ART. IX. — *Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. WORTMAN.

[Continued from page 46.]

Family Oxyænidæ Cope.

WITH the Oxyænidæ we enter upon the consideration of a group of the Creodonta in which the teeth had already made considerable progress towards the more typical sectorial structure, even at the beginning of the Wasatch, in which deposits their remains are first met with. This family is represented in this horizon, as far as now known, by the single genus *Oxyæna* Cope, containing two, or perhaps three, well-marked species of fairly sizable dimensions. No species that can be placed ancestral to it have as yet been found in either of the older Torrejon or Puerco Beds, and it would appear probable that they were migrants from the north or from Asia, along with the Artiodactyle and Perissodactyle Ungulates, the Primates, certain of the Carnassidents, including the Felids and Canids, the Rodents and others, at the beginning of the Wasatch epoch. These two or three species appeared simultaneously at all the localities of the Wasatch, in the Big Horn, Bear River, and San Juan Basins, and this fact of itself would seem to indicate a very general and widespread distribution.

The probable immediate successor of the genus in the Wind River deposits is a species which Cope referred to the distinct genus *Protopsalis;* but I have pointed out* that this genus, as far as at present known from fragmentary remains, does not differ materially from one of the Bridger representatives which Leidy described under the generic title of *Patriofelis.* It should be borne in mind, however, that this Wind River form is known from a few fragments only, and it will be somewhat surprising if, when its osteology is more completely known, it does not exhibit a stage of development intermediate between *Oxyæna* and *Patriofelis.* In the Bridger, the main *Oxyæna* line is continued in the two species of *Patriofelis*, large, powerful Creodonts in which the teeth had become much specialized and reduced in number, in a manner not dissimilar to that of the Felids. In this stage also appears suddenly, without any known forerunners in any older formation, a less distinctly specialized type, *Limnocyon* Marsh, in which the teeth are more generalized than in *Oxyæna.* The genus is represented by three or four well-marked specific modifications, one of which persisted to the close of the Eocene, in what I have

* Bull. Amer. Mus. Nat. Hist., 1894, p. 130.

described* as the genus *Oxyænodon*, from the Uinta. In this group, the species are of uniformly smaller size, one of which is among the smallest of the known Creodonts, and all of them, as far as I am at present aware, are characterized by shallow, remarkably thick jaws, provided with a disproportionately large symphysis. A single species of a closely allied form was described by Filhol from the Phosphorites of Quercy in France, under the name of *Thereutherium thylacodes*. This species is the latest and most specialized of the *Limnocyon* series, since, according to Filhol's figures, the last superior molar is much reduced, the first premolar has become single-rooted, and the internal cusp of the trigon in the lower molars has disappeared.

It will be observed, therefore, that we have in this family two distinctive series or lines of descent, one beginning in *Oxyæna* and culminating, according to our present knowledge, in *Patriofelis*, as I have already very fully pointed out,† and a second series beginning in *Limnocyon* and terminating in *Thereutherium*. These two series I choose to regard as two distinct divisions or subfamilies, which may be designated, according to the characteristic genera, the Oxyæninæ and the Limnocyoninæ.

Owing to our imperfect knowledge of the osteology of the Limnocyoninæ, the definition of the Oxyænidæ cannot be very fully given at present, but the teeth are sufficiently known to afford very good grounds for distinction from the other families of the Creodonts. I define it upon the dentition as follows:

Two subequal tuberculo-sectorial lower molars, in which the internal cusp of the trigon and the tubercular heel progressively decrease in size or disappear in the later forms; second inferior molar slightly larger than first; two superior molars, of which the last is transverse when present, but becomes small or disappears in advanced stages of evolution; most highly developed sectorial teeth consisting of first molar above and second molar below, but fourth premolar above and first molar below also sectorial; two external cusps of first superior molar tending to unite, and internal cusp becoming reduced or disappearing in advanced forms, as in Hyænodontidæ.

The two subfamilies may be distinguished by the following characters:

Lower jaw of considerable vertical depth and not especially thickened from side to side; symphysis not particularly enlarged; fibula not articulating with calcaneum, and trochlear surface of astragalus ungrooved, with head very oblique. Oxyæninæ.

* Bull. Amer. Mus. Nat. Hist., June, 1899, p. 145.
† Bull. Amer. Mus. Nat. Hist., 1894, p. 163.

Lower jaw shallow and relatively very thick from side to side; symphysis much enlarged; fibula articulating with calcaneum (*Limnocyon*); astragalus considerably grooved, and head with comparatively little obliquity. Limnocyoninæ.

Subfamily Oxyæninæ.

Of the first of these two subfamilies, as already remarked, there are two known genera *Oxyæna* and *Patriofelis;* but it is not improbable that a transition or annectent form between these two will be found in Cope's Wind River *Protopsalis tigrinus.* It appears to be more or less doubtful whether we yet know the exact lines of specific descent in this group. As at present constituted, the genera may be distinguished as follows:

Dental formula, I.$\frac{3}{3}$, C.$\frac{1}{1}$, Pm.$\frac{4}{4}$, M.$\frac{2}{2}$; second upper molar present, transverse; internal cusp of first upper molar distinct; second lower molar with internal cusp and heel. *Oxyæna.*

Dental formula, I.$\frac{3}{2}$, C.$\frac{1}{1}$, Pm.$\frac{3}{3}$, M.$\frac{1}{2}$; second upper molar absent; internal cusp of first superior molar vestigial; second lower molar without internal cusp and with vestigial heel. *Patriofelis.*

Patriofelis ferox Marsh.

Patriofelis Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 10;
Limnofelis ferox Marsh, this Journal, August, 1872, p. 10, Separata;
Limnofelis latidens Marsh, this Journal, August, 1872, p. 10, Separata;
Oreocyon latidens Marsh, this Journal, November, 1872, p. 406;
Patriofelis ferox Wortman, Bull. Amer. Mus. Nat. Hist.

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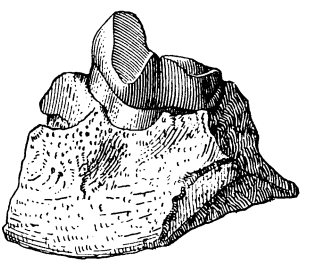

FIGURE 65.— Portion of left lower jaw, with last lower molar in place, of *Patriofelis ferox* Marsh (type of *Limnofelis ferox* Marsh): three-fourths natural size. (Type.)

The type of this species, figure 65, consists of a fragment of a left lower jaw bearing the last lower molar, together with some few fragments of the skull, vertebræ, and ribs. Professor Marsh said of it in his original description, "The tooth preserved resembles the corresponding one of the lion in its general shape, but is proportionally broader anteriorly, the base of the crown being subtrilateral in outline, with the inner side the longest." This brief description gives the main characters of the specimen very accurately, but it is important to note that more complete specimens have shown the tooth in question to be a second molar; it is not, therefore, strictly homologous with the sectorial lower

molar of the lion, which is the first. This fact, however, was impossible of determination from the fragmentary specimens known at the time Professor Marsh's description appeared. The crown is composed of an anterior and posterior cusp, which represent the external and anterior cusps of the trigon, respectively; of these the posterior is broken away, but it is evident that they were laterally flattened and drawn out upon their edges so as to form a pair of effective blades, as in the sectorial molar of the Felidæ. The internal cusp of the trigon has completely disappeared, and the heel is represented by a mere vestigial spur.

The second specimen of this species was at first referred by Professor Marsh to a distinct species, *Limnofelis latidens*, together with the lower jaw of the immature individual already considered under the head of *Ælurotherium*. He subsequently removed it, using the present specimen as the type, to the distinct genus *Oreocyon*, which he established for its reception. It is now evident, however, that this species is the same as *Limnofelis ferox*, and the name *Oreocyon latidens* therefore becomes synonymous with *Patriofelis ferox*.

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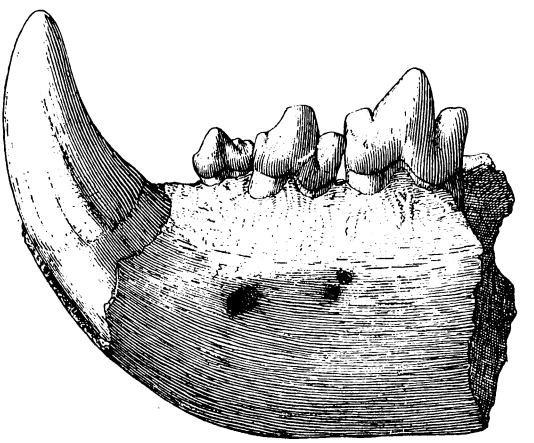
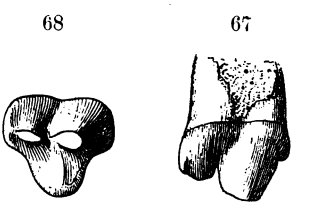


FIGURE 66.—Anterior part of lower jaw of *Patriofelis ferox* Marsh (type of *Oreocyon latidens* Marsh); side view; three-fourths natural size.

The specimen, figure 66, consists of the coössified anterior part of both mandibular rami, carrying both canines, the alveoli, and most of the roots of the incisors, the three premolars upon the left side, and the first and second premolars upon the right side. There are, in addition, some fragments of the posterior portions of the jaw, including a condyle, a well-

preserved superior premolar, probably the fourth, and the greater part of the right humerus.

The jaw is deep and the symphysis strong and heavy. The two rami are firmly coössified, but traces of the suture are plainly visible. The canines are large, somewhat laterally compressed at the base, with a recurved pointed crown. The incisors are two in number upon each side, one being placed almost directly behind the other; their roots are much compressed from side to side and they are relatively small. The first premolar of the series, which corresponds with the second of *Oxyæna*, is a two-rooted tooth implanted obliquely to the long axis of the jaw; its crown is made up of a single pointed anterior cusp, to which is added a broad posterior heel bearing a minute cusp in the center. The second premolar is similar, with the exception that there is a distinct anterior basal cusp and the heel is thrown up into a more or less cutting ridge. The third premolar is considerably larger than the two in advance of it, but the crown is composed of the same elements as that of the second. The superior premolar, figures 67, 68, which presumably corresponds with the fourth of *Oxyæna*, is a three-rooted tooth; its crown is composed of two external and one internal cusps. Of the two externals the anterior is the larger, of a more or less conical form, having its posterior edge produced. The posterior is blade-like and smaller. The internal cusp has a thick rounded form, and is supported by an independent root. The structure of this tooth may therefore be said to be distinctly sectorial.



FIGURES 67, 68.—Fourth superior premolar of *Patriofelis ferox* Marsh (type of *Oreocyon latidens* Marsh); outer and crown views: three-fourths natural size.

Numerous other more or less fragmentary remains of this species are contained in the collection, but as they do not add anything to a knowledge of the osteology, which I have already described in considerable detail from the unusually complete skeleton in the American Museum,* their consideration may be here omitted. It is a source of some satisfaction to note that the conclusions which I reached from a study of the rather fragmentary and imperfectly preserved teeth are herewith completely verified.

In my somewhat exhaustive treatise upon this subject, I was led to express the opinion that these animals were plantigrade, and probably aquatic in habit, pointing out at the same

* Osteology of Patriofelis, a Middle Eocene Creodont, Bull. Amer. Mus. Nat. Hist., May, 1894.

time their relationship with the modern Pinnipedia, the derivation of which may perhaps be traceable to some member of the Oxyænidæ. In a paper recently published, Professor H. F. Osborn has dissented from these views, and expressed the opinion that these forms were terrestrial or arboreal in habits, and subdigitigrade* in gait.

I shall proceed, therefore, to an examination of the paper in detail, and shall first consider a method there presented, by means of which we are said to be able to determine with infallible cer-

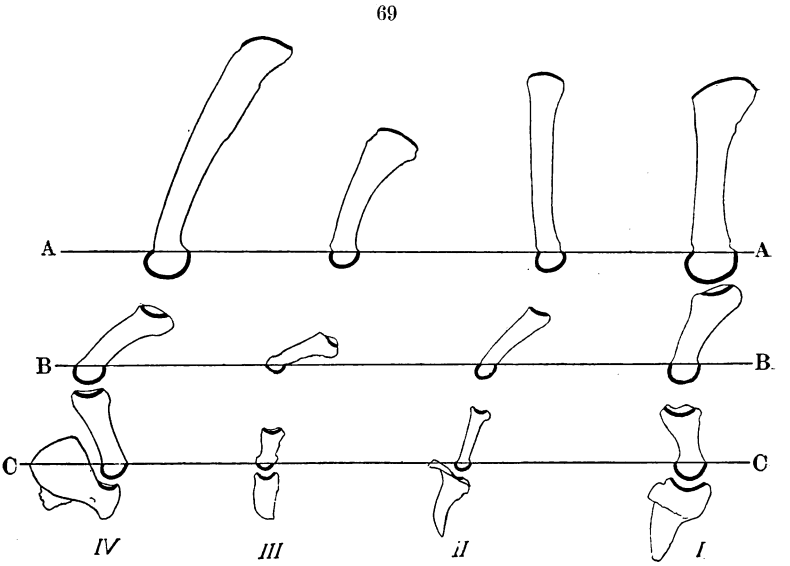


FIGURE 69—Angulation of facets in feet of (I) *Ursus*, (II) *Procyon*, (III) *Patriofelis*, (IV) *Felis*, showing increased obliquity in relation to increased angulation. A, distal facets of metacarpals; B, distal facets of first phalanx; C, distal facets of second phalanx. (Diagram after Osborn.)

tainty the gait of an animal, living or extinct, whether plantigrade, subplantigrade, or digitigrade. Professor Osborn says, p. 270: "The writer has pointed out that the angulation of the limbs in Ungulates is expressed in the angles which the proximal and distal facets make with the long axes of the shafts; *considering the shafts as perpendicular, facets in horizontal planes indicate straight limbs; facets in oblique planes indicate angulate limbs.* Exactly similar principles apply to the hand and foot of Unguiculates, as shown in Fig. 3. In the passage from *Otaria* (secondarily plantigrade), [to] *Ursus*

* Oxyæna and Patriofelis Re-studied as Terrestrial Creodonts, Bull. Amer. Mus. Nat. Hist., Dec. 1900.

(primarily plantigrade), *Procyon* (subdigitigrade), and *Felis* (digitigrade), we see that the planes of the distal facets give certain indication of the modes of progression."

In other words, by an examination of the distal ends of the metapodials, one can certainly tell whether these bones are carried in a plane parallel to the surface upon which the animal walks (plantigrade), or perpendicular to it (digitigrade), in the act of progression—a very important and valuable discovery if true. Now if there is any truth in this hypothesis, it appears to me that the character of the distal ends of the metapodials in two such typical and widely different-gaited animals as a cat and a bear would exhibit such marked and unmistakable differences in these particulars, that one would be able to tell at a glance whether the animal in question were plantigrade or digitigrade. As a matter of fact, however, and, I may add, of the most common observation and knowledge, the amount of difference in the distal articular surfaces of these bones in the cat and bear is so surprisingly small, that, in themselves, they do not give the faintest or slightest hint at such marked differences in gait. According to Professor Osborn's own showing in his diagram, the differences in the extent, arrangement, and planes of these facets, in the two animals, are very slight indeed. It should be here observed that in the diagram, if the metapodial of the bear is placed in its natural position with reference to the phalanges, the corresponding bone of the cat must be rotated to the left somewhere in the vicinity of ninety degrees, in order to represent the position which it naturally assumes in the foot of that animal. If, therefore, the planes of these facets fail to record a difference of nearly *ninety degrees of arc*, in determining the position of the bone in this case, it is pertinent to inquire how far they can be trusted in any other case. It is sufficiently obvious, I take it, that if the position of the metapodial is incapable of being fixed by this method, it is practically worthless in the further determination of the gait of the animal, since the position of these bones is the all-important factor in the case.

Let us next turn our attention to the phalanges. I quote again from the paper in question, p. 271. "As regards angulation, *Patriofelis* is shown to occupy a position intermediate between *Procyon* and *Felis*, with a decidedly *angulate* foot, the angles between phalanges 1 and 2 being especially acute. This proves that the metapodials, as well as phalanges 1 and 2, were raised off the ground by plantar and palmar pads as in *Felis*. Taking a conservative view, the feet of *Patriofelis* may be described as subdigitigrade in position. The straight terminal claws indicate that they entirely lacked the grasping and tearing power developed in *Felis*."

Using the previous examples, the cat and the bear, in the

matter of the distal facets of the first phalanges, I have taken the trouble to make careful and extensive comparisons of numerous species of these two types, and I find that the differences in the arrangement, extent, and planes, are as little marked as they are in the distal ends of the metapodials, and, in themselves, afford as little evidence of the difference in gait of the two animals. The conclusion is therefore obvious, and

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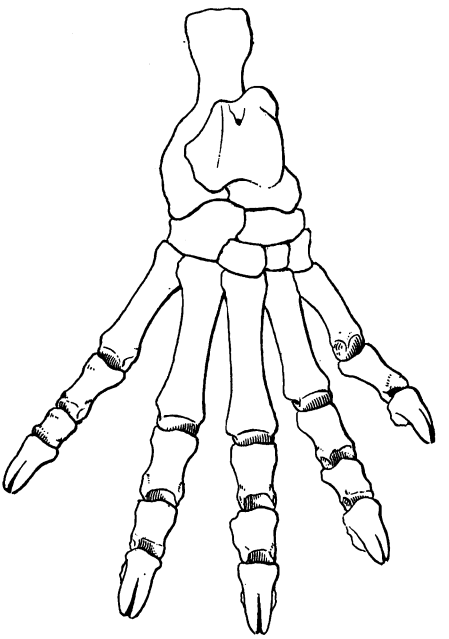

FIGURE 70.—Right hind foot of *Patriofelis ferox* Marsh; three-eighths natural size. (After Wortman.)

I think enough has been said to show that the planes of the articular facets, as applied to the feet of the Carnivora, have *little or no value* in determining whether a given animal is plantigrade or digitigrade.

Let us next direct our attention to the feet of *Patriofelis*. I find it necessary, first of all, to state that the position in which Osborn has placed the phalanges, in the diagram, instead of being less angulate than those of *Felis*, are decidedly more so. It certainly, therefore, does not occupy a position between *Procyon* and *Felis*, but a position more advanced in this particular than *Felis* itself, the fallacy of which will be evident to any anatomist at a glance. Either the diagram is wrong or the statement is incorrect, since both cannot be true.

Although there are numerous specimens of the first phalanges of *Patriofelis ferox* in the Marsh collection, after the most careful examination I fail to detect *a single example in which the distal articular surface is limited in the manner depicted by Professor Osborn in his diagram.* These specimens, moreover, agree perfectly in this respect, not only with the original figure, figure 70, of the American Museum specimen, published in my paper, but what is still more to the point, they agree with the photograph of the same specimen which Professor Osborn himself reproduces, figure 2, p. 169, of the paper under discussion. What more conclusive or final testimony is it possible to adduce in support of the contention that this diagrammatic representation of these facets is wrong and the conclusions drawn from them are entirely erroneous?

I am still of the opinion that we shall find it necessary to retain our old methods for judging the gait of these extinct animals, methods which have for their basis a consideration of the entire organization of the foot, and such as are calculated to help us as near to the truth as we shall ever be likely to come.

Among the living Carnivora the plantigrade foot is characterized by short slightly interlocking metapodials and spreading toes, whereas in the typical digitigrade foot the metapodials are more elongate, compressed, and interlocking, and the toes less spreading. In the former the naked plantar and palmar pads are enlarged and extended so as to wholly underlie these bones, while in the latter these pads are restricted to their distal ends. Judged upon the merits of this class of evidence, the feet of *Patriofelis ferox* were as plantigrade as those of the modern bears, a conclusion which, to my mind, is clearly indicated by every feature of its podial anatomy.

The third section of this paper is devoted to the so-called "Specialized Characters of the Oxyænidæ," and upon this topic I feel it necessary, if only in the interests of clearness, to make a few remarks. In the first place it is important to note that if the term "specialized" is employed in the usual or ordinary sense, common to the subject, then out of the thirty or more characters enumerated, comparatively few can be correctly called *specialized.* I have always understood this term to denote a condition the reverse of generalized, or in other words one which is uncommon, peculiar, particular, and different from others; it is also employed in the sense of advanced. The specialized characters of the Oxyænidæ should therefore be taken to indicate those which it possesses that are different from, or advanced over and above, the other families of the suborder to which it belongs. We shall presently see to what extent the characters therein enumerated are entitled to be set down as "specialized characters" of the Oxyænidæ.

I will next take up these characters *seriatim*, and make such comments as appear to me to be needful and necessary in connection with each one separately. They are as follows:

(1) "Progressive shortening of the face and elongation of cranium with reduction of teeth and development of jaw muscles;"	(1) I have explicitly and distinctly stated in my paper, p. 132, that the length of the face in *Patriofelis* is not known with certainty: it is, however, probably correct and a truly specialized character.
(2) "high sagittal crest; (3) occiput narrow;"	(2), (3) The occiput is unusually low and broad in certain species of *Limnocyon*, and the sagittal crest little developed; they do not, therefore, apply to the entire family.
(4) "a preglenoid crest;"	(4) Common to many other Creodonts and not true of two species of *Limnocyon;* unknown in *Thereutherium.*
(5) "a large postmastoid foramen;"	(5) Now known to be the stylomastoid foramen; its posterior position is also characteristic of certain members of the Mesonychidæ and is not known in any of the Limnocyoninæ, except in one species where it opens below.
(6) "no postglenoid foramina;"	(6) Stated in my paper on *Oxyæna* (Bull. Amer. Mus. Nat. Hist., 1899, p. 142) as probably present in this species; also known to be present in at least two species of *Limnocyon.*
(7) "mandibular condyles scroll-like (as in Felidæ);"	(7) Also true of many other Creodonts.
(8) "atlas with form and vertebrarterial canal as in Felidæ (Wortman);"	(8) Same character is found in other species of Creodonts, notably *Sinopa*, *Mesonyx*, and *Dromocyon.*
(9) "axis with elongate spine;"	(9) Unknown in *Oxyæna* and all other members of the family, but the same is true of *Mesonyx*, *Dromocyon*, and *Sinopa.*
(10) "certain dorsals and lumbars with progressively revolute zygapophyses (as in Mesonychidae and certain Pinnipedia, *Phoca*;"	(10) If described as having a double tongue and groove articulation, it is a truly specialized character of the family. "Revolute" is an altogether inappropriate and incorrect expression as applied to it. Neither Mesonychidæ nor *Phoca* has this character of articulation.
(11) "lumbars with progressively developed anapophyses;"	(11) Also true of other species of Creodonts, but unknown in the Limnocyoninæ.
(12) "scapula, humerus, and ulna of about equal length;"	(12) Unknown in all the Limnocyoninæ.
(13) "scapula very large, spreading superiorly (imperfectly known in *Oxyæna*), supra- and infraspinous fossæ subequal;"	(13) Scapula practically unknown in all species of the family except *Patriofelis.*

(14) "powerful acromion and metacromion processes:"	(14) Unknown in all the Limnocyoninæ.
(15) "humerus with exceptionally elongate and prominent deltoid crest, powerful supinator ridge, large entepicondyle and entepicondylar foramen;"	(15) Deltoid crest in two species of *Limnocyon* reduced; other characters common to all primitive Creodonts and carnivorous Marsupials and therefore not specialized.
(16) "olecranon process of ulna elongate, ulna grooved anteriorly;"	(16) True of nearly all Creodonta known, likewise carnivorous Marsupials; therefore primitive.
(17) "limited rotation of forearm owing to proximal expansion of radius;"	(17) Not true of *Oxyæna* nor any species of *Limnocyon* thus far known.
(18) "feet [toes] spreading;"	(18) True also of many other Creodonts; not a specialized character.
(19) "trapezium extended transversely (as in Pinnipedia, Wortman);"	(19) Not known in any species of Limnocyoninæ, but probably a distinctive and specialized character.
(20) "dorsal portion of distal metapodial facets hemispherical, ventral portion keeled (as in Fissipedia, Wortman);"	(20) True also of all Creodonta, Carnassidentia, and Carnivorous Marsupials thus far known; therefore not specialized in any sense.
(21) "digits angulate, the second phalanges strongly flexed upon first phalanges;"	(21) According to my own view this is incorrect.
(22) "subungual (retractile) processes of distal phalanges well developed (as in Pinnipedia; in Fissipedia subungual processes small, foramen vestigial, Wortman);"	(22) I prefer to believe that the introduction of the word "retractile" into my original statement is a *lapsus calami* on the part of the author, since he must surely know that a "retractile" process upon the under side of the claw is a sheer impossibility.
(23) "ilium expanded on superior (post-iliac) border into a broad lamina;"	(23) Unknown in Limnocyoninæ.
(24) "pubic symphysis not anchylosed;"	(24) Likewise true of all Creodonts and Carnassidents thus far known, and therefore generalized.
(25) "patella large;"	(25) No larger than in *Mesonyx*, *Dromocyon*, *Sinopa*, and many others.
(26) "fibula unreduced, articulating with side of astragalus but not articulating with calcaneum (progressive):"	(26) Fibula articulates with calcaneum in *Limnocyon*, but not known to do so in any other species of Creodonts.
(27) "tibia with twisted shaft and cnemial spine;"	(27) Tibia unknown in the Limnocyoninæ, but cnemial crest is present in all Creodonta known. The twisted tibia is strongly indicative of aquatic habit and is probably specialized.
(28) "tibio-astragalar facet flat, obliquely placed;"	(28) Fairly well grooved in one species of *Limnocyon*, and not very oblique. In *Patriofelis* probably specialized and indicative of an aquatic habit.

(29) "calcaneo-cuboidal facet very oblique;"	(29) Not known in all species of *Limnocyon*, but probably characteristic of the family and specialized.
(30) "large astragulo-cuboidal facets;"	(30) True of nearly all Creodonts.
(31) "external calcaneal tubercle large (as in many Creodonts and Amblypods)."	(31) Should have been stated all Creodonts known.

It will thus be seen that these characters are for the most part true only of the single genus *Patriofelis* and cannot be applied to the entire family.

I pass next to a consideration of the probable habits of *Patriofelis*, and for the sake of putting the matter clearly I quote my original conclusion, which was as follows: "From the structure of the limbs more than any other feature in the osteology of *Patriofelis*, I am led to conclude that it was aquatic or semi-aquatic in habits. The broad, flat, plantigrade feet, with their spreading toes, suggest at the first glance their use for swimming." The opposite view as stated by Osborn is as follows: "In this connection a careful restudy of all the evidence led the writer to the opposite conclusion, that these were powerful *terrestrial, or partly arboreal, animals, analogous to the Cats in habits of feeding*, with analogous (not homologous) sectorials, clumsy in limb structure, without prehensile claws, and presenting no evidence of successors among the modern Carnivora."

As regards the view that these animals were arboreal or partly so, I have little comment to make; it is to my mind, however, so extremely improbable, if not impossible, that I hesitate to give it serious consideration. Its fallacy, it seems to me, is clearly evident when it is remembered that among the living Carnivora the habitual climbers are almost without exception light, agile, sharp-clawed species, capable of sufficiently swift movement to capture arboreal prey. A heavy, clumsy, blunt-clawed type like *Patriofelis* would be as much out of place in the trees as could well be imagined. We thus limit the question either to an aquatic manner of life or a terrestrial one or both, since there is no evidence that the animal had fossorial habits.

Any conclusion we may reach must take into consideration and accommodate itself to the following facts: (1) That whatever constituted the chief food supply of the animal was of such a nature as to cause unusual wear of the teeth, since in almost every known specimen that had reached maturity, the teeth are much worn; (2) that the animal was strictly carnivorous; (3) that its prey, whatever it may have been, was evidently not swift and active, otherwise it could have easily escaped so awkward and clumsy a creature; (4) that the manner of cap-

turing its prey and its habits of feeding were not analogous nor similar to those of the cats, since the evidence positively forbids the idea of any prehensile powers of the claws, one of the most preëminently distinguishing features of the Felidæ in this respect; and (5) that it was likewise not similar to that of the dogs, for the structure of the limbs disproves the suggestion of a runner.

What osteological character or characters do the living aquatic Carnivora possess, by means of which their habits could be detected if known from their skeletons alone? The various degrees of modification for a swimming habit are progressively shown by such types as the mink, otter, sea-otter, sea-lion, and seal. The mink and otter are semi-aquatic, the sea-otter more aquatic, and the sea-lion and seal almost exclusively so. The limbs, and especially the feet, exhibit the greatest amount of modification of any parts of the skeleton and the degree of this modification is proportioned to the extent of the aquatic habit. In cases of extreme specialization, as in the sea-lion and seal, the fore and hind feet are almost equally modified, but in such an example as the sea-otter, it is only the hind feet that show any considerable adaptive changes of this character. This is also true of the mink and otter, but in these types the difference between the fore and hind feet is not so great.

It is for this reason that I limit what I shall have to say to a consideration of the posterior limbs; and it should be noted that all these aquatic or semi-aquatic species are plantigrade in gait when upon land, that the metatarsals are short and little interlocking, and that the toes are spreading. Taking the foot of the sea-lion as an extreme type, it will be seen that when placed with the plantar surface upon the ground, in the direction of the long axis of the body, the articular surface for the tibia looks upwards and very much inwards, so that if the tibia is articulated it does not occupy a vertical position as in the terrestrial species, but leans very much inwards towards the median line. If made to assume a vertical position the plantar surface of the foot is turned strongly inwards. At the same time the tibia is twisted in such a way that the fore and aft planes of the articular faces of the two ends do not coincide. These characters in connection with the elongation of the phalanges constitute the chief peculiarities of the hind limbs of the aquatic Carnivora, and, as far as known, are present in all of them. With the exception of the elongation of the phalanges, *Patriofelis* exhibits these identical characteristics of the hind limbs, and if they have any significance at all, *they indicate an aquatic or partially aquatic habit of the species.* I have yet to discover any evidence which opposes itself to the correctness of this view.

I have suggested that the animal preyed upon the numerous

species of turtles that inhabited the Bridger lake, and this is rendered all the more probable by the presence in these deposits of coprolites of some large carnivorous Mammal, which contain fragments of turtle shell. While it is not known with certainty to what species these coprolites pertain, it is, I think, in connection with the probable aquatic habits of the species, a fair presumption that they refer to *Patriofelis*. The great wear of the teeth as well as the power of the jaws accord well, moreover, with the view that they were used for crushing the strong bony coverings of the turtles, which may be said to have literally swarmed in the tropical or semi-tropical waters of the ancient lake or river as the case may be. The suggestion of Osborn that the specialization of the teeth and the increase in the size of the jaws are reasons for disbelieving in its aquatic habits has little force. An exactly parallel case is seen in *Potamotherium* and *Lutra* (ancestor and descendant), in which the same thing has occurred. The teeth have been reduced in number, enlarged and specialized, and the jaws shortened and increased in size, notwithstanding *Lutra* is to-day preëminently a fish eater.

Touching their relationship to the Pinnipedia I have no new facts to add. I have not asserted that the seals have been derived from any known species of *Patriofelis*, but that they *may have* been derived from some as yet undiscovered member of this group, and the reasons for such a belief, which have already been fully stated, have not, to my mind, been in any way affected by this restudy of the subject on the part of Professor Osborn.

Subfamily Limnocyoninæ.

As already remarked, this group appears for the first time in the Bridger and continues into the Uinta. According to our present understanding, the three or four American species appear to be best classified in the single genus *Limnocyon*, although it is not altogether improbable that two of them, when more fully known, will require to be placed in separate genera. The European representative of this subfamily, *Thereutherium*, is distinct and shows a considerable advance over the American species in the matter of tooth specialization. The two genera may be distinguished as follows:

First premolar above and below two-rooted; last superior molar transverse, relatively large, with three well-developed roots and external and internal cusps; inferior molars with moderate-sized basin-shaped heels and internal cusps. *Limnocyon.*

First superior premolar above and below single-rooted; last superior molar much reduced, vestigial; heels of inferior molars reduced, and internal cusps vestigial or absent. *Thereutherium.*

[To be continued.]