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CORYPHODONTS OF MONGOLIA, *EUDINOCERAS MONGOLIENSIS* OSBORN, *E. KHOLOBOLCHIENSIS* SP. NOV.[1]

BY H. F. OSBORN AND W. GRANGER

Two superior premolar teeth (Fig. 1) were discovered in 1923 by Andrews and Osborn in the Irdin Manha, Upper Eocene horizon, and were described (Osborn, 1924.626, p. 2)[2] as *Eudinoceras mongoliensis.* They are narrower but otherwise strongly resemble the corresponding premolar teeth (Fig. 8) in *Uintatherium* (=*Dinoceras* Marsh). This resemblance misled the present authors (Osborn and Granger) to believe that one of the horned Dinocerata had been discovered in Mongolia. The name *Eudinoceras* implied an improvement or advance on the corresponding *Dinoceras lucare* premolars (Figs. 5, 8) and the senior writer confidently anticipated (*op. cit.*, 1924.626) that in *Eudinoceras* the premolars would be found to be relatively shorter and broader than in *Dinoceras* and that the *Eudinoceras* skull would be found to be shorter.

In 1923 no cranial or other remains of *Eudinoceras mongoliensis* were found in the Irdin Manha, Upper Eocene, to confirm or to disprove the supposed discovery of Dinocerata, but in the year 1925 Andrews and Granger found in the underlying Kholobolchi formation of the Kholobolchi Nor Basin, two crania (Figs. 2, 6) obviously related to *Coryphodon* rather than to *Dinoceras.* Upon examination the *premolar* teeth of these Kholobolchi crania prove to resemble those of *Eudinoceras mongoliensis,* while the *molar* teeth and crania strongly resemble corresponding parts in *Coryphodon.* Accordingly W. D. Matthew, a member of the 1925 expedition, wrote (Peking, May 14, 1926) as follows:

> The coryphodont skulls are magnificent specimens and I think are quite nearly related to *Eudinoceras,* but a stage more primitive if, as would now seem likely, *Eudinoceras* is a descendant of *Coryphodon.* It is a bit strange to me that no trace of a foot bone of an amblypod has been found in the Mongolian Eocene.

Thus *Eudinoceras* represents a new phylum of the family Coryphodontidæ rather than a phylum of the Uintatheriidæ (including *Dino-*

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[1] Publications of the Asiatic Expeditions of The American Museum of Natural History. Contribution No. 107

[2] Osborn, H. F., 1924.626. *Eudinoceras,* Upper Eocene Amblypod of Mongolia. Amer. Mus. Novitates, No. 145, Nov. 10, 1924, pp. 1–5, text figs. 1, 2.

ceras). Remains of these new coryphodonts are relatively rare, for on the expeditions of 1923 and 1925 only eight specimens were discovered, geologically distributed as follows:

UPPER EOCENE HORIZONS OF EASTERN MONGOLIA
(OSBORN, 1930.832[1])

Ulan Shireh, 150′+ Shara Murun Basin	*Eudinoceras kholobolchiensis*, ref.	Left superior canine, Amer. Mus. 26276 (Fig. 7).
	Eudinoceras kholobolchiensis ref.	Second right inferior molar, r.M_2, Amer. Mus. 26130 (Fig. 10).
	Eudinoceras kholobolchiensis ref.	Fragment of supratemporal crest of cranium (Field No. 638).
Irdin Manha, 100′+ Iren Dabasu Basin	*Eudinoceras mongoliensis* Osb.	Type: Fourth left superior premolar, l.P^4, Amer. Mus. 20101 (Fig. 1).
		Paratype: Fourth right superior premolar, r.P^4, Amer. Mus. 20102 (Fig. 1).
		Referred: First right superior premolar, r.P^1, Amer. Mus. 20134 (Fig. 9).
Kholobolchi, 250′± Kholobolchi Nor Basin	*Eudinoceras kholobolchiensis* sp. nov.	Type: Complete cranium with imperfect dentition, probably female, Amer. Mus. 21744 (Figs. 2, 6).
		Paratype: Upper portion of larger cranium, probably male, Amer. Mus. 21745 (Figs. 2, 6).

The Andrews-Granger expedition of 1930 has added to the above the remains of eight coryphodonts, which greatly extend our knowledge of the evolution of the Coryphodontidæ in Mongolia. The surprising new discovery is that the coryphodonts survived as companions of the giant titanothere *Baluchitherium* to an horizon above the summit of the Eocene (Baron Sog formation).

[1]Osborn, H. F., 1930.832. Ancient Vertebrate Life of Central Asia. Discoveries of the Central Asiatic Expeditions of the Museum of Natural History in the Years 1921–1929. "Livre Jubilaire publié à l'occasion du Centenaire de la Société Géologique de France, 1830–1930," pp. 519–543.

ERRATA

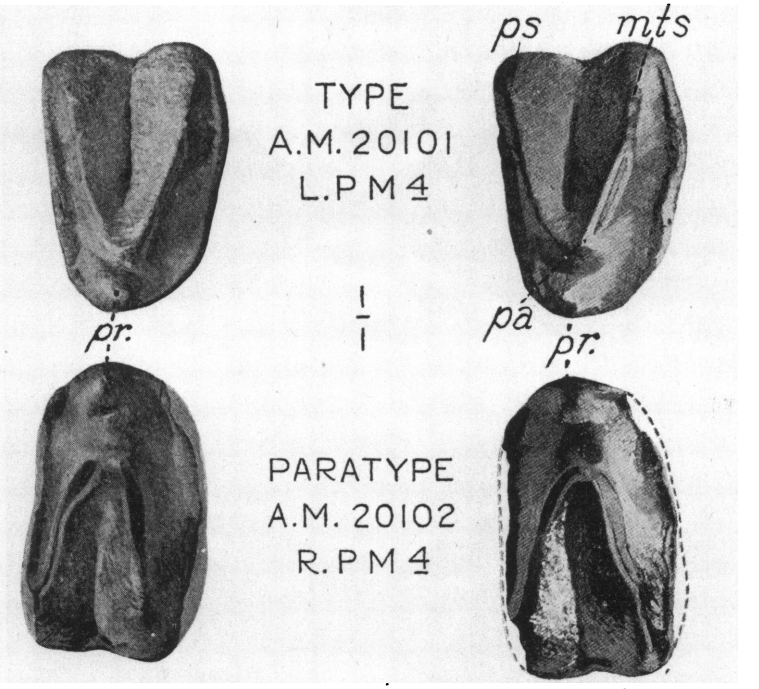
For American Museum Novitates No. 459

Page	2,	line	6	from	top:	For	Eudinoceras	kholobolchiensis	read	E.	mongoliensis
"	2,	"	9	"	"	"	"	"	"	"	"
"	2,	"	12	"	"	"	"	"	"	"	"
"	7,	"	12	"	"	"	"	"	"	"	"
"	10,	Caption	for	Fig.	7:	"	"	"	"	"	"
"	12,	Caption	for	Fig.	10:	"	"	"	"	"	"

Eudinoceras mongoliensis Osborn, 1924[1]

Irdin Manha formation, Protitanotherium grangeri life zone, southeastern Mongolia. Type (Amer. Mus. 20101) collected by Andrews June 1, 1923; paratype (Amer. Mus. 20102) collected by Osborn September 15, 1923.

The type (l.P^4) and paratype (r.P^4), i.e., fourth superior premolars of the left and right sides (Fig. 1), misinterpreted by Osborn as belonging to a progressive uintatheriid, prove to belong to a new type of cory-



TYPE FOURTH SUPERIOR PREMOLARS, LEFT AND RIGHT

Fig. 1. *Eudinoceras mongoliensis* Osb. Type (upper) and paratype (lower), Irdin Manha formation, collection of 1923. Natural size.

pa, paracone = primary cone; *ps*, parastyle; *mts*, metastyle; *pr*, protocone = secondary ingrowth from the primary paracone.

phodontid, as shown by comparison with the fourth left and right superior premolars in the geologically older specific stage *Eudinoceras kholobolchiensis* (Fig. 3). The transversely broad and anteroposteriorly compressed type and paratype premolars of *E. mongoliensis* are clearly shown in figure 1 in reversed illumination; this clearly reveals the V-

[1]See footnote 2 on page 1.

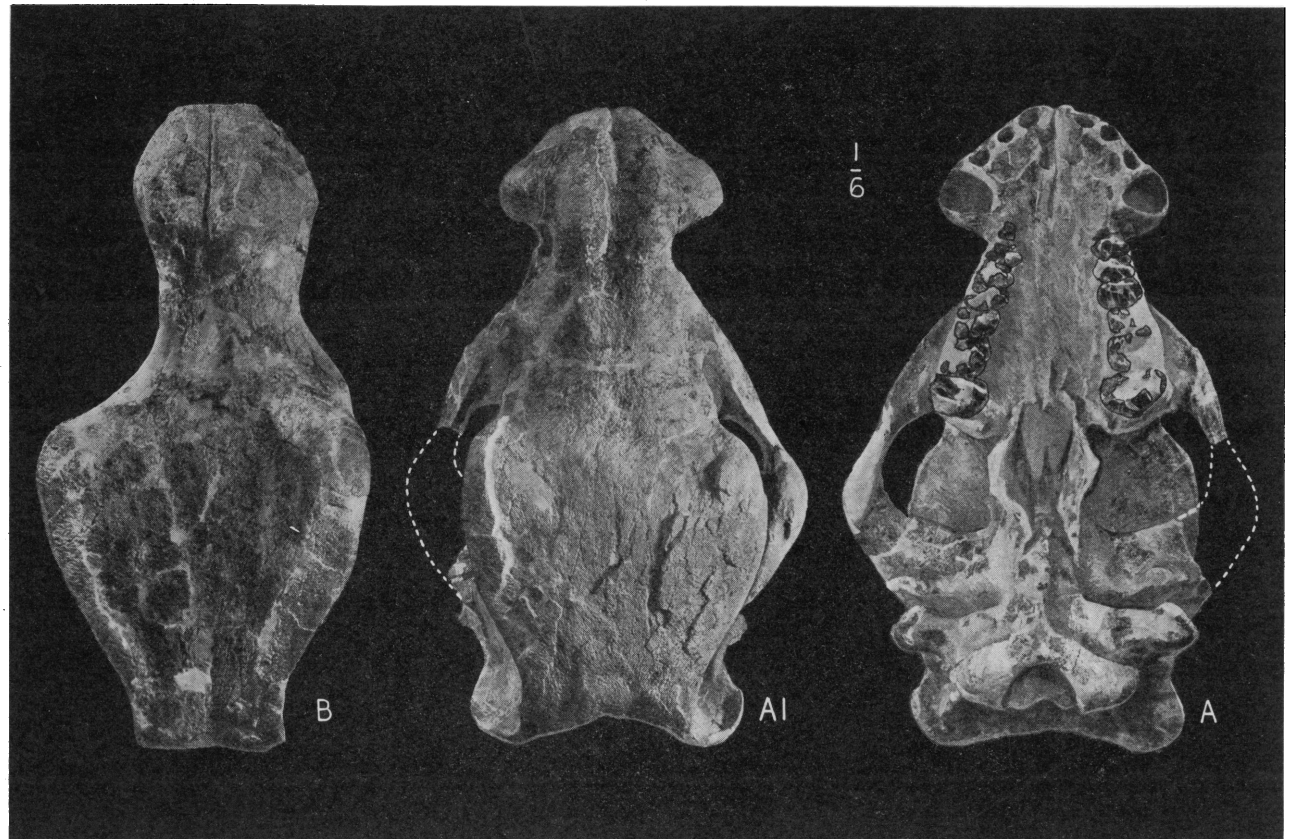


Fig. 2. *Eudinoceras kholobolchiensis.* Type and paratype crania after photographs. One-sixth natural size.

A, A1, Type cranium (Amer. Mus. 21744), superior and palatal aspects. Linear measurement tip of premaxillaries to opening of foramen magnum, 488 mm.; premaxillaries to occipital condyles, 516 mm. This is probably a *female* skull.

B, Paratype cranium (Amer. Mus. 21745). Superior aspect. This is probably a *male* skull.

shaped crests converging to the paracone (*pa*) apex, internal to which is the rudimentary protocone (*pr*); the pre- and postcingular basins are relatively narrow. In the type description and figure (Osborn, 1924.626, p. 2, fig. 2) the type and paratype premolars were transposed; comparison with *E. kholobolchiensis* (Fig. 3) proves that the type of *E. mongoliensis* (Amer. Mus. 20101) is an l.P^4, the paratype (Amer. Mus. 20102) an r.P^4, as correctly shown in the new type figure (Fig. 1).

COMPARATIVE MEASUREMENTS IN MILLIMETERS

	L.P^4			R.P^4		
	ap.	tr.	I.	ap.	tr.	I.
Eudinoceras mongoliensis Osborn						
Type (Amer. Mus. 20101)	26	36	72			
Paratype (Amer. Mus. 20102)				27	41	66
Eudinoceras kholobolchiensis sp. nov.						
Type (Amer. Mus. 21744)	25	40	62	28	39	72
Dinoceras mirabile Marsh						
Type (Yale College Mus. 1036)	23	30	77			
Dinoceras lucare Marsh						
Type (Yale College Mus. 1038)	23	28	82			

Eudinoceras kholobolchiensis sp. nov.

TYPE.—Amer. Mus. 21744. Cranium with nearly complete dentition of both sides, P^1-M^3; crowns of molars, l.M^{1-3}, partly fractured, also of r.P^1 and r.P^2; cranium and palate complete; probably female. Figures 2, 3, 6.

PARATYPE.—Amer. Mus. 21745. Upper portion of larger cranium, probably male; palatal dentition entirely wanting. Figures 2, 6.

LOCALITY AND HORIZON.—Kholobolchi formation (250 ft.), Eudinoceras kholobolchiensis life zone, yielding *Eudinoceras kholobolchiensis;* also a small perissodactyl, and unidentified material, mostly fragmentary; Kholobolchi Nor Basin, western Mongolia.

SPECIFIC CHARACTERS.—The superior molars of *Eudinoceras kholobolchiensis* type (Figs. 3 and 6, B5, B3) are much more progressive, i.e., *lophodont*, than those of *Coryphodon testis* (Fig. 4) which are selenolophodont. The premolars of *E. kholobolchiensis* differ widely in the small, conical protocone (*pr*) from those of *C. testis* with a crescentic protocone; they differ from those of *E. mongoliensis* (Fig. 1) in the shallower and less compressed trigon (=*pa, ps, mts*), also in the much larger protocone and pre- and postcingular shelves.

DENTITION

PREMOLARS.—According to the above measurements the type upper premolars (Fig. 3) differ from those of *Eudinoceras mongoliensis* in measurement, proportion, length, breadth, and anteroposterior-transverse index, also in greater prominence of the conical protocone (*pr*);

like the American coryphodonts, e.g., *Coryphodon testis* of Wyoming (Fig. 4), they retain four functional premolars, unlike the uintatheres (*Dinoceras lucare*—Fig. 8) in which only three premolars are retained. The first upper premolar, r.P^1, as shown in the type (Fig. 3) of *E. kholobolchiensis* and in (Fig. 9) *E. mongoliensis* ref., quite closely re-

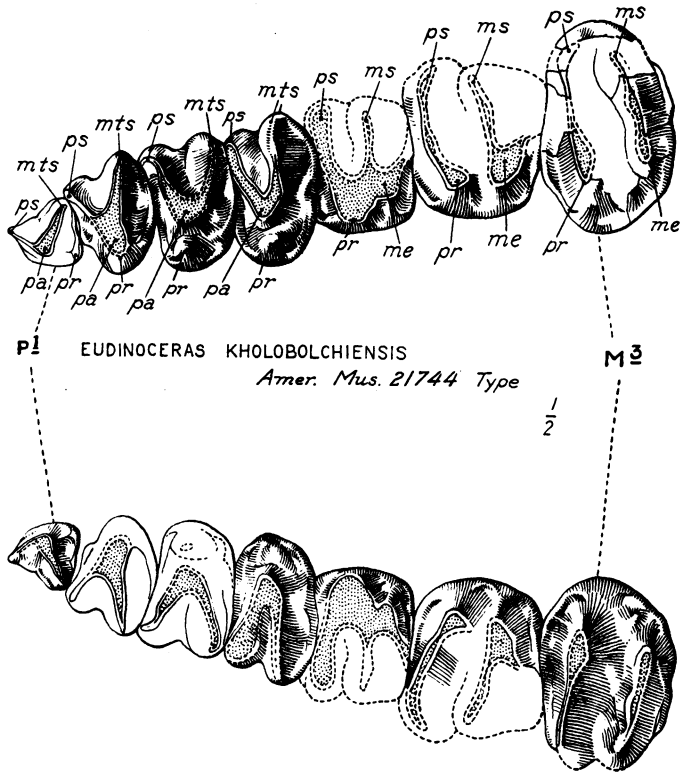


Fig. 3. *Eudinoceras kholobolchiensis* sp. nov. Superior grinding teeth (P^1-M^3) of type skull (Amer. Mus. 21744). One-half natural size.

CUSP HOMOLOGIES AS DETERMINED BY SIMPSON, 1929

pa, primary cone of premolars (probably paracone+metacone).
ps, parastyle (antero-external secondary style).
mts, metastyle (postero-external secondary style).
pr, protocone (secondary internal cone), compare figure 1(*pr*).
me, metacone (postero-internal cone of molars).
ms, mesostyle (median external style).

Observe that in P^4 of *Eudinoceras kholobolchiensis* the protocone (*pr*) and the internal cingulum are much stronger than in the type of *E. mongoliensis*.

sembles that of *C. testis* (Fig. 4). The other premolars, P^{2-4}, present small conical protocones instead of the broad crescentic protocones of *C. testis*.

MOLARS.—The superior molars, M^{2-3}, of the type of *Eudinoceras kholobolchiensis* (Fig. 3—½ nat. size) quite closely resemble those of *Coryphodon testis* (Fig. 4—½ nat. size). In M^3, however, the posterior crest (*ms–me*) is much longer and more nearly parallel to the anterior

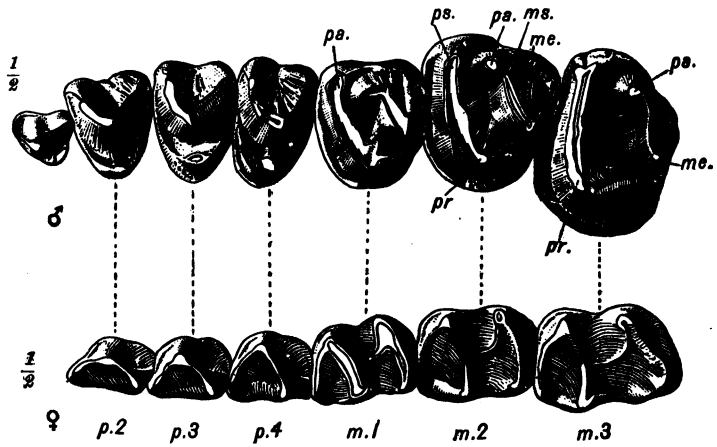


Fig. 4. *Coryphodon testis*, Lower Eocene, middle Wasatch levels of Wyoming. After Osborn, 1898.148, p. 204, fig. 22. One-half natural size.

(Upper) Superior grinding series of the left side, male (Amer. Mus. 274).

(Lower) Inferior grinding series of the right side, female (Amer. Mus. 2868).

The molar and premolar homologies are on the older Cope-Osborn system rather than on the newer Gregory-Simpson system shown in figure 3.

crest (*ps–pr*) than in *C. testis* (*pa–me*—Fig. 4); in none of the Wasatch, Wyoming, coryphodonts is the posterior crest or metaloph so fully developed or lophoid.

Similarly in the referred inferior molar (Amer. Mus. 26130—Fig. 10) of *Eudinoceras kholobolchiensis* the anterior and posterior transverse crests (pr^d–me^d = protolophid, hy^d–en^d = hypolophid) are parallel, directly transverse, or lophoid.

In brief, the premolars and molars of *Eudinoceras* represent a specific and generic line of evolution independent from that of the American coryphodonts, but, as with the cranium, the premolars indicate that this phylum is much nearer *Coryphodon* than *Uintatherium* (= *Dinoceras*). Finally, this phylum cannot be derived from that of the Lower Eocene

Pantolambda, in which the premolars have crescentic internal protocones, or from the Upper Cretaceous *Protolambda* (Osborn, 1898.148, p. 172[1]), in which the crescentic premolar protocones are strongly developed as in the American *Coryphodon;* consequently the *Eudinoceras* phylum of Coryphodontidæ seems very ancient.

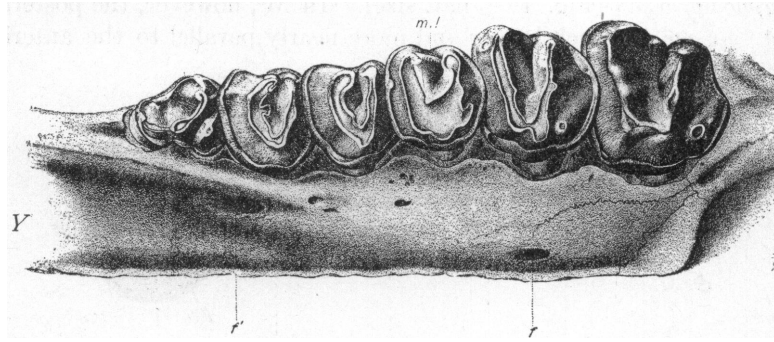


Fig. 5. Superior premolar-molar series, l.P^2-M^3 (P^1 is absent in *Dinoceras*), of *Dinoceras lucare* Marsh. One-half natural size. After Marsh (Monograph of the Dinocerata, 1884, Pl. IX). Compare figure 8.

CRANIUM

The cranium, male and female, is clearly illustrated in superior, palatal, lateral, and anterior aspects (see Figs. 2, 6), so that detailed description is unnecessary. In dimensions it is closely similar (see Osborn, 1898.148, figs. 20, 21) to the next to largest known American crania of the Lower Eocene, namely, *Coryphodon testis* and *C. elephantopus*.

COMPARATIVE MEASUREMENTS IN MILLIMETERS

	Coryphodon elephantopus	*Coryphodon testis* Male	*Eudinoceras kholobolchiensis* Type, female, (Amer. Mus. 21744)	*Eudinoceras kholobolchiensis* Paratype, male, (Amer. Mus. 21745)
Length: Premaxillaries to occipital condyles	440e	514	516	570
Breadth: Transverse zygomata			360	
Breadth: Across summit of cranium			230	280

To these major proportions we may add, as a tribute to our late lamented colleague, Dr. William Diller Matthew, a direct citation from

[1]Osborn, H. F., 1898.148. Evolution of the Amblypoda, Part I. Taligrada and Pantodonta. Bull. Amer. Mus. Nat. His., Vol. X, Art. XI, pp. 169–218.

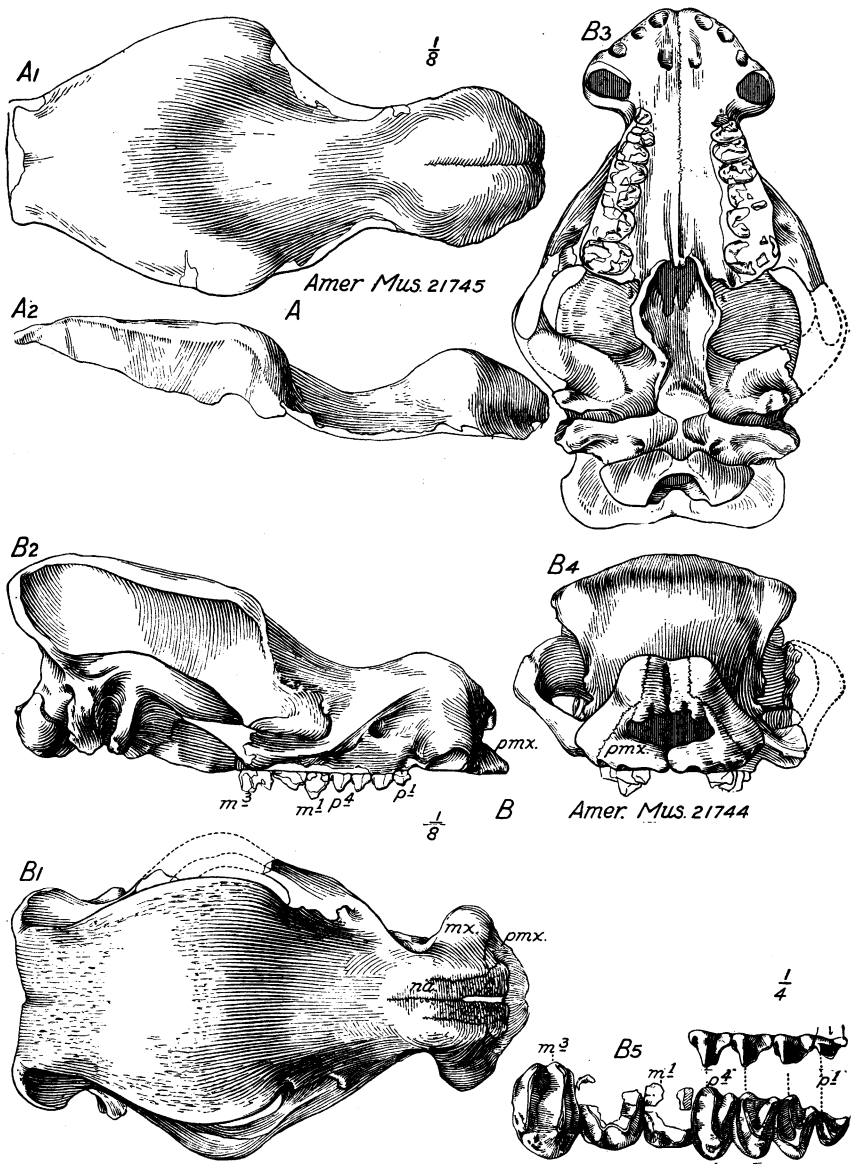


Fig. 6. *Eudinoceras kholobolchiensis.* Type and paratype crania; superior dental series. Crania of uniform one-eighth reduction; teeth one-fourth natural size.

A1, A2, *Eudinoceras kholobolchiensis* paratype (Amer. Mus. 21745). Top and side views of supposed adult *male* cranium (compare Fig. 2B).

B1–B5, *Eudinoceras kholobolchiensis* type cranium (Amer. Mus. 21744).

B1, superior aspect (compare Fig. 2A1).

B2, right lateral aspect.

B3, palatal aspect (compare Figs. 2A and 3).

B4, anterior aspect.

B5, superior dental series (composition of two sides), compare figure 3.

his observations and measurements of the same type cranium of *Eudinoceras kholobolchiensis*, made at the American Museum headquarters in Peking during the winter of 1925–1926 (letter dated May 26, 1926).

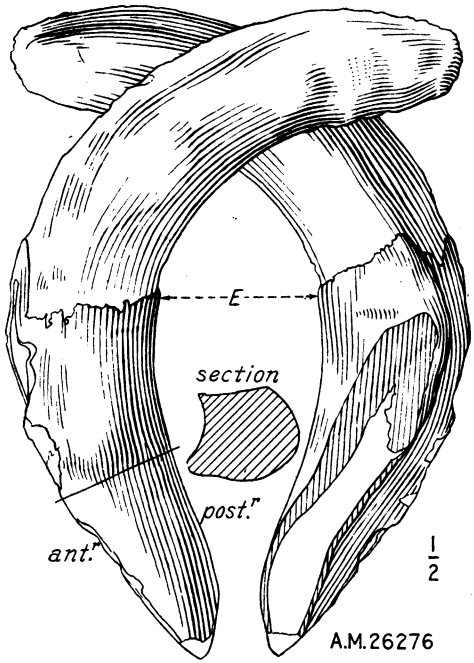


Fig. 7. *Eudinoceras kholobolchiensis* ref. Left superior canine tooth (Amer. Mus. 26276), external and internal aspects and section of mid-crown. This is possibly a male tooth belonging to the paratype male cranium (Amer. Mus. 21745) of larger size (compare Fig. 2B, and 6A).

DESCRIPTION BY WILLIAM DILLER MATTHEW

Field No. 544. Coryphodontid skull, found by Buckshot 7–8 m. south of camp on Kholobolchi Nor.

General proportions of skull much like *Coryphodon* but exaggerated, and with a large maxillary boss above the canines. Not clear how far back nasals extend; the frontals may come up to form at least the back of this boss; the superior branch of premaxilla extends up to brace it on fronto-external face. Broad flattened top composed probably of frontals, parietals and supra-occipitals, but sutures not clearly distinguishable. Lachrymal tubercle prominent on margin of orbit which is small and very shallow, no definite postorbital processes on either frontal or jugal side. Jugal extends up in long superior branch forming a strong bridge anteroposteriorly from anterior end of zygoma. Canines very large, strongly flaring. The top is wider than in any known *Coryphodon*.

Teeth coryphodontid except that premolars have reduced internal crescent, molars shattered, but the last appears to be somewhat like *Metalophodon* [Cope], only more transversely oval.

Characters suggest a specialized descendant of *Coryphodon* intermediate between the American species and *Eudinoceras* in the premolar construction, but much nearer to the latter. If *Coryphodon* represents Lower Eocene stage and *Eudinoceras* early Upper Eocene, this might be

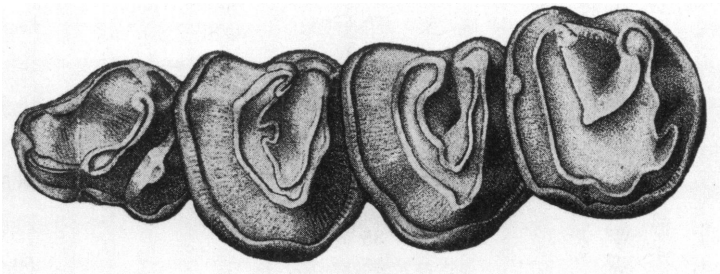


Fig. 8. Superior premolars, l.P^2-M^1, of *Dinoceras lucare* Marsh. Natural size. After Marsh (Monograph of the Dinocerata, 1884, Pl. IX). Compare figure 5.

Observe resemblance to premolars of *Eudinoceras* (Figs. 1 and 3).

late Middle Eocene. Note that *Metalophodon* is from the Black Buttes Lower Eocene, which appears to be a rather advanced form in its tendency to transverse crests on molars.

Note that in [Field] No. 544 there is an apparent tendency to reduce the anterior wing of the premolars, leaving the posterior wing as a straight transverse crest. The whole evolutionary tendency in the dentition would seem to be towards tapiroid transverse cresting in molars and premolars. This same tendency is seen in some of the Irdin Manha [contains genotype *Eudinoceras mongoliensis* Osb.] and Shara Murun perissodactyls (*Depéretella*, etc.).

Remarkable fact that no trace of an amblypod foot bone has turned up in any of the Mongolian Eocene (except in the Gashato Paleocene).

[Comparative Measurements in Millimeters

Type Cranium (Amer. Mus. 21744) and Dentition]

Length of skull, condyles to pmx inclusive					516
" " occiput to nasals					502
Breadth of skull, across zygomata (one side est'd)					380 [360]
" condyles					165 [159]
" across mastoid processes (ab't)					260
" " postglenoid processes					254
Length, postglenoid to condyles inclusive (ab't)					120
" dentition, incisive alveolus to M^3 incl.					284.5
" cheek teeth, P^1-M^3					177
" posterior nares to condyles					263
Breadth of palate across M^3					200
" palate in front of P^1					94
" across canine alveoli					200
Diam. of I^1	alveolus,	anteropost.	15	Transverse	20
" I^2	"	"	16.5	"	17
" I^3	"	"	17.5	"	16.5e
" C^1	"	"	36	"	47.5
" P^1		"	17.5	"	16.5
" P^2		"	22.5	"	32
" P^3		"	23.5	"	35
" P^4		"	22.3 [25]	"	38.5
" M^1		"	26.5	"	
" M^2		"	35	"	
" M^3		"	35	"	50.5

Fig. 9

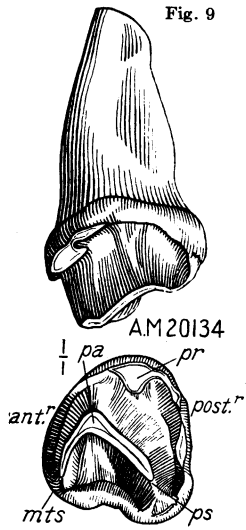


Fig. 10

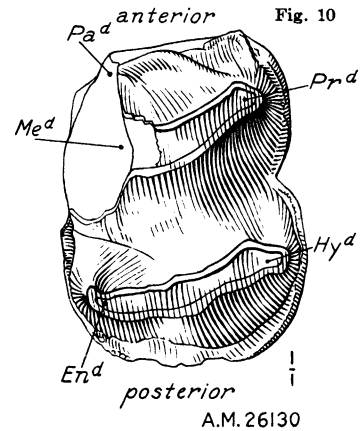


Fig. 9. *Eudinoceras mongoliensis* ref. First superior premolar of the right side, r.P^1. Natural size. Amer. Mus. 20134. For comparison with the corresponding premolar, r.P^1, of *Coryphodon testis* of the Lower Eocene, middle Wasatch levels of Wyoming. See figure 4.

Fig. 10. *Eudinoceras kholobolchiensis* ref. Second right inferior molar, r.M_2 (Amer. Mus. 26130). Observe that this tooth is similar to that of the r.M_3 of *Coryphodon testis* (Fig. 4).

Pa^d, paraconid; *pr^d*, protoconid; *me^d*, metaconid; *hy^d*, hypoconid; *en^d*, entoconid.

CONCLUSIONS

While concurring with the above cranial description by Matthew, the present authors await further material obtained in 1930 to determine whether or not the premolar evolution shown in these two species of *Eudinoceras* is, as Matthew implies, a retrogressive simplification and fore-and-aft compression of the Lower Eocene doubly crescentic premolar of *Coryphodon testis*, namely, by the degeneration of the internal protocone (*pr*) from the internal crescent observed in the Lower Eocene coryphodont premolars both of the Wasatch (Fig. 4) and Soissonnais (Fig. 11). In this more or less prominent internal crescent the *Coryphodon oweni* Hébert (after Hébert, 1857) agrees with all the species described by Cope from the American Wasatch.

The reverse interpretation is that this internal protocone (*pr*) is progressively increasing in size, as suggested by Osborn in his description of *Eudinoceras mongoliensis*. This suggestion will be put to the proof by the subsequent Oligocene stage of *Eudinoceras* discovered by us in 1930.

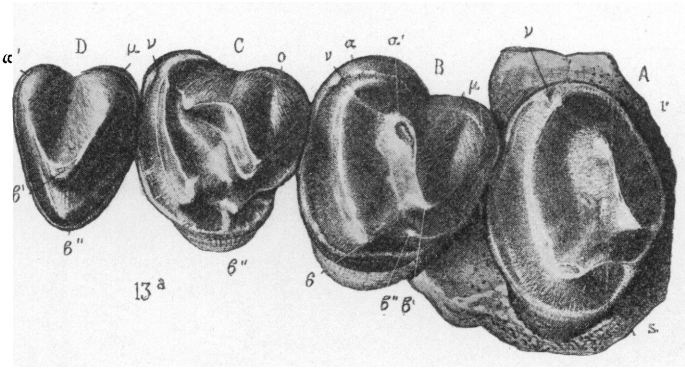


Fig. 11. Left superior grinders, P^4-M^3, of *Coryphodon oweni* Hébert, natural size, after Hébert, Ann. Sci. Nat., Ser. IV, Tome VI, 1856, Pl. III, fig. 13a.

These Soissonnais molars are slightly more progressive than those of *Coryphodon testis* (Fig. 4) in the reduction of the median external cusp (*a'*), which is slightly stronger in *C. testis* (Fig. 4, *pa*). This evolution from the Soissonnais to the Wasatch form consists of the conversion of the metaloph into a simple transverse lophoid crest, by the loss of the distinctive foldings marked *pa*, *ms*, *me* in figure 4.