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Article XV.—NEW TITANOTHERES OF THE HUERFANO

By Henry Fairfield Osborn

Renewed exploration of the Huerfano Basin of Colorado by the American Museum party under Mr. Walter Granger assisted by Mr. George Olsen, with the coöperation of Mr. R. C. Hills of Denver, during the season of 1918, has resulted in very important additions to our knowledge of this Lower Eocene fauna and of its relations to the little-known fauna of the base of the Bridger formation, Wyoming, known as Bridger A.

The geologic results will be fully reported by Mr. Hills. The general palæontologic results will be reported in detail by Mr. Granger. In the meantime, immediate description of the new titanotheres seems desirable.

Besides the collections referred to in the following description of the Huerfano fauna, there is a small collection in the United States National Museum made by Mr. J. Milligan for Mr. Hills about 1885. It includes upper molar teeth referable to the titanotheres.

GEOLOGIC RELATIONS

The Huerfano proves to be about 3500 feet in thickness. Its faunistic subdivision, as already described by Osborn and Wortman,[1] is in the two life zones:

Upper Huerfano, Huerfano B, fauna of surviving *Eotitanops*, of *Palæosyops* (*Limnohyops*) *fontinalis*, of *Eometarhinus*, of *Trogosus*, etc., which now appears to be of similar age to the fauna of the base of the lower Bridger, namely, Bridger A, *Trogosus*, *P. fontinalis* zone.

Lower Huerfano, Huerfano A, fauna of abundant *Lambdotherium* and rare *Eotitanops*, similar to that of the Lost Cabin formation, upper Wind River levels, Wind River B, *Lambdotherium-Eotitanops* zone.

New Section of the Huerfano Beds

The accompanying section (Fig. 1), prepared by Mr. Granger from his recent exploration, considerably alters our previous estimates both of the thickness of the Huerfano formation, which now rises to 3500 feet, and the relations of the respective Wind River and Bridger faunæ. The

[1]Osborn, H. F., 1897, Bull. Amer. Mus. Nat. Hist., IX, pp. 247–258.

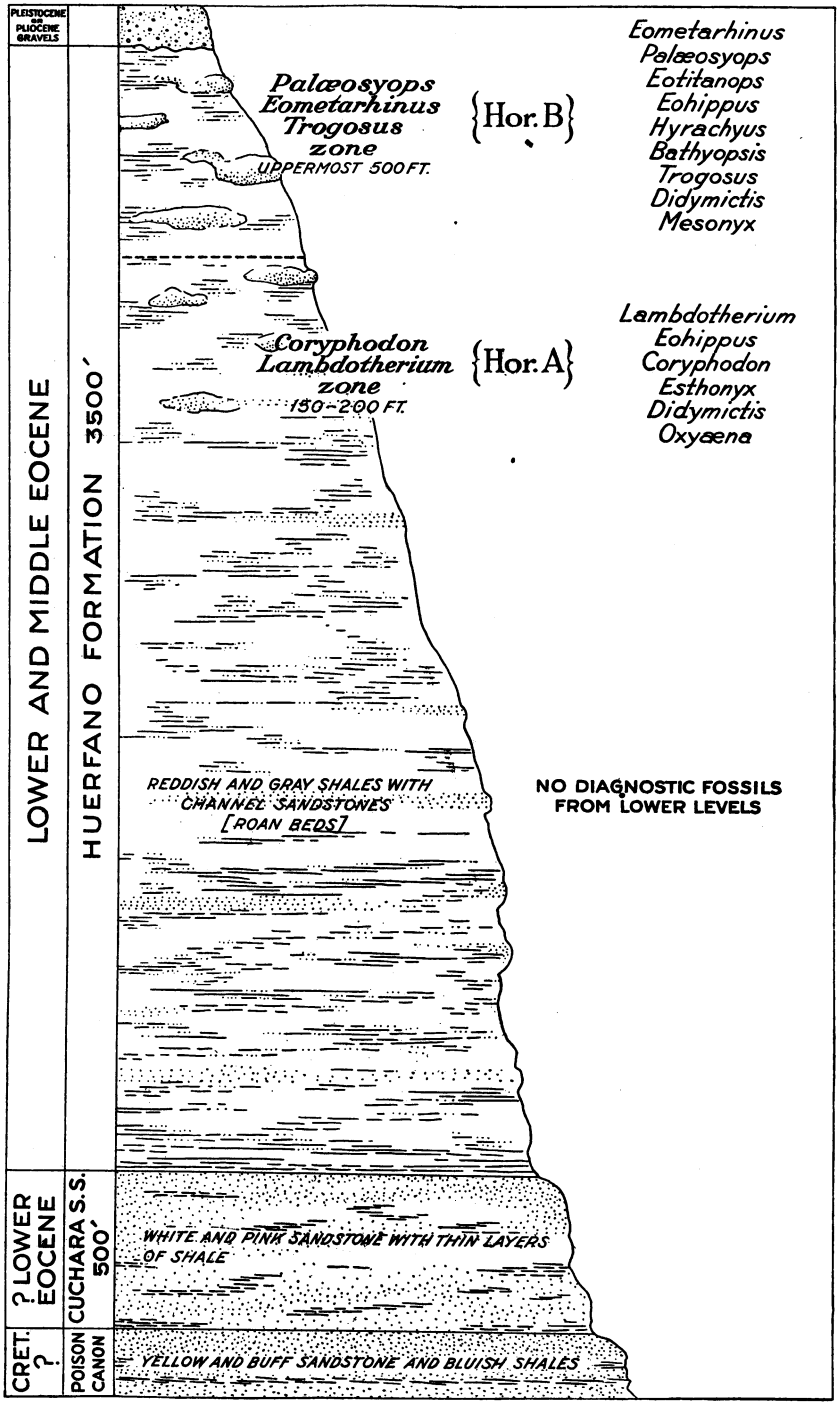

Fig. 1. New section of the Huerfano formation from our present knowledge of the faunal levels. After Granger, 1919.

Wind River *Lambdotherium* zone, Huerfano A, proves to be between 150 and 200 feet in thickness and is located at the bottom of the upper third of this formation, although the exact level has not been ascertained. The Bridger *Palæosyops fontinalis, Eometarhinus, Trogosus* zone occupies the uppermost 500 feet. This section corresponds with the line drawn from the western edge of the formation, near the mouth of Poison Cañon, eastward to Gardner, along the Huerfano-Muddy Divide, thence southeast to the Cuchara outcrop on South Oak Creek.

NEW PALÆONTOLOGIC RESULTS

The chief new results are as follows: (1) The discovery in Huerfano B of six specimens which cannot be separated specifically, or by measurement, from the type of *Palæosyops* (*Limnohyops*) *fontinalis* Cope, the only titanothere certainly known to occur in Bridger A. (2) The correlation of Huerfano B with Bridger A is further sustained by the presence of *Eometarhinus huerfanensis*, an ancient species which carries the *Metarhinus-Mesatirhinus* group of titanotheres, hitherto known only in the upper Bridger, back to the base of the Bridger, a discovery of great phyletic interest. (3) At the same time, the correlation of Huerfano A with Wind River B is strengthened by the presence of two known species of *Lambdotherium* and a third new one, all of which occur in both formations. (4) The discovery in Huerfano B of two diminutive known species of titanotheres referred to the genus *Eotitanops*, namely, *E. gregoryi*, *E. brownianus*, and of the new species, *E. minimus*, appears to indicate the survival of a dwarfed group. *E. minimus* is a pygmy compared with the contemporary *Eometarhinus huerfanensis* and with the still larger *Palæosyops fontinalis*.

The conspectus of these results in titanothere evolution appears as follows:

	I Wind River B (Lost Cabin)	II Lower Huerfano (Huerfano A)	III Upper Huerfano (Huerfano B)	IV Lower Bridger (Bridger A)
Lambdotherium popoagicum	*	*(?)		
Lambdotherium priscum	*	*		
Lambdotherium progressum	*	*		
Lambdotherium magnum	*	*		
Eotitanops brownianus			*	
Eotitanops gregoryi			*	
Eotitanops minimus				
Eometarhinus huerfanensis				
Palæosyops (*Limnohyops*) *fontinalis*				*

FOUR SPECIES OF *LAMBDOTHERIUM* FROM THE LOWER HUERFANO, *LAMBDOTHERIUM* ZONE

In 1897 a specimen of *Lambdotherium* was discovered in the lower Huerfano by Wortman and provisionally identified as *L. popoagicum*, at that time the unique species of the Wind River. The discovery of three other specific stages in the evolution of this genus, common to Wind River B and Huerfano A, may be described in the order of evolution.

Lambdotherium priscum Osborn

This Wind River species is identified in Huerfano A by Amer. Mus. 17526, a fine pair of jaws from Garcia Cañon. The specific character of p_3, *without trace of metaconid*, is clearly shown in Fig. 3. This species is represented by another jaw, with teeth of the same size, Amer. Mus. 17528, in which p_3, *also without metaconid*, is in a slightly more advanced stage of evolution, the talonid being broader.

This species is also doubtfully represented by the imperfect specimen of upper teeth referred to *L. popoagicum* by Wortman, Amer. Mus. 2688, as well as by the newly found specimen, Amer. Mus. 17529, of approximately the same size.[1] In this specimen, Amer. Mus. 17529, found three miles east of Gardner Butte, the isolated upper teeth of two sides, including p^3-m^3, show the following characters: (1) molars slightly smaller than in the referred specimen of *L. progressum;* (2) conules and cingulum not so well developed; (3) measurements slightly inferior to those of the type of *L. popoagicum*.

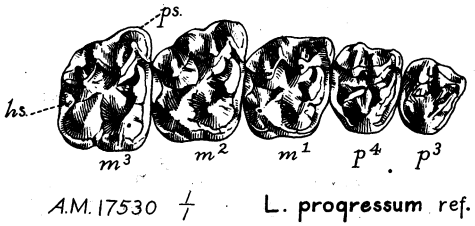

Fig. 2. Upper teeth of *Lambdotherium progressum*, referred specimen from Huerfano A.

Lambdotherium progressum Osborn

This Wind River type is distinguished by p_3 *with strong metaconid*, i.e., submolariform. A series of molar teeth, p^3-m^3, represented in Fig. 2,

[1]The types of *L. popoagicum* and *L. priscum* are both lower jaws from the Wind River; since there are two lower jaws from the Huerfano positively referable to *L. priscum* and none referable to *L. popoagicum* it seems best to assign these two sets of upper teeth to *L. priscum* also.

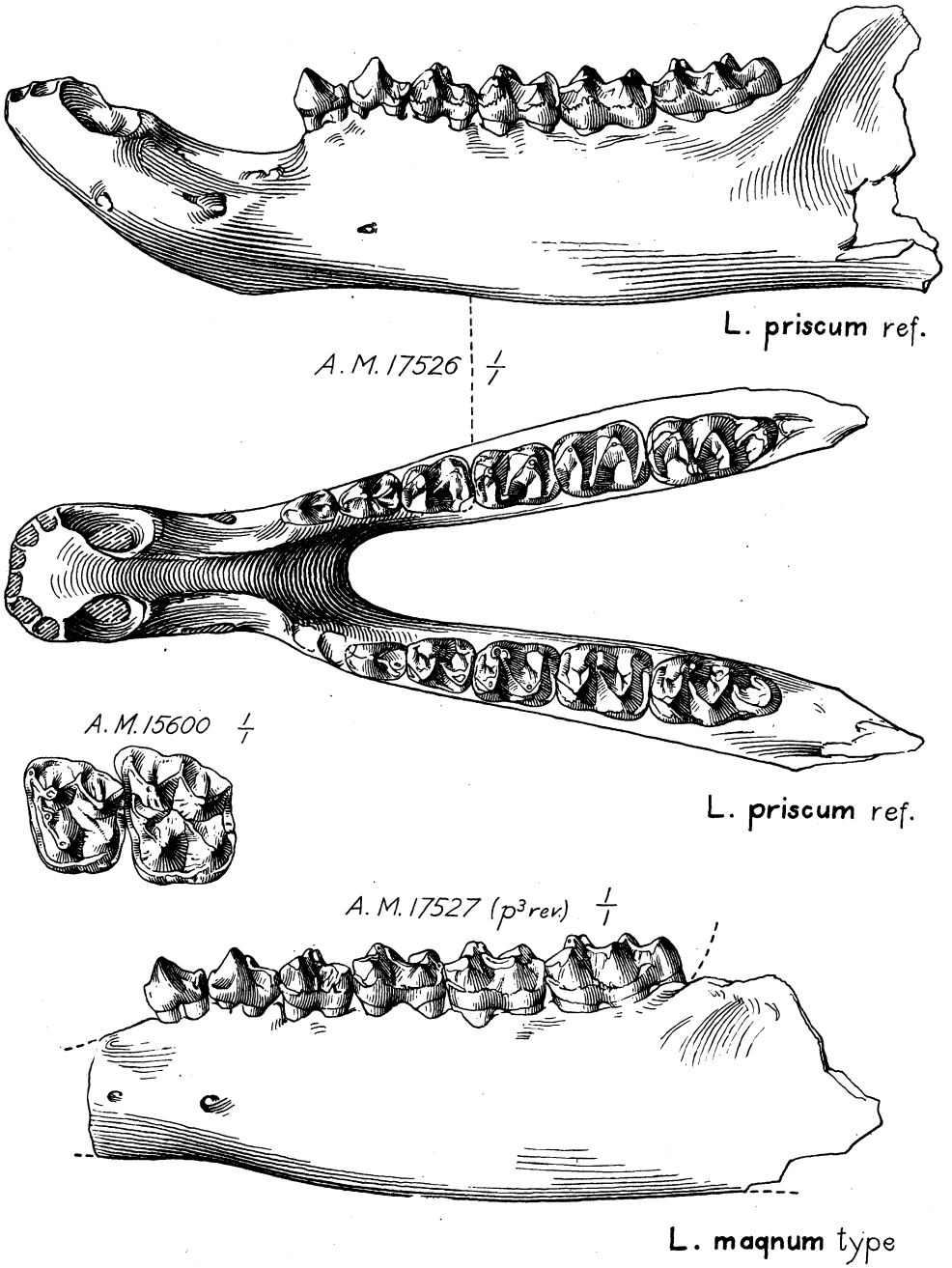

Fig. 3. No. 17526. Lower jaw of *Lambdotherium priscum*, referred specimen from Huerfano A. Outside and crown views.

No. 17527. Outer view of type jaw of *Lambdotherium magnum*, Huerfano A.

No 15600. First and second upper molars of *Lambdotherium magnum*, referred specimen from the Wind River Horizon of the Bighorn Basin, Wyoming.

from the highest level of the lower Huerfano, is referred to *L. progressum* on the following grounds: (1) the upper teeth fit pretty well those of the type of *L. progressum* from the Wind River; (2) the parastyle is especially prominent at the antero-external angle of m^2, m^3; (3) m^3 with prominent hypocone and cingular hypostyle; (4) outer cusps of premolars approximated, conules prominent; (5) cingulum strong on p^4 and m^3.

With these specimens, association doubtful, were found the calcaneum, portion of a tibia, and a proximal phalanx.

Lambdotherium magnum, new species

Exceeding in size any other known lambdothere is the type jaw, Amer. Mus. 17527 from the Garcia Cañon, lower Huerfano, containing a complete inferior series, p_2-m_3 of both sides, represented in Fig. 3. (1) These teeth exceed in length over all (.074) those of the type of *L. popoagicum* in which the same teeth measure .069. (2) P_3 has a rudimentary metaconid and paraconid, in the same stage of evolution as in *L. popoagicum*. (3) Of similar large size is a referred specimen, Amer. Mus. 15600, from the Bighorn, west end of Tatman Mt. These referred grinders, m^1, m^2, coincide closely in size with the type of *L. magnum* and may be regarded as a paratype, as represented in Fig. 3.

MEASUREMENTS OF INFERIOR TEETH P_2–M_3 AND SUPERIOR TEETH M^1–M^2

					P_2-M_3
Huerfano A	Ref.	*L. priscum*	Amer. Mus. 17526	.....	.067
Wind River B	Type	*L. popoagicum*	" " 4863	.....	.069
" " B	"	*L. progressum*	" " 14917	.....	.071e
Huerfano A	"	*L. magnum*	" " 17527	.....	.074
					M^1-M^2
Huerfano A	Ref.	*L. priscum*	Amer. Mus. 17529	.....	.0215
" A	"	*L.* "	" " 2688	.....	.0225
Wind River B	"	*L. popoagicum*	" " 14902	.....	.0250
Huerfano A	"	*L. progressum*	" " 17530	.....	.0235
Wind River B	"	*L. magnum*	" " 15600	.....	.0275

These measurements show that there is not a great range in size between the smaller and the larger animals referred to this genus.

THREE SPECIES OF DWARF *EOTITANOPS* FROM THE UPPER HUERFANO, *TROGOSUS* ZONE

The true Wind River beds contain (1) the larger titanotheres *Eotitanops borealis* (Cope), *E. princeps* Osborn and *E. major* Osborn; (2) also two diminutive types of titanotheres, *E. brownianus* (Cope) and

E. gregoryi Osborn, the latter, up to the present time, the smallest true titanothere known. It is supposed that the larger forms (1) are ancestral to the Bridger Palæosyopinæ (*Palæosyops, Limnohyops*); the smaller forms (2) appear to be represented, in the Huerfano, in survivals of three stages of diminishing size, as follows.

Eotitanops brownianus (Cope)

This diminutive titanothere is represented by a single referred specimen, Amer. Mus. 17441, m_3 of the right side, from Apodock Gulch, two miles southeast of Gardner and close to the border line between the upper and lower Huerfano. This referred tooth (Fig. 4, *C*) is precise in size with the corresponding tooth (measured by the root) of the *E. brownianus* type from the Wind River; no other comparison can be made.

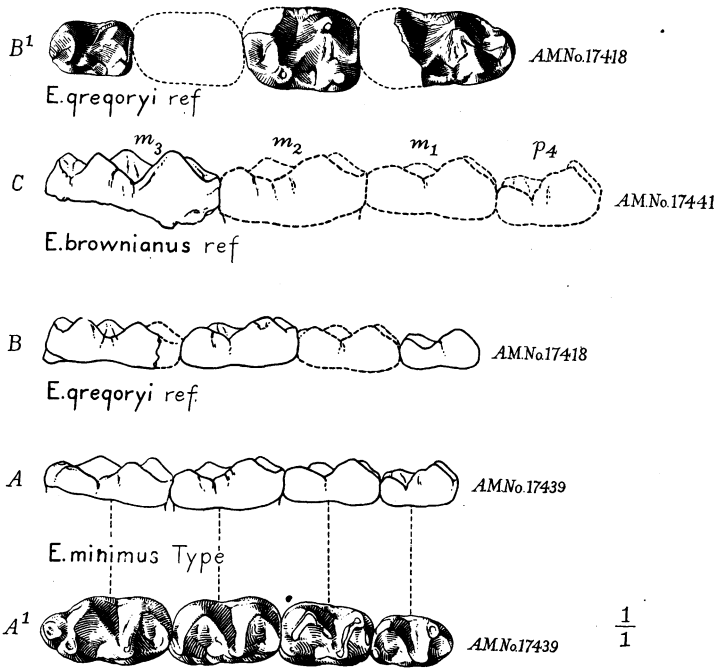

Fig. 4. Diminutive species of *Eotitanops* belonging to Huerfano B.
A, *A*1, *E. minimus*, type.
B, *B*1, *E. gregoryi*, referred specimen.
C, *E. brownianus*, referred specimen.
The hypoconulid of the m_3 in the type of *E. minimus* is abnormal.

Eotitanops gregoryi Osborn

Of the same size as the type of *E. gregoryi* from the Wind River are the referred isolated teeth, p_4, m_{2-3}, from the upper Huerfano, two miles north of Gardner, Amer. Mus. 17418 (Fig. 4, *B*, B^1).

Eotitanops minimus, new species

In reference to the fact that it is the smallest true tianothere known, these type lower molar teeth, p_4-m_3, Amer. Mus. 17439 (Fig. 4, *A*, A^1), from the lower level of the upper horizon of the Huerfano formation, Colorado, Huerfano B, are assigned a new specific name on the following grounds: (1) the measurement of p_4-m_3 (.053) is much less than that (.058) of the corresponding teeth in *E. gregoryi;* (2) the other characters are so similar to those of *E. gregoryi* as to suggest that this is a related form.

The accompanying figures (Fig. 4, *A*, *B*, *C*) exhibit the dimensional proportions of the above species of *Eotitanops.* It has been found from the large number of measurements of Eocene titanotheres that no single species exhibits so great a range of size.

SPECIES OF PALÆOSYOPINÆ AND DOLICHORHININÆ FROM THE UPPER HUERFANO, *TROGOSUS* ZONE

The discovery of two very distinct true titanothere phyla in the Lower Eocene confirms the theoretic separation of the titanotheres into various subfamilies as occurring in Lower Eocene time. In the Huerfano we have evidence of two subfamilies, as follows:

PALÆOSYOPINÆ (Perhaps derived from the Eotitanopinæ)	DOLICHORHININÆ (*Manteoceras-Metarhinus-Mesatirhinus-Dolichorhinus* group)
Hornless	Osseous horn rudiments at naso-frontal junction
Slender nasals	Nasals very stout, laterally decurved
Sub-brachycephalic	Mesaticephalic
More robust proportions	Smaller proportions

The first subfamily is represented by numerous specimens of *Palæosyops fontinalis* Cope; the second group is represented by the single type specimen of the new genus *Eometarhinus huerfanensis,* as described below.

Palæosyops fontinalis Cope

This species is represented by the remains of six individuals from the upper Huerfano beds, as follows:

Amer. Mus. 17411, superior dentition and portion of palate, Huerfano-Muddy Divide, two miles west of Gardner, Colorado, 414 feet below the top of the Huerfano formation.

" " 17425, series of right upper grinders, p^3-m^3, two miles north of Gardner, 400 to 500 feet below the top of the Huerfano.

" " 17414, three superior molars, fragmentary, three miles north of Gardner, 400 to 500 feet below the top of the Huerfano formation.

" " 17413, two upper molars and incisor, three miles north of Gardner, 400 to 500 feet below the top of the Huerfano formation.

" " 17417, m_1, p^1 and milk teeth, two miles north of Gardner, 400 to 500 feet below the top of the Huerfano formation.

" " 17450, lower canine and fragment of m_3, Huerfano-Muddy Divide, two miles west of Gardner, about 250 feet below the top of the Huerfano.

These specimens range from 250 feet to 500 feet below the top of the Huerfano formation. A finely preserved palate, Amer. Mus. 17411 (Fig. 5, *A*), of an aged individual, and the unworn upper teeth, Amer. Mus. 17425 (Fig. 5, *D*), of a young individual, afford a close comparison with the two permanent teeth of the type of *Palæosyops fontinalis* from Bridger A and are very similar both in characters and in measurement.

	Type *Palæosyops fontinalis* 5107 Amer. Mus. Bridger A	17425 Amer. Mus. Upper Huerfano	17411 Amer. Mus. Upper Huerfano	17414 Amer. Mus. Upper Huerfano	17413 Amer. Mus. Upper Huerfano	*Palæosypos paludosus* 13032 Amer. Mus. Bridger B 1
m^1-m^3	....	.083	.077	....	.....	.091
p^4 a. p.	....	.0165	.0163	....	.....	.018
p^4 tr.	....	.0215	.0215	....	.....	.022
m^1 a. p.	.022	.023	.0225	....	.0235	.025
m^1 tr.	.026	.026	.026	....	.026e	.026
m^3 a. p.	....	.029	.027	.030	.028	.032
m^3 tr.	....	.034	.0315	.034	.0325	.034
p^1-m^3	....	.146e	.141	....	.....	.160
p^1-p^4	....	.063e	.063	....	.....	.071

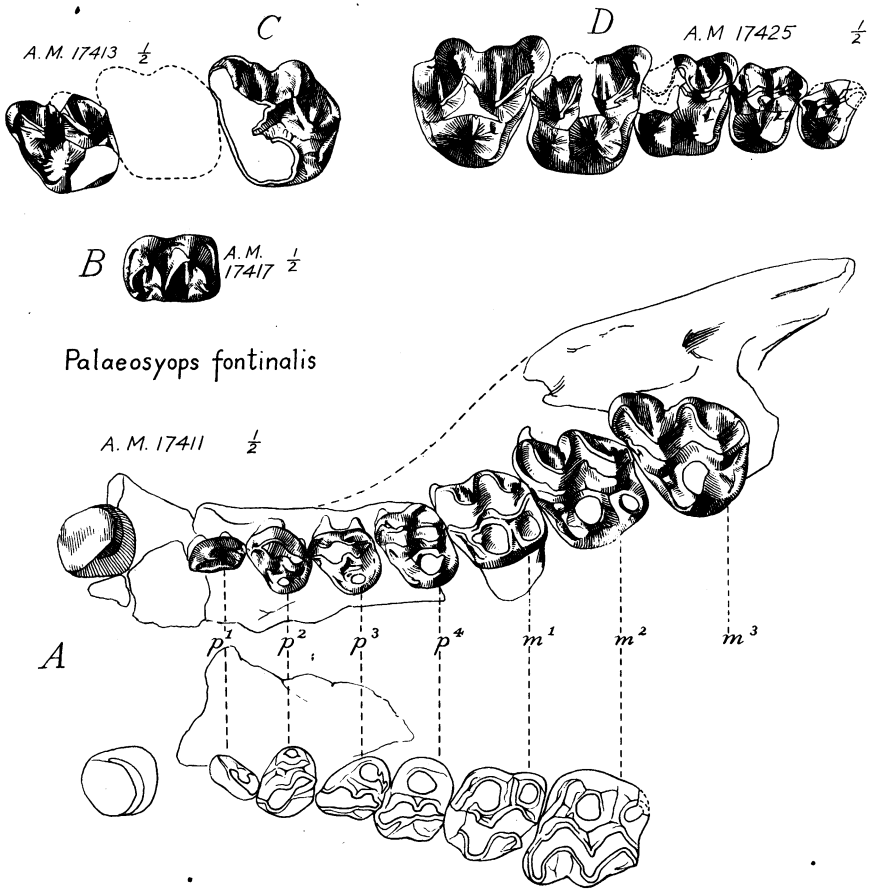

Fig. 5. *A, B, C, D,* referred specimens of *Palæosyops fontinalis.* All from Huerfano B. Teeth one-half natural size.

While these teeth are practically identical in size and characters with those of the type of *P. fontinalis*, they are smaller than those of the primitive species of *P. paludosus* and *Limnohyops* from Bridger B 1 and Bridger B 2. The whole superior grinding series, p^1-m^3, measures .141 (No. 17411).

The distinctive specific characters of *P. fontinalis* are: (1) parastyle very prominent; (2) protoconules reduced; (3) meta- and hypocones closely compressed; (4) no trace of metaconules; (5) no hypocone on m^3; (6) premolars very simple; (7) restored palate of considerable

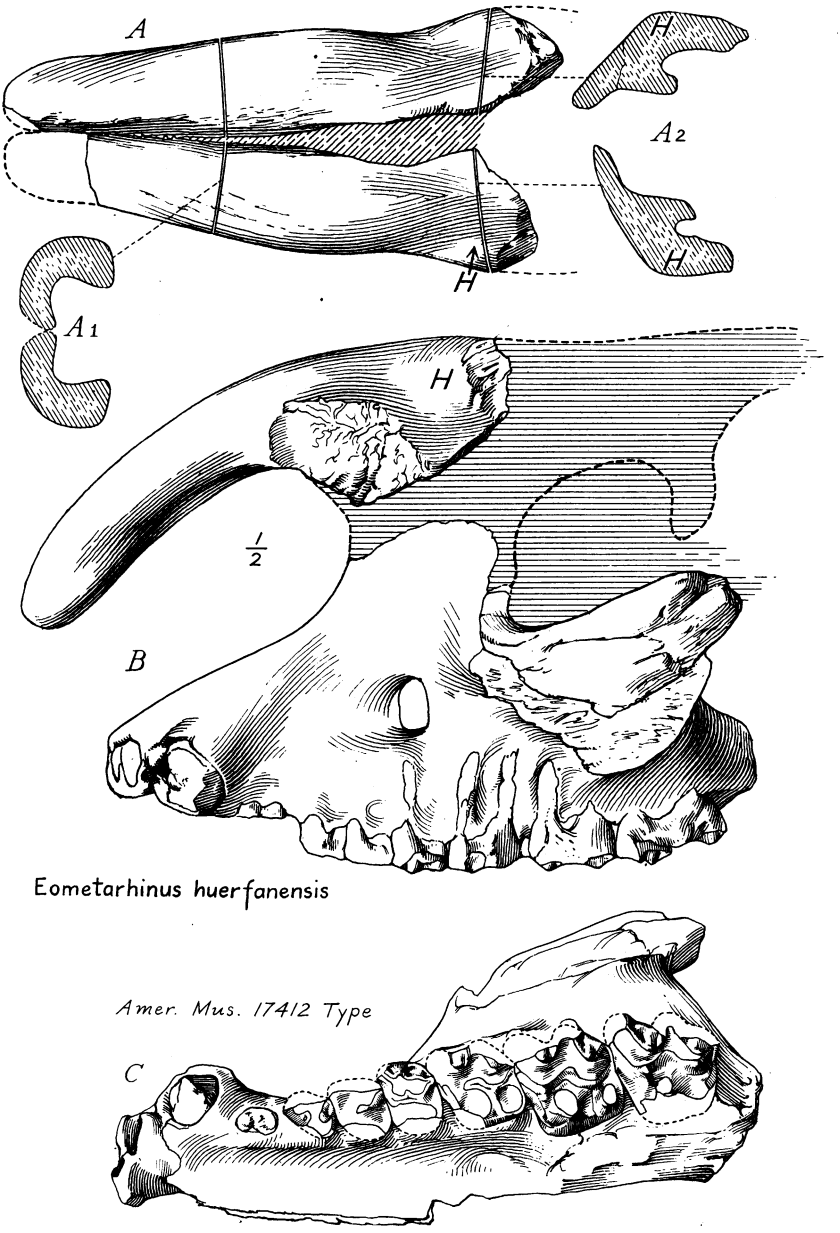

Fig. 6. Type skull of *Eometarhinus huerfanensis*, from Huerfano B. One-half natural size.
H, Horn rudiments in section.
A^1, A^2, Anterior and posterior nasal sections.

breadth, and (8) the maxillaries send back a splint on the outer side of the malars, as in typical *Palæosyops*.

Since all these six individuals from Huerfano B agree closely in size with each other and with the type of *P. fontinalis*, they establish Huerfano B and Bridger A as the *Palæosyops fontinalis* zone, distinguished by true ancestors of *Palæosyops* inferior in size to any known members of this genus in Bridger B.

Eometarhinus huerfanensis, new genus and species

GEOLOGIC LEVEL.—The geologic level on which this type specimen was found is 205 feet below the top of the Huerfano formation, Huerfano B.

TYPE LOCALITY.—Huerfano-Muddy Divide, three miles west of Gardner, Huerfano basin, Colorado.

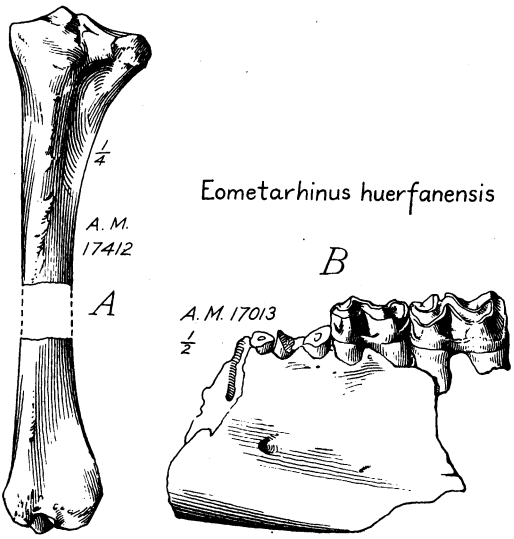

Fig. 7. *Eometarhinus huerfanensis: A*, tibia found associated with the type skull; *B*, fragment of the left ramus with first and second molars, referred specimen.

GENERIC CHARACTERS.—Small; ancestral to *Metarhinus;* with rudimentary fronto-nasal horn; nasals elongate; overhanging premaxillaries, decurved as in *Metarhinus;* no infraorbital shelf; characters apparently intermediate between those of the *Metarhinus* and *Mesatirhinus* phyla.

SPECIFIC CHARACTERS.—Inferior in all measurements to *M. megarhinus*. Premolars with small deuterocone. P^1-m^3, .124; p^1-p^4, .053; m^1-m^3, .072.

This new genus and species from the upper Huerfano is founded upon the anterior portion of a skull (Amer. Mus. 17412) representing an animal widely distinct in all its characters from the contemporary *P. fontinalis* and more closely related to the other group of Middle Eocene titanotheres to which *Metarhinus*, *Mesatirhinus* and *Dolichorhinus* belong. The most surprising character in an animal of this geologic antiquity is the very rudimentary osseous horns at the junction of the nasals and frontals (Fig. 6, *H*), indicating the horn rudiment, a very ancient character in this phylum. Nasals are long, arched, decurved and revolute on lateral borders, thus resembling the rhinal type in the metarhine group. The malars below the orbits are prominent. There was probably no infraorbital shelf, as in *Rhadinorhinus*. The comparative measurements of *Eometarhinus*, of *Mesatirhinus megarhinus* and of the contemporary *Palæosyops fontinalis* are shown below.

	Eometarhinus Amer. Mus. 17412	*Mesatirhinus megarhinus* Amer. Mus. 12202	*Palæosyops fontinalis* Amer. Mus. 17425
p^1-m^3	.124	.147	.146e
p^2-m^3	.109	.133	.131e
m^1-m^3	.072	.083	.083
p^4 a. p.	.014	.0175	.0165
p^4 tr.	.018e	.023	.0215
m^1 a. p.	.021	.025	.023
m^1 tr.		.0265	.026
m^3 a. p.	.0255	.028	.029
m^3 tr.		.031	.034

The dental formula is normal. The premolars are small, apparently very simple in pattern. The anteroposterior diameters of the molars appear to exceed the transverse; as they are in fractured condition, no accurate measurements can be taken. Apparently a hypocone on m^3.

A tibia (Fig. 7, *A*), found in association with the type skull, measures .275 (est.) in extreme length.