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AMERICAN MUSEUM OF NATURAL HISTORY.

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VOLUME XIV, 1901.

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**Article I.—ADDITIONAL OBSERVATIONS ON THE  
CREODONTA.**

By W. D. MATTHEW.

CONTENTS.

I. Classification. Arrangement of the Creodonta, chiefly on the basis of the specialized carnassial.

II. Family Viverravidæ. Characters of the skull and skeleton of *Viverravus* Marsh (= *Didymictis* Cope), as shown in two species, *V. protenus* and *V. leptomylus* Cope.

III. Family Arctocyoniidæ. Fore and hind feet of *Clænodon*, with a discussion of its relations to the Ursidæ.

IV. Family Hyænodontidæ. Revision of the classification. Revision of the genus *Sinopa* (*Stypolophus*) with descriptions of two new forms.

V. Family Mesonychidæ. The oldest known mammal skull (*Triisodon heilprinianus*). Dentition and skeleton of *Pachyæna gigantea*. Pseudo-marsupial characters of the Mesonychidæ.

I.—CLASSIFICATION.

In classifying any group which includes a large proportion of primitive types we must use some combination of two methods. A division may be considered either as a group of forms resembling a given type within certain limits, or as including a particular line of development. Osborn has termed these two principles of classification the "horizontal" and "vertical"; it appears to

the present writer that *group* and *race* would more truly express their intent. By the former method the unspecialized ancestral types of several families are placed in a separate family, from which the later families are derived. This is on the ground that the distinctions between the different lines of descent were not at first wide enough to be of family value, and that the different primitive types resembled each other more than they did any of the later specialized types. The other method of classification divides up these primitive types among the various specialized families to which they are ancestral or approximately ancestral. The group conception — the Latin *familia* = household — is, of course, the original use of the term; the race conception — the English *family* — has been introduced to meet the new conditions brought in by the doctrine of evolution and the development of palæontology.

It seems to the writer that either principle, used exclusively, results in obscuring, or at least imperfectly indicating, the real relationships the expression of which should be its chief purpose. The group method ignores parallelism, and fails to properly emphasize the lines of descent. The race method equally fails to emphasize the near relationship of the primitive root types, and in practice causes much confusion and apparent variance of opinion by the attempt to divide into different families species among which the distinctions have not yet become of generic value.

Among the fossil Mammalia these two methods are used in very varying proportion. In some groups, such as the Perissodactyls, the divisions have been drawn 'vertically,' all the ancestors of a family being placed in that family, so that the primitive Perissodactyls of the Lower Eocene, exhibiting no more difference in the sum of their characters than the different species of modern *Rhinoceros*, are divided among six different families, the typical forms of which are extremely different from any of these primitive forms; and the various species are moved about from one to another of these families with the utmost facility by every author who attacks the problem anew. In fact, constant specific distinctions are not always easy to find among them. In other groups, such as the Creodonta, all the ancestors of the modern types, together with those ancient types which have left no

descendants, are placed in a separate suborder, distinguished by the absence of a specialized character common to all the modern families. Similarly among the Creodont families, the primitive types have been grouped separately from the specialized ones by almost all writers, the family distinctions being on points of specialization or non-specialization.

The present writer is in a position to appreciate very much the evil effects of unnecessary changes in nomenclature and is inclined to deprecate most strongly the perpetual changes caused by a too strict adherence to laws of priority which were not designed for palæontology, and do not entirely fit its requirements. With the progress of the science it becomes more and more evident that a very large proportion of the earlier species were founded on indeterminate material; and the vain attempt to find reasons for identifying these fragments with one or another of the species distinguishable by more perfect material has wasted a vast amount of time, and, however valuable from an antiquarian standpoint, adds not one iota to our knowledge of the fossil animals themselves and their place in nature. Scientific names are not different from other names—they are merely arbitrary terms representing each a certain conception; and it appears to the writer that custom should be the chief rule to govern their use.

With classifications the case is different. A classification is not arbitrary, but an expression of the natural relationship as nearly as our knowledge of the species and the limitations of the method used will permit. Conservatism in classification would mean cessation in the increase of our knowledge of a group; uniformity in it would be impossible, unless all observers attached the same relative importance to the same characters. A comparatively slight divergence of opinion on the last point may involve an entire upset in the classification scheme. A graphic method (such as is used on p. 21 in illustrating the relations of three of the Creodont families) would more accurately express the conception; but in such a method it is seldom possible to include all members of a group—the physical difficulties of space of two dimensions prevents the complete representing of poly-dimensional relationships.

In venturing, therefore, on very considerable changes in classification from that generally accepted, and embodied especially in

so accurate and recent a text-book as Prof. Zittel's, I must disclaim any really radical changes in relations, except in a few cases. The recent study of far more complete Creodont material than has ever before been accessible has led American students to perceive the fundamental importance of certain lines of genetic cleavage somewhat less appreciated hitherto, and to make these the primary basis for division rather than differences which are now perceived to be in large part only contrasts between primitive and specialized types.

First in importance among these characters of divergent specialization is the position of the carnassial teeth. In the primitive types the shear between upper and lower molars is absent or rudimentary and about equally developed on all three molars. In some of the specialized types it is chiefly between  $p^4$  and  $m_1$ , as in all modern Carnivora. In others it is chiefly between  $m^1$  and  $m_2$ , or between  $m^2$  and  $m_3$ . A large number of the primitive genera of the Creodonta show, in some of their species at least, a more or less evident tendency towards one of these three specializations.

A primary division on these lines, worked out by Dr. Wortman and the writer, and published by Wortman a year ago ('99, p. 139), had been previously independently elaborated though not published by Prof. Osborn for use in his University lectures, in either case chiefly the result of study of the large series of Creodonta in the American Museum collections.

Another line of cleavage as yet imperfectly known, but which may prove to be of importance equal to or greater than the above, lies in the character of the claw-phalanges. In one group of Creodonts they are short, wide, and split, indicating a more or less hoof-like claw, probably used for locomotion only. In the other they are like those of most modern Carnivores, sharp, laterally compressed, bearing apparently a sharp curved claw which could be used as a weapon. This character is known in the following:

No carnassial	<i>Arctocyoniidae</i>	<i>Clanodon</i> (both species)	} Sharp-clawed.
Carnassial $\frac{p^4}{m_1}$	<i>Viverravidae</i>	<i>Viverravus</i> (two species)	
" $m_2^3$	<i>Hyænodontidae</i>	<i>Hyænodon</i>	} Blunt-clawed.
" $m_3^1$	<i>Oxyanidae</i>	<i>Oxyæna</i> , <i>Patriofelis</i>	
No carnassial	<i>Mesonychidae</i>	<i>Pachyæna</i> , <i>Mesonyx</i>	



Thus, as far as it goes, this distinction coincides with that between the *Creodonta adaptiva* (carnassial  $\frac{p^4}{m_1}$ ) and *Creodonta inadaptiva* (carnassial not  $\frac{p^4}{m_1}$ ). *Arctocyon* must be included with the adaptive types and *Mesonyx* with the inadaptive, although they have no true carnassials, an arrangement which seems to be supported by a variety of minor skeletal characters. But the evidence is entirely inadequate at present to use this as a primary basis of division. Its constancy in both the small and large genera of a family has not been proved, and until this is proved it is always possible that the blunt claws are correlated with the size of the species, not with its true relationships.

Zittel ('94), following Schlosser and Scott in large part, divides the Creodonta as follows (I omit invalid or unimportant genera) :

- I. *Oxyclanidæ*. Molars tritubercular, pointed cusp, no shear; premolars trenchant. *Oxyclænus*, *Chriacus*, *Protochriacus*, *Tricentes*, *Mioclænus*, *Protogonodon*.
- II. *Arctocyonidæ*. Molars quadritubercular, low-cusped, no shear; premolars trenchant. *Arctocyon*, *Clænodon*, *Anacodon*.
- III. *Triisodontidæ*. Upper molars tritubercular, lower molars with two high cusps and talonid. No shear. Premolars high and pointed. *Triisodon*, *Goniacodon*, *Microclænodon*, *Sarcothrausten*.
- IV. *Mesonychidæ*. Upper molars tritubercular, lower molars with high and low cusp and talonid. No shear. Premolars high and pointed. *Dissacus*, *Pachyæna*, *Mesonyx*.
- V. *Proviverridæ*. Upper molars and  $p^4$  tritubercular, protocone far in and well forward. Lower molars with high tricuspid trigonid and low talonid. *Hyænodictis*, *Deltatherium*, *Sinopa*, *Proviverra*, *Quercytherium*, *Didelphodus*, *Prorhysæna*.
- VI. *Palæonictidæ*. Jaw shortened. Third upper and lower molar absent. Molars tritubercular,  $p^4$  and  $m_1$  large. Premolars thick. *Palæonictis*, *Amblyctonus*, *Patriofelis*.
- VII. *Hyænodontidæ*. Upper molars with external blade and internal tubercle. Third upper molar transverse or absent. Lower molars sectional with low, trenchant heel. *Oxyæna*, *Protopsalis*, *Hemipسالodon*, *Pterodon*, *Dasyurodon*, *Thereutherium*, *Hyænodon*.
- VIII. *Miacidæ*.  $p^4$  and  $m_1$  carnassial. Last upper molar small, transverse. *Miacis* (= *Uintacyon*), *Didymictis* (= *Viverravus*), ? *Vulpavus*.

The following changes, mainly dependent on recent discoveries, seem advisable :

*Oxycænidae*. *Miocænus* is either Primate or Condylarth, *M. acolytus* certainly the former.<sup>1</sup> *Protogonodon* is Condylarth (although difficult to separate from *Protochriacus* in the lower dentition).

*Triisodontidae* should, as Wortman suggests ('99, p. 146), be considered as a subfamily of Mesonychidae.

*Proviverridae* is a heterogeneous group of genera, chiefly unspecialized types of different phyla. I believe it can be broken up with advantage, the more primitive types being placed with the Oxycænidae, to which they are very close; the more advanced genera being distributed among the specialized families. *Hyænodictis* has the lower molars of the Mesonychidae, but the upper teeth are like those of *Pterodon*; I am unable to see how the two styles of tooth could work together in the same jaw, and compelled to suggest incorrect association. *Deltatherium* is very close to *Chriacus* of the Oxycænidae. Some of the species of *Sinopa*, though not all, show the specialization of  $m_3^2$  as carnassials, and all show characters, in the upper molars especially, allying them with either the Oxyænidae or Hyænodontidae. *Proviverra* is rather closer to *Sinopa* than to the Oxycænidae; *Didelphodus* and *Prorhizæna* are unspecialized types with a leaning towards the *Sinopa* characters. *Quercytherium* seems to be a very aberrant Hyænodont.

*Palæonictidae*. With this and the succeeding family an entire upset of the classification seems necessary, for *Patriofelis* is rather closely related to *Oxyæna*, which is very far from being closely related to *Pterodon* and *Hyænodon*; the resemblances between them are strictly parallelisms. We therefore divide these families as follows:

PALÆONICTIDÆ.  $P_4^1$  and  $m_1$  carnassial, posterior teeth disappearing. *Palæonictis*, *Amblyctonus*, ? *Ælurotherium*.

OXYÆNIDÆ.  $M_1^1$  and  $m_2^2$  carnassial, posterior teeth disappearing. *Oxyæna*, *Patriofelis* (= *Protopsalis*), *Thereutherium*, *Telmatocyon*.

HYÆNODONTIDÆ.  $M_3^2$  carnassial,  $m_2^2$  disappearing. *Hyænodon*, *Pterodon*, *Quercytherium*, *Cynohyænodon*, *Sinopa*, ? *Didelphodus*, ? *Palæosinopa*.

"*Miacidae*."—Wortman and the writer have shown in a recent paper ('99, p. 110) that *Miacis* is a synonym of *Vulpavus* and

<sup>1</sup> The primate skeleton from the Puerco described by Osborn and Earle in 1895, and referred to *Indrodon*, is *M. acolytus*. *M. turgidunculus*, *lemuroides*, *inæquidens*, ? *opisthacus*, and ? *turgidus* may also be placed provisionally among the Primates.

*Didymictis* of *Viverravus*. The name *Miacidæ* therefore cannot be used, although the family *Viverravidæ* there proposed by us may perhaps be extended so as to take in *Vulpavus* and *Uintacyon*, should these prove to have the Creodont carpus.

The analysis of the Creodonta on the primary basis of the specialized carnassial will stand thus :

I. CREODONTA PRIMITIVA. No specialized carnassial ; tritubercular upper and lower molars, shear rudimentary or absent. Claws unknown.

*Oxyclenidæ*. Includes some genera with Lemuroid affinities in the dentition.

II. CREODONTA ADAPTIVA. Carnassial when present on  $p^4$  and  $m_1$ . Claws, where known, of modern type, and probably carried more or less free of the ground. Scapholunar-centrale early uniting (podials tending towards true Carnivore type).

1. Post-carnassial teeth disappearing.....*Palæomictidæ*.

2. Post-carnassial teeth becoming tubercular.....*Viverravidæ*.

3. No carnassials, molars becoming flat-crowned, premolars disappearing.....*Arctocyonidæ*.

III. CREODONTA INADAPTIVA. Carnassial when present not on  $p^4$  and  $m_1$ . Claws, where known, blunt, hoof-like, resting on the ground. No tendency to union of the carpals (podials tending towards Ungulate type).

1. Carnassials  $m_1\frac{1}{2}$ . Shearing teeth.....*Oxyænidæ*.

2. Carnassials  $m_1\frac{2}{3}$  " ".....*Hyænodontidæ*.

3. No carnassials, teeth with high, round, blunted cusps, upper molars tritubercular, lower molars premolariform.....*Mesonychidæ*.

There is probably a definite correlation between the hoof-like claws and the lack of union among the carpals in *Oxyæna*, *Mesonyx*, and *Hyænodon* ; but that the division in foot-characters coincides with that based on carnassial specialization is not yet proven.

The Creodonta Adaptiva early gave rise to the true Carnivora (by union of the carpals), and are not known to have existed later than the Wasatch, although the Middle Eocene of *Vulpavus* and *Uintacyon* may, when the carpus is known, prove to be Creodonts. The Creodonta Inadaptiva persisted side by side with true Carnivora until the close of the Oligocene, but none of them can be admitted as ancestral to any true Carnivore, unless the supposition that has successively been raised about each of the three families, connecting them with the Pinnipedia, should be proven by satisfactory evidence.

Of the modern Carnivore families we may derive the *Viverridæ*, *Canidæ* and *Procyonidæ*, and perhaps the *Mustelidæ*, from

the Viverravidæ; the Felidæ and ? Hyænidæ probably from the Palæonictidæ; the Ursidæ either from Arctocyonidæ or, with the Canidæ, from Viverravidæ—as discussed later in this paper.

As for the Pinnipedia, it appears to me that there is no evidence sufficient to justify our deriving them from any known type of Creodont or Carnivore, and that their ancestors are not very likely to be found in the almost exclusively terrestrial fauna of the fossil beds of the Bad Lands. (See also Osborn, '00.)

## II.—Family VIVERRAVIDÆ *Wortman & Matthew.*

### **Viverravus** *Marsh.*

Syn., *Didymictis* COPE.

“The lower jaws in this genus are long, very slender and compressed; the last two molars are tubercular.<sup>1</sup> Both have the posterior part of the crown quite low and the anterior half elevated and composed of three angular cusps. The four teeth anterior to these<sup>2</sup> are much compressed. The upper flesh tooth closely resembles that in some of the Viverridæ, and the genus should probably be referred to that group.”—*Marsh*, '72, p. 7, of separate.

“Inferior molars six, consisting of four premolars and two molars. True molars, a posterior tubercular and an anterior tuberculo-sectorial, *i. e.*, with three elevated cusps and a posterior heel. Premolars with a lobe behind the principal cusp. Canine teeth directed forward, and close together, so that it is doubtful whether there were any incisors. An ungual phalange of the typical species is strongly compressed. Humerus distally expanded transversely and margin pierced by humeral artery. Astragalus exhibits two entire trochlear faces, the wider external and directed interosuperiorly, the inner presenting superointeriorly. They are separated by an obtuse longitudinal angle and are little or not at all concave transversely. The form is depressed. The head supports a single transverse convex facet for the navicular, and with the neck is as long as the trochlear portion.”—*Cope*, '84, p. 304.

A fragmentary skeleton found in the Big Horn Valley by the Princeton Expedition of 1884 was described by Prof. Scott ('87, p. 169) under the name of *Didymictis altidens*. As this species is not otherwise known to occur in the Wasatch, it is possible that the specimen should be referred to the closely allied *V. (D.) protenus*. Two somewhat more complete skeletons found in the Wasatch of the Big Horn Valley by the American Museum Expedition of 1896 further illustrate the

<sup>1</sup> Meaning, apparently, with tubercular heel. The context favors this interpretation. Marsh apparently meant at this time to include in the genus forms like *Telmatoctyon*.

<sup>2</sup> *I. e.*, premolars 1-4.

genus, and by means of the information now available concerning other Creodonts we are able to summarize the characters of *Viverravus* as follows :

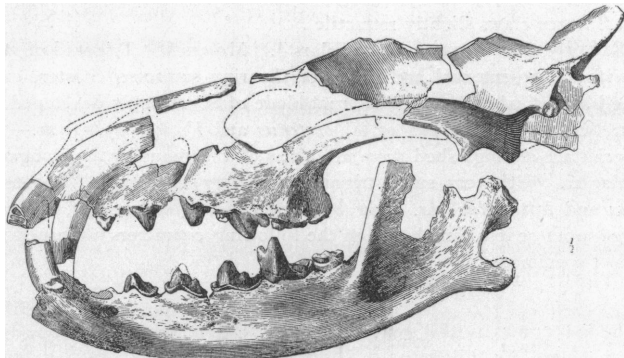


Fig. 1. *Viverravus protenus* Cope. Fragmentary skull and jaws, one-half natural size. No. 2830, Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exp. 1896.

1.—GENERAL CREODONT CHARACTERS.—Skull very large in proportion to skeleton, brain very small and of low type, tail large (presumably long), neck longer than in most modern Carnivora. Limbs rather short with large joints and heavy muscular attachments. Feet small, spreading, scaphoid and lunar separate. Fibula large, separate from tibia. Radius with oval proximal facet, and trihedral simply concave undivided distal facet. Part of a presternal bone preserved is like that of *Phenacodus wortmani*. Humerus with prominent deltoid crest reaching far down on the bone; distal extremity broad, not deep, with entepicondylar foramen.

2.—FAMILY AND GENERIC CHARACTERS.— $\frac{p^4-m^1}{m_1}$  carnassials. Lower carnassial with high triangular trigonid shearing against posterior edge of  $p^4$  and anterior edge of  $m^1$ , which are extended externally into shearing blades. Molars  $1-2$  tubercular, heel of  $m_1$  and all of  $m_2$  tubercular or becoming so, premolars trenchant with posterior cusps in front of heel. Jaws long and slender, incisors reduced and canines approximated. Femur with second trochanter interior instead of posterior, third trochanter well developed on external side, one fourth the length from the head of the bone. A

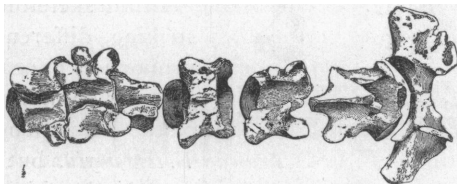


Fig. 2. *Viverravus protenus*, No. 2830. Cervical vertebrae, from above. One-half natural size.

clearly marked facet between fibula and calcaneum. Trochlea of astragalus very flat, distal facet strongly convex from above downward, almost flat transversely,



neck rather long. Tarsals serial; a lunar facet on unciform. Entocuneiform deep, but remarkably short for a Creodont, not as long as the ectocuneiform. Toes 5-5, the first short and stout, not opposable. Claw phalanges compressed, sharp, without hood, middle phalanges asymmetrically excavated on upper side of shaft (? hence claws slightly retractile).

3.—GENERIC CHARACTERS.—Premolars  $\frac{1}{4}$ . Molars  $\frac{3}{8}$ . Trigonid of  $m_1$  very high, with antero-external and posterior shearing surfaces. Postero-external shearing blade of  $p^4$  and antero-external blade of  $m^1$  strongly developed.

4.—SPECIFIC CHARACTERS of *V. protenus* and *V. leptomylos* var.—These two species are distinguished from all others of the genus by the elongate low tubercular  $m_3$  with very small trigonid and very long heel. The teeth of *protenus* and *leptomylos* var. show no very constant differences, but may be separated more or less completely on the following characters (averaged from a number of specimens):

	<i>V. leptomylos</i> var.	<i>V. protenus</i> .
Length $p_{3-4} : m_{1-2}$	mm. 20.3 : 19.1 = 1.06	25.9 : 21.4 = 1.21
“ $p^4 : m^{1-2}$	11.5 : 14.2 = 0.81	14.5 : 16.7 = 0.88
Blade $p^4$ to length	4.6 : 11.5 = 0.40	6.1 : 14.5 = 0.42
Transv. to longitud. diam. $m^1$	11.8 : 8.1 = 1.45	15.3 : 10.1 = 1.52

The above proportions show *V. protenus* as nearly one fourth larger, with the premolars larger in proportion, somewhat longer

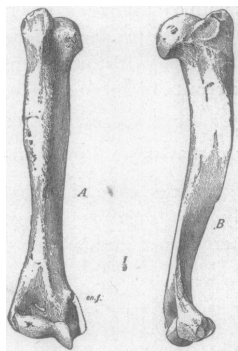


Fig. 3. *Viverravus protenus*, No. 2830. Right humerus; A, from in front; B, from outside. One-half natural size.

shearing blade on  $p^4$ , and  $m^1$  more extended transversely. The same character and extent of distinctions are found between different species of Canidæ, but they are much more constant.

In the skeleton some striking differences in proportion appear. *V.*

*protenus* has limb bones of the same length as

*V. leptomylos* but aver-

aging nearly a third stouter (the dentition of *V. protenus* being one fourth larger). The modern Civet, intermediate between the two in size of skull, has limb bones one fourth longer than the

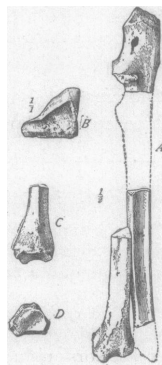


Fig. 4. *Viverravus protenus*, No. 2830. A, parts of left radius and ulna, from in front; B, right unciform, from in front; C, posterior view of distal end of radius. One-half natural size, except B, which is natural size.

larger species, and stouter in proportion, while the neck is over one half longer.

The cat, in which the back and upper limb-bones are of nearly the same size and the lower limb bones considerably longer, has a head and jaws of about half the dimensions of *V. protenus*, and much shorter neck.

The following table<sup>1</sup> will give an idea of the proportions of these animals :

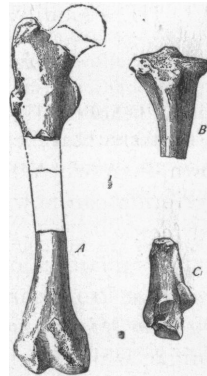


Fig. 5. *Viverravus protenus*, No. 230. A, parts of right femur, from in front; B, proximal end of right tibia; C, left calcaneum. One-half natural size.

	<i>Viverravus protenus.</i>	<i>Viverravus leptomyxus</i> var.	<i>Viverra civetia.</i>	<i>Felis catus.</i>
Humerus, length.....	94	e.89	117.6	97
"    circumference of shaft.....	27.5	21.5	34.7	25
"    diameter of distal end.....	21			19
Femur, length.....	e.97.5	97	136	103
"    circumference of shaft .....	27	21	36	26
Radius, length.....		63	103	91
"    circumference of shaft.....	17	12		
Ulna, length.....		85.5	131.4	104
"    circumference of olecranon.....	30	23.2		
Calcaneum, length.....	27	22.5		29
Tarsus, length (including calcaneum).....		29		
"    width across navicular and cuboid.....		12.6		
Skull, length.....	167.5		158	91
Jaw, length.....	130		111.2	63
Dentition, length.....	83.7	e.66.4	75	34
Seven cervical vertebræ, length.....	102		164	

<sup>1</sup> The measurements are given in millimetres. e = estimated.

III.—Family ARCTOCYONIDÆ (*Gervais*) *Cope*.*The Manus and Pes of Clænodon.*

In a previous article ('97, p. 289) I have given some account of the foot structure of this interesting Creodont, now more fully known than when first described by Cope ('83, p. 547). This description can now be supplemented by figures of the fore and hind feet.

It was mainly on the characters of *Clænodon* (*Mioclænus*) *ferox* that Professor Cope based his views as to the position of the genus *Mioclænus* Cope ('84, p. 324), referring it to the Arctocyoniidæ, which included this and many other species of divergent affinities, separated by Scott ('92) as distinct genera. Judging from Cope's descriptions of the skeletal material of *M. ferox* at his command, he was evidently strongly impressed with its resemblance to Marsupials, an idea which led him astray in parts of his description. I do not think that this resemblance is wholly a case of parallelism, for all the Creodonta of the Basal Eocene were quite nearly allied, and certain of them show primitive marsupial characters that it is very difficult to explain without admitting a closer connection between Marsupials and Placentals than their modern differentiation would lead one to believe. *Clænodon* has, however, no marsupial characters except such as must be considered an inheritance from the common stock which gave rise to both Marsupials and Placentals. Its progressive characters are placental carnivore.

Several genera of this group have been described. Without discussing the validity of *Hyodectes* and *Heteroborus*, defined by Cope on the basis of descriptions of European Arctocyons, we may say that three genera are sufficiently known for discussion of their relationships. These are :

*Arctocyon* Blv., type *A. primævus* Blv.; referred species, *A. gervaisi*, *A. deulii* Lem., all Basal Eocene of Europe.

*Anacodon* Cope, type *A. ursidens* Cope, Lower Eocene of America.

*Clænodon* Scott, type *C. (Mioclænus) ferox* Cope; referred species, *C. corrugatus* (Cope), Basal Eocene of America.

To these should perhaps be added *Arctocyonioides* Lem., type *A. sp. innom.* Lem., Basal Eocene of Europe; referred species?

*A. (Mioclenus, Clenodon) protogonioides* Cope, Basal Eocene of New Mexico.

The last genus is distinguished only by the smaller quadrate teeth—simpler than those of *Clenodon* if the reference of *Mioclenus protogonioides* be correct. The type species is little known.

If the foot bones figured by Osborn ('90, p. 60) are correctly referred to *Arctocyon*, there are important differences in foot-structure between it and *Clenodon*, the former having no fibular facet on the calcaneum, while the ungual phalanx is much less compressed. The figure given by Lemoine ('78, pl. IV) of a calcaneum of *A. gervaisi*, is much more like those of *Clenodon ferox* and *C. corrugatus* and appears to indicate a fibular facet. I think it probable that the bones figured by Osborn are those of some other Creodont. The skeletal structure of *Anacodon* is unknown.

The dental distinctions are :

<i>Clenodon.</i>	<i>Arctocyon.</i>	<i>Anacodon.</i>
<i>Upper premolars</i> moderately reduced, the first one-rooted, second two-rooted, third and fourth three-rooted with high trihedral protocone and weak cingular cusps at the bases of the three solid angles.	<i>Upper premolars</i> considerably reduced, first one-rooted, second and third two-rooted, fourth large with strong deuterocone.	<i>Upper premolars</i> much reduced, the first and second minute or absent, third two-rooted, fourth small with a strong deuterocone and rudimentary third and fourth cusps.
<i>Upper molars</i> with three low subequal cusps, strong metaconule, somewhat weaker hypocone and very small paraconule. Metaconule weak and hypocone absent on $m^2$ .	<i>Upper molars</i> as in <i>Clenodon</i> .	Molar cusps obsolete.

These distinctions are based on the typical species of each genus. It is probable that the other species referred to *Arctocyon* are closer to *Clenodon*, but the present evidence seems to warrant holding the three genera separate. *Arctocyonides* if correctly represented by the American species *A. (Mioclenus, Clenodon) protogonioides* (Cope) is the most primitive of the family, but hardly deserves more than subgeneric separation from *Clenodon*.

This genus, while close to *Arctocyon*, is distinctly less specialized, and the differences seem to warrant generic separation. *Anacodon*, of the Wasatch, is much more specialized than any of the Basal Eocene species. All the genera, as far as known, have long, sharp, serrate canines, somewhat flattened and very little worn, premolars in various stages of disuse and reduction, molars becoming flat-topped and quadrate. The little-used premolars and canines may be contrasted with those of the Mesonychidæ and Oxyænidæ, in which they were well worn, often to enamelless stumps. The canines may have been chiefly for defense against enemies, the animal not being to any extent carnivorous.

The fore and hind feet here figured are of much interest, showing for so early a period an unusual degree of specialization in certain characters.

#### *The Fore Foot.*

The carpus is distinguished especially by the large rectangular *centrale*, lying half under the lunar, half under the scaphoid and *fused to the latter bone*.

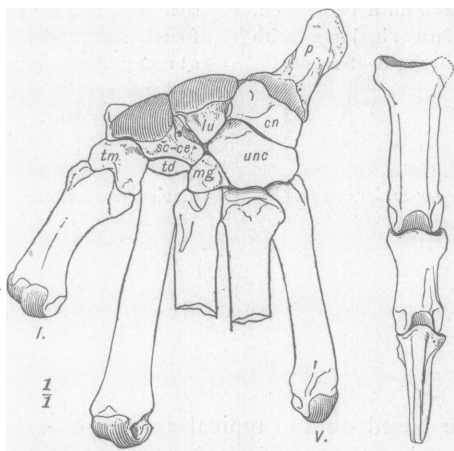


Fig. 6. *Cladodon corrugatus* (Cope). Fore foot, natural size. Specimen No. 2456. Torrejon Beds, Wyoming.

The lunar-centrale facet still persists but the lunar-scaphoid facet has disappeared, replaced by a roughened bony surface; this probably points to an approaching union of scaphoid and lunar. The *lunar* is keeled, and faceted for centrale and magnum on one side, for unciform on the other. The *magnum* has a broad centrale facet and narrow lunar facet separated

by a sharp keel. This arrangement would, upon union of the scapho-centrale and lunar give a proximal keeled facet on the magnum fitting into a correspondingly grooved facet on the



scapholunar, exactly as is found among Ursidæ, instead of a flat facet such as characterizes Canidæ and Felidæ.

The *unciform*, *cuneiform*, and *pisiform* are of the usual primitive type, the former having a broad lunar facet separated by an angle from that for the cuneiform. The *trapezoid* has not been found, but was evidently small, ovate, with a narrow facet for the magnum and pinching out on the radial side so as barely to touch the trapezium. The *trapezium* is large with triangular upper surface and projects in a blunt point underneath the centrale and trapezoid.

There are five *metacarpals*, the first only two thirds as long as the rest, but stout in proportion, and divergent though hardly opposable. Its proximal facet allowed considerable play, and is keeled toward its superior surface. The other metacarpals are narrower, longer, and much closer together, with but little play on the carpus.

The *phalanges* are keeled about as in the bears, a little curved and somewhat angulate in section. The *ungual phalanges* are more specialized than in any known Creodont and the majority of Carnivores. They are large, high, and much compressed, quite as much so as in Ursidæ but with no trace of basal sheath.

#### *The Hind Foot.*

The *tarsus* shows some interesting characters. The tibial and fibular articulating surfaces are of nearly equal width, and the fibula has a considerable facet on the calcaneum. The ectal astragalo-calcaneal facet is oblique as is usual among the earlier

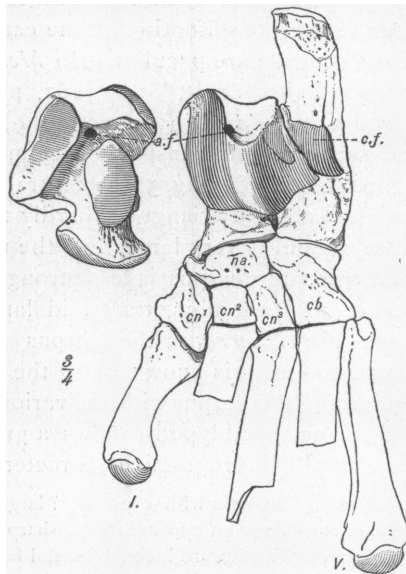


Fig. 7. *Cladodon ferox* (Cope). Hind foot, three-fourths natural size. Type specimen No. 3268. Torrejón Beds, Wyoming.

Creodonts, and is separated by a slight angle from the fibulo-calcaneal facet. The trochlea of the astragalus is very shallow, the foramen<sup>1</sup> is present, and the notch for the flexor digitorum wide though not very deep. The head of the astragalus is considerably flattened, about as much as in Ursidæ or Felidæ. The *cuboid* has a rather narrow astragalar facet, concave, and separated by an angle from the rather flat calcaneal facet. The corresponding facet on the astragalus is not separable from the navicular facet. The *entocuneiform* is large and *metatarsal I* short, stout, and divergent, though with less play than the corresponding metacarpal. The other four metatarsals are of about equal length, the second being wedged in proximally between the ecto- and ento-cuneiforms.

#### *Comparisons.*

The union of the centrale with the scaphoid is an interesting stage in the consolidation of the carpus. The position and size of the centrale are peculiar. In *Mesonyx* it lies entirely beneath the scaphoid (Scott, '87, p. 161, pl. VII, fig. 1). In *Dissacus* (Osborn and Earle, '95, p. 33, fig. 9) it is less completely so, but the shape is rhombic instead of rectangular. In *Hyænodon* (Scott, '87, p. 182, pl. VII, fig. 5) the centrale lies partly under the lunar, but is small and triangular, hardly touching the magnum, while the trapezoid is very large, and the unciform has no lunar facet. In *Oxyæna* the carpus is less strongly interlocking, the centrale smaller and rhombic, trapezoid larger, trapezium different in shape. In *Viverravus* the carpus is narrower, foot probably slenderer—little is known as to the arrangement of the carpals. Comparing this carpus with the various primitive Creodonts, Condylarths and Amblypods, shows a great deal of similarity among them all. The progressive characters in *Clanodon* seem to be :

1. Union of centrale with scaphoid ; ? large size of centrale, almost excluding magnum from lunar on upper surface ; sharp keel of magnum.
2. Grooving and inward facing of distal facet of trapezium.
3. Stout semi-opposable first metapodial, and length of fifth.

<sup>1</sup> The use of this foramen seems to be unknown. Prof. Osborn has suggested that it may have held an extension of the interosseous ligament, which lies between the two astragalo-calcaneal facets and connects the astragalus with the calcaneum. If this ligament originally passed up to the tibia, its disappearance would be directly connected with the keeling of the proximal and flattening of the distal end of the astragalus, all being due to the transference of the main ankle-joint from the distal to the proximal end of the astragalus, *i. e.*, the evolution of the mammal from the reptilian stage of development in this character.

4. High compressed claw ; extension upward of distal facets of 1st and 2d phalanges and to some extent of distal metapodial keels.
5. Slender, serrate, unworn canines.
6. Reduction of premolar dentition.
7. Low-cusped quadrate molars,  $m_3$  somewhat reduced.

The first of these characters leads towards the Carnivora generally, except the sharp-keeled magnum, which seems to point especially towards the Bears. It may, however, be merely the additional brace required for large-clawed feet. The semi-opposed thumb is a character pointing towards arboreal types, hardly to any known Ursidæ. The proportions of the phalanges agree with those of the Ursidæ and of some other Carnivora (*Procyon*, etc.). The high compressed claw-phalanx suggests the Ursidæ very strongly ; the greater extension of the facets is a modernization common to all the sharp-clawed types.

In the dentition all three characters point to the Ursidæ and to no other Carnivora. The elongation of the second molar after the disappearance of the first is exactly paralleled by the Raccoons in evolving from the Canidæ through *Phlaocyon* — a very similar adaptation not carried so far as in the Ursidæ.

The argument for placing the Arctocyonidæ ancestral to the Ursidæ is, then :

1. They belong by their foot structure to the adaptive Creodonta, the teeth not placing them in either the adaptive or inadapative group.
2. The three chief progressive characters of the teeth are those which distinguish the bear dentition.
3. The claws are far advanced towards the type found in the Ursidæ and in hardly any other Carnivora.
4. The one marked distinction that I can see to separate the bear-carpus from that of other Carnivora is found in process of formation in *Clanodon*.

5. The proportions of the digits show a specialization found in the Bears and in hardly any other Carnivora.

Against this may be urged :

1. *Clanodon* has the thumb more opposable than in the modern Ursidæ.

2. *Anacodon* has the premolar dentition as much reduced as in the modern Ursidæ.

[*January, 1901.*]

(In either case, this may indicate that neither *Clanodon* nor *Anacodon* is precisely in the line of Bear descent, but does not seriously weaken the arguments given above as to the derivation of the Bears from the family Arctocyonidæ.)

3. The real objection to the theory lies in the remarkable approximation of certain of the Dog and Bear families in Upper Miocene time. Although, as Schlosser has recently shown, *Hyænarcos* and *Amphicyon* cannot stand in the direct line of descent, yet they exhibit a striking gradation between the two families and might well be considered as survivals of primitive links connecting the two. *Cephalogale* also, among the more ancient Canidæ, shows several approximations to the Ursidæ, and is placed by Dr. Schlosser as ancestral to the family ('99, 146).

There are some characters, however, that have not been bridged, and these are perhaps more important than they appear at first sight.

1. All Canidæ have triangular upper molars. All Ursidæ have quadrate upper molars.

2. All Canidæ have the inner cusp of  $p^4$  anterior. All Ursidæ have it medial.

The trigonal molar and the anteriorly placed triticocone are indications of a formerly tuberculosectorial dentition, and apparently very difficult to get rid of. *Procyon*, however, seems to show us an earlier stage of their disappearance in a line descended from the Canidæ; so that we may yet discover the intermediate stages in the Ursid phylum.

To sum up—the *Arctocyons* were progressing towards the Bear line in all the most distinctive characters of both teeth and feet. But the wide gap between Lower Eocene and Middle Miocene makes any connection between the two somewhat uncertain. In the Canid line, on the other hand, we have a number of apparently intermediate stages known. But these intermediate stages cannot have been actually in the line of descent, and even if they are unaltered descendants of more ancient types we still have a gap of some importance unbridged. The connection, moreover, is based on teeth alone. Professor Osborn, in discussing the evolution of the Mammalia, remarks: "The teeth and feet, owing to the frequent parallels of adaptation, may wholly mislead us if taken alone; while if considered together they give

us a sure key ; for no case of exact parallelism in both teeth and feet between two unrelated types has yet been found or is likely to be." (*Osborn*, 1893, p. 10.) If *Clænodon* be totally unrelated to the Ursidæ it is an exception to this statement, and, as far as I recall, the only one. And yet the evidence is very strong for deriving the Ursidæ from primitive Dogs.

#### IV.—Family HYÆNODONTIDÆ *Cope*.

In this family are included, as Wortman has already indicated ('99, p. 139), most of the genera grouped by Schlosser under the name Proviverridæ. *Deltatherium* belongs with the Oxyclænidæ ; the position of *Didelphodus* and *Palæosinopa* is uncertain, as they fail to show the progressive characters of either group. *Sinopa* and *Cynohyænodon* clearly belong in it, *Proviverra* somewhat less clearly, while *Quercytherium* appears to be an aberrant member. The progressive characters of the two families may be contrasted thus :

##### *Hyænodontidæ.*

Upper molars with connate external cusps, developing a shear, especially between  $m^2$  and  $m_3$ . Last upper molar becoming transverse and disappearing. Heels of lower molars disappearing,  $me^d$  disappearing,  $pa^d$  advancing to form a cutting blade. Dentition functionally carnivorous (*cf.* Felidæ).

##### *Oxyclænidæ.*

Upper molars becoming quadrate. Fourth lower premolar becoming molariform. A considerable diastema developing behind canines with disappearance of  $p_4$ . Dentition functionally insectivorous (*cf.* Lemurs, Opossums, and some Insectivores).

All the above Hyænodont characters are exhibited to a greater or less extent by various species of *Sinopa*, though always in an early stage of progress. Most of them are exhibited by *Cynohyænodon* and *Proviverra*, which besides are extremely close to *Sinopa*. The same is true of *Quercytherium* except for the very peculiar premolars (which are approximated in *Cynohyænodon minor* if the reference to this species be correct of a fine specimen in the Paris Museum). *Palæosinopa* and *Didelphodus* can be placed here only on account of general resemblance to the Proviverrines and lack of the progressive characters of any other group. The generic definitions will be :

*Hyænodon*.  $M^2$  absent ;  $m^{1-3}$  without protocone, para- and metacone united ; metastyle forming a shearing blade larger than the united *pa.* and *me.* ;  $m_{1-3}$  without metaconid or heel. Jaw long, slender.

*Pterodon*.  $M^2$  transverse reduced;  $m^{1-3}$  triangular with well-developed protocone, *pa.* and *me.* connate, metastyle blade smaller;  $m_{1-3}$  without metaconid but with small trenchant heel. Jaw short and deep.

*Sinopa*.  $M^2$  transverse;  $m^{1-3}$  sharply triangular with widely separated protocone, *pa.* and *me.* connate to varying degree, metastyle and parastyle extended into small shearing blades.  $M_{1-3}$  with high triangular trigon and low basin heel,  $pa^d$  and  $me^d$  of equal size,  $pr^d$  much higher.

*Didelphodus*.  $M^2$  subtransverse unreduced.  $M^{1-3}$  sharply triangular with widely separate crescentic protocone, *pa.* and *me.* somewhat connate, parastyle and metastyles moderately developed. Lower molars with triangular trigonid of three equal cusps ( $pa^d$  internal), and large heel.

*Palaeosinopa*.  $M^2$  ? subtransverse;  $m^{1-3}$  somewhat quadrate, external styles not much developed. Lower molars with low trigonid of three equal cusps ( $pa^d$  anterior) and large bicuspid basin heel.

*Quercytherium*. Molars much as in *Sinopa*. Premolars distinguished by extreme robustness and large size,  $p^2_3$  being the largest.

The genera *Limnocyon* Marsh, *Stypolophus* Cope, and *Prototomus* Cope are, as Scott holds, synonyms of *Sinopa* Leidy, except *L. riparius*, subsequently (Marsh, '99) separated under the name *Telmatocyon*. *Triacodon* Marsh is perhaps founded on incomplete molars of either *Sinopa* or *Viverravus*. The species placed in it by Cope in 1872 was afterwards correctly referred by him to *Stypolophus*. *Proviverra* is very close to *Sinopa*, but, though very imperfectly known, seems to differ from any of the species of *Sinopa* in its short jaw and reduced premolar region, approximating *Prorhizæna*. *Cynohyænodon cayluxi* is hardly distinguishable in dentition from *Sinopa*, but seems to be somewhat more advanced in skull characters. It is hardly worthy of generic separation. *C. minor*, if correctly represented by the upper and lower jaws referred to it in the Paris Museum, is more nearly allied to *Quercytherium*, having the same proportions in the premolars, which, however, are not nearly so robust. *Hemipsalodon* does not seem separable from *Pterodon*; and *Pseudopterodon*, according to Scott, is probably founded on milk teeth of *Pterodon* (Scott, '92). *Thylacomorphus* is known only by the back of a skull described by Prof. Gervais in 1876, but not figured. It was conjecturally referred by Schlosser to *Cynohyænodon*. It is, however, not a Creodont at all, but an Anoplothere, probably *Diplobune quercyi*.

The accompanying table will show the conception which this paper attempts to explain of the relationship of the genera and limits of the families of Inadaptive Shear-toothed Creodonts, the Oxyænidae, Oxyclænidae, and Hyænodontidae:



***Palaeosinopa veterrima*, n. g. et sp.**

*Palaeosinopa veterrima* "Wortman," MATTHEW, Bull. Amer. Mus. Nat. Hist., 1899, p. 31. Name only.

*Stypolophus whitia* OSBORN & WORTMAN, '92, p. 110, not *S. whitia* Cope.

**Generic characters:** Dentition  $\frac{3 \cdot 1 \cdot 4 \cdot 3}{3 \cdot 1 \cdot 4 \cdot 3}$  Metastyle moderately extended on  $m^3$ , rudimentary on  $m^1$ . Trigonid of three subequal cusps; heel larger than trigonid,  $hy^d$  and  $en^d$  strong,  $hl^d$  present on all molars; strong only on  $m^3$ . The worn state of the upper molars in the type specimen precludes exact comparison with *Didelphodus*, to which the genus is most closely allied.

***Specific characters:***

Upper incisors rather large, roots not compressed, the third placed behind and within the second, leaving a deep notch for the lower canine between  $i^2$  and  $c^1$ . Canines rather small, first upper premolar one-rooted, second two-rooted, third two-rooted, but with the posterior root the

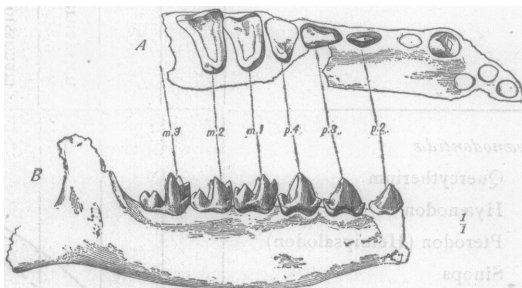


Fig. 8. *Palaeosinopa veterrima* Matthew. A, upper jaw, from below, type specimen, No. 95; B, external view of lower jaw, co-type, No. 150a. Both natural size, from the Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exp. 1891.

wider, crown with robust protocone and rudimentary postero-internal heel; fourth three-rooted with well-separated internal cusp. First and second molars with rudimentary hypocone or postero-internal cingulum, third molar transverse apparently large. First lower premolar one-rooted, others two-rooted, trenchant, with small heels and minute anterior basal cusps.

Type No. 95, upper and lower jaws, teeth badly worn. Associated type, No. 150a, a lower jaw with unworn teeth. Referred specimens Nos. 2849, 2851, 2852. All from the Lower Eocene Wasatch Beds of the Big Horn Valley, Wyoming.

***Measurements of Type Specimen.***

Upper dentition (approximate) $i^1m^3$	49
“ molars (approximate)	15
“ premolars “	21
First upper molar, antero-post.	5.3; transv. 7.4
Second “ “ “	8 “ 8.1
Lower dentition, $c^1-m^3$	41
“ true molars	16.6
“ premolars	18
Depth of jaw below $p^3$	6
“ “ “ “ $m^3$	12



**Palæosinopa didelphoides (Cope).**

*Ictops didelphoides* COPE, Bull. Hayden Survey, VI (1881), p. 192; Tert. Vert., p. 268.

*Palæictops didelphoides* MATTHEW, '99, p. 35.

The lower jaw fragment from the Wind River Beds, referred to *Ictops* by Prof. Cope, more probably belongs in this genus. In absence of characteristic parts its reference is provisional.

**Sinopa Leidy, 1871.**

*Stypolophus* COPE, Pal. Bull. No. 2, Proc. Am. Phil. Soc. 1872, 466.

*Prototomus* COPE, Report on Fossil Vert. N. M., Ann. Rep. U. S. G. S. W. of 100th Mer., 1874.

*Limnocyon* MARSH, in part, Am. Journ. Sci. 1872, Vol. IV, p. 122.

The original types of *Sinopa*, *Stypolophus*, and *Limnocyon* were from the Middle Eocene of Wyoming. Cope afterwards described a number of species from the Wasatch under the name of *Prototomus*, which he afterwards (1877) united with *Stypolophus*. Scott (1892) united both with *Sinopa*, and an examination of the types of *Limnocyon* shows that they also should be referred to this genus.

Besides the characters given on a previous page the following may be noticed :

Dentition  $\frac{3 \cdot 1 \cdot 4 \cdot 3}{3 \cdot 1 \cdot 4 \cdot 3}$ . First premolar two-rooted. Brain small. Lower premolars composed of principal cusp and trenchant heel (no second posterior cusp). *Me.* of  $m^2$  reduced or absent. Incisors small, the upper ones in a row.

**Sinopa rapax Leidy, 1871.**

From the Bridger Beds, Wyoming. Type, a lower jaw with more or less broken molars, figured in Extinct Vert. Western Terrs. The species is of medium size with apparently a rather large heel on  $m_1$ , but with vestigial heel (*vide* Cope, '84, p. 289) on the third. I am unable to find other specific characters in Leidy's figure. Length of  $p_4$ - $m_3$ , 31mm.

**Sinopa vera (Marsh).**

*Limnocyon verus* MARSH, Am. Jour. Sci. 1872, Vol. IV, p. 122.

From the Bridger Beds, Wyoming. A large-species with protocones of  $m^1$  and  $m^2$  much compressed. Third premolar narrow and trenchant. Length of  $p_4$ - $m_3$ , estimated, 40mm.

***Sinopa agilis* (Marsh).**

*Limnocyon agilis* MARSH, Am. Jour. Sci. 1872, Vol. IV, p. 202 (published Aug. 7).

*Stypolophus brevicealcaratus* COPE, Pal. Bull. No. 3; Proc. Am. Phil. Soc. 1872, p. 469 (published Aug. 7); Tert. Vert., p. 291, pl. xxiv, fig. 9.

From the Bridger Beds, Wyoming. I have preferred Prof. Marsh's name for this species as based on a much more complete specimen, including upper and lower teeth and many parts of the skeleton. The type of *S. brevicealcaratus* is a fragment of the lower jaw with  $m_{2-3}$ . Prof. Cope's determination of the teeth as  $m_{1-2}$  is, I think, incorrect.

This species, of medium size, is very close to *S. whitie* but may be distinguished by the smaller heels of the lower molars, especially of  $m_3$ . It may prove to be identical with *S. rapax* Leidy.

***Sinopa pungens* (Cope).**

*Stypolophus pungens* COPE, Pal. Bull. No. 2; Proc. Am. Phil. Soc. 1872 (Vol. XII), p. 460 (Aug. 3); Tert. Vert., p. 291, pl. xxiv, fig. 8.

Type of the genus *Stypolophus*. Bridger Beds, Wyoming. A rather primitive species of medium size with long tricuspid heel on  $m_3$ , approaching *Palaeosinopa*. Trigon not very high. Represented by a lower jaw fragment, No. 5015, Cope Collection, Amer. Mus. Nat. Hist.

**[? *Sinopa insectivora* (Cope).]**

*Stypolophus insectivorus* COPE, Pal. Bull. No. 3; Proc. Am. Phil. Soc., Vol. XII, 1872, p. 469.

Bridger Beds, Wyoming. The type of this species has been lost or mislaid and its position in the genus cannot now be determined. Prof. Cope's figures in Tertiary Vertebrata are evidently incorrect, the outline of the tooth as viewed from within and from without being different.

**[*Sinopa aculeata* (Cope).]**

*Triacodon aculeatus* COPE, Pal. Bull. No. 1; Proc. Am. Phil. Soc. 1872, Vol. XII, p. 460.

*Stypolophus aculeatus* COPE, Ext. Vert. N. M. Rep. Wheeler Survey, IV, ii, 112. Not *S. aculeatus*, Tert. Vert., p. 299.

Bridger Beds, Wyoming. This species was founded on part of the crown of a lower molar, subsequently lost or mislaid, and the tip of a premolar crown. It is indeterminate specifically, generically or even in family, and the name has no standing. The upper and lower jaws in the Princeton Museum figured and referred to this species by Prof. Cope in 1884 more probably belong to *S. strenua*.

### ***Sinopa hians* (Cope).**

*Stypolophus hians* COPE, Rep. Wheeler Survey, Vol. IV, pt. ii, p. 118, pl. xxxviii, figs. 12-20.

Wasatch of New Mexico and Wyoming. The type is an extremely fragmentary and badly preserved skeleton from the Wasatch of New Mexico. The anterior premolars are spaced and the last two lower molars subequal. Fourth premolar wider posteriorly. The other characters given by Prof. Cope are common to the genus.

The most important distinctive character seems to be the subequal second and third molars. On this ground I place here No. 2850 Amer. Mus. Coll., which agrees fairly well in size, has the anterior premolars somewhat less spaced, and a narrower heel to  $p_4$ . It is a young individual, with teeth scarcely worn, hence perhaps the less spacing of the premolars. It consists of upper and lower jaws, fragments of the skull, a few vertebræ, and parts of nearly all the limb bones.

Third lower molar as large as second, first considerably smaller. Angle between anterior and posterior shear of lower trigonids averaging  $45^\circ$ . Incisors present but number uncertain. Meta-style on  $p_4$  small. *Pa.* and *me.* rather closely connate.  $M^3$  considerably reduced with vestigial metacone.

The brain is smaller than that of *Cynohyænodon cayluxi* although the dentition is one third longer. Compared with that of *Thylacinus* the brain is much smaller in all dimensions, smoother in surface, and with olfactory and cerebellar lobes smaller in proportion, but not in any degree covered by the cerebral lobes.

The limb bones are for the most part a little stouter than those of the domestic cat, not very different in size from those of *S. whitæ*. They are apparently shorter and stouter in proportion, resembling those of *Viverravus protenus* on a smaller scale. The vertebræ are too poorly preserved for exact comparison.

*Measurements, No. 2850.*

$c^1-m^8$ .....	70;	$c_1-m_8$ .....	68;	$m_1-m_8$ .....	25
Diameters of $m^1$ , anteroposterior		8,	transverse		9
"	$m^2$	"	9	10.5	
"	$m^3$	"	4		
"	$m_7$	"	9.5		
	$m_8$	"	9		
Depth of jaw under $m_7$			19		

***Sinopa whitæ* (Cope).**

*Stypolophus strenuus* COPE, Bull. Hayd. Sur. No. VI, p. 192.

*Stypolophus whitæ* COPE, Proc. Am. Phil. Soc., Vol. XX, 1882, p. 161;  
Tertiary Vertebrata, p. 292, pl. xxvb, figs. 8-14.

Wind River assise, Wyoming. This species is somewhat smaller than *S. hians*, and is distinguished from it by the reduction in size of the last lower molar and the more anteroposterior direction of the trigonid shear. In the upper molars the protocone appears to be more compressed and placed further backward relatively to the outer cusps, and the metacone of  $m^3$  has entirely disappeared. The species is close to *S. agilis* of the Bridger, which has the heels of the lower molars more reduced. It is the best known species of the genus and was fully described and figured by Prof. Cope in 1884.

Nos. 4780 (type), 4781, and 4782.

*Measurements.*

$c^1m^8$ .....	63	$c_1-m_8$ .....	66	$m_1-m_8$ .....	22.5
Diameters of $m^1$ , anteroposterior		8,	transverse		7
	$m^2$		8	10	
	$m^3$		3	9	
	$m_8$	?	8.3		
	$m_8$	?	8.3		
Length of heel of $m_8$			3		
Depth of jaw below $m_8$			19		

***Sinopa strenua* (Cope).**

*Prototomus strenuus* COPE, Syst. Catal. Eoc. Vert. N. M., Rep. Wheeler Survey, p. 10.

*Stypolophus*, Final Rep. Wheeler Survey (U. S. G. S. W. 100th Mer.), IV, ii, p. 117, pl. xxxix, fig. 11.

Wasatch assise, New Mexico and Wyoming. Type from New Mexico, in National Museum, Washington. Referred specimens

Nos. 97 and 98, from the Big Horn Valley, Wyoming, Am. Mus. Coll. 1891. All fragments of lower jaws.

It is quite impossible to separate this species from *S. whitæ* on our present knowledge, but when more complete material is found it will probably show some distinctions. In particular I should expect to find the metaconid present on  $m^3$ , as it is on all known Wasatch and no known Wind River species of the genus. I therefore hold the species separate provisionally and refer the Wasatch specimens to *S. strenua*. The characters are: size medium,  $m_3$  smaller than  $m_2$ , shear of trigonids  $55^\circ$ – $60^\circ$  from transverse;  $p^3$  with small internal and somewhat larger postero-external cusp; teeth compressed with angulate cusps.

A somewhat smaller variety or distinct species has  $m_3$  less reduced and shear more transverse. It may prove to be *S. multicuspis*. (Am. Mus. Nos. 2815, 4220, 96, and 4218, Wasatch assise, Wyoming.)

### ***Sinopa multicuspis* (Cope).**

*Prototomus multicuspis* COPE, Syst. Cat. Eoc. Vert. N. M., Rep. Wheeler Survey, 1874 (1875).

*Stypolophus*, Ext. Vert. N. M., Final Rep. Wheeler Survey, IV, ii, p. 116. Tertiary Vertebrata, p. 290.

Wasatch assise, New Mexico. The type is an upper jaw, separable by the much reduced  $m^3$  (if this tooth be complete). The co-type is a piece of a lower jaw, with which the small specimens referred to above most nearly agree.

### **[*Sinopa secundaria* (Cope).]**

*Prototomus secundarius* COPE, Syst. Cat. Eoc. Vert. N. M., Rep. Wheeler Survey, 1874 (1875), p. 9.

(*Stypolophus*), Ext. Vert. New Mex., Final Rep. Wheeler Survey, IV, ii, 115.

Wasatch assise, New Mexico. All the characters given in the descriptions are common to the genus. The specimen has not been figured. The measurements hardly separate it from *S. multicuspis*.

### ***Sinopa viverrina* (Cope).**

*Prototomus viverrinus* COPE, Rep. Foss. Vert. N. Mex., Rep. Wheeler Survey, 1874, 13 (125); Syst. Cat. Eoc. Vert. N. M., Rep. Wheeler Survey, 1874 (1875), 9.

(*Stypolophus*), Ext. Vert. New Mex., Final Rep. Wheeler Survey, IV, ii, (1877), p. 112, pl. xxxviii, figs. 1–11; Tertiary Vertebrata, p. 290.

Type of the genus *Prototomus*. Wasatch assise, New Mexico and Wyoming. The small size distinguishes it from any other Wasatch species. Judging from Professor Cope's figures it is also distinguished by the simplicity of  $p^4$ , which is little more molariform than  $p^3$  of the larger species. The species appears to be quite primitive in other characters as well, and I am disposed to place with it a few lower jaw fragments in our collections containing molars of appropriate size in which, while the trigonid is high, the metaconid is better developed, the shear more transverse, and the whole tooth wider than is usual in the genus. (Am. Mus. Nos. 94 and ? 2971.)

***Sinopa opisthotoma*, sp. nov.**

*Stypolophus* sp. innom. OSBORN & WORTMAN, Bull. Am. Mus. Nat. Hist. 1892, 110. "No. 99 is much larger than any described species of *Stypolophus*."

Wasatch assise, Wyoming.

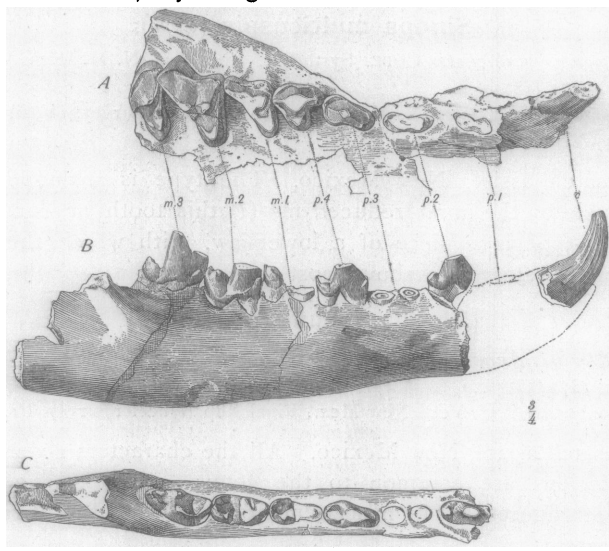


Fig. 9. *Sinopa opisthotoma* Matthew. Upper and lower jaws, three-fourths natural size, type specimen No. 99, Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exp. 1891. A, upper jaw, from below; B, lower jaw, from outside; C, from above.

With the type (No. 99), upper and lower jaws, teeth well preserved, I associate provisionally No. 101, upper and lower jaw

fragments not well preserved, which either is a very large individual of this species or represents a distinct species undescribed.

Anterior premolars spaced;  $p^2$  without distinct accessory cusps;  $p^4$  with main cusp conical-lenticular; internal cusp conical, postero-external cusp not extended into a shearing blade. Outline of  $m^1$  and  $m^2$  obtuse-angled triangles, metastyle especially extended on  $m^2$  *pa.* and *me.* but little connate;  $m^2$  with small metacone, transverse diameter greater than that of  $m^1$ .  $M_3$  with well-developed heel;  $m_3$  in type with much reduced metaconid, advanced paraconid forming a ~~shearing~~ blade more nearly anteroposterior than in any other *Sinopa*, and narrow heel. In No. 101  $m_3$  is normal in character, with more transverse shear and larger heel.

The depth of the jaw is moderate in the type; in No. 101 it is excessive, although the wear of the teeth does not indicate a much older animal. Both have the same rounded cusps, comparatively slight approximation of *pa.* and *me.*, simple  $p^4$ , wide  $m^2$ , extended blades on  $m^1$ - $m^2$  and other characters, so that if distinct the two are evidently closely allied.

#### Measurements.

	No. 99	No. 101
Length $c^1$ - $m^2$	83	
“ $m^1$ - $m^2$	26	
“ $m^1$ - $m_3$	31	32
Diameters of $p^4$ , anteroposterior	10	11
“ “ transverse	10	10
“ $m^1$ { anteroposterior	9	? 11
“ “ { transverse	10	? 11
“ $m^2$ { anteroposterior	12	12
“ “ { transverse	13	14
“ $m^2$ { anteroposterior	6	6
“ “ { transverse	14	14
Length $p_3$ - $p_4$ anteroposterior	18.5	23
“ $m_1$	8	
“ $m_2$	10	10
“ $m_3$	13	13
“ heel of $m_3$	4	6
Width “ “ “	4	5
Depth of jaw at $m_3$	19	31

## V.—Family MESONYCHIDÆ Cope.

*Triisodon heilprinianus* Cope.

Two very incomplete and poorly preserved skulls of this species are of especial interest as the first skulls described from the lower or true Puerco Beds, and hence the *oldest mammal skulls known*.

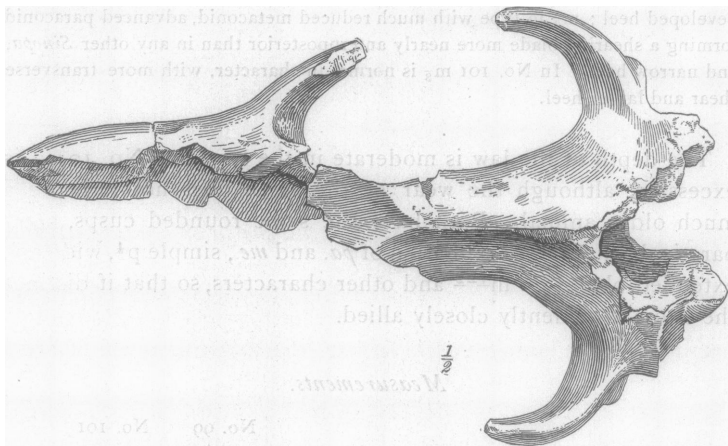


Fig. 10. *Triisodon heilprinianus* Cope. Part of skull, from above, one-half natural size. No. 764, Lower or True Puerco Beds, San Juan Basin, New Mexico. Amer. Mus. Exp. 1892.

The skull compares most nearly with those of *Arctocyon* (Cenozoic), *Mesonyx* (Bridger and Uinta), and *Periptychus* (Torrejon). All have many characters in common :

Brain small, of low type ; zygomatic arches broad ; occipital and sagittal crests very high ; palatal and basicranial axes parallel (*i. e.*, face not at all bent down on basicranial axis) ; mastoid well exposed, tympanic bulla rudimentary or absent ; basisphenoid broad and slightly convex downward ; glenoid fossa deep and long, post-glenoid process moderately developed ; paroccipital process stout not long, confluent with mastoid, projecting laterally rather than downwards ; muzzle thick and heavy, premaxilla with wide ascending process and long contact with nasals. (Nares terminal.)

All the above characters are primitive ones which will probably be found in nearly all Basal Eocene Placentals. The following characters, more or less peculiar to *Triisodon*, I judge to be also primitive.



Zygomatic process of the squamosal moderately stout, as in *Periptychus*, placed well back on the side of the skull (its anterior

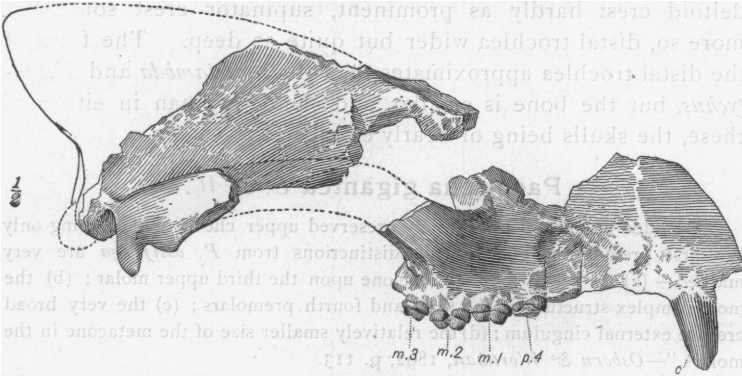


Fig. 11. *Triisodon heilprinianus*. No. 764. Side view of skull, one-half natural size. Outline of occiput from No. 3181.

edge one fourth the skull-length from the occipital condyle) as in *Mesonyx*. In *Arctocyon* it is placed further forward, besides being more massive, reducing the length of the zygomata, which are increased in width though not proportionately.

The postorbital process on the frontal appears to have been less developed than in *Mesonyx*; on the malar it appears to have been absent. The postorbital constriction of the skull is very marked, as much so as in *Arctocyon*, more than in *Mesonyx* or *Periptychus*.

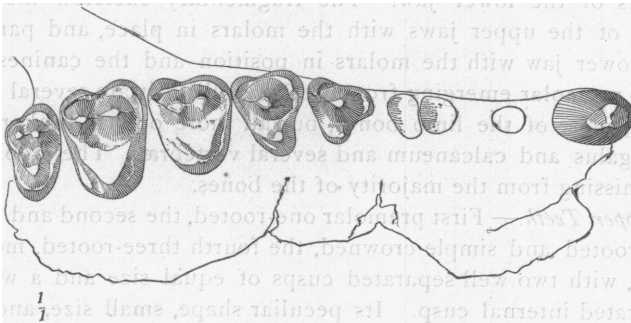


Fig. 12. *Triisodon heilprinianus*, No. 764. Upper dentition, crown view, natural size.

The occipital bones seem to have been firmly sutured together, breaking away rather easily from the rest of the skull.

With the skull were found a few fragments of the skeleton. A *humerus* resembles that of *Arctocyon*, but is smaller and shorter, deltoid crest hardly as prominent, supinator crest somewhat more so, distal trochlea wider but quite as deep. The form of the distal trochlea approximates that of *Pantolambda* and *Peripitychus*, but the bone is smaller and slenderer than in either of these, the skulls being of nearly equal size.

### ***Pachyæna gigantea* O. & W.**

"Founded upon a series of finely preserved upper cheek teeth lacking only the first premolar. The specific distinctions from *P. ossifraga* are very marked—(a) the presence of a metacone upon the third upper molar; (b) the more complex structure of the third and fourth premolars; (c) the very broad crenate external cingulum; (d) the relatively smaller size of the metacone in the molars."—*Osborn & Wortman*, 1892, p. 113.

This is one of the largest of the Creodonta, being exceeded in size of skull only by some undescribed specimens of *Mesonyx* in the Museum collections. *Hemipsalodon grandis* Cope, though much larger in skeleton,<sup>1</sup> seems to have had a somewhat smaller skull. Part of a skull and jaws (No. 2823) and a fragmentary skeleton (No. 2959) are here described. Both are from the Wasatch beds of the Big Horn Valley, Wyoming, collected by the Expedition of 1896.

The skull preserves the second premolar and third molar, and alveoli of all the upper teeth except the incisors, also most of one ramus of the lower jaw. The fragmentary skeleton includes parts of the upper jaws with the molars in place, and parts of the lower jaw with the molars in position and the canines and third premolar emerging from the jaw. With it are several loose teeth, most of the limb bones, but all more or less broken, the astragalus and calcaneum and several vertebræ. The epiphyses are missing from the majority of the bones.

*Upper Teeth.*—First premolar one-rooted, the second and third two-rooted and simple crowned, the fourth three-rooted, molari-form, with two well separated cusps of equal size and a widely separated internal cusp. Its peculiar shape, small size, and unusual wear suggest that it is a persistent milk tooth; this view is strengthened by the fact that the corresponding premolar in the

<sup>1</sup> If the femora referred to it by Professor Cope really belong to the species, which I consider very doubtful, as the proportion of skull and body would be most unusual for a Creodont.

lower jaw has dropped out early, its alveolus being closed up. Median (? upper) incisors with large very much compressed root and small crown. Lateral incisor with large root of oval section and small pointed crown. Canine large of round-oval section.

**Lower Teeth.**—Canines large, moderately stout, regularly oval in section, set near together (inter-space about half width of canine). First premolar one-rooted, second two-rooted, third true premolar emerging from the jaw, stout, with protoconid directed strongly backward, wide, square-based, low trenchant heel and no anterior basal cusp. No indication of a fourth permanent premolar could be found in the immature individual, but the state of preservation of the specimen does not make it possible to disprove the existence of one. The temporary premolar is indicated by some remains of an alveolus. In the adult

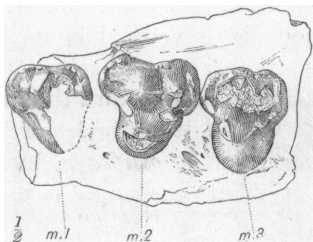


Fig. 13. *Pachyena gigantea* Osborn & Wortman. Three upper molars in place. Crown view, one-half natural size. Young individual. No. 2959, Wasatch Beds, Big Horn Basin, Wyoming. Amer. Mus. Exped. 1896.

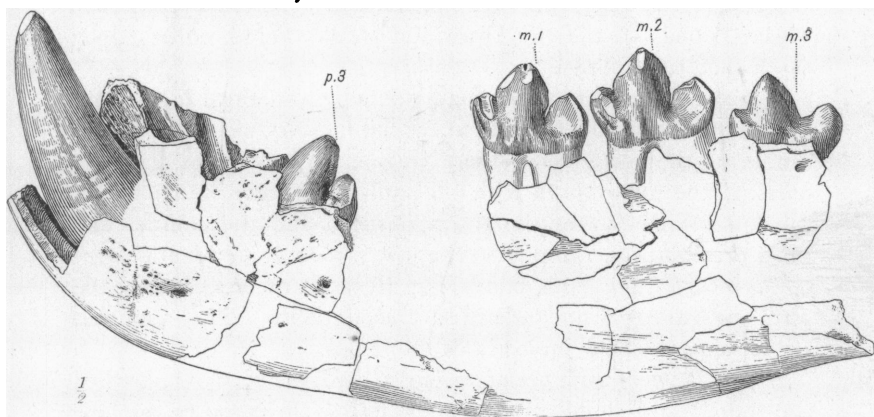


Fig. 14. *Pachyena gigantea*, No. 2959. Fragmentary lower jaw, external view, one-half natural size.

jaw, as already observed, the temporary fourth premolar had fallen out and its alveolus closed without replacement. The first and second molars have a vestigial metaconid; traces of it are discernible also on the third. All three are shaped like those of *P.* [January, 1901.]

*ossifraga*, rectangular in outline when seen from above with high stout protoconid ridged before and behind, large well separated trenchant heel, and smaller less trenchant paraconid. The protoconid is vertical in  $m_g$ , projects slightly forward in  $m_g$ , and somewhat more backward in  $m_T$ . The second molar is the largest and the third the smallest of the three.

The angle of the lower jaw is inflected, more so than in *Disacus* or *P. ossifraga*, less than in *Mesonyx uintensis*. In *M. obtusidens* "the angle is prolonged into a stout hook much like that of *Stypolophus*" (Scott, '87, p. 157), hence is quite different from the other Mesonychidæ, in which there is a progressively increased inflection of the angle, reaching a maximum in the Upper Eocene *Mesonyx uintensis* where it is almost like that of a Marsupial.

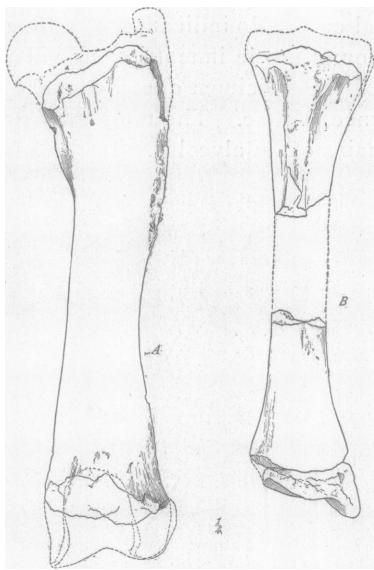


Fig. 15. *Pachyana gigantea*, No. 2959. Left femur and right tibia, from in front, one-fourth natural size.

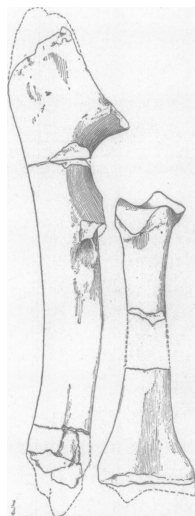


Fig. 16. *Pachyana gigantea*, No. 2959. Right ulna and radius, one-fourth natural size.

The skeleton is very massively proportioned; the limb bones are somewhat shorter than those of *P. ossifraga*, but one-fourth thicker in the shaft, although the animal is not full grown. The few dorsal vertebræ preserved are short and thick

in the centra, and heavy in the arches — apparently short-spined. The calcaneum has a small fibular facet. The astragalus is very short and wide, with flatter trochlea, shorter neck, and smaller sustentacular process than in *P. ossifraga*; it has the distinct cuboidal facet common to the Mesonychidæ, and the navicular facet is flat transversely (slightly concave in *P. ossifraga*, flat in *Dissacus*, convex in *M. obtusidens*).<sup>1</sup>

The most interesting point in regard to this animal is the question of the succession of the teeth. If, as our specimens seem to indicate, the fourth premolar belongs to the milk series, and is not replaced by a permanent tooth, then *this species approximates the marsupial dental formula*, with four true molars and three premolars. The progressive inflection of the angle of the jaw in the Mesonychid phylum is another character of some importance approximating them to the Marsupials. From what we know of the phylum we must regard both these characters as acquired in the Mesonychidæ; the question then arises — are they not also acquired in the Marsupialia? This is a matter hardly suitable for discussion within the limits of this paper; I present the evidence for what it is worth. That there is a progressive inflection of the lower jaw in the Mesonychidæ is certain; the evidence for the retention of the fourth milk molar may be summarized as follows:



Fig. 17. *Pachyana gigantea*, No. 2959. Left calcaneum and astragalus, from above, one-fourth natural size.

1. In the upper jaw the last premolar has the ordinary character of a milk molar (small size, short roots, thin enamel, precocious molarization) and is more worn than the first molar or the third premolar, hence probably appeared before either of them.

2. In the lower jaw the fourth premolar has disappeared and its alveolus closed up in an adult specimen, while in a young individual indications exist of an early protruded tooth, but none of a replacing tooth although the third permanent premolar is completely formed and emerging from the jaw.

This evidence cannot be considered satisfactory, especially in

<sup>1</sup> Professor Scott's statement regarding the last species is that the navicular is concave in both directions. This involves apparently an astragalus convex both ways.

view of the fact that in *Triisodon*, the only other Mesonychid in which the replacement of the teeth has been observed, there is a permanent fourth lower premolar, though protruded rather late in life, considerably after  $m_3$  (Cope, '84, 270).

## COMPARATIVE MEASUREMENTS

	<i>Pachyena gigantea</i>			<i>P. ossifraga</i>	<i>Mesonyx obtusidens</i>	<i>M. uintensis</i>
	No. 72	2823	2959			No. 1892
Length of skull.....		e. 450		e. 380	279	e. 440
$p^1 m^2$ .....	e. 162	163		135	98	137
$m^{1-3}$ .....	e. 79	78	75	54		
Breadth palate at $m^2$ ...		135		e. 101	78	121
Depth jaw below $m_3$ ...		94	73	68	50	
Length $m_1$ - $m_3$ .....			99	63	51	(88 <sup>1</sup> )
Humerus, width distal end.....			93	62		
Femur, length.....			e. 290	315		
" circumference of shaft.....			108	86		
Ulna, length.....			e. 293	286	207	
" circumference of shaft.....			87	65		
Radius, diameter of head			49	34	23	
" circumference of shaft.....			67	53		
Tibia, length.....			e. 265	275	205	
" diameter of distal end.....			58	43	25	
" circumference of shaft.....			87	74		
Calcaneum, length.....			98	77	56	
" width.....			49	41		
Astragalus, length.....			61	44	31	
" width.....			58	41	18	
Posterior dorsals, av'ge length of 4 centra...			34		e. 30	
Posterior dorsals, av'ge width of 4 centra....			58		e. 25	

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<sup>1</sup> From type specimen. 'e.' = estimated from an incomplete specimen.

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