213-235

103 A

Oligocene - Early Miocene Ruminants from the Valley of Lakes (Central Mongolia)

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(With 9 text-figures, 1 table and 1 plate)

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Abstract

Fossil ruminants from Oligocene and Lower Miocene deposits in Mongolia are referred to six families and 17 genera. New data support the stratigraphic model based on rodent biozonation and ⁴⁰Ar/³⁹Ar-dating of basalts. The occurrence of the gelocids *Paragelocus* and *Pseudogelocus* and diverse bovids are first recorded from the Late Oligocene of Asia. *Pseudogelocus mongolicus* n. sp. is described.

Zusammenfassung

Aus dem Oligozän und Unter-Miozän der Mongolei wurden Ruminantia beschrieben, die 6 Familien und insgesamt 17 Gattungen angehören. Sie unterstützen das Stratigraphie-Konzept das auf der Biozonierung nach Nagetieren und auf der ⁴⁰Ar/³⁹Ar-Datierung von Basalten beruht. Es gelang der erste Nachweis der Gelocidae *Paragelocus* und *Pseudogelocus* und einer Vielfalt von Boviden des Ober-Oligozäns in Asien. *Pseudogelocus* n. sp. wird neu beschrieben.

Introduction

The present paper describes ruminant remains collected in the Valley of Lakes in Central Mongolia during the 1995-1997 field seasons. The work was carried out in the frame of a joint Austrian-Mongolian project (FWF: P-10505-GEO) and as a part of interdisciplinary studies in the course of the IGCP project Nr. 326 "Oligocene-Miocene Transition in the Northern Hemisphere".

The mammal faunal succession in the Valley of Lakes is very important for the Oligocene - Early Miocene mammalian biochronology because the faunal sequence has been calibrated there with radiometrically dated basalts. Throughout the Hsanda Gol and Loh Formations, several biozones were established based on rodent assemblages (DAXNER-HÖCK et al. 1997, HÖCK et al. 1999). Three basalt layers serve as geochronologic markers. The main stages in the evolution of ruminants in Mongolia, and their correlation with global climatic changes, were based first on the study of ruminant remains

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Fig. 1a: Localities of ruminants collected by the Austrian-Mongolian team in Mongolia.

collected from the same deposits by the Mongolian Paleontological Expedition of the USSR Academy of Sciences in the 1950s and by the Joint Soviet-Mongolian Paleontological Expedition in the 1970s and 1980s. The material is stored in the Paleontological Institute of the Russian Academy of Sciences (PIN). Two major adaptive radiations of ruminants in Asia occurred at the Eocene-Oligocene and Oligocene-Miocene transitions (VISLOBOKOVA 1996, VISLOBOKOVA et al. 1996, VISLOBOKOVA 1997). The first of these radiations led to the increase in diversity of traguloids and the first appearance of pecorans (cervids and bovids). These bio-events were related to the aridification in Central Asia caused by the global cooling, the dropping of World Ocean level and the desappearance of continental seas from the huge territories of Western Siberia and Turgai. The second



Fig. 1b: View of the Taatsiin Gol valley near Tsagaan Ovoo, and the plateau towards west. The brick red sediment layers represent the lower Hsanda Gol Formation which is overlain by the dark basalt layer (basalt I) of 15-20 m in thickness. The Hsanda Gol sediments above basalt I are not visible from the view point. The brownish sediments on top are parts of the Loh and the Tuyn Gol Formations. In front the tent of a local nomad family. (Photo from G. DAXNER-HÖCK).

adaptive radiation led to the increase in diversity of pecorans and to the appearance of new subfamilies of cervids and bovids due to marked humidization and increase of the variety of bitopes in Asia caused by the global warming. In the Valley of Lakes, three stages in the evolution of ruminants corresponded to the intervals 34-32 Ma, 32-29.5 Ma, and 29.5-22 Ma (VISLOBOKOVA 1996, VISLOBOKOVA et al. 1996, VISLOBOKOVA 1997).

The new ruminant fossils, recovered from 1995-1997 (Austrian-Mongolian joint project), support the sequences and stages in ruminant evolution and dispersal established on the PIN material. The new data also coincide well with the rodent data and support the characterization and the stratigraphic range of most biozones. Moreover, the ruminants provide new data on the evolution and occurrence of ancient gelocids and bovids. This fossil material is kept at the Natural History Museum in Vienna (NHMW), Inv. Nr: NHMW2001z0069-0120.

Abbreviations used in this paper are: DAP, anteroposterior diameter; DT, transverse diameter; L - length; W - width. Abbreviations for locality names are as follows: TGL – Taatsiin Gol left; TGR- Taatsiin Gol right; TGW- Taatsiin Gol west (=Khunug Valley); SHG - Hsanda Gol; DEL - Del; TAT - Tatal Gol; IKH - Ikh Argalatyn Nuruu; UNCH -Unkheltseg; UTO - Ulaan Tolgoi; HL - Khongil; * - surface collecting.

Systematic paleontology

Suborder Ruminantia

The not abundant but representative fossil remains of ruminants from 10 localities (Fig. 1) belong to 6 families and 17 genera.

Praetragulidae VISLOBOKOVA, 2001

The family comprises the Asian genus *Praetragulus* and two American genera *Simimeryx* and *Parvitragulus* (VISLOBOKOVA 2001).

Praetragulus VISLOBOKOVA, 1998

Praetragulus gobiae (MATTHEW & GRANGER, 1925)

M a t e r i a l: Fragments of lower jaw with m1 and m1-m3; TAT-D/1; Coll. NHMW 2001z0096/0001/1-2. Lower jaw with p4; TGR-B*; Coll. NHMW 2001z0097/0001/1.

M e a s u r e m e n t s (in mm):

	p4	m1	m2
L	6.7	7-7.3	8.7
W	5.5	4.5-4.6	5.3

R e m a r k s: The tooth structure and size correspond to those of *Praetragulus gobiae* (*= Lophiomeryx gobiae*) known from the Late Eocene of Ergilin-Dzo (*=*Ardyn Obo) and from the Early Oligocene of Tatal-Gol (MATTHEW & GRANGER 1925; VISLOBOKOVA 1998). The specimens differ from another species of the genus, *P. electus* from the Early Oligocene of Khoer-Dzan, by their smaller size, a relatively long p4, the lower molar-crowns and by a larger mesostyle.

Archaeomerycidae SIMPSON, 1945

The group was established as a subfamily within the Tragulina by SIMPSON (1945) with a single genus *Archaeomeryx*. The family rank was introduced by VISLOBOKOVA & TROFIMOV (2000).

It currently comprises four genera: *Archaeomeryx*, *Miomeryx*, *Xinjiangmeryx* and *Notomeryx* (VISLOBOKOVA & TROFIMOV 2000, VISLOBOKOVA 2001). The NHMW collection contains only *Miomeryx*.

Miomeryx MATTHEW & GRANGER, 1925

Miomeryx sp.

M a t e r i a l and m e a s u r e m e n t s (in mm): M3 (7.6 × 6); TGR-AB/21; Coll. NHMW 2001z0103/0001. M2; TGR-AB/22/2; Coll. NHMW 2001z0104/0001. P4; TAT-D1; Coll. NHMW 2001z0105/0001.

R e m a r k s: The molar crowns are low, weakly crescentic, with well-developed parastyle and mesostyle and a strong cingulum. The teeth are indistinguishable from those of *Miomeryx*. *Miomeryx* from Taatsiin Gol right differs from *Archaeomeryx* by the relatively narrow crowns of M2 and M3, a weaker metastyle, a more developed pillar of the paracone, and by a larger size. *Miomeryx* and *Archaeomeryx* were originally referred to the Hypertragulidae (MATTHEW & GRANGER 1925). *Miomeryx* was described based on the upper jaw with P2- M3. The new data confirm a close relationship of this genus with *Archaeomeryx* (VISLOBOKOVA & TROFIMOV 2000, VISLOBOKOVA 2001).

Gelocidae SCHLOSSER, 1886

Gobiomeryx TROFIMOV, 1957

Gobiomeryx dubius TROFIMOV, 1957

M a t e r i a l: Lower jaw with m2-m3; TAT-D/1; Coll. NHMW 2001z0098/0001/1. 9 molars; TAT-D/1; Coll. NHMW 2001z0098/0002/1-9.

M e a s u r e m e n t s (in mm):

	n	min	max	mean
m1 L	2	6.6	6.7	6.65
W	2	4.3	4.6	4.4
m2 L	3	7.5	7.8	7.66
W	3	5.0	6.5	5.5
m3 L	2	9.3	10.0	9.65
W	2	4.0	4.3	4.15

D e s c r i p t i o n and r e m a r k s: The teeth correspond well to those of *Gobiomeryx dubius* in size and in the very low and narrow crowns, a two-cusped third lobe (talonid) with an additional tubercle in front of the hypoconulid, and in a well-developed ecto-stylid. The species was described from the Early Oligocene of Erguil Obo (=Ergilin-Dzo or Ardyn Obo) based on a fragment of a lower jaw with m1-m3 (TROFIMOV 1957).

Gobiomeryx sp.

(Fig. 2)

M a t e r i a l and m e a s u r e m e n t s: $1 m1(6.6 \times 4.3)$; HL-A/2; Coll. NHMW 2001z0099/0001/1. M2 (6.8 × 8.8); SHG-A/18-20; Coll. NHMW 2001z0100/0001/1. 1 m1 (6.7 × 4.6); SHG-A/18-20; Coll. NHMW 2001z0100/0001/2. 1 M2, 1 m2; SHG-A/18-20; Coll. NHMW 2001z0100/0001/2-3. Lower jaw with p2-p3 (4.7 × 2; 6.3 × 2.8); TGR-AB/22; Coll. NHMW 2001z0101/0001/1. 1 m3; SHG-AB/12; Coll. NHMW 2001z0102/0001/1.

R e m a r k s: The major specimens are about the same size as the type species, yet cannot be identified on the species level.

Pseudomeryx TROFIMOV, 1957

Pseudomeryx gobiensis TROFIMOV, 1957 (= P. hypertalonidus TROFIMOV, 1957) (Plate 1, Fig. 1)

M a t e r i a l: 1 p4; SHG*; Coll. NHMW 2001z0106/0001. 9 teeth; TAT-D/1; Coll. NHMW 2001z0107/0001/1-9. Lower jaw with p3; TAT-D*; Coll. NHMW 2001z0108/0001/1.

M e a s u r e m e n t s (in mm):

	N	min	max	mean
p4 L	2	6.0	6.3	6.15
W	2	3.1	3.2	3.15
m1 L	2	6.0	6.3	6.15
W	2	4.2	4.3	4.25
m2 L	2	6.5	6.5	6.5
W	1	4.5		4.5
m3 L	3	9.2	9.4	9.26
W	3	4.2	4.2	4.2

R e m a r k s: The p4 is without the entoconid and has a posteriorly elongated metaconid, forming an almost closed fossettid with the hypoconid. The m3 possesses a complex third lobe (talonid) with two crescents and with a posterior tubercle. *Pseudomeryx gobiensis* was described based on the fragment of the lower jaw with m1-m3 from Tatal Gol (TROFIMOV 1957). The teeth from the NHMW collection differ from the type of *P. gobiensis* in a less elongated separate posterior tubercle; this is within the variation of the species. They are in all respects indistinguishable from additional material of *P. gobiensis* in the PIN collection and are assigned to this species.

Pseudomeryx sp.

M a t e r i a l: 1 p4; IKH-A/1; Coll. NHMW 2001z0112/0001. 1 m1; TAT-D/3; Coll. NHMW 2001z0109/0001. Lower jaw with m1; TGR-AB/22; Coll. NHMW 2001z0110/0001. 1 m3; TGR-B*; Coll. NHMW 2001z0111/0001. 1 m3; UNCH-A/3; Coll. NHMW 2001z0113/0001.

M e a s u r e m e n t s (in mm):

	p4	m1	m3
L	7.2	6.7	10-11
W	3.5	3.8	4.2-4.6

R e m a r k s: The teeth seem to be too large to be within the size range of *P. gobiensis* and are attributed to *Pseudomeryx* sp.

Prodremotherium FILHOL, 1877

Prodremotherium sp. (Plate 1, Figs. 2-4)

M a t e r i a l: 1 m2; IKH/1-2; Coll. NHMW 2001z0092/0001;1 m3; IKH-A/1-2; Coll. NHMW 2001z 0092/0002. Lower jaw with d4-m1; IKH-A/2-4; Coll. NHMW 2001z0093/0001.

Measurements:

	d4	m1	m2	m3
L	7.5	8.5	7.5	
W	3.2	4.7	5.8	5.8

R e m a r k s: The tooth structure is similar to that of *Prodremotherium* but is insufficient for determination on the species level. *Prodremotherium* ranged across Europe and Asia in the Oligocene. With regard to size, the form from the Ikh Argalatuyn Nuruu locality is somewhat smaller than *P. elongatum* from Quercy and approaches *P. trepidum* from the Late Oligocene of the Benara locality, Georgia (GABUNIA 1964). In Mongolia, a small *Prodremotherium* was discovered in Shunkht (VISLOBOKOVA 2001).

Pseudogelocus SCHLOSSER, 1902

Pseudogelocus mongolicus sp. nov.

(Plate 1, Figs. 5-11)

Derivatio nominis: The species is named after Mongolia.

Type locality: Taatsiin Golright (Plate 1, Fig. 10).

Holotype: p4; Coll. NHMW 2001z0070/0001/1.

T y p e 1 e v e l: TGR-AB/22/2.

O t h e r l o c a l i t i e s: Tatal Gol; Taatsiin Gol left; Ikh Argalatyn Nuruu.

D i a g n o s i s: On unworn p4 protoconid with double posterior wing (protocristid), metaconid enlarged in anteroposterior direction and almost confluent anteriorly with paraconid; entoconid with small additional crest; *Palaeomeryx* fold present.

D i f f e r e n t i a l d i a g n o s i s: Other than *P. suevicus*, *P. mongolicus* has a more complicated occlusal pattern of p4 with a double posterior wing of the protoconid and with a small additional crest at the entoconid.

M a t e r i a l: Lower jaw with p1-p3; TAT-D/1; Coll. NHMW 2001z 0069/0001. 1 d4; TAT-D/1; Coll. NHMW 2001z0069/0002. M3; TAT-D/1; Coll. NHMW 2001z0069/0003. M2; TGR-AB/22/2; Coll. NHMW 2001z0070/0003. M2; TGR-AB/22/2; Coll. NHMW 2001z0070/0002. 1 p4; TGR-AB/22/2; Coll. NHMW 2001z 2/0001. 1 m2; TGR-AB/22; Coll. NHMW 2001z 3/0001. 1 m1; TGL-A/11a; Coll. NHMW 2001z0072/0001. 1 m1; IKH A*; Coll. NHMW 2001z0073/0001.

	M2	d4	p1	P2	P3	p4	m1	m2
L	7	5.5	1.7	2.5	5.7	5.3	5.2-5.4	5.6
W	5.2-5.3	2.3			1.8	2.7	3.2-3.5	3.5

D e s c r i p t i o n: M2 and M3 have a well-developed metaconule and an additional small tubercle situated anterior to this cusp, a strong cingulum, and an oval entostyle in section. The mesostyle and pillar of the paracone are very strong. The latter is bent anteriorly. On M3, the posterior wing of the protocone is primitively short and directed posteriorly and slightly bucally. On the worn M2 (NHMW 20001z0071/0001), the "cristid" between the inner side of the paracone, the posterior wing of the protocone and the

anterior wing of the metaconule form a low and wide triangle directed lingually.

On d4, the anterior lobe has parallel outer and inner crests. The valleys of the anterior and medial lobes are widely confluent. The medial and posterior lobes are narrowly open posterolingually. The outer cusp of the medial lobe possesses two wings directed obliquely backwards: the first - very weak and low - reaches the anterior wing of the posterior outer cusp; the second ends lingually in the valley between the medial and posterior crests. The posterior wing of the posterior lingual crest is long but is not confluent with a strong posterior lingual style. The cingulum is well developed. Two flattened ectostyles are present. The p1 is present. The diastema between p1 and p2 is not developed. The p2 is very short with a high and pointed protoconid and with a pronounced paraconid and parastylid. The p3 is very elongated, about twice as large as p2. On this tooth, the paraconid is less developed than in p2, the protoconid is slightly displaced anteriorly, a weak metaconid is directed obliquely backwards, and the posterior wings of the entoconid and hypoconid are directed to the posterior angles of the crown. The p4 has a well-developed bifurcated paraconid and parastylid. An enlarged anteroposterior metaconid is almost confluent anteriorly with the paraconid. A very elongated wing of the entoconid possesses a small additional fold. The protoconid is slightly displaced anteriorly, with a double posterior wing (protocristid). The hypoconid is confluent with the entostylid. The m1 is clearly crescentic, with a very long anterior wing of the hypoconid, a well-developed cingulum and with a low and flattened ectostylid. A very small *Palaeomeryx* fold is present on the posterior wing of the protoconid, beginning from the second third of the crown height. The anterior border of the crown of m1 is transversely enlarged.

R e m a r k s: The genus *Pseudogelocus* was known only from Europe. The genus was stated by SCHLOSSER (1902) with a single species *P. suevicus* based on a fragment of the lower jaw with p4 and m1 from Oerlinger Thal. HEISSIG (1978) combined that species with *Paragelocus scotti*, described by SCHLOSSER (1902) from Hochberg and Veringestadt, into one species *Pseudogelocus scotti* (see SUDRE & BLONDEL 1996). However, the morphological differences of the holotypes of the type species testify to the validity of both genera. The remains of *Pseudogelocus* from Mongolia have revealed additonal differences between them. The p4 and m1 from Mongolia are similar to the holotype of the type species *P. suevicus*, in size, proportion and general structure. It is assigned to this genus, but the p4 differs in certain peculiar features which are reflected in the greater complexity of its occlusal pattern.

M e a s u r e m e n t s (in mm):

Paragelocus SCHLOSSER, 1902

Paragelocus aff. scotti SCHLOSSER, 1902 (Plate 1, Figs. 12-15)

M a t e r i a l: M3 ; TGW-A*; Coll. NHMW 2001z0089/0001. M3; UNCH -A*; Coll. NHMW 2001z0090/0001. Upper jaw with P2-P3; UNCH-A*; Coll. NHMW 2001z0090/0002. 1p3; UNCH-A*; Coll. NHMW 2001z0090/0003.

M e a s u r e m e n t s (in mm):

	P2	P3	M3	p3
L	5.8	6	6.2	5.2
W	3.5	4.5	7.8-8	2.4

D e s c r i p t i o n and r e m a r k s: P2 has a very weak protocone. On P3, the protocone is more developed, conical or weakly crescentic.

The transversely elongated crown of M3 is strongly narrowed posteriorly: the posterior edge of the crown is about thirty percent shorter than its anterior edge. A transverse cristid is present between the inner side of the paracone, the posterior wing of the protocone and the anterior wing of the metaconule.

The upper molars resemble – in their size and strongly compressed transverse parastyle, their enlarged, almost confluent meso- and metastyles, their bifurcated anterior wing of the metaconule and by the presence of the fold of the protocone and a strong cingulum at the base of the protocone – those of *Paragelocus scotti* from Veringestadt and *P*. cf. *scotti* from Mas de Got (Quercy) (SCHLOSSER 1902; SUDRE & BLONDEL 1996).

The structure of p3 from Unkheltseg closely resembles p4 of *P. scotti* from Hochberg, although it possesses a stronger paraconid and the weaker metaconid and entoconid. These differences reflect a typical trend in the molarization of the premolars of most tragulines.

The teeth from Mongolia have some similarities with the teeth of a gelocid from Detan, Czechoslovakia, described as *Pseudogelocus* (FEIFAR 1987) but more likely belonging to *Paragelocus*. The genus *Paragelocus* was regarded as being congeneric to *Gelocus* (GINSBURG & HUGUENEY 1987) or to *Pseudogelocus* (HEISSIG 1978; FEIFAR 1987; SUDRE & BLONDEL 1996), but it undoubtedly represents a separate genus. The valid name of its type species is *Paragelocus scotti*. Its synonyms are *Pseudogelocus scotti*, *Iberomeryx matsoui* and *Cryptomeryx matsoui* (SUDRE & BLONDEL 1996). The Mongolian species is closely related to *P. scotti* from Hochberg and Veringestadt described by SCHLOSSER (1902).

Lophiomerycidae JANIS, 1987

Lophiomeryx POMEL, 1853

Lophiomeryx angarae MATTHEW & GRANGER, 1925

M a t e r i a l and m e a s u r e m e n t s : Lower jaw with p3-p4 (8×3.2 ; 7.8 × 4.1); SHG-basis; Coll. NHMW 2001z0076/0001. Fragmentary M3; TAT-D/1; Coll. NHMW 2001z0077/0001.

Re m a r k s: The specimen is indistinguishable in size and structure from the type of *Lophiomeryx angarae* described from Ergilin Dzo (Ardyn Obo) (MATTHEW & GRANGER 1925). The species occurred in the Late Eocene and Early Oligocene of Mongolia (VISLOBOKOVA 1997).

Lophiomeryx sp.

(Fig. 3)

M at erial and m e as ur e m ents: Lower jaw with d2-d3 (5.6×2.1 ; 6.8×3); TAT; Coll. NHMW 2001z0078/0001.

R e m a r k s: The d1 was developed, its alveole is present. The d2 and d3 have the pointed protoconid and hypoconid and therefore resemble the p3 and p4 of *Lophiomeryx* in their dental patterns.

Cervidae GRAY, 1821

We regard the Dremotheriinae and Lagomerycinae as subfamilies of the Cervidae and do not include the Dremotheriinae in the Moschidae (VISLOBOKOVA 1990).

Dremotheriinae GINSBURG & HEINTZ, 1966

Eumeryx MATTHEW & GRANGER, 1924

Eumeryx culminis MATTHEW & GRANGER, 1924 (Plate 1, Fig. 16)

M a t e r i a l: Lower jaw with p2-m1; SHG-basis; Coll. NHMW 2001z0074/0001. 1 p4; TAT-C/2; Coll. NHMW 2001z0075/0001.

M e a s u r e m e n t s:

	p2	p3	p4	m1
L	3.6	4.8	5-5.3	5.8
W	1.5	2.3	2.9-3	3.5

R e m a r k s: The p1 was developed. The p4 possesses the well-developed paraconid, entoconid and hypoconid and a weakly anteroposteriorly enlarged metaconid. The m1 has a *Palaeomeryx* fold. The tooth size and structure are similar to those of *Eumeryx culminis* described by MATTHEW & GRANGER (1924).

*Eumeryx imbellis*VISLOBOKOVA, 1983 (Plate 1, Figs. 17-18)

M a t e r i a l: Upper jaw with P4-M2; SHG -A/18-20; Coll. NHMW 2001z0079/0001. Fragments of lower jaw with p4; SHG*; Coll. NHMW 2001z0080/0001. Fragments of lower jaw with p4; SHG*; Coll. NHMW 2001z0080/0002. Fragment of lower jaw with p4; IKH-A/3-4; Coll. NHMW 2001z0081/0001. Two fragments of lower jaw with p4-m3 and m2-m3; IKH-A/3-4; NHMW 2001z 0081/0002/1-2.

VISLOBOKOVA & DAXNER-HÖCK: Oligocene – Early Miocene Ruminants from the Valley of Lakes

	P4	M1	M2	p4	m1	m2	M3
L	4.5	5.7	6.2	5.7-6	6.3	6.5-7	9.7
W	5.4	6.8	7.5	2.7-3.1	3.2-3.7	4-4.5	4.1

R e m a r k s: This species differs from *E. culminis* by the higher crowns, more developed stylids, and by a more developed *Palaeomeryx* fold in the lower molars. The p4 has a higher and a more anteroposteriorly enlarged metaconid and a more strongly developed paraconid.

Eumeryx sp.

M a t e r i a l: M3; IKH-A*; Coll. NHMW 2001z0083/0001. M2; IKH-A*; Coll. NHMW 2001z0083/0002. 4 teeth and fragments of jaws; IKH-A*; Coll. NHMW 2001z0083/0003. 2 teeth m2 and m3; SHG*; Coll. NHMW 2001z0084/0001. Lower jaw with M1; TGR-B/1; Coll. NHMW 2001z0085/0001. 1 m1; IKH-A/1; Coll. NHMW 2001z0086/0001. Lower jaw with m1; IKH-A/1-2; Coll. NHMW 2001z0087/0001.

R e m a r k s: Judging from their size and structure, the specimens undoubtedly belong to *Eumeryx* but cannot be identified on the species level.

Amphitragulus POMEL, 1846

Amphitragulus sp.

(Plate 1, Fig. 19)

M a t e r i a l: Upper molar; IKH-B/5; Coll. NHMW 2001z0091/0002. Fragment of lower jaw with m1-m2; IKH-B/5; Coll. NHMW 2001z0091/0001. Fragment of lower jaw with p3; IKH-B/5; Coll. NHMW 2001z0091/0003.

M e a s u r e m e n t s (in mm):

M e a s u r e m e n t s (in mm):

	p3	m 1	m2
L	5.2	6.8	7.8
W	2.3	4.2	4.5

R e m a r k s: The size is small but larger than in *Eumeryx*. In the lower molars, the parastylid is strong and rounded, the mesostylid is rather weak and directed obliquely backwards, the ectostylid is low and flattened, the *Palaeomeryx* fold is present. The teeth in size, structure, shape and height correspond to those of *Amphitragulus*.

Dremotherium GEOFFROY, 1833

Dremotherium cf. guthi JEHENNE, 1987

M a terial and m e as u r e m e n t s: Lower jaw with m1-m2 (12.3×7.1 ; 12.8×9.1); TGR-C/2; Coll. NHMW 2001z0094/0001.

R e m a r k s: These rather high crowns are similar in size and structure to those of *Dremotherium guthi* described from the Late Oligocene of France. The specimen from Taatsiin Gol are tentatively assigned to this species. Earlier, *D.* cf. *guthi* was found in the upper Shand-Gol Formation at the Yagan Tologoi locality on the Dzabhan River (VISLOBOKOVA et al. 1996).

Lagomeryx ROGER, 1904

Lagomeryx sp.

M a t e r i a l and m e a s u r e m e n t s: 1 p4 (9 × 4.3); UTO-A/5; Coll. NHMW 2001z0119/0001. 1 m3 (11.5 × 5.2); UTO*; Coll. NHMW 2001z0120/0001.

R e m a r k s: Judging from the structure of p4, the crown height, and almost smooth enamel, the teeth can be identified as *Lagomeryx* sp. The genus was widespread in Europe and Asia in the beginning of the Early Miocene. In Mongolia, the most ancient remains of *Lagomeryx* were recovered from the Loh Formation of the Ulaan Tolgoi locality (VISLOBOKOVA et al. 1996). In China, the most ancient representatives of the genus were present in the Sihong fauna correlated to MN 4 (QIU1990).

Bovidae GRAY, 1821

Palaeohypsodontus TROFIMOV, 1958

Palaeohypsodontus sp.

(Fig. 4)

M a terial and measurements: $1m3 (8.8 \times 4)$; TGW-A/2a; Coll. NHMW 2001z0115/0001.

D e s c r i p t i o n and r e m a r k s: This very small m3 with its typical *Palaeohypsodondus* structure is similar in size to that of *P. asiaticus* described by TROFIMOV (1958) from Tatal Gol on the basis of a fragmentary lower jaw with m2-m3. However, the specimen from the Khunug Valley (TGW) differs from the type and from *Palaeohypsodontus*, which was recovered from Menhen-Teg (VISLOBOKOVA et al. 1996), by its more strongly pronounced "step-by-step" position of the occlussal surfaces of lobes. It therefore cannot be assigned to *P. asiaticus*.

?Palaeohypsodontus sp.

M a t e r i a l: M1 and d4; DEL -B/12; Coll. NHMW 2001z0117/0001-2.

R e m a r k s: Both teeth possess typical bovid structures and correspond in size with *Palaeohypsodontus*. The genus was known only by the structure of the lower molars. So there is some uncertainty that described teeth belong to *Palaeohypsodontus*.

225



Fig. 2-7: (2) *Gobiomeryx* sp., (3) *Lophiomeryx* sp., (4) *Palaeohypsodontus* sp., (5) Bovidae gen. 1, (6) Bovidae gen. 2, (all x3), (7) ?*Gobiocerus* sp. (x3).

(2) Right lower jaw with p2-p3, occlusal, TGR-AB/22, Coll. NHMW 2001z0101/0001, (3) Right lower jaw with d2-d3, occlusal, TAT, Coll. NHMW 2001z0078/0001, (4) Right m3, a, occlusal, b, buccal, TGW-A/2a, Coll. NHMW 2001z0116/0001, (5) fragmentary right lower molar, a, occlusal, b, buccal, TGW-A*, Coll. NHMW 2001z0114/0001, (6) Right P4; DEL-B/12, occlusal, Coll. NHMW 2001z0115/0001, (7) Left M3, occlusal, IKH-B/5, Coll. NHMW 2001z0095/0001.

Bovidae gen. 1 (Fig. 5)

M a t e r i a l: Fragmentary lower molar; TGW-A*; Coll. NHMW 2001z0114/0001.

R e m a r k s: The fragmentary lower molar from Taatsiin Gol west (=Khunug Valley) is represented by the first lobe of the m2 or m3. The crown is larger and higher than in *Palaeohypsodontus* and differs from this genus by a well-developed parastylid and by a pronounced ridge of the metaconid. The specimen also differs from *Hanhaicerus*, known from the Oligocene of China, by a more hypsodont crown. The specimen undoubtedly does not belong to these genera but is insufficient to describe a new genus.

Bovidae gen. 2 (Fig. 6)

M at erial and m easurement (in mm): P4 (5.2×6); DEL-B/12; Coll. NHMW 2001z 0115/0001.

R e m a r k s: The crown of P4 has the weak buccal styles, almost vertical external side and rather strongly inclined lingual surface. The tooth belongs to a larger form than *Palaeohypsodontus* or Bovidae gen. 1, but is smaller than *Gobiocerus*. The genus cannot be identified at present because of the poor knowledge of ancient bovids.

Gobiocerus SOKOLOV, 1952

?Gobiocerus sp. $(Ei \sim 7)$

(Fig. 7)

M aterial and measurements: M3 (11.7 \times 11.7); IKH-B/5; Coll. NHMW 2001z 0095/0001.

R e m a r k s: The genus *Gobiocerus* is described from the base of the Loh Formation of the Ulan-Tologoi locality (SOKOLOV 1952) based on the lower jaw fragment with m2 and m3. The genus is known only from Mongolia. The specimen from Ikh Argalatyn Nuruu corresponds with *Gobiocerus* in size and in the development of ridges and styles of the lower molars; it is tentatively assigned to this genus.

Eotragus PILGRIM, 1939

Eotragus sp.

M a t e r i a l: Fragmentary skull with incomplete horn; UTO-A/5; Coll. NHMW 2001z0118/0001.

M e a s u r e m e n t s (in mm):

Pedicle DAP	19.7
Pedicle DT	18.0
Horne base DAP	21.5
Horne base DT	18.5

D e s c r i p t i o n and r e m a r k s: Medium sized. The frontal is not pneumatized. The horn base is situated above the orbit. The horn core is straight, almost vertical, without keels, oval in section. The structure and size of the specimen are similar to those of *Eotragus*. In Mongolia, the genus was known from the Loh Formation in Ulaan-Tolgoi and in Shine-Us (VISLOBOKOVA et al. 1996). *Eotragus* became widespread in the Middle Miocene of Europe and Africa.

Biostratigraphy

Seven biozones (A, B, C, C1, D, D1, and E) have been distinguished based on rodent genera and species from all respective fossil horizons (DAXNER-HÖCK et al. 1997; HÖCK

et al. 1999). Five of them (A, B, C, C1 and D1/2) can be characterized by ruminants (Fig. 8). We use here the same scheme that was given for the first description of the biozones (DAXNER-HÖCK et al. 1997).

Biozone A:

- 1) Integrated ruminant list: *Praetragulus gobiae*, *Miomeryx* sp., *Gobiomeryx dubius*, *Gobiomeryx* sp., *Pseudomeryx gobiensis*, *Pseudomeryx* sp., *Pseudogelocus mongolicus*, *Lophiomeryx angarae*, *Lophiomeryx* sp., *Eumeryx culminis*.
- 2) Characteristic species: Praetragulus gobiae, Pseudomeryx gobiensis, Pseudogelocus mongolicus, Lophiomeryx angarae, Eumeryx culminis.
- 3) First/last record:

First record: Pseudomeryx, Pseudogelocus mongolicus, and Eumeryx.

Last record: Lophiomeryx angarae.

- 4) Characterization: Coexistence of Late Eocene and Early Oligocene species; a considerable diversity of gelocids; the first appearance of cervids.
- 5) Localization and lithostratigraphic position: Hsaanda Gol Formation below basalt I (31.5 Ma), Hsanda-Gol (SHG-C/1), Tatal Gol (Tat-C/2; D/1,3-4;D*), Khongil (HL-A/2).

Biozone B:

1) Integrated ruminant list: *Praetragulus gobiae, Miomeryx* sp., *Gobiomeryx* sp., *Pseudomeryx gobiensis, Pseudomeryx* sp., *Prodremotherium* sp., *Pseudogelocus mongolicus, Paragelocus* aff. scotti, Eumeryx imbellis

Eumeryx sp.

- 2) Characteristic species: *Praetragulus gobiae*, *Pseudomeryx gobiensis*, *Paragelocus* aff. *scotti*, *Eumeryx imbellis*.
- 3) First/last record:

First record: Prodremotherium, Paragelocus aff. scotti, and Eumeryx imbellis.

Last record: *Praetragulus gobiae*, *Miomeryx*, *Gobiomeryx*, *Pseudomeryx*, and *Pseudo-gelocus*.

- 4) Characterization: large diversity of tragulines, especially gelocids; replacement of *Eumeryx culminis* by *E. imbellis*.
- 5) Localization and lithostratigraphic position: Hsanda Gol Formation above basalt I (31.5 Ma), Ikh Argalatyn Nuruu (IKH- A/1-4; IKH- A*), Hsanda Gol (SHG- AB/12, A/18-20); Taatsiin Gol left (TGL- A/11); Taatsiin Gol right(TGR-AB/ 21-22; TGR-B/1; TGR- B*); Unkheltseg (UNCH-A*, A/3).

Biozone C:

1) Integrated ruminant list: *Paragelocus* aff. *scotti*, *Prodremotherium* sp., *Dremotherium* cf. *guthi*, *Palaeohypsodontus* sp., *Bovidae* gen. 1, *Cervidae* indet.

ARTIODACTYLA					
RUMINANTIA	А	В	С	C1	D1/2
Praetragulidae					
Praetragulus gobiae	х	Х			
Archaeomerycidae					
Miomeryx sp.	х	Х			
Gelocidae					
Gobiomeryx dubius	х				
Gobiomeryx sp.	х	х			
Pseudomeryx gobiensis	х	х			
Pseudomeryx sp.	х	Х			
Prodremotherium sp.		Х	х		
Pseudogelocus mongolicus n. sp.	х	Х			
Paragelocus aff. scotti		Х	х		
Lophiomerycidae					
Lophiomeryx angarae	х				
Lophiomeryx sp.	х				
Cervidae					
Eumeryx culminis	х				
Eumeryx imbellis		Х			
<i>Eumeryx</i> sp.					
Amphitragulus sp.				х	
Dremotherium cf. guthi			х		
Lagomeryx sp.					Х
Bovidae					
Palaeohypsodontus sp.			х		
?Palaeohypsodontus sp.					
Bovidae gen. 1			х		
Bovidae gen. 2				х	
?Gobiocerus sp.				Х	
Eotragus sp.					х

Fig. 8: List of genera and species of ruminants collected by the Austrian-Mongolian team in the Valley of Lakes in Central Mongolia.

- 2) Characteristic species: Dremotherium cf. guthi.
- 3) First/last record:
 - First record: *Dremotherium*. Last records: *Paragelocus* aff. *scotti*.
- 4) Characterization: sharp decrease of biodiversity of tragulines; increase in the diversity of primitive cervids (dremotheriins) and bovids.

5) Localization and lithostratigraphic position: Hsanda Gol Formation, Taatsiin Gol (TGR-C2, C/1, C*); Loh Formation, Khunug valley (TGW-A/2a, A*).

Biozone C1:

- 1) Integrated ruminant list: *Amphitragulus* sp., ? *Palaeohypsodontus* sp., *Bovidae* gen. 2, ?*Gobiocerus* sp.
- 2) Characteristic species:
- 3) First/last record: First record: *Gobiocerus*.
- 4) Characterization: absence of tragulines; increase in biodiversity of bovids; co-existence of *Amphitragulus* and *Palaeohypsodontus*; first appearance of *Gobiocerus*.
- 5) Localization and lithostratigraphic position: Hsanda Gol Formation, Del (DEL-B/12), Loh Formation, Ikh Argalatyn Nuruu (IKH-B/5).

Biozone D1/2:

- 1) Integrated ruminant list: Lagomeryx sp., Eotragus sp.
- 2) Characteristic species:
- 3) First/last record: First record: *Lagomeryx, Eotragus*.
- 4) Characterization: co-existence of Lagomeryx and Eotragus.
- 5) Localization and lithostratigraphic position: Loh Formation, Ulaan Tolgoi (UTO-A/5, UTO-A*).

Biochronology and correlation

The new data on ruminants coincide well with the data on rodents and support the stratigraphic position of biozones A, B, C, C1, and D1/2, originally established based on rodent assemblages (DAXNER-HÖCK et al. 1997; HÖCK et al. 1999).

The summarized data on biochronology and correlation of the Oligocene-Early Miocene of the Valley of Lakes, based on ruminants, are presented in the correlation chart (Fig. 9).

The biozone A is Early Oligocene in age and older than 31.5 Ma. The fossil remains from this biozone were recovered from the Hsanda Gol sediments below basalt I (Höck et al. 1999). Except for *Pseudogelocus*, all species and genera of ruminants occurred only in Mongolia. So far, *Pseudogelocus* was known only from the Early Oligocene of Europe (*P. suevicus* recorded in MP21). In Mongolia the genus is represented by the new species *P. mongolicus* n.sp.

The biozone B is assigned to the Early Oligocene between 31.5 and 28 Ma. The fossil remains were recovered from the Hsanda Gol sediments between basalt I and II (HÖCK et al. 1999). *Praetragulus gobiae* does not occur later than Early Oligocene. *E. culminis*, characteristic for biozone A, is replaced in biozone B by a more advanced species,



Fig. 9: Oligocene-Miocene biochronology of Central Mongolia based on biozones and on basalt datings. (Modified after Höck et al. 1999: Fig. 22)

i.e. *E. imbellis. Pseudomeryx gobiensis* is typical of the Early Oligocene of Mongolia. *Paragelocus scotti* is typical for the Early Oligocene of Western Europe (MP 21-23) (JEHENNE 1985, SUDRE & BLONDEL 1996). The occurrence of *P.* aff. *scotti* in Mongolia can be due to the faunal exchange with Europe at the beginning of the Oligocene at the MP21/MP22 transition after 32 Ma. *Lophiomeryx* also dispersed to Europe from Central Asia during that time (VISLOBOKOVA et al. 1996, VISLOBOKOVA 1997).

The biozone C is dated approximately 28 Ma. The fossil remains are recorded from the upper part of the Hsanda Gol sediments immediately below and above the basalt II (HÖCK et al. 1999). *D. guthi* is typical of the Late Oligocene of Western Europe (MP 28-30). The last occurrence of *P. scotti* in Europe is connected with MP 23. The co-existence of *D.* cf. *guthi* and *P.* aff. *scotti* might occur in the intervening span between MP23 and MP28 and could be referred to the beginning of the Late Oligocene.

The biozone C1 has an intermediate position between the biozones C and D and seems to belong to the later Late Oligocene (HöCK et al. 1999). The remains of ruminants were found in the highest part of the Hsanda Gol sediments. The most abundant rodents of biozone C1, *Yindirtemys deflexus* and *Y. gobiensis*, are recorded from the Chinese Tabenbulukian of Late Oligocene age (TONG et al. 1995, HöCK et al. 1999). The co-existence of *Amphitragulus*, *?Palaehypsodontus* and *?Gobiocerus* in biozone C1 could occur at the end of the Oligocene or at the beginning of the Miocene. *Gobiocerus* was known before in Mongolia in the Early Miocene. It cannot, however, be excluded that the genus first appeared in Central Asia at the Oligocene-Miocene transition. In addition to *Gobiocerus* and *?Palaehypsodontus*, a Bovidae gen. 2 occurred in biozone C1. A sharp increase of diversity of bovids in Mongolia may reflect the palaeoenviromental changes to more arid conditions. Data from biozone C1 provide new evidence on the occurrence of ancient bovids and support a Central Asian origin of this family.

The biozone D1/2 is referred to the second part of the Early Miocene. The co-existence of *Amphitragulus* (known from the PIN collection), *Lagomeryx* and *Eotragus* is typical for this period. The remains come from the Loh Formation of the Ulaan Tolgoi localities.

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Annalen des Naturhistorischen Museums in Wien 103 A

Plate 1

Pseudomeryx gobiensis TROFIMOV, 1957

Fig. 1: Right p4, SHG*, Coll. NHMW 2001z0106/0001.

Prodremotherium sp.

Fig. 2: Right m2, IKH-A/1-2, Coll. NHMW 2001z0092/0001.

Fig. 3: Right m3, IKH-A/1-2, Coll. NHMW 2001z0092/0002.

Fig. 4: Right lower jaw with d4-m1, IKH-A/2-4, Coll. NHMW 2001z0093/0001.

Pseudogelocus mongolicus sp. nov.

Fig. 5: Right M2, TGR-AB/22/2, Coll. NHMW 2001z0070/0002.
Fig. 6: Right M2, TGR-AB/22/2, Coll. NHMW 2001z0070/0003.
Fig. 7: Left M3, TAT-D/1, Coll. NHMW 2001z0069/0003.
Fig. 8: Left d4, TAT-D/1, Coll. NHMW 2001z0069/0002.
Fig. 9: Left lower jaw with p1-p3, TAT-D/1, Coll. NHMW 2001z0069/0001.
Fig. 10: H o l o t y p e: Right p4, TGR-AB/22/2, Coll. NHMW 2001z0070/0001.
Fig. 11: Left m1, TGL-A/11a; Coll. NHMW 2001z0072/0001.

Paragelocus aff. scotti SCHLOSSER, 1902

Fig. 12: Left maxilla with P2-P3, UNCH-A*, Coll. NHMW 2001z0090/0002.
Fig. 13: Right M3, UNCH-A*, Coll. NHMW 2001z0090/0001.
Fig. 14: Left M3, TGW-A*, Coll. NHMW 2001z0089/0001.
Fig. 15: Right p3, UNCH-A*, Coll. NHMW 2001z0090/0003.

Eumeryx culminis MATTHEW & GRANGER, 1924

Fig. 16: Right lower jaw with p2-m1, SHG-C/1, Coll. NHMW 2001z0074/0001.

Eumeryx imbellis VISLOBOKOVA, 1983

Fig. 17: Right maxilla with P4-M2, SHG -A/18-20, Coll. NHMW 2001z0079/0001. Fig. 18: fragment of left lower jaw with p4, SHG*, Coll. NHMW 2001z0080/0001.

Amphitragulus sp.

Fig. 19: fragment of left lower jaw with m1-m2, IKH-B/5, Coll. NHMW 2001z0091/0001.

All figs. occlusal, x3.

VISLOBOKOVA & DAXNER-HÖCK: Oligocene – Early Miocene Ruminants from the Valley of Lakes Plate 1



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