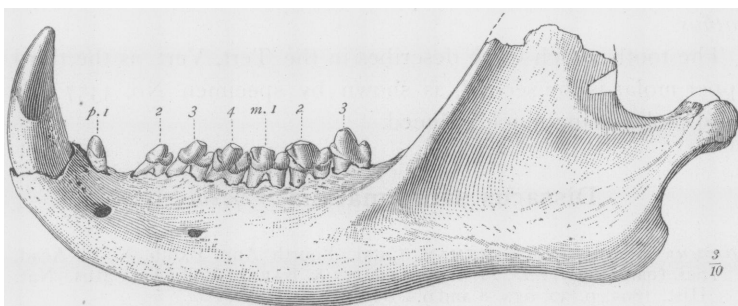


Fig. 9—*Dissacus saurognathus* Wortman. Three-tenths natural size. External view. Type No. 2454.

MIACIDÆ.

This family is represented in the Basal Eocene only by the already highly specialized *Didymictis*, which became extinct at the close of the Lower Eocene. The ancestor of *Miacis* has not been found in the Basal Eocene of New Mexico. The known species of *Didymictis* of the Wasatch show no definite advance on the Torrejon one, whose position may be seen in the following table, which is somewhat altered from that given by Cope in Tert. Vert., p. 305.

- I. M_3 with high trigon and long compressed heel.
 - * P_4 rather large, with two small posterior lobes and an external cingulum. *D. haydenianus*, Torrejon.
 - ** P_4 rather small, with one posterior lobe and no cingulum. *D. dawkinsianus*, Wind River (and Wasatch).
- II. M_3 with low trigon and long oval heel. P_4 large, with one posterior lobe and an external cingulum.
 - * Heel of m_3 longer.
 - $M_{1-2} = .016-.018$*D. leptomytus*, Wasatch (and Wind River).
 - $M_{1-2} = .019-.020$*D. protenus*, Wasatch.

¹ Scott, Jour. Phil. Acad., Vol. IX, p. 181.

**Heel of $m_{\frac{3}{2}}$ shorter, cusps more conic.

$M_{T-\frac{3}{2}} = .025$ *D. altidens*, Wind River and Wasatch.

III. $M_{\frac{3}{2}}$ short, subquadrate, with heel represented by a single median cusp.

* $P_{\frac{3}{2}}$ small, with a posterior cutting ridge slightly lobed, and no cingula.

* $M_{T-\frac{3}{2}} = .011$ *D. massetericus*, Wasatch.

To the last division may belong *D. curticens* of the Wasatch, but only the root of $m_{\frac{3}{2}}$ is known in this species.

The known species of *Didymictis* do not give any clear evidence of their evolution in the successive horizons in which they occur. It may be as well to state definitely the occurrence of species so far as the evidence in the American Museum Collections will go. In the Torrejon we find *D. haydenianus* as the characteristic species, *D. primus* being probably a synonym, certainly so in the type specimen. A single fragment indicates a larger species of the size of *D. protenus*. In the Wasatch *D. protenus* is the most abundant species; a smaller form may be either a small race of this species or a large variety of *D. leptomylos*. The large *D. altidens* and the small *D. dawkinsianus* are rare in the Wasatch, and two other species, *D. curticens* and *D. massetericus*, are represented each by a single specimen. In the Wind River *D. altidens* and *D. dawkinsianus* are the common forms, and *D. leptomylos* is represented by a single specimen. It does not seem practicable to make any genetic arrangement from the above facts—indeed the characters of the teeth would seem to be associated with the size of the species and not its age.

***Didymictis haydenianus* Cope.**

Didymictis haydenianus COPE, Proc. Am. Phil. Soc. 1882-3, 464; Tert. Vert. 306, Pl. xxiii, figs. 12 and 13; Trans. Am. Phil. Soc. 1888, 304; SCOTT, Proc. Phila. Acad. 1892.

Didymictis primus COPE, Proc. Am. Phil. Soc. 1883-4, 309; SCOTT, loc. cit.

The type of *D. haydenianus* is a lower jaw fragment with two molar teeth. The second molar Cope describes as with a narrow compressed heel; this appearance is exaggerated, however, by the loss of the enamel from one side of the heel. The subsequently described *D. primus* is credited with a normal heel to the second lower molar, but allowing for the loss of enamel in the type of *D.*

haydenianus there is no difference in the form of the teeth. Two species may perhaps be separated on distinctions in the upper jaw, but the condition of the material at hand does not warrant it at present.

The fourth lower premolar in this species is peculiar. A strong ridge curves backward and inward from the protoconid to the posterior edge of the tooth, where the cingulum rises from each side to meet it. This ridge is divided by deep cross cuts so as to form two lobes or cusps posterior to the protoconid, besides the less distinctly separate cingular cusp. On its concave internal side is a small basin opening internally. The cingulum is carried around the outside of the tooth, ending anteriorly in a strong well-separated paraconid. This bilobate heel is not seen in other species of *Didymictis*; they have only one cusp inside the cingulum, except in a few Wasatch specimens referred to *D. leptomyilus*, which have a rudimentary second cusp. The internal basin of the heel of p_4 is not developed to any extent in the other species.

ARCTOCYONIDÆ (*Gervais*) *Cope*.

"True molars tubercular, last superior not transverse."¹

Carpus alternating, centrale large, partly under lunar, fused with scaphoid in the known forms. Tarsus with astragalo-cuboid facet, not distinguishable on the astragalus. Digits 5-5, the first reduced. Claws compressed, bear-like.

Clænodon *Scott*.

Mioclænus COPE, in part.

Upper molars quadrate, with strong posterior intermediate cusp and weaker hypocone. Upper premolars triangular, high-cusped, without deutercone. Inferior molars with low paraconid on m_1 , none on the others. Lower premolars with high trenchant cusps and small heels successively increasing posteriorly. Dental formula, $\frac{1-1-3-2}{1-1-4-3}$. Premolars and canines with sharp crenulate ridged edges anteriorly and posteriorly. Molars with low cusps and generally corrugated surface. Scaphoid fused to centrale, lunar separate. Trapezium large triangular. Astragalus with foramen. Calcaneum with large fibular facet.

¹ Cope, Tert. Vert., p. 259.

Clænodon ferox (Cope).

Mioclanus ferox COPE, Proc. Am. Phil. Soc. 1882-3, 547; Tert. Vert. p. 328, Pl. xxivf and xxivg; Trans. Am. Phil. Soc. 1888, 332; (*Clænodon*) SCOTT, Proc. Phila. Acad. 1892, p. 299; OSBORN & EARLE, Bull. Am. Mus. 1895, p. 26.

The *scapho-centrale* of this species was figured¹ but not recognized by Prof. Cope. It is formed by the union of the scaphoid with a large flat rectangular centrale which lay half under the scaphoid, half under the lunar. The radial facet is nearly at right angles to the distal facets, indicating probably a plantigrade manus. There is a small semicircular facet for the lunar, directed proximal-externally, and a large distal-external facet for the magnum. The two distal facets, for the trapezium and trapezoid, are large, the former being on the scaphoid proper, the latter on the centrale portion of the bone. There is also a small trapezium facet on the internal end of the centrale part. The *cuneiform* is rather short and thick, with two sub-equal proximal facets, and well-fitting distal and internal facets for the unciform and lunar respectively. The *unciform* has a lunar facet about half the width of that for the cuneiform, and moderately well distinguished from it; the distal facets are not separated. The shape of the unciform is much like that of *Euprotogonia*. The *trapezium*² is large, triangular, with an irregular proximal facet for the scaphoid proper, two small proximal-external ones not well separated from the first for the centrale and trapezoid, a large flat external facet for the second metacarpal, and a large distal-internal concave facet for the first metacarpal.

The astragalus and metapodials and some other bones of this individual are also described by Prof. Cope. The bone which he describes as the head of a marsupial bone³ is probably the head of the fibula; it is much like that of the bear, differing however in that the tibia facet is mainly superior instead of internal—this is no doubt associated with the broad flange on the calcaneum for the support of the lower end of the fibula.

¹ Tert. Vert., Pl. XXIVg, fig. 8, r, s and t.

² Loc. cit., figs. u and v.

³ Loc. cit., p. 336, Pl. XXIVg, figs. 8, p and q.

Clænodon corrugatus (Cope).

Mioclanus corrugatus COPE, Proc. Am. Phil. Soc. 1882-3, 556; Tert. Vert. p. 341, Pl. xxivf, fig. 5; (*Clænodon*) SCOTT, Proc. Phila. Acad. 1892.

It is difficult to make much satisfactory distinction from *C. ferox*, except in the size. The spacing of the premolars is an inconstant character, as is also the depth of the jaw. The teeth seem to be more robust and massive in the larger species, and there is a fairly constant difference in size, *C. corrugatus* being about one-fourth smaller.

Specimen No. 2456, found by Mr. Brown, American Museum Expedition 1896, contains the nearly complete upper and lower dentition, and bones of the fore and hind feet. The lunar, magnum and scaphoid (scapho-centrale) of the left side are preserved, along with the metacarpals.

The *scaphoid* is like that of *C. ferox*. The *magnum* has its lunar and scaphoid facets of equal size, narrow, at right angles to one another and separated by a keeled edge. The *lunar* has two strongly concave distal facets at right angles for the magnum and unciform. The carpus is therefore not alternating only, but completely interlocking. The *pisiform* is long and slender. Of the *metacarpals* the first is short and stout, the second about one-half longer but no thicker, the fifth somewhat shorter and slenderer than the second. The distal ends of the third and fourth are not preserved. The first metacarpal was at an angle to the rest, but not opposable.

Enough of the hind foot is preserved to show the characters of the *tarsus*. There is a considerable astragalo-cuboid facet visible on the cuboid, but not on the astragalus.¹ The calcaneum had a broad flange for the fibula outside the external astragalar facet; the heel was not so long as in *Euprotogonia*, hardly as long as in *Dissacus*. The first *metatarsal* was reduced in length, but not the fifth. An *ungual phalange* preserved is high and compressed, much like that of a bear but rather longer and without basal sheath. It is very different from the small wide semi-ungulate type seen in *Oxyæna* or *Mesonyx*.

¹ Judging by analogy from the Mesonychidæ and others, this character would be constant within the limits of a family. I have therefore placed it in the definition of the *Arctocyoniidæ*

? *Clænodon* *protogonioides* (Cope).

Miocænus protogonioides COPE, Am. Nat. 1882, 833; Tert. Vert. p. 340, Pl. xxivg, fig. 9, xxvf, fig. 17; Trans. Am. Phil. Soc. 1888, 329; (*Clænodon*) SCOTT, Proc. Phila. Acad. 1892.

The type of this species is from the Puerco, and consists of the two last upper molars. The rest of the specimens come from the Torrejon, and, considering the imperfection of the type and the improbability of a species passing through to the later formation without change, can be referred only provisionally to *C. protogonioides*.

It is a smaller and considerably less specialized species than *C. corrugatus*. The molar cusps are higher, the transverse width of the upper molars greater, the intermediates equal in size and the hypocone very small. Upper premolars unknown. The lower molars have the paraconid absent except on m_1 , where it is small. The last lower molar is long-heeled, as in *C. ferox* and *C. corrugatus*, but the trigon of m_1 is not unusually small, nor the paraconid advanced as in those species. The third and fourth lower premolars have small anterior and posterior cingular cusps. The surface of the teeth is not corrugate, nor is there any serration on the edges of the premolars.

POSITION OF CLÆNODON.

Clænodon has made a marked advance toward the carnivore type in the fusion of the scaphoid and centrale.¹ The scapholunar contact with its small facet and large unfacetted area indicates perhaps the approaching fusion of the scaphoid and lunar. Yet the primitive character of the carpus is shown by its strong resemblance in many points to that of the Condylarthrs, especially *Euprotogonia* and *Pantolambda*. This is seen in particular in the large triangular trapezium, and in the shape of the unciform, lunar and magnum. The reduction of the first digit only, the shape of the claws, the thoroughly plantigrade foot, the shape and proportions of the scaphoid and lunar, and various minor characters of the skeleton, strengthen the resemblance to

¹ As opposed to the reduction and final disappearance of the centrale in the early ungulate types.

the Bears which the teeth at once suggest. Were the lunar to fuse with the scapho-centrale, the resultant bone would be very like the scapho-lunar of *Ursus*. The reduction of the trapezium and loss of fibulo-calcaneal facet might be expected. The non-serial tarsus of *Clanodon*, and the chain of more or less intermediate forms between the Miocene Canidæ and the Ursidæ, are serious objections; nevertheless I believe that the Arctocyoniidæ are probably ancestral to the modern Ursidæ.

INCERTÆ SEDIS.

*Oxyacodon Osborn & Earle.*¹

Additional material enables me to add another species to the typical form, and amend the description as follows:

Lower premolars laterally compressed, high and trenchant with minute talons, deutoconid on p_2 minute or absent. Molars short and wide with high angular cusps, trigonid somewhat elevated above talon, paraconid reduced. Hypoconulid on m_3 high and sharp. Premolars not crowded, the anterior ones not reduced in size. Upper teeth unknown. It may belong to the Anisonchinæ, but the molars do not show the closed basin of the heel peculiar to that group, and are wide instead of compressed.

Oxyacodon apiculatus Osborn & Earle.

Bull. Am. Mus. Nat. Hist. 1895, p. 25, fig. 6.

Premolars strongly compressed, deutoconid absent.

Dimensions: P_3-m_3 , .0258; m_{1-3} , .0123. Six specimens. Puerco.

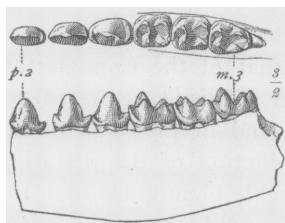


Fig. 10.—*Oxyacodon agapetillus* Cope. Three halves natural size. Crown and internal views of lower jaw. No. 3547a.

Oxyacodon agapetillus (Cope).

Anisonchus agapetillus COPE, Proc. Am. Phil. Soc. 1883-4, p. 320; Trans. Am. Phil. Soc. 1888, 305.

Premolars moderately compressed, minute deutoconid on p_4 .

Dimensions: P_3-m_3 , .0210; m_{1-3} , .0103. Four specimens. Puerco.

¹ Bull. Am. Mus. Nat. Hist., 1895, p. 25.

Carcinodon Scott.¹

The genus is characterized, besides the points of difference pointed out by Scott, by a small trigon and long heel on the molars. The molars are much like those of the Chriacidæ, to which it may belong. Only the lower teeth of a single species and specimens are known.

Carcinodon filholianus (Cope).

Miocænus filholianus COPE, Trans. Am. Phil. Soc. 1888, 329.

CONDYLARTHRA Cope.

Primitive Ungulates retaining many unguiculate features, including in particular the Creodont astragalus, with distinct neck and convex head. Podials arranged wholly or in part in serial order. Humerus with entepicondylar foramen. A third trochanter on femur. Teeth short crowned, bunodont or selenodont, tritubercular or developing quadrituberculy. Canines small, dental formula complete in all known forms. Plantigrade or digitigrade, toes 5-5, the lateral ones reduced in digitigrade forms.

This group comprises the primitive Ungulata of the Basal Eocene, together with certain inadapative forms which persisted through the Lower Eocene (Wasatch and Wind River). It includes the ancestors of the later Ungulates, not yet sufficiently specialized to require removal to separate orders. It does not form a genetic line as do the divisions of the more advanced forms, but represents the first stage of ungulate evolution. The group is nearly related to the early Creodonta, and its hypothetical ancestral type or types would be strictly Creodont. The Condylarthra therefore do not form a homogeneous suborder. Its members had diverged more than they had progressed.

To Cope's three Condylarth families, the Phenacodontidæ, Periptychidæ and Meniscotheriidæ, Osborn and Earle have added a fourth, the Mioclænidæ, with the single genus and species *Mioclænus turgidus*. To the last I add several small species

¹ Proc. Phila. Acad. Nat. Sci., 1892, p. 323.

referred to *Mioclenus*, although probably meriting generic distinction, and one which certainly must be separated.

As thus constituted, the Condylarthra include four divergent lines. The first leads into *Phenacodus*, developing digitigradism and quadrituberculy, and related to the Perissodactyla. The second was strictly tritubercular, plantigrade, but with a non-serial tarsus, and related to the Amblypoda in skeletal structure. The third, with a peculiar type of selenodonty, retained a very primitive tarsus, and may perhaps be ancestral to the Litopterna and Hyracoidea, as suggested by Cope¹ and Wortman,² or to the Chalicotheres according to Osborn.³ The fourth retained the most primitive type of teeth, but in the absence of any satisfactory evidence as to its skeletal structure, can be placed here only provisionally. If this family was truly condylarth, it was perhaps related to the Artiodactyls. In the first two groups the development of the teeth was mainly in the addition of cusps, and but little in the direction of altering their shape. In the fourth group we have a pronounced selenodontism; in the third there is a multicuspid tendency in *M. turgidus*, while in *P. opisthacus* there is a tendency towards selenodontism.

The four families are contrasted in the following table :

Of Amblypod affinities, PERIPTYCHIDÆ.	Of Perissodactyl affinities, PHENACODONTIDÆ.	? Of Artiodactyl affinities, MIOCLÆNIDÆ.	? Affinities with the <i>Litopterna</i> or <i>Chalicotheres</i> , MENISCOTHERIIDÆ.
Molars with persistent- ly tritubercular sym- metry.	Molars early develop- ing quadritubercular symmetry.	Molars with trituber- cular symmetry.	Molars with quadri- tubercular symmetry.
Bunodont multicuspid.			Selenodont.
Premolars generally enlarged.	Premolars not en- larged.	Premolars not usually enlarged.	Premolars not en- larged.
Tarsus not serial.	Tarsus practically serial.	Tarsus unknown.	Tarsus serial.
Carpus unknown, prob- ably alternating.	Carpus becoming serial.	Carpus unknown.	Carpus serial, with centrale.
Plantigrade.	Digitigrade.	Unknown.	? Plantigrade.

The Pantolambdidæ might well be placed among the Condylarthra with the above definition of the term. Their evident re-

¹ Am. Nat., 1891, 688.

² Comparative Anatomy of the Teeth of the Vertebrata, 1886, p. 476. Science, Dec. 11, 1896, and Bull. Am. Mus. Nat. Hist., 1896, 262.

³ Am. Nat., 1891, 911; 1892, 507, and 1893, 127.

lationship to *Coryphodon* of the Wasatch in the teeth, and to a less extent in skeletal structure, makes it more convenient to place them as Amblypods. If they are so considered it involves some difficulty as to the position of the Periptychidæ. In the Periptychinæ the skeleton, as Osborn and Earle have pointed out,¹ is very like that of *Pantolambda*; in the Anisonchinæ, it seems to be intermediate between *Pantolambda* and *Euprotogonia*. The teeth in both Periphychinæ and Anisonchinæ are entirely distinct from either, and show resemblances which almost surely indicate the close relationship of the two sub-families.

Osborn has given this resemblance in foot-structure as a reason for removing the Periptychidæ to the Amblypoda,² and Prof. Cope in his last published words adopted this view.³ If we adhere to Cope's original definition of the Condylarthra, this, indeed, is the only possible solution. But I do not think it the most natural arrangement; the resemblances to the Amblypods, in the case of the Anisonchinæ at least, are only technical, and as to the Periptychinæ, it seems reasonable to consider that *Pantolambda* retained the primitive Condylarth skeleton while developing an Amblypod dentition. Osborn⁴ has shown that Cope's classification of the Ungulates cannot be accepted without some modifications; as re-defined above, the order Condylarthra covers a number of types which have much in common, and are very difficult to place in any of the specialized groups.

PERIPTYCHIDÆ.

In foot-structure this family shows a marked resemblance to the Pantolambdidæ, and through them to the Amblypoda proper. Astragali and many skeletal bones of *Periptychus rhabdodon* and *Pantolambda bathmodon* are almost indistinguishable. The dental characters, on the other hand, show no resemblance except in the persistent tritubercular symmetry. The Anisonchinæ, as far as known, stand in an intermediate position as regards the foot, between *Periptychus* and *Euprotogonia*. In *Ectoconus* the foot was much like that of *Periptychus*, but somewhat more primitive.⁵

¹ Bull. Am. Mus. Nat. Hist., 1895, 47.

² Loc. cit.

³ Am. Nat., 1897.

⁴ Trans. Am. Phil. Soc., 1889, 558.

⁵ The astragalus was described by Cope in 1888.

Subfamily PERIPTYCHINÆ.

Periptychus *Cope.*

This is one of the few genera that pass through from the Puerco to the Torrejon. I recognize only one species from the Puerco, *P. coarctatus*. The second one described from that horizon, *P. brabensis*, was based on specimens somewhat crushed laterally, so that the apparent proportions and outline of the teeth are changed.

Periptychus coarctatus *Cope.*

Periptychus coarctatus COPE, Tert. Vert. Pl. xxixd, explanation and figs. 7-8; Trans. Am. Phil. Soc. 1888, 354; OSBORN & EARLE, Am. Mus. Bull. 1895, 54.

Periptychus brabensis COPE, Trans. Am. Phil. Soc. 1888, 354. Not *P. brabensis* O. & E. Am. Mus. Bull. 1895, p. 55.

There is a wide difference between this species and its successors; the teeth are much less specialized. The antero-internal cusp of the lower premolars is entirely wanting; it is always strongly developed in the Torrejon species. The premolars, both upper and lower, are more pointed and less inflated. The molar cusps are higher and rounder, and no subsidiary cusps appear besides the six normal ones. Molars and premolars show more or less obsolete external cingula.

This species, with its synonym *P. brabensis*, occurs only in the lower beds. The specimen described as *P. brabensis* in the 1895 Bulletin, is the milk dentition of *P. carinidens*.

Periptychus rhabdodon (*Cope*).

Catathleus rhabdodon COPE, Am. Nat. 1881, 830; Proc. Am. Phil. Soc. 1881, 487; 1882-3, 564 (brain-cast).

Periptychus rhabdodon COPE, Tert. Vert. 1885, 391, Pl. xxiiif and g, lvii, figs. 1 and 2; Am. Nat. 1884, 801, figs. 1-2 and 6-9; SCHLOSSER, Morph. Jahrb. XII, 35; OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 53.

The most abundant species of the Torrejon. It does not occur in the lower beds. The dentition and all that is known of the skeletal structure have been fully described by Cope.

Periptychus carinidens Cope.

Periptychus carinidens COPE, Am. Nat. 1881, 337; Proc. Am. Phil. Soc. 1881, 484; 1882-3, 561; Tert. Vert. 403, Pl. xxva, fig. 16, xxiiid, figs. 14-15, xxivg, fig. 5.

P. brabensis OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 55. Not *P. brabensis* of Cope.

This species appears to be good, although not very well defined. It differs from *P. rhabdodon* in its smaller size, narrower molars with longer heel on the third, and less robust premolars. Strictly intermediate specimens are known, but are less common than the extreme types. The species is common but not nearly as abundant as the larger form.

Subfamily ANISONCHINÆ.

The teeth of this group relate them to *Periptychus*, although the build and habits of the two seem to have been widely different. The astragalus is flat and wide, with short neck and wide head bearing a considerable cuboid facet; but the trochlea is not so flat as in *Periptychus*, nor the neck so short. The flange (for the support of the fibula) on the outer side of the astragalus is also prominent and sharp-pointed, as in *Euprotogonia*.

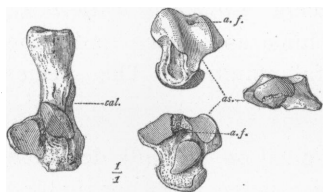


FIG. 11.—*Hemithleus kowalevskianus* Cope. Calcaneum, superior view; and superior, inferior and anterior views of astragalus, No. 3503. Natural size.

Osborn and Earle have already described the skeletal characters of *Haploconus lineatus* of the Torreon. I figure an unusually perfect calcaneum and astragalus which were found in the lower beds associated with jaws and parts of the skeletons of two individuals; the

larger one is *Conacodon entoconus*, the smaller probably *Hemithleus kowalevskianus*, though in the absence of the premolars we are not able to distinguish it with certainty from *Anisonchus gillianus*. The figured specimens belong to the smaller individual; to it belongs also a slender tibia with very high cnemial crest and small head with a rather large semilunar fibular facet perpendicu-

lar to the axis of the bone. To the larger specimen belong the distal ends of a tibia and fibula much like those of *Periptychus*, except that the fibula is larger, has a prominent external process just above the outside of the facet, and the tibia has a facet less oblique antero-posteriorly, and with sharper and more prominent internal hook.

Osborn and Earle consider that the primary division in this subfamily should be made rather on the shape than on the complexity of the premolars. Cope's separation is nevertheless an entirely constant one for the Puerco-Torreon species, which fail to show any evidence of evolution in cusp-building. We may therefore make a second division based on the complexity of the premolars. This gives four well-defined types, which should rank as distinct genera. They may be classified thus :

A.—With flat premolar cusps.

1. Third upper premolar with internal cusp—*Anisonchus* Cope. Two species—*A. sectorius* Cope, *A. gillianus* Cope.
2. Third upper premolar simple—*Haploconus* Cope. Two species—*H. lineatus* Cope, *H. corniculatus* Cope.

B.—With round premolar cusps.

1. Third upper premolar with internal cusp—*Hemithlaeus* Cope. One species—*H. kowalevskianus* Cope.
2. Third upper premolar simple—*Conacodon*, gen. nov. Two species, *C. entoconus* Cope, *C. cophater* Cope.

A number of other species are described by Cope, but all appear to be synonyms of the above, except *Anisonchus agapetillus*, which we remove from the *Anisonchinæ* and place under the genus *Oxyacodon* O. & E., of doubtful affinities. The species considered invalid are :

1. *Haploconus xiphodon* Cope. Founded on the milk dentition of *H. lineatus*, the fourth milk premolar being taken for the first molar. By cutting into the jaw of specimens referred by Cope to this species, I have exposed the third molar, proving the dentition to be temporary.

2. *Haploconus angustus* Cope. The type and one other individual are considerably smaller than *H. lineatus* ; the other specimens are intermediate in size, and as there is no other constant distinction, the species may best be considered as an individual variation of *H. lineatus*.

3. *Anisonchus coniferus* Cope. The type is a worn upper jaw fragment of *Conacodon entoconus*, the third premolar so worn as to produce a false appearance of an internal cusp. A careful comparison with *C. entoconus* shows that this cusp was probably not present. The remaining specimens referred to the species belong mostly to *Hemithlæus kowalevskianus* Cope.

4. *Hemithlæus apiculatus* Cope. The species is indistinguishable from *Anisonchus gillianus* Cope, and comes from the same level, being the only species with flat premolar cusps found in the lower beds. The species with round premolar cusps, on the other hand, are entirely confined to the lower beds.

5. *Anisonchus mandibularis* Cope. As re-defined by Cope in his last article on the Puerco, this species is represented by two individuals, one being a single fourth lower premolar, the other, parts of both jaws not well preserved. I am unable to see in it more than an unusually large individual of *A. sectorius*, which is an abundant species, varying considerably in size.

6. *Zetodon gracilis* Cope. The two specimens representing this species are suspiciously like crushed jaws of small *Anisonchi*, such as *A. gillianus*. In the absence of an uncrushed specimen, the existence of this extraordinary type of tooth can hardly be considered as proven.

Family PHENACODONTIDÆ Cope.

The three genera of this group, *Protogonodon* of the Puerco, *Euprotogonia* of the Torrejon, and *Phenacodus* of the Wasatch and Wind River, appear to stand in direct ancestral relationship. Unfortunately we have no skeletal material of *Protogonodon*; it is probable that it would show a synthetic type, Creodont by definition, Ungulate in relationship.

The advance noted in the family is especially in the following characters: The *manus* and *pes* developed from a plantigrade pentadactyl unguiculate to a digitigrade functionally tridactyl ungulate type. Preceding the reduction of the digits we find alternation in the podials, the lunar reaching over on the unci-

form, and the scaphoid probably on the magnum, and the astragalus very slightly on the cuboid. This was not continued and tended to disappear in *Phenacodus*, for reasons noted later. A characteristic feature found in both *Euprotogonia* and *Phenacodus* is the depression of the cuboid with reference to the navicular and ectocuneiform, and of the fourth metatarsal with reference to the third,¹ an inheritance probably from unguiculate ancestors whose paws were used for grasping and striking. The character is found in the Cats and in some of the Primates. The *teeth* developed from simple molars and premolars of the primitive creodont type to sextitubercular molars above and quadritubercular below, the premolars tending to become molariform, and the molars developing additional cusps (multicuspid). In short the family passed through the same changes which we suppose to have occurred in the earliest unknown stages of development of the Perissodactyla, but with certain limitations and retention of ancestral features. They were not able to change the molar tubercles into crests; and they did not develop alternating podials. This is true, however, only for the known members of the family; a *tendency* towards both of these changes is seen, and it may have been stronger in species as yet unknown or insufficiently known. While we are unable to consider *Euprotogonia* as the direct ancestor of the Perissodactyla, yet it had many characters approximating it to them. It is probable that the common ancestor of the typical Ungulata was thoroughly an unguiculate, and that the first separation into the phyla of Phenacodonts, Perissodactyls and Artiodactyls accompanied or preceded the development of hoofs from claws.

¹ *I. e.*, the navicular, ectocuneiform and Mt. III overlap the cuboid and Mt. IV.

Family PHENACODONTIDÆ.

	PUERCO. <i>Protagonodon.</i> Two species.	TORREJON. <i>Euprogonia.</i> One very variable species.	WASATCH. <i>Phenacodus.</i> Several well-defined species.	WIND RIVER. <i>Ectocion.</i> ¹ One species.
Skeleton.....	Small.	Small, variable.	Large and small.	Small.
	Unknown.	Slender, semi-plantigrade.	Stout, digitigrade.	? Slender.
		Astragalus flat.	Astragalus more keeled.	Astrag. ? strongly keeled.
		Astrag. foramen present.	Astrag. foramen absent.	
		Tarsus nearly serial.	Tarsus serial.	
		Carpus interlocking.	Carpus nearly serial.	
	Small.	Equal to pr., fixed.	Equal to pr., fixed.	Equal to pr.
	None.	Variable, small or none.	Well developed.	Well developed.
	None.	Variable, minute or none.	" "	Equal to pr., crescentic.
	? Absent.	Small, variable.	Equal to pr., fixed.	
		" "	Smaller than pr.	
		Small, variable.	Small, variable.	Minute.
	Well developed, fixed.	Contracted.	Contracted.	Crescent heel.
	Open.	Variable, strong.	Stronger and fixed.	} Fully molariform.
	Variable, minute or absent.	One or two small cusps.	Two strong cusps.	
	Simple cingular cusp.	Small, position variable.	Strong, far forward.	
	Small cingular cusp.	None.	Strong.	
	None.			

¹ See Bull. Am. Mus. Nat. Hist., 1896, 83.

Upper teeth.

{ hy. on m¹⁻². . .
" " m². . .
ms. on m¹⁻². . .
tr. on p⁴.
" " p³. }

Lower teeth.

{ pad on m₁₋₃. . .
basin-heel. . .
ded on p₄.
heel of p₄.
pad on p₄.
ded on p₃. }

Protogonodon *Scott.*

Earle has suggested¹ this genus as an ancestor of the Artiodactyla, and in the Puerco paper of 1895 attention is called to the incipient selenodontism observed in a specimen of upper teeth referred to it. I believe, however, that its relations were rather with *Euprotogonia*, and that the Puerco ancestor of the Artiodactyls should be a form with teeth like those of the smaller species of *Mioclaenus* or *Protoselene*. The points connecting *Protogonodon* with *Euprotogonia* are: the presence in most specimens of an incipient deuterocooid on the fourth lower premolar, the short stout premolars, whose proportionate size and shape do not differ much from the Torrejon genus, the presence of a small hypocone on the upper molars, and especially the general shape of these teeth, which recalls strongly that of *Euprotogonia*. The described species, *P. pentacus* Cope, is rather larger than *E. puercensis*, and shows but small range of variation. There is a smaller undescribed form, indicated on labels by Prof. Cope as *P. stenognathus*, which fulfills more nearly the requirements for the direct ancestor of *E. puercensis*.

Protogonodon stenognathus, n. sp. (Cope, MSS. name only.)

The type No. 3198 consists of fragments of the lower jaw with the three true molars, which are smaller than in *P. pentacus* and somewhat narrower. The third is much narrower, with compressed heel. The cingula are obsolete on all the molars. With the type I associate No. 761, an upper jaw with the last four molar teeth and the root of p³. The fourth premolar has a very strong internal cusp but apparently no triticocone. The molars have well developed intermediates, large protocone, small but distinct hypocone on m¹ and m², and strong cingula encircling three sides of the tooth. The transverse width of the teeth is greater than that of *Euprotogonia*, but their outline otherwise much resembles it.

Nos. 822 and 3566a probably belongs to this species.

¹ Am. Nat., 1893, 377.

Dimensions . . .	No. 3198.		No. 761.
m_{T-3}	= .029	p^3-m^3	= .040
m_{T-3}^1 longit.	= .0101	m_{T-3}^1	= .025
" transv.	= .0064	m^3 longit.	= .0102
m_T longit.	= .0093	m^3 transv.	= .0069
" transv.	= .0076	m^3 "	= .0111

Euprotoponia Cope.

A number of species have been described as belonging to this genus, but after a careful review of all the known material I am unable to recognize more than two distinct forms, a larger one, very abundant, and a smaller represented by three specimens only. The species have been founded solely on characters of the teeth, and mainly on progressive characters, which naturally are extremely variable. As all the material comes from a single level we cannot recognize in these any stages of evolution, and they are too inconstant to denote more than individual difference. The distinction from *Phenacodus* is based on the fourth upper premolar which in *Phenacodus* has two subequal external cusps, while in *Euprotoponia* the posterior external cusp or trittocone is rudimentary or absent.

Euprotoponia puercensis (Cope).

- Phenacodus puercensis* COPE, Proc. Am. Phil. Soc. 1881, 492; Am. Nat. 1884, 900, fig. 22; Tert. Vert. p. 488, Pl. xxve, figs. 12 and 13, lviiif, figs. 8 and 9; (*Protogonia*) COPE, Trans. Am. Phil. Soc. 1888, 359; SCHLOSSER, Morph. Jahrb. Bd. XII, 1887, p. 11; (*Euprotoponia*) COPE, Am. Nat. 1893, 378; OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, p. 64, fig. 19; WORTMAN, Bull. Am. Mus. Nat. Hist. 1896, p. 106, fig. 16.
- Phenacodus calceolatus* COPE, Proc. Am. Phil. Soc. 1883, 561; Tert. Vert. p. 487; (*Protogonia*) COPE, Trans. Am. Phil. Soc. 1888, 359.
- Protogonia subquadrata* COPE, Proc. Am. Phil. Soc. 1881, 492; Tert. Vert. p. 426, Pl. lviiif, figs. 11 and 12; (? *Mioclanus*) OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 64.
- Protogonia plicifera* COPE, Am. Nat. 1882, 833; Tert. Vert. p. 424, Pl. xxvf, figs. 2 and 3; Trans. Am. Phil. Soc. 1888, p. 359; (*Euprotoponia*) WORTMAN, Bull. Am. Mus. Nat. Hist. 1896, p. 106, fig. 17.
- Mioclanus floverianus* COPE, Trans. Am. Phil. Soc. 1888, 330; (*Tetracle-nodon*) SCOTT, Proc. Phila. Acad. 1892, p. 299.

The collections in the Museum contain nearly two hundred specimens now referred to this species. Although a rather wide range of variation is thus included within its limits, it does not seem practicable to make any separation. The variation in size

is: $m_{1-3} = .024$ to $.030$ m. The mesostyle is usually present though small, on the first molar, and frequently appears on the second, sometimes on the third. The fourth premolar has usually an antero-intermediate cusp (paraconule) and sometimes a postero-intermediate (metaconule). The postero-external cusp on p^4 (trittocone) is small or absent. Other very variable characters are the size and shape of the last upper and lower molar and of the heel of the third lower premolar, and the prominence of the paraconid, which is usually almost obsolete on $m_{\frac{2}{2}}$ and $m_{\frac{3}{3}}$, but sometimes rather clearly marked. The trittoconid is developed to a variable extent on $p_{\frac{4}{4}}$, sometimes being as far separated from the other cusps as in *P. primævus*. The deutoconid on p^3 is occasionally present though very small. None of these variations show any degree of constancy or any association one with another.

Protoгония calceolata. This species was founded on a single fragmentary individual, differing from *puercensis* only in that a lower premolar, the third or fourth according to Cope, has a flattened heel. The premolar in question is very like the third premolar of *puercensis*, with which the remaining teeth and the skeletal fragments agree entirely, and in view of the variability in this character the species must be discarded till better evidence of its distinctness appears.

Protoгония subquadrata. In his last reference to this species, in 1888, Cope makes it a synonym of *puercensis*. Osborn and Earle have revived it, placing it nearer to *Miocænus* than to *Euprotoгония*. It does not appear to the present writer to be a valid species.

Protoгония plicifera. The main distinction between this form and *puercensis* is the prominence of the paraconid on the last two molars. Cope in 1888 considers the species as doubtfully valid, as "specific difference cannot be predicated on the presence or absence of this cusp." Additional material fails to confirm the separation; most specimens of *puercensis* have some trace of the paraconid on all three molars, and a smaller number exhibit it more prominently in varying degree.

Miocænus (Tetraclænodon) floverianus. This species was founded on jaw fragments and skeletal bones of an old individual of

E. puercensis, in which the fourth lower premolar was mistaken for the first molar. The position of the mental foramen just in front of the supposed first molar shows the actual position of the tooth in the jaw. The fragments of jaw are accompanied by a nearly complete humerus, most of one side of the pelvis, and fragmentary vertebræ, all which are fully described by Prof. Cope.

SKELETON OF EUPROTOGONIA.

A skeleton of *E. puercensis*, found by Mr. Granger of the American Museum Expedition of 1896, contains both hind limbs and feet complete, the greater part of the pelvis, the centre of nearly all the vertebræ, most of the right fore-limb and parts of the left, the lower jaws and upper teeth. This important discovery enables us to fix definitely the position and relations of this most primitive Ungulate.

The animal was slender, long-limbed, of proportions nearer those of *Protorohippus* than *Phenacodus*, but smaller and proportionately lower at the shoulders. It had a very long and heavy tail.

The right hind limb and foot are absolutely complete, down to the sesamoids. The facets on the bones are very perfect, so that their exact relations can be clearly seen. The foot was semi-plantigrade, five-toed, with extremely narrow hoofs very like claws. The side toes are reduced, but not as much as in *Phenacodus*. The astragalus differs considerably from that of *Phenacodus*; it is much wider and flatter, less keeled, with longer neck and flattened head. The astragalus foramen is present and clearly cut, surrounded by a depressed area, and the trochlea is situate mainly in front of this, not extending as far back as in *Phenacodus*.

The calcaneum is longer than in *Phenacodus*, the end of the tuber calcis less oblique. The calcaneal side of the tarsus and metatarsus is depressed below the level of the astragalar side, the third metatarsal overlapping the fourth. This is likewise the case in

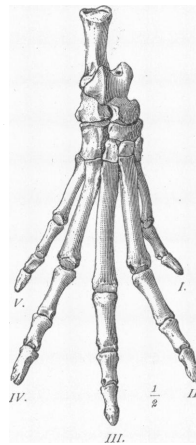


Fig. 12.—*Euprotogonia puercensis* Cope. Hind foot, one-half natural size. No 2468.

Phenacodus, in some specimens if not all, and is apparently an inheritance from unguiculate ancestry. The second cuneiform is shortened and Mt.II pushed up between the first and third. The entocuneiform is larger than in *Phenacodus*. The first and fifth digits are much less reduced, the metatarsals being about three-fifths the length of Mt.III, the first somewhat slenderer and considerably curved, having a large proximal facet which allows considerable lateral play of the digit, and a smaller internal facet for Mt.II. The fifth metatarsal is slightly curved, and has a flattened head with strong external hook projecting under the calcaneum; it has two small facets for the cuboid and Mt.IV. These two lateral digits appear to have been somewhat separate from the rest, and were evidently undergoing a rapid reduction.

The distal end of the *fibula* has its plane at right angles to the distal tibial facet; the proximal end is widely flared, the shaft quite slender. The *tibia* is slender, with a prominent sharp crest; the proximal end of the bone is bent backwards and the plane of the cotyli is at an angle of about 60° to the axis of the shaft. The patella is ovate, not high, rather small. The *femur* is slender but with well-developed trochanters; the sides of the rotular groove do not project above the plane of the shaft;¹ the distal end is less enlarged than in *Phenacodus*, and is bent backward so that the plane of the middle of the condyles is not far from being parallel to the axis of the shaft. This, in connection with the position of the tibial cotyli, I believe indicates customary great flexure of the knee; crushing of the bones might account for part, but not for all of it. The great trochanter is higher than the head of the femur, wide and truncate, enclosing a deep fossa; the lesser trochanter is rather sharp and thin, the third somewhat larger and placed about two-fifths of the length from the proximal end.

The *pelvis* is of the same general type as that of *Phenacodus* but longer and slenderer; it is not sufficiently well preserved for exact comparison.

The *vertebrae* preserved are the centra probably of seventeen cervicals and dorsals, seven lumbar and eighteen caudals, the sacrum being weathered into fragments. The cervicals are short

¹ Other individuals show that there was considerable variation in this respect.

and obliquely procœlous ; the dorsals, probably the eleven posterior ones, are small, the anterior ones having triangular sections, the posterior transversely oval. The lumbar s are much longer and wider, with flattened oval section and a hypapophysial keel developing on the posterior ones. Six or seven are preserved ; there is no indication of any more, and the lumbar formula was probably the same as in *P. primævus*. The caudals appear to be all present except a few posterior ones. Eighteen are preserved, the length regularly increasing in the first few and not sensibly diminished till the eighteenth. The neural arches are complete to about the eighth and then break up into open grooves. The total length of the part of the tail preserved is about fourteen inches ; to this must be added two or three inches for the tip. The extreme length therefore was not less than sixteen or seventeen inches, although the animal stood only a foot high at the rump.

The humerus is slender, with tuberosities less developed than in either species of *Phenacodus* ; the deltoid ridge extends far down on the shaft ; the condylar surface is wide transversely but not deep ; the entepicondylar foramen is well marked, the epicondyles not prominent.¹ The *ulna* has a large truncate olecranon, not bent backward as in the Ungulata, but its axis continuous with that of the shaft. The shaft is moderately slender, much flattened. The *radius* is smaller proximally than the *ulna*, somewhat larger at the distal end ; the distal facets are like those of *Phenacodus*.

Only two bones of the *carpus* are preserved, the right magnum and left unciform. The unciform shows a considerable lunar facet at an angle to that for the cuneiform. The facets for the fourth and fifth metacarpals are of equal size, indicating a less reduction of the fifth digit than in *Phenacodus*. The magnum has a comparatively small upper surface, and is extended proximally into a keel separating two nearly equal facets, one for the lunar, the other supporting the scaphoid, or as may be suspected, a centrale, or both (the surface is not well enough preserved to be certain on this point). The trapezoid facet is small, and does not reach the upper surface of the magnum.

¹ Described by Cope from a somewhat less crushed bone, Trans. Am. Phil. Soc., 1888, 331.

The trapezium, cuneiform and unciform are preserved in another specimen (No. 2547a); the trapezium is rather large, fits closely to the carpus, has two equal external facets for Mc.II and the trapezoid, a somewhat larger proximal facet for the scaphoid, and a distal facet for Mc.I, not much smaller than the facets for Mc.III and Mc.IV and V on the magnum and unciform. The first digit was therefore not greatly reduced, nor did it project out from the rest of the foot as a dew-claw.

POSITION OF EUPROTOGONIA.

In every detail of its skeletal structure, *Euprotogonia* shows a most striking resemblance to the Creodonts. The customary bend of the knee and elbow, the long heavy tail, the semi-plantigrade five-toed foot are general points of likeness, and when we compare the separate limb-bones, the close relationship becomes apparent, especially close to the more primitive types. As in *Pachyaena*,¹ the fore-limbs were comparatively short, so that the animal seems to have been higher at the rump than at the shoulder—how far this might have been modified by the flexure of the limb it is not possible to say.

The carpus is much like that of *Dissacus* in several respects. The carpals, it will be observed, are *alternating*, not serial. The keeled magnum with small upper surface, the trapezoid small and nearly crowded away from the magnum, and the alternation of the two rows of podials, are characters shown by all of the four Basal Eocene forms in which the carpus is known (*Dissacus*, *Clanodon*, *Pantolambda* and *Euprotogonia*, *Psittacotherium* being here excluded from consideration). The centrale was certainly present in *Dissacus*, quite probably in *Euprotogonia*, and perhaps in *Pantolambda*. It should be observed that the displacement is greater in the short-footed plantigrade *Pantolambda*, *Clanodon* and *Dissacus* than in the more digitigrade, long-toed *Euprotogonia*. This evidence, though not conclusive, points unmistakably towards an alternating carpus as the primitive one. In *Phenacodus* the carpus is more nearly serial, although it varies

¹ Cope, Tert. Vert., p. 366. The humerus figured by Prof. Cope (Pl. XXVIIIc, fig. 1), probably belongs to *Phenacodus nuniensis*.

in different individuals, and there is always a lunar-unciform contact. But if *Phenacodus* is a direct descendant of *Euprotogonia*, this serialism must be secondary. As to *Meniscotherium*, not enough is known of its ancestry to say whether its carpus, serial as figured by Marsh, is primitive or not.

For these reasons I do not consider the interlocking carpus of *Euprotogonia* as a bar to its being ancestral to *Phenacodus*, although it involves some breaking away from the generally accepted view on this point.

The humerus and other skeletal bones of *Euprotogonia* (in the type of *Miocænus flowerianus*) were described by Cope as those of a Creodont, and as "not presenting any but specific differences from" *Clanodon* and *Triisodon*.¹ The pelvis is distinctively Creodont rather than Ungulate in type, as is that of *Phenacodus*, being long and slender with ilia narrow and curved, not expanded anteriorly. These characters are primitive, their possession by both Creodonts and Condylarths serving to show how closely we are approaching the common origin of the two groups.

In every point where *Euprotogonia* differs from *Phenacodus*, it approaches the Creodonts—or rather approaches that hypothetical group from which descended both Creodonts and Condylarths. It stands therefore in a strictly intermediate position, and warrants us in believing that its Puerco ancestor, *Protogonodon*, was in all respects a true Creodont, of generalized type, except as to the teeth, which had already started on their development towards the Ungulata.

Euprotogonia stands nearer to the early Horses than does *Phenacodus*, but I do not think that it can be considered the direct ancestor of *Hyracotherium*. It has the distinctive cusps of *Phenacodus* in a rudimentary stage; it does not exhibit any tendency to form crests; the last molar is small with no hypocone, and the skeleton exhibits no indications of an advance from the primitive type towards *Hyracotherium* in particular, while it has many points of resemblance to *Phenacodus*. We must go somewhat lower down than the Torrejon to find the junction of the Equine and Phenacodont phylæ. And it must be supposed that their common ancestor was a clawed animal, for *Euprotogonia* is in the first stage

¹Trans. Am. Phil. Soc., 1888, p. 320.

of development as a hoofed mammal, and shows very little else of the ungulate type of skeleton. In the Torrejon representatives of the horse family, one would expect to find the molars showing some trace of approaching lophodonty, the last one of full size, and the astragalus with some indications of a perissodactyl development. In most other respects it might well approximate *Euprotogonia*.

Euprotogonia minor, n. sp.

Protogonia zuniensis COPE, Trans. Am. Phil. Soc. 1888, 305, name only, part. Not on p. 359 *loc. cit.*; nor *Phenacodus zuniensis* COPE, Proc. Am. Phil. Soc. 1881, 492; 1882-3 (1881) 180, and Tert. Vert. p. 491, pl. lviii, fig. 10.

The type and all the specimens originally referred to *E. zuniensis* Cope are identical with *Tricentes subtrigonus*, and are certainly not *Euprotogonia*. They are all lower jaws. Two specimens containing fragments of both upper and lower jaws, Nos. 3896 and 3897, were subsequently referred by Prof. Cope to the same species. These two seem to indicate a small species of *Euprotogonia*, though they cannot be determined with certainty in the absence of the fourth premolar. They are very distinct from the type of *E. zuniensis*, being larger and with a different style of lower molar. In 1888 Prof. Cope referred "three individuals" to this species, presumably the type and Nos. 3896 and 3897. This original type is, however, *T. subtrigonus*, and the species represented by Nos. 3896 and 3897 must be re-named. No. 3896, which contains upper and lower molars of the permanent dentition, may be taken as type. No. 3897 is a young individual with milk dentition. To these may be added No. 3904. The definition of the species will be:

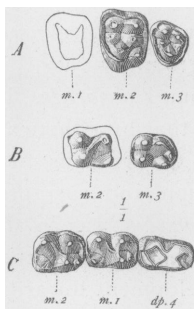


Fig. 13.—*Euprotogonia minor* Matt. A and B, upper and lower molars of type specimen No. 3896. C, lower molars and fourth milk molar of another individual, No. 3897. All crown views, natural size.

Upper true molars sextubercular, differing from those of *E. puercensis* in the smaller size, the series measuring .0191 as against .0222 to .0255. Last upper and lower molar disproportionately small, the upper (.0048 × .0062) more rounded than in *E. puercensis*, and not appressed against the second molar. (The shape

of m^2 in the common species is quite variable, so that this is not a very good distinction.) The paraconid is well developed in the three specimens referred to *E. zuniensis*. Fourth permanent premolar unknown, the last lower milk premolar (No. 3897) is like that of the larger species except in size. The trigon is large, the paraconid strong, not quite equalling the proto- and metaconid, and placed far forward. The tooth is in this respect not unlike the *permanent* fourth premolar of *Phenacodus*. The proto- and metaconid are well separated, and all three cusps strongly trihedral, with a crest curving forward and inward from proto- to paraconid. The heel is like that of the first molar but considerably narrower. Dimensions of the tooth in this species: Length, .0073, width of trigon, .0039, of heel, .0042. The corresponding measurements in *E. puericensis* (No. 3833) are, .0100, .0057, .0063.

Family MIOCLÆNIDÆ *O.* & *E.*

It is with much hesitation that the following species are grouped under the Condylarthra. They are known almost exclusively by the characters of the teeth, and these are very unsatisfactory. The dental series is complete, without diastema, the canines hardly larger than the adjoining teeth, the grinding teeth mostly low-cusped, and well-worn in old individuals, the premolars simple with cusps inflated to a varying extent. Such evidence as we have indicates a skeleton little specialized, not very different from *Euprotogonia*, and where differing, approaching the smaller Periptychidæ so far as these last are known. The teeth are tri-tubercular, but not persistently so as in the Periptychidæ and Amblypoda, for when the hypocone appears in the upper molars it is in a position to develop quadrituberculy.¹ They differ likewise from the Periptychidæ in having a basin-like heel on the lower molars opening inward instead of being closed internally as in all that family by the entoconid. The premolars are more or less inflated and sometimes enlarged, but this is not constant even specifically, and cannot be relied on as evidence of their relationship to the Periptychidæ. The upper premolars have a deuterocone on the third and fourth, while the lower ones are simple with small heels.

The group may not be homogeneous; the teeth of some of its members have a vague resemblance to the Wasatch Monkeys,

¹ That is, the position of the hypocone is more posterior, less internal than in the Periptychidæ, and the primitive molar cusps are not approximated to the centre of the tooth.

Hyopsodus and *Pelycodus*, some to the Artiodactyl *Pantolestes*. Neither of these likenesses is supported by skeletal characters.

Under the type genus *Mioclænus* I place, besides *M. turgidus*, several small species of less aberrant form, but whose characters are not very well known. *M. opisthacus* Cope is so far different from the others that it must be separated generically.

Mioclænus Cope.

Premolars inflated more or less strongly. Third and fourth upper premolar similar, each with internal cone. Lower premolars with small heels. Last molar reduced. No entoconid on lower molars.

Prof. Cope referred a large number of the Basal Eocene species to this genus, and regarded it as a Creodont of generalized type, a starting point to which the various groups of flesh-eaters might be traced back. Prof. Scott in 1892 restricted the name *Mioclænus* to the type and other species with low massive premolars equalling or exceeding the molars in size, and speaks apparently with favor of Schlosser's suggestion¹ that *Mioclænus* is a Condylarth. Osborn and Earle in 1895 quote the history more fully than I have done, and propose the Mioclænidæ as a fourth family of Condylarth with the single genus and species *Mioclænus turgidus* Cope. The relations of the species now added are :

- A. Premolars and molars very much inflated.
 - 1. Last molar reduced. $M_{T-8} = .019$ *M. turgidus* Cope.
 - 2. Last molar unreduced..... *M. lydekkerianus* Cope.
- B. Smaller species with premolars less inflated.
 - 1. Last molar somewhat reduced. $M_{T-8} = .013$ *M. lemuroides*.
 - 2. Last molar somewhat reduced, molar cusps much higher than in the preceding species. $M_{T-8} = .0118$.. *M. turgidunculus* Cope.
 - 3. Last molar greatly reduced. Cusps low. $M_{T-8} = .0113$

M. inæquidens Cope.
 - 4. Last molar scarcely reduced. Cusps rounded. $M_{T-8} = .0105$.

M. acolytus Cope.

Mioclænus turgidus Cope.

Mioclænus turgidus COPE, Am. Nat. 1881, 830; Tert. Vert. 325, pl. lvii f, figs. 3-4, xxve, figs. 19-20; Trans. Am. Phil. Soc. 1888, 321; SCOTT, Proc. Phila. Acad. 1892, 321; OSBORN & EARLE, Bull. Am. Mus. Nat. Hist. 1895, 50.

Mioclænus zittelianus COPE, Trans. Am. Phil. Soc. 1888, 334.

¹ Morph. Jahrb., Vol. XII (1886), p. 37, foot-note.

Although this is an abundant species, we have almost no knowledge of the skeleton. A sacrum associated with teeth of *M. turgidus* is described by Osborn and Earle as of ungulate rather than carnivore type. A calcaneum is associated with No. 3157, determined as *M. turgidus* by Prof. Cope. This is more like the calcaneum of the Anisonchinæ than that of *Euprotogonia*, but all three are closely similar. It is much less like *Periptychus* or *Pantolambda*. A radius, with part of the shaft missing, is associated with a few teeth in No. 4058a. This is considerably different from *Euprotogonia*, the head being rounder and less expanded, the shaft more curved and probably shorter, the distal end less flattened, while the distal facets are quite different in shape, the scaphoid facet being apparently quite small, though not well separated from the lunar facet. The distal end of a tibia with No. 3157 shows that the astragalus was flat and oblique about as in *Hemithlæus*. Altogether, as far as it goes, the skeletal material with this species tends to place it as intermediate between Periptychidæ and Phenacodontidæ, while its teeth are more primitive than either, the premolars reminding one of *Thlæodon* of the Laramie. The outline of the jaw is Condylarth, very like that of *Euprotogonia*, less like any Periptychid.

Removal of the matrix from the type specimen of *M. zittelianus* shows that, like *M. turgidus*, it had internal cusps on the third and fourth upper premolars. It does not show any other important differences from the common species.

A single specimen appears to indicate a species of size equal to *M. turgidus*, but with the last molar unreduced. This is the type of *M. lydekkerianus* Cope.¹ The other specimens referred to that species are *Tricentes* and *Protochriacus*.

***Mioclænus turgidunculus* Cope.**

Mioclænus turgidunculus COPE, Trans. Am. Phil. Soc. 1888, 334, type specimen only.

M. acolytus COPE, loc. cit., one specimen doubtfully referred.

The additional material now at hand shows that the Torrejon specimens referred by Prof. Cope to *M. turgidunculus* belong to

¹ Trans. Am. Phil. Soc., 1888, 328.

an allied but distinct species, and that the true *turgidunculus* is a Puerco species only. To it I refer specimen No. 3212, a Puerco specimen which Prof. Cope referred doubtfully to *M. acolytus*. This specimen shows p_{T-4} and m_T , and part of the upper molar series. The upper molars are not well exposed, and I am unable to distinguish them from the Torrejon species except that they were somewhat smaller and the last molar slightly less reduced. The cusps were probably higher. The lower incisors and canine must have been very small and without diastema; the first pre-



Fig. 14. — *Mioclanus turgidunculus* Cope. Four lower premolars and one molar, from the inside. No. 3212. Natural size.

molar is small, probably one-rooted, the second is two-rooted, larger than p_T , the third and fourth are much larger, moderately inflated. All four are recurved and heeled, the heel of the fourth larger than the others. The first molar has a small but well-defined paraconid, rather high rounded cusps, heel scarcely lower than trigon and somewhat constricted off from it. Hypoconid strong, well-defined, the internal shelf of the heel breaking up into small cusps without a distinct entoconid, basin deep, opening forward and inward. Differs from the species described below in its smaller size, smaller pms_{T-2} , molar smaller and much less turgid, with higher cusps and more rectangular outline.

The above description is from specimen No. 3212. The type, No. 3291, shows the fourth premolar and first two molars of the upper jaw, and can be distinguished from the Torrejon form only by the somewhat smaller size and higher cusps and a little difference in the shape of p^4 . In specimen No. 3314, p^2 or p^3 is seen to be simple, without internal cusp, and m_3 reduced to nearly the same extent as *M. lemuroides*. Nos. 3300 and 3474a are also probably this species.

***Mioclanus lemuroides*, sp. nov.**

Mioclanus turgidunculus COPE, Trans. Am. Phil. Soc. 1888, 334, part.

The type of this species is No. 2421, a nearly complete pair of lower jaws, showing p_2 - m_3 and alveoli of all the front teeth. It is represented by fifteen other specimens, all from the Torrejon beds, including two referred by Prof. Cope to *M. turgidunculus*.

There were three small incisors; the canine was somewhat larger, about the size of the first premolar; the first premolar was one-rooted, the second is two-rooted, larger, recurved, and minute-heeled. The third and fourth are still larger, stouter, recurved and moderately inflated, the heel of the fourth larger than the others. The molars are very simple, broad and short and considerably inflated, with more or less oval outline, the cusps low, no paraconid, no entonconid, and a simple shallow basin in the heel. Length from i_1 - m_3 = .0343; p_3 - i_1 = .0135; m_1 - i_1 = .0129. The shape of the jaw is that of *Euprotogonia* and of *M. turgidus*; the teeth are much less inflated than in *M. turgidus*, but more so than in the preceding species. The type is from the Rio Torrejon, San Juan Basin, New Mexico.

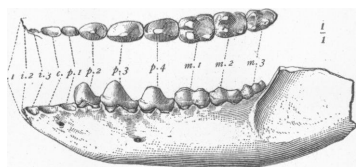


Fig. 15.

Fig. 15.—*Mioclænus lemuroides* Matt. Lower jaw, crown and outside views. Type specimen No. 2421. Natural size.



Fig. 16.

Fig. 16.—*Mioclænus lemuroides* Matt. Upper teeth, crown view. No. 4025. Natural size.

Another specimen (No. 4025) shows the upper teeth with part of the lower jaw containing the last premolar. The third upper premolar is subtriangular with a well-separated internal cusp; the fourth is wider transversely, more nearly oval, the internal cusp almost as large as the protocone. The first and second molars are slightly larger than p^4 , with rudimentary hypocone and minute intermediates. The third molar is but two-thirds the diameter of the second. All the teeth have low rounded cusps, and external cingula obsolete except on m^1 and m^2 . Length, p^3m^3 = .019; m^1 - i^3 = .011.

Mioclænus inæquidens (Cope).

Tricentes inæquidens COPE, Proc. Am. Phil. Soc. 1883-4, 317; Trans. Am. Phil. Soc. 1888, 336, fig. 8; (*Ellipsodon*) SCOTT, Proc. Phila. Acad. 1892, 298.

Mioclænus minimus COPE, Trans. Am. Phil. Soc. 1888, 335. Not *M. minimus* COPE of Proc. Am. Phil. Soc. 1882-3, 468, and Tert. Vert. 327, pl. xxve, figs. 22-24.

The type specimen (No. 3095) is a palate partly buried in very hard matrix. The front teeth are very vaguely indicated and might be interpreted in at least two ways. Either the first premolar is minute or absent, as Prof. Cope believed, and the canine moderately large, or the first premolar is spaced (displaced probably) and the canine unknown. The latter view brings the front

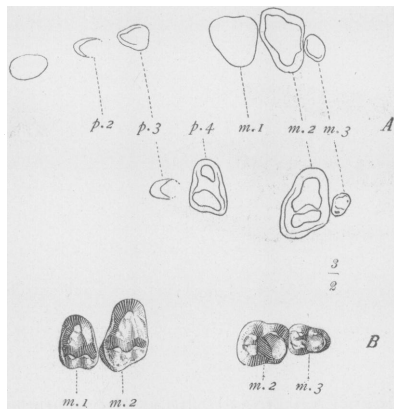


Fig. 17.—*Mioclanus inaequidens* (Cope). A. Outline of upper teeth. Type, No. 3095. B. Upper and lower molars, crown view, No. 3298.

teeth into harmony with the other *Mioclæni*. The upper molars and last two premolars are quite of the type of *M. lemuroides* but more simple, the molars trituberculate with no internal cingulum and obsolete external one, intermediates minute or absent, no hypocone. Third and fourth premolar with strong internal cusp, others apparently simple. Last molar minute, transversely oval. Lower molars very simple, paraconid absent, protoconid and metaconid approximated, opposite, blunted; small hypoconid on heel, basin very much depressed internally, no entoconid. Last molar much reduced, oval, cusps low and flattened, basin shallow and nearly as high as the cusps. The characters of the lower molars are taken from No. 3298. Nos. 3096, 3296 and 3299 also belong to this species.

Mioclænus acolytus (Cope).

Hyopsodus acolytus COPE, Proc. Am. Phil. Soc. 1882-3, 462. Tert. Vert. p. 282, pl. xxiii d, figs. 5-6; (*Mioclænus*) COPE, Trans. Am. Phil. Soc. 1888, 335.

Mioclænus minimus COPE, Proc. Am. Phil. Soc. 1882-3, 468; Tert. Vert. p. 327, pl. xxve, figs. 22-24. Not *M. minimus* COPE, Trans. Am. Phil. Soc. 1888, 335. See also SCOTT, Proc. Phila. Acad. 1892, 323.

This is the smallest of the Torrejon species, the three lower molars measuring only ten and a half millimetres in length. The shape of the molar cusps is like those of *Hyopsodus*, but the cusps are lower and the internal crest lacking; the postero-internal cusp (entoconid) is not present, and the anterior cusps are opposite, not alternating. The premolars are quite different, being entirely simple with small heels and moderately inflated. Upper teeth scarcely known; an upper jaw (the type specimen, No. 3208) with two premolars partly exposed indicates that these teeth were rather large with obsolete external cingula, the fourth with a large interior cusp, the third with a small one or simple.

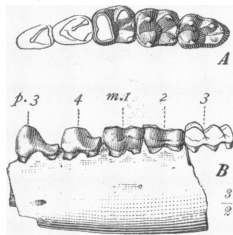


Fig. 18.—*Mioclænus acolytus* (Cope). A. Lower teeth, crown view, No. 3292a. B. Lower jaw, outside view, No. 3294.

Cope's original type of *Mioclænus minimus* appears to be identical with this species; the specimens on which the revised description of 1888 was based are a larger form, quite distinct from this one and belong to *M.* ("Tricentes") *inaequidens* Cope.

Protoselene, gen. nov.

Premolars not much inflated, lower ones trenchant. Fourth upper premolar with strong internal cusp (deuterocone) and distinct postero-external cusp (triticocone). Third premolar nearly simple. Last lower premolar with strong heel; anterior ones simpler. Entoconid well developed on lower molars.

Protoselene opisthacus (Cope).

Mioclænus opisthacus COPE, Am. Nat. 1882, 833; Proc. Am. Phil. Soc. 1883-4, 312; Trans. Am. Phil. Soc. 1888, 332, fig. 5; SCOTT, Proc. Phila. Acad. 1892, 321; (*Hemithlæus*) COPE, Tert. Vert. 407, pl. xxvf, figs. 8 and 9.

Hemithlæus baldwini COPE, Am. Nat. 1882, 853; Tert. Vert. 328, pl. xxvf, fig. 16.

This species has rather advanced molars combined with premolars of the simple type found in *Miocænus*, but more trenchant. The molar cusps show a departure from the rounded form in the direction apparently of selenodontism. The type of selenodontism, if such it be, does not appear to be one that led up into any later form, for it was tritubercular in the upper molars, the protocone combining with the intermediates while the hypocone is left out-

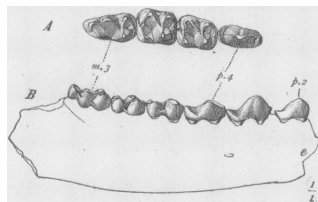


Fig. 19. — *Prostoselene opisthacus* (Cope). A. Lower teeth, crown view, No. 3278. B. Lower jaw, outside view, No. 2435. Both natural size.

side. This is not marked, however. The lower molars have the outer cusps quite strongly crescentic, the inner ones still rounded. The last molar is long with a strong hypoconulid projecting backward medially. The paraconid is present on all the molars, although small, entoconid strong and hypoconulid distinct. Lower

premolars rather compressed, trenchant, their width varying; in some specimens they are moderately inflated. A rudimentary heel on p_2 , a rudimentary anterior cusp and small heel on p_3 , and small anterior cusp and strong two-cusped heel on p_4 . Upper molars with distinct, though very small, parastyle and mesostyle, small intermediates tending to fuse with the protocone into a crescent, and small hypocone.

Specimen No. 2435, from which the above description is taken, has some skeleton fragments preserved, as well as upper and lower jaws. A calcaneum is in general proportions like that of *Euprotogonia*, but the shape of the sustentacular is different, being less sharply triangular and projecting less internally—in this the bone resembles the *Anisonchinæ*. There is no roll facet for the fibula, but facing quite externally is a small concave oval facet, whose peculiar shape and position I cannot explain—it may be some accidental peculiarity. The calcaneum has an oblique ectal astragalar facet, and thus forbids any near relationship to the Artiodactyla. The proximal part of a humerus shows a moderately well developed greater tuberosity, the lesser one being small. The head is somewhat rounder and more elongated anteroposteriorly than in *Euprotogonia*. The deltoid ridge is flat-

topped and continued well down on the shaft but not prominent. A median metacarpal is rather long and slender and has a small, nearly lateral facet for the unciform and a small nearly proximal facet for the overlapping second metacarpal. Fragments of the femur, pelvis and of several vertebræ are preserved, but I recognize nothing characteristic about them.

This skeleton is slightly smaller than that of *Indrodon malaris*, No. 823, described in this Bulletin (1895), although the teeth are one-half larger. There is not much doubt about the correctness of the association. As far as it goes, it indicates a Condylarth, but the evidence is far from convincing. The heel of the calcaneum is compressed laterally, instead of rounded as in *Indrodon*, or angulate or flattened as in some modern Primates. The tuberosities are unequal as in *Euprotogonia*, not sub-equal as in *Indrodon*. The low deltoid crest is a distinction from such Rodents as *Plesiarctomys*, in which it is a high compressed flange. The ridge was probably low in *Indrodon*, but is not preserved in No. 823.

Considerable variation occurs in premolars of this species, as to their size and stoutness, but I cannot detect any constancy in this character. The type specimen is a large individual; the rest of the specimens referred to this species by Prof. Cope are smaller and less robust, as is also the type of *Mioclanus baldwini*. One individual is recorded as coming from the lower beds, but shows no difference from the rest.



Fig. 20.—*Protoselene opisthacrus* (Cope). Head of humerus, proximal view, natural size, No. 2435.

AMBLYPODA *Cope*.

Family PANTOLAMBDIDÆ *Cope*.

Pantolambda Cope.

The collections of the Museum Party of 1896 contain a number of fine specimens of both species of this interesting genus, but their description is reserved for the present, and will be included in a forthcoming paper by Prof. Osborn. As already ob-

served, *Pantolambda* comes very near to being a Condylarth, under the definition given in this paper, but on account of its undoubted connection with the Amblypoda it is better to remove it from the group of undifferentiated Ungulates.

EDENTATA.

Suborder GANODONTA *Wortman.*

The Basal Eocene members of this group have been fully discussed and illustrated by Dr. Wortman in previous papers,¹ and call for no further mention here.

FOOT STRUCTURE OF BASAL EOCENE MAMMALS.

On theoretical grounds it has been generally expected that the feet of the Puerco Ungulates and Creodonts would show for the most part a serial podium, perhaps a serial metapodium. This expectation has not been realized, as is shown by a list of Basal Eocene species in which the foot is more or less known :

		CARPUS.	TARSUS.
<i>Primates</i>	<i>Indrodon malaris</i>	Unknown	Serial.
<i>Creodonta</i>	<i>Triisodon heilprinianus</i>	"	Non-serial.
	<i>Dissacus navajovius</i>	"	"
	" <i>saurognathus</i>	Non-serial. . .	"
	<i>Clænodon ferox</i>	"	"
	" <i>corrugatus</i>	"	"
<i>Condylarthra</i> . .	<i>Euprotogonia puercensis</i>	"	Serial (approx'ly).
	<i>Periptychus rhabdodon</i>	Unknown	Non-serial.
	<i>Ectoconus ditrigonus</i>	"	"
	<i>Anisonchinae</i>	"	"
<i>Amblypoda</i>	<i>Pantolambda bathmodon</i>	Non-serial. . .	"
	" <i>cavirictus</i>	"	"
<i>Edentata</i>	<i>Psittacotherium multifragum</i>	"	Unknown.

All these species have much in common about foot structure, and the rest of the skeleton offers but few characteristic points of distinction. In all the known forms the magnum is very small, keeled and facettèd for lunar and scaphoid or centrale, the lunar of moderate size, keeled and facettèd for magnum and unciform, the trapezoid small and trapezium large. Metacarpals II and III

¹ Bull. Am. Mus. Nat. Hist., 1896, 259, and 1897, 59. Also 'Science,' Dec. 11, 1896, p. 865.

have facets for the magnum and unciform respectively, as well as their proper facets for trapezoid and magnum. The centrale is separate in one Creodont, fused in another; in the Condylarths and Amblypods its presence may be suspected, but it was probably not large if it had not already disappeared (by absorption, not by fusion). In the hind foot the astragalus is but little keeled, with round head, and neck of varying length. The calcaneum has only two astragalar facets, the ectal being oblique to the axis of the bone and convex internally, the sustentacular of about equal size slightly concave. The heel is straight and long. Except in *Euprotogonia*, the most progressive Condylarth, and in the ?Primate *Indrodon*, the cuboid has a considerable astragalar facet. The presence of a tibiale has not been shown, although an apparent internal facet is more or less distinguishable on the head of the astragalus in several species; but that this really indicates a bone I am by no means certain. The three cuneiforms are present, the second being quite short, with the second metatarsal pushed up between the first and third cuneiforms.

The conclusion to which the study of these feet leads, apart from any theoretical considerations, seems to me to be as follows:

The primitive condition of the carpus was alternating, with the centrale present. By *absorption* of the centrale a serial carpus, except for the lunar-unciform contact, was produced. By *fusion* of the centrale with the scaphoid the alternating type of carpus would be maintained. That this primitive alternating carpus was preceded by an entirely serial carpus of the type of *Meniscotherium* is quite possible, but there is no evidence of it.

In the tarsus we find no evidence to support the theory of primitive serialism. Only in *Euprotogonia*, the most progressive of the group, do we find an approximately serial tarsus, and this is accompanied by a slender foot adapted for running, and by reduced side toes. The drift of all the evidence is towards relegating the primitive serial carpus and tarsus back into the unknown Cretaceous.

NOTE ON THE USE OF THE TERM CONDYLARTHRA.

Cope proposed the term Condylarthra (1881) with *Phenacodus* as the type genus, as a suborder of Perissodactyla distinguished
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by (1) astragalus with convex head, (2) astragalus articulating with navicular only, (3) a third trochanter on the femur. In this group he placed the Phenacodonts, Periptychids and (later) *Meniscotherium*. Subsequently (1885) he altered the arrangement making a new Order Taxæopoda, to include the Condylarths and *Hyrax*, defining it as with serial carpus and tarsus, *Hyrax* being placed in a separate suborder distinguished by the blunt hoofs and peculiar astragalo-fibular articulation. Rüttimeyer, Osborn and others have shown that this later conception is by no means strictly applicable, and our present knowledge enables us to state definitely that none of the forms referred to the Condylarthra have an entirely serial carpus, except perhaps *Meniscotherium*, of which the carpus is figured by Marsh as serial. *Phenacodus* has a serial tarsus and a carpus which, though not entirely serial, is not interlocking. But this condition is secondary, for in *Euprotogonia*, its direct ancestor, the carpus is partly interlocking, and the tarsus is not quite serial. In *Pantolambda* the carpus is interlocking, and the tarsus strongly displaced; in *Periptychus* the carpus is not known, but the tarsus is extremely close to *Pantolambda*, and from this and many other resemblances I believe it safe to consider that the carpus was also interlocking. In *Haploconus* the carpus is unknown, the tarsus moderately displaced. We may note that the short-toed plantigrade *Pantolambda* shows the greatest departure from the serial type, while the longer-toed semi-digitigrade *Phenacodus* and *Euprotogonia* show the closest approach. In fact, whatever may be the force of the theoretic arguments in favor of the serial foot being the primitive ungulate type, it receives no support from what we know of the foot-structure of the Condylarths. If it was the primitive structure, the first departure from it must have long antedated the separation of Creodonts and Ungulates.

It is convenient, however, to use a term which will include these primitive Ungulates, some of which gave rise to the later orders, while the great majority have left no descendants. The earlier conceptions of Kowalevsky and other European scientists do not furnish any satisfactory basis for a clear definition of the *Protungulata* (Urungulaten), as the group must now be understood. Marsh's re-definition (1884) is more complete,

and recognizes more nearly their proper position—but it is hypothetical, is inapplicable to the forms here considered in several respects, notably in ascribing to the group a serial tarsus and carpus with centrale present, and is antedated by Cope's *Condylarthra*.¹ The latter was based on actual skeletons, and its first distinction, the round-headed astragalus, is the one most characteristic of all the forms of the group. Osborn's modification of Cope's original classification (*Trans. Am. Phil. Soc.*, 1889, 559) is likewise inapplicable to most of the forms here included.

I would re-define it, then, as including primitive Ungulates retaining many unguiculate characters, among which the most characteristic is the convex-headed astragalus with distinct neck. Other characters found in the known members of the group are :

2. Dental series complete, usually without diastemata, teeth short-crowned, canines not large.
3. Skull low, brain small and smooth.
4. Radius and ulna separate, subequal, toes five, with narrow hoofs. Humerus with entepicondylar foramen, and condyles wide but not deep.
5. Femur with third trochanter.
6. Fibula complete, articulating with astragalus and barely touching calcaneum.
7. Tarsus not far from serial, toes five, the side ones sometimes reduced.

¹ *Am. Nat.*, 1881, 1018.

