

## 陕西府谷晚中新世蓝牛化石<sup>1)</sup>

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**摘要:** 尽管中国发现的中新羚(偶蹄目,牛科,蓝牛族)化石较少,但由于其重要的生物年代学意义而备受重视,被作为与欧洲 Vallesian 期动物群对比的重要分子。描述了新近在陕西府谷喇嘛沟发现的头骨标本。依据下颌骨形态与牙齿特征,将其归入 *Miotragocerus gregarius* (Schlosser, 1903)。新发现的材料完善了该种的鉴定特征:中等大小的蓝牛类;角心强烈后倾,中等分散度,具前后两条棱,横断面呈椭圆形;雄性个体角心前的额骨部分强烈隆升,雌性个体则无明显隆起;脑颅部分成梯形,其最大宽度在角心后,最小宽度在枕骨位置上;基枕骨前后突之间没有沟槽发育;P2 与 P3 具发育且后置的次尖;p4 下后尖前后向扩展。对比研究表明,该种较 *Miotragocerus spectabilis* 原始,而后者为中国发现的蓝牛类的最后代表且于中新世末期绝灭。对比巴基斯坦以及欧洲的蓝牛,认为中国的 *Miotragocerus* 可能与欧洲的种类关系较为密切,而不同于巴基斯坦的 *Tragoptax*。最新的研究资料表明,*Miotragocerus* 在中国主要发现于晚中新世中晚期(Turolian 期),可能在 8 Ma 之前从欧洲迁移至东亚,由于剧烈的气候及生态环境的改变于晚中新世末期与 Urmitheriinae 等大型牛科化石一起绝灭。

**关键词:** 陕西府谷,晚中新世,牛科

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### LATE MIOCENE BOSELAPHINI (BOVIDAE, ARTIODACTYLA) FROM FUGU, SHAANXI PROVINCE, CHINA

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**Abstract** Though rarely reported from China, *Miotragocerus* has long been considered as one of the Vallesian equivalent indicators in the comparison with European faunas. Study on new specimens of *Miotragocerus gregarius* improves its diagnostic characters. Comparison with European and Pakistan taxa reveals that *Miotragocerus* possibly migrated into Eastern Asia before 8 Ma, and evolved independently into *M. spectabilis*, which went extinct at the end of Late Miocene together with some large bovids, such as all genera of Urmitheriinae, due to dramatically climate and ecological changes at the end of the Late Miocene.

**Key words** Fugu, Shaanxi Province, Late Miocene, Boselaphini

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## 1 Introduction

In contrast to their diversification and abundance in western Eurasia, fossil Boselaphini from China are rare, and only found at a few late Miocene localities. Schlosser (1903) was the first to describe some fragmentary materials, mostly isolated teeth, as different species of *Tragocerus* from unknown provenance. Then, Bohlin (1935) ascribed further material to two of Schlosser's species, *Tragocerus spectabilis* and *T. gregarius*, based on the Lagrelius collection from different localities in Baode. During the last decade, there were cited also some *Miotragocerus* in the faunas of Fugu and Hezheng, however without description (Xue et al., 1995; Deng et al., 2004). Aside from these Northern China fossils, *Selenoportax* was claimed from Lufeng, Yunnan, unfortunately, without description and figures either (Han, 1985).

The earliest Boselaphini may come from Pakistan at 17.6 Ma (Solounias et al., 1995). In Europe, *Miotragocerus* species are reported from Middle Miocene to the earliest Late Miocene, and then replaced by *Tragoportax* during the Vallesian stage (Gentry et al., 1999). The questions are how long *Miotragocerus* survived, and when the Boselaphini migrated to China.

From 1980's till now, a large quantity of fossils of the *Hipparion* fauna from Laogaochuan, Fugu County, Shaanxi Province were found by local farmers. Xue et al. (1995) gave a faunal list and distinguished two fossil levels: the earlier Lamagou fauna and later Miaoliang fauna. Till now, a few taxa of the Lamagou fauna have been described, e.g. *Dinocrocota*, *Simocyon*, *Acerorhinus*, *Chilotherium*, and *Schansitherium* (Zhang and Xue, 1996; Wang, 1997; Deng, 2000, 2001, Guan et al., 1998). By faunal comparison and the presence of *Dinocrocota* and *Miotragocerus*, the Lamagou fauna was thought to be earlier than the typical Baode fauna that was considered firmly to be contemporaneous with the classic *Hipparion* faunas of Maragheh, Pikermi, and Samos. Hence the Lamagou fauna was considered as upper part of MN9 and MN10 (Qiu et al., 1999). However, study on *Dinocrocota* suggested that the Lamagou fauna should possibly be compared with the Early Turolian rather than Vallesian stage of West Eurasia (Zhang, in press).

In the 2003 field season, the author acquired two almost complete skulls from a local farmer. The skulls were from the tunnel that yielded the Lamagou fauna.

Study of the new fossils and revision of the old materials may improve understanding of immigration and evolution of Boselaphini in China and on the biochronology of the *Hipparion* faunas.

Terminology herein follows Gentry (1992). The length and width of the teeth are of their maximum dimensions using the vernier calipers to the nearest 0.1 mm. The specimens described in this paper are housed in IVPP.

## 2 Systematic paleontology

**Artiodactyla Owen, 1848**

**Bovidae Gray, 1821**

**Bovinae Gray, 1821**

**Tribe Boselaphini Knottnerus-Meyer, 1907**

***Miotragocerus* Stromer, 1928**

***Miotragocerus gregarius* (Schlosser, 1903)**

(Figs. 1 ~ 3)

**Material** An almost complete skull with mandibles, atlas, and part of axis of the same individual (IVPP V 14401); An almost complete skull (V 14402); a partial horn core (V 14403).

**Diagnosis (Revised)** Medium sized boselaphine. Horn cores tilted strongly backwards, with moderate divergence, and the cross section is oval shaped with one anterior and one posterior keels

developed. The frontals at the anterior base of horn cores strongly elevated in males, but not in females. The braincase is rectangular in shape, with the greater width just posterior to the horn cores, and the minimum width at the occipital. There is no central groove between the anterior and posterior tuberosities on the basioccipital. P2 and P3 have developed and posteriorly positioned hypocones, and p4 has an enlarged metaconid, extending anteriorly and posteriorly.

**Measurements** See Tables 1 ~ 3.

**Table 1 Skull measurements of *Miotragocerus gregarius*** (mm)

	V 14401	V 14402
Length from P2 to condyle	200	205
Maximum width	123	131
Distance between supraorbital foramina	49.5	44
Distance between ridges behind horn cores	66	78
Length of braincase behind horn cores	74.5	> 70
Height of occipital	67	69
Maximum width of occipital	82	94
Antero-posterior diameter of horn cores at base	41	55
Transverse diameter of horn cores at base	26.5	38

**Table 2 Lower cheek teeth measurements of *Miotragocerus gregarius*** (mm)

		p2	p3	p4	m1	m2	m3	p2 ~ m3	Lp	Lm
V 14401	L / W	13.1/6.6	15.7/8.5	15/10	15.5/13.5	19/15	26.5/13.3	108.4/	44.6/	62.3/

**Table 3 Upper cheek teeth measurements of *Miotragocerus gregarius*** (mm)

		P2	P3	P4	M1	M2	M3	P2 ~ M3	LP	LM
V 14401	L / W	15.3/10.5	14.3/14.9	12.9/16.2	14.2/18.5	18/20.5	21.5/21.2	90.6/	41.8/	52.6/
V 14402	L / W	15.6/12	14.4/14.4	12.5/16.1	14.4/19	18.7/20.4	19.6/21.8	93.8/	43.7/	52.2/

**Description** The skull of specimen V 14401 is laterally crushed (Fig. 1). The incisors, nasals and premaxilla are not preserved. The right horn core has only the base left, and the left one has about 34 mm preserved above the pedicle. The left jaw preserved the horizontal ramus behind m1, and the right jaw lost the anterior part (anterior to p2).

The horn cores, well separated at the base, are straight, centrally hollowed (on the preserved part at least), above the orbits and strongly posteriorly inclined. The pedicles are strong and high up. The cross section is compressed oval shaped, with a prominent anterior and a postero-external keels. The outer surface is slightly more convex than the inner side. The maximum width lies on the posterior part. The longitudinal axis of the horn core is antero-interiorly orientated, at about 30 degrees with the longitudinal axis of the skull. The estimated length/width at base are 41/26.5 mm.

The nasals, though not preserved, should be rather short by the anterior position of their posterior ends. The frontals depressed centrally and slightly domed laterally. The supraorbital foramina are small, located at the anteriorly extended slope of the horn core pedicles. No deep pits developed around the foramina. There developed frontal sinus that extends to the horn cores upwards. There is only slight uplifting between the horn cores. The upper orbital rim is short and sloping gradually from the pedicles. There exists only slightly bending of the posterior part of the frontal. Together with the posterior part of frontal, the anterior part of parietal formed a depressed area, buttressed by moderate strong ridges and the horn cores. There is no postcornual fossa. From the postero-medial side of the horn cores backwards, there raised moderate temporal ridges, which converge posteriorly, and remain wide apart at the point of their closest approach at the parietal-

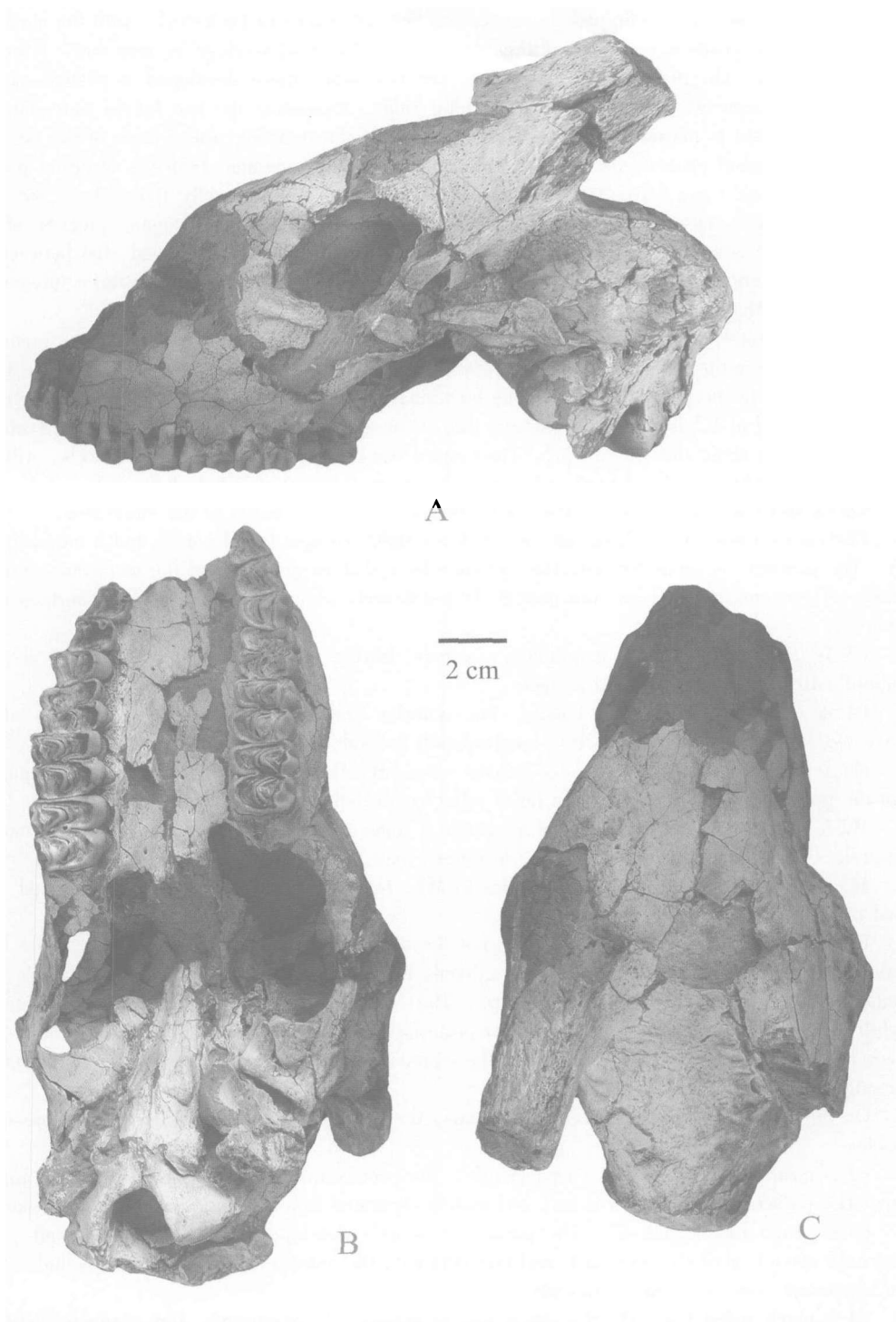


Fig. 1 Skull of *Miotragocerus gregarius* (V 14401)  
A. lateral view; B. ventral view; C. dorsal view

supraoccipital suture. The brain case is narrow and becomes narrower backwards, with the maximum width lies at the position just behind the horn cores. The nuchal ridge is very low, however, expands laterally. On the upper one third of the occipital, there developed a triangle shaped process, which connects with the central occipital ridge, separating the two lateral parts laterally faced. The mastoid is narrow and constrained upwards by the narrower upper parts of the occipital surface. The mastoid process protrudes far downwards, and is separated from the occipital process by a deep and wide gap. The tympanic bulla is small and mediolaterally flat. There are three squamosal foramina near the squamosal-parietal suture. Above the zygomatic process of the squamosal, there is a large fossa. The basioccipital is basically rectangular shaped, flat between the anterior and posterior tuberosities, with a central ridge in the anterior part. The posterior tuberosities are much larger than the anterior ones.

The infraorbital foramen is set above P2 at a very low position. Though broken, the preorbital fossa seems to be quite large and deep. The maxillary processes are not protruding, but rose up as the lower border of the preorbital fossa. The lachrymal seems to be large, and anteriorly extended. The posterior end of M3 is just at the vertical line of the anterior rim of orbit. The anterior border of the palatine is at about the level of M2. The central fossa of palatine extends backwards, with the posterior end not known; the lateral indentation is just at the posterior end of the M3.

Cheek teeth are brachyodont. The premolar row is long in relation to the molar row.

P2 is semicircular in occlusal outline, with a roughly straight labial border and a round lingual line. The parastyle is separated with the paracone by a shallow groove, and the metacone protrudes labially. Hypocone is very large and posteriorly positioned, which makes the occlusal surface wider posteriorly.

P3 is similar to P2 in morphology, except having a stronger parastyle, and a more longitudinally compressed occlusal surface.

P4 is much wider than its length. The anterior branch of the central fossette is almost transverse, and the posterior branch is longitudinally extended.

M1 is well worn, with the anterior fossette worn out. The lingual anterior lobe is more angular than the posterior lobe. There exists a basal pillar connected with the posterior lobe.

M2 is slightly larger than M1. The mesostyle is about the size of parastyle, and larger than the metastyle. The anterior rib is much more developed than the posterior one.

M3 is the largest one, and very similar to M2, but with the posterior lobe constrained. The basal pillar is smaller.

Both the left and right lower jaws have not the diastema parts preserved (Fig. 2A). The lower borderline of the horizontal ramus is slightly curved, and the depth increased slowly backwards. The mental foramen is below the protoconid of p3. The coronoid process is very high up. It inclines slightly backwards, and the tip passes further posteriorly than the most posterior edge of the angular process. The articular process is just below the coronoid process, with a narrow indentation above. The angular process is diagonal shaped.

On the labial surface of the ascending ramus, there are slightly raised ridges for the masseteric muscles.

p2 is narrow, with the main cusps visible. The protoconid is the most prominent and highest cusp. The paraconid is a narrow ridge, and widely separated from the less developed metaconid.

p3 is much larger than p2. The paraconid is well developed, and extends lingually. The metaconid extends strongly backwards and connects with the entoconid to enclose the medial valley. The hypoconid does not protrude labially.

p4 is much wider than p3. The paraconid is transversely orientated, and connected with the anterior extension of the metaconid to enclose the anterior valley. The metaconid also extends backwards, and connects with the entoconid to enclose the medial valley. By these connections, the lingual wall is completely enclosed and flat without valley visible on the lingual side.

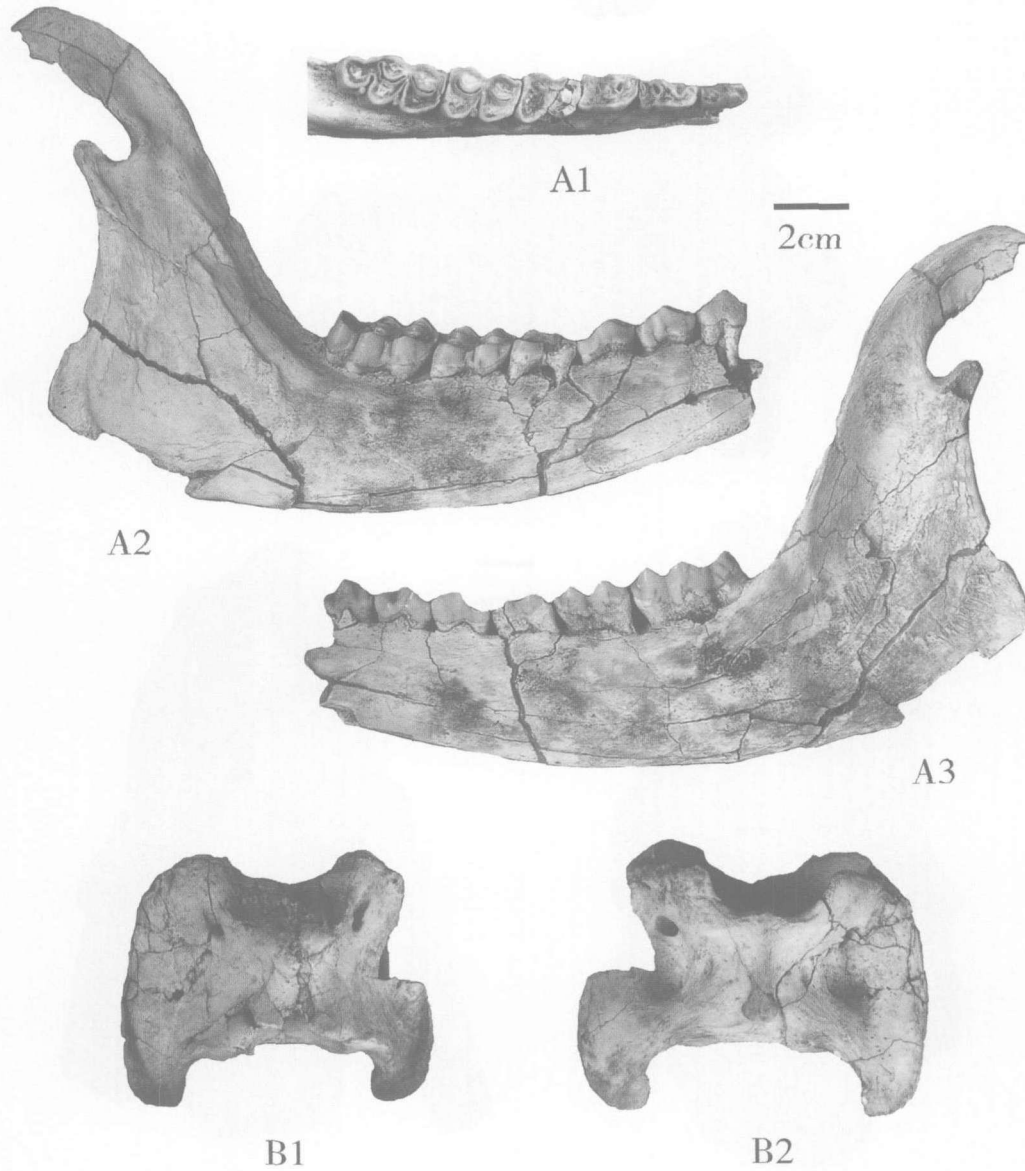


Fig. 2 Right lower jaw and atlas of *Miotragocerus gregarius* (V 14401)  
 A. right lower jaw: A1. occlusal view, A2. labial view, A3. lingual view;  
 B. atlas: B1. dorsal view, B2. ventral view

m1 is well worn. The occlusal structures are almost invisible.

The occlusal outline of m2 is rectangular, with the anterior lobe narrower than the posterior one. There is no goat fold. The lingual walls at the metaconid and entoconid are slightly out-bowed. The basal pillar is large and high up to the occlusal surface.

The main part of m3 is very similar to m2. There developed very large and slightly labially offset hypoconulid, however, without central fossette. There are two basal pillars on the labial side.

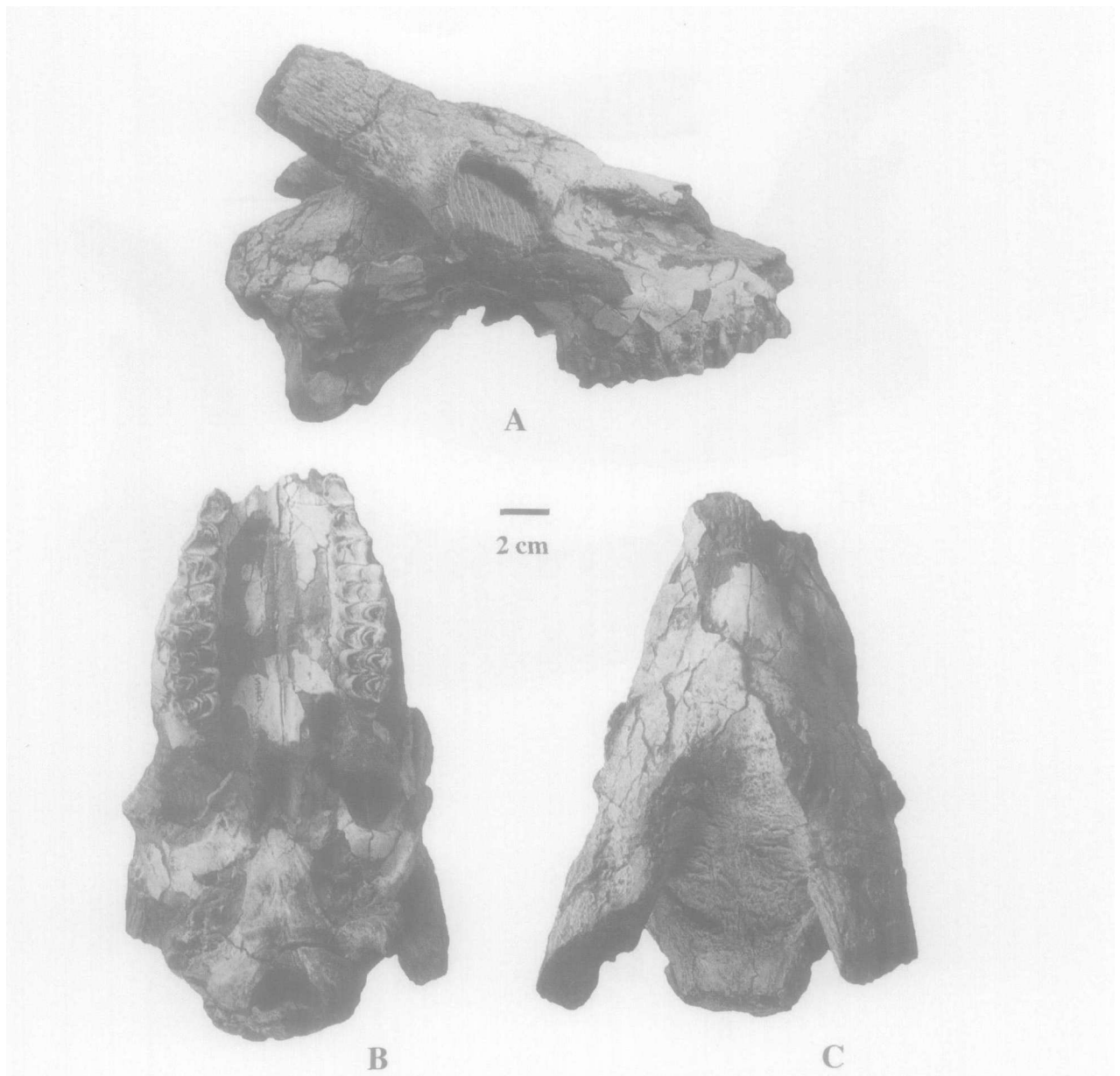


Fig. 3 Skull of *Miotragocerus gregarius* (V 14402)  
A. lateral view; B. ventral view; C. dorsal view

The atlas is basically rectangular in ventral view with the lateral transverse process edges parallel each other (Fig. 2B). The posterior ends of the transverse process extend inwards. The articular fossettes with the occipital condyles are deep. On the posterior part of the ventral side, there developed a tubercle.

V 14402 is an almost completely preserved skull of roughly the same age as V 14401 by the tooth wear (Fig. 3). The anterior part of nasals and premaxilla are lost, and the horn cores have

only the bases preserved. Horn cores (L/W: 55/38 mm) are much more robust and strongly convergent anteriorly than V 14401. The anterior base of the keels extends downwards to the frontals. The supraorbital foramina are located in the lateral slopes of the strongly elevated frontals. The intercornual area enclosed is triangular shaped. The buttress behind the horn cores has well developed rugosities and the ridges are higher and stronger. Temporal ridges are more developed. The preorbital fossa is deep and wide, with the posterior ridge extends to the anterior rim of orbit, and the anterior edge to the P2. Other characters are basically identical with V 14401.

V 14403 is only a partial left horn core without the tip and base preserved. The cross section is roughly oval shaped, with a more out bowed surface (ATD/TD: 45.5/26 mm).

### 3 Sexual dimorphism

The size and morphology of both sexes of *Boselaphini* has been widely discussed (Thenius, 1948; Meladze, 1967; Solounias, 1981; Moyà-Solà, 1983; Spassov and Geraads, 2004). The two individuals represented by V 14401 and V 14402 are of the same age by the stage of tooth wear. The late middle wear of the teeth suggests that V 14401 cannot be dismissed as an immature male. They share exactly same tooth characters and some skull characters, i. e. the angle of the facial and cranial axis, narrow face with strong preorbital fossa, location and inclination of horn cores, and structure of basioccipital etc. However, the robustness and divergence of horn cores, the elevation of frontals anterior to the horn cores, and the development of the buttress behind the horn cores differ greatly. These differences are herein accordingly explained as sexual dimorphism. V 14402 should be a male, and V 14401 a female. The partial horn core of V 14403 might be a female by its slender outline.

### 4 Nomenclature

By the horn cores having keels and no torsion, braincase little angled on the facial axis, strong temporal ridges on the cranial roof, brachyodont cheek teeth with basal pillars, and relatively long premolar rows, the specimens described here can be assigned to the boselaphine group with no doubt, and further to the *Miotragocerus-Tragoportax* complex by the compressed and oval cross section of the horn cores.

However, the nomenclature of *Miotragocerus-Tragoportax* complex has long been in some confusion (Solounias, 1981; Moyà-Solà, 1983; Bouvrain, 1994; Spassov and Geraads, 2004). Gaudry (1861) named *Tragocerus* based on the type species *Capra amalthea* Roth et Wagner, 1854 from Pikermi. Kretzoi (1968) noted that *Tragocerus* was preoccupied by a beetle genus name. Gentry (1971) suggested referring all species of "*Tragocerus*" to *Miotragocerus*, which had been named by Stromer (1928) based mainly on a partial skull from Oberföhring with demarcations on horn cores. *Tragoportax* was named by Pilgrim (1937) on the materials from Siwaliks, Pakistan. In his systematic study on fossil bovids from Samos, Solounias (1981) redefined *Miotragocerus* for those species having real demarcations on horn cores, and *Tragoportax* for those without demarcations and having derived tooth characters. Contrary to Solounias's definition, Moyà-Solà (1983) defined *Miotragocerus* as an endemic European taxon for those having concavities on the proximal lateral surface of the metatarsals, and referred all the species previously assigned to "*Tragocerus*" to *Tragoportax*. Although both classifications are artificial, Moyà-Solà's definition has mostly been followed (Bouvrain, 1994; Gentry et al., 1999; Gentry, 2003). However in their recently published paper, Spassov and Geraads (2004) again rearranged the *Miotragocerus-Tragoportax* complex. *Tragoportax* was defined as a large boselaphine with a well depressed area on the postcornual fronto-parietal surface, the basioccipital having a longitudinal groove between the anterior and posterior tuberosities, anterior rugosities growing downwards from the anterior keel at



the base of horn cores being absent or weak, and less compressed horn cores, the occipital being trapezoid shaped etc. For them *Miotragocerus* includes two subgenera, *Miotragocerus* (*Miotragocerus*) Stromer, 1928 and *Miotragocerus* (*Pikermicerus*) Kretzoi, 1941. *Miotragocerus* was defined as a small sized boselaphine with the postcornual area of the skull not depressed or raised as a low plateau, the basioccipital having no median groove between the anterior and posterior tuberosities (definitely known in the subgenus *Pikermicerus*), and anterior rugosities at base of horn cores usually strong, extending onto the frontal along the keel which often has several demarcations etc. According to their classification, it would be very difficult to assign the Fugu specimens into either of the two genera. The oval cross section and the well developed anterior and postero-external keels, well developed intra and postcornual buttress with rugosities, derived premolar structures and larger size all fit their diagnosis of *Tragoptax*, however the basioccipital has no groove between the tuberosities which is a very important character for the classification.

The type specimen of the type species *Tragoptax salmontanus* has horn cores with a moderate inward curvature. The tips re-approach, which does not exist in other fossils described as "*Tragocerus*" or *Tragoptax*, or even in *Miotragocerus monacensis*. Whether this Siwalik form is generically different from other forms referred to this genus remains to be verified.

The horn cores of Fugu specimens have oval shaped cross sections rather than triangular shaped, and further without antero-internal keels. Judging by the remnants of the horn cores, there seems to be no torsion and curvature. The intercornual surface is basically on the same plane as the buttress behind, whereas there exists an obtuse angle between these two parts on *T. salmontanus*.

Compared with the partial skull from Oberföhring of *Miotragocerus monacensis* (Stromer, 1928), the skulls from Fugu have the same oval shaped horn cores, with only two keels developed, without torsion and inward curvature. By these horn core characters, the Fugu taxa should be accordingly referred to *Miotragocerus* rather than *Tragoptax*.

Considering the confused and disputed recognition of the *Tragoptax-Miotragocerus* complex, and the uniqueness of the type species of *Tragoptax*, I would rather follow Gentry (1971) herein and temporarily refer all the Chinese species into *Miotragocerus* before systematic and detailed study on the difficult issue.

## 5 Comparison

Schlosser (1903) named four species of *Miotragocerus* from China, i. e. *M. gregarius*, *M. spectabilis*, *M. ? sylvaticos*, and *?M. kokeni* based on isolated teeth. Bohlin (1935) thought that both the latter two species had not enough material to justify their referral to *Miotragocerus*, and further that the teeth described as *M. kokeni* were a mixture of different taxa.

*Miotragocerus gregarius*, as further described by Bohlin (1935), was only represented by two partial mandibles. The morphology and size of these two mandibles are almost identical with the

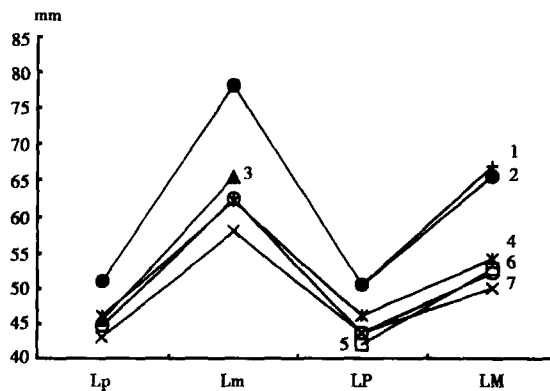


Fig. 4 Diagram showing tooth measurements of the two species of *Miotragocerus* from China  
Lp. length of lower premolar row; Lm. length of lower molar row; LP. length of upper premolar row; LM. length of upper molar row; the measurements of lower tooth row of *M. spectabilis* (Bohlin, 1935) are calculated by the upper/lower ratio of V 14401  
1 ~ 2. *Miotragocerus spectabilis* (Bohlin, 1935); 3. *M. gregarius* (Bohlin, 1935); 4. *M. gregarius* (Schlosser, 1903); 5. *M. gregarius* (V 14402); 6. *M. gregarius* (V 14401); 7. *M. gregarius* (Schlosser, 1903)

Fugu materials (Fig. 4). The tooth measurements and characters also suggest they might be conspecific. The p4 metaconids on Bohlin's specimens are not expanded enough to enclose the lingual wall as on the new specimens. This difference might be due to the age.

The partial skull referred to *Miotragocerus spectabilis* has a higher frontal elevation anterior to the horn cores and a sharp angle between them. The buttress behind is not in a same plane with the anterior part. The anterior keels converged more closely at the base. The brain case bent downward more sharply, and the cranial-facial axis angle is much larger. The M3 is located posteriorly to the anterior rim of orbit. And teeth are larger and more hypsodont with relatively shorter premolar rows.

Compared with *Miotragocerus spectabilis*, the Fugu *M. gregarius* shows some primitive characters: size smaller (Fig. 4); the frontal part anterior and between the horn cores is less abruptly elevated; horn cores are less closely located on the frontal anteriorly and separated posteriorly etc. *Miotragocerus spectabilis* might be the last representative of Boselaphini in Eastern Asia.

Compared with the European species: *Miotragocerus monacensis* from Oberföhring of Germany and Hostalets Inferiore of Spain (Moyà-Solà, 1983); *M. pannoniae* from Sopron of Hungary, Höwenegg of Germany, and Inzersdorf of Austria; *M. gaudryi* from Pikermi of Greece etc., the two *Miotragocerus* species from China show more derived tooth characters: such as the large and antero-posteriorly extended metaconid on p4, large and posteriorly located hypocone on P2 ~ P3, shorter premolar row relative to the molar row; higher elevation of frontals on male individuals etc. By the size, Chinese species are comparable with *Tragoportax rugosifrons* from Samos and Vathylakkos of Greece (Bouvrain, 1994). However, the latter species has the metaconid extended anteriorly, the longitudinal axis of horn cores formed a less sharp angle.

*Tragoportax amalthea* from Pikermi shows separation of the paraconid and paraconulid and expansion of the metaconid on p4 which fit the Chinese species.

## 6 Discussion

In their study of the Cavicornia (= Bovidae) from Yushe basin, Teilhard and Trassaert (1938) described a new species, ? *Tragocerus laticornis*. By the less laterally compressed, widely apart setting, and strongly divergent horn cores, and no elevation on the frontals, it is very difficult to relate this species with all known *Miotragocerus* species, and further with Boselaphini.

From Chinese Middle Miocene, there had never found any trace of Boselaphini. It can be consequently postulated that boselaphines migrated into Eastern Asian from western Eurasia at the early Late Miocene as earliest. By the morphology, these Chinese species are more closely related with the European taxa rather than the Siwalik forms, such as *Tragoportax salmontanus*.

The Lamagou fauna should be earlier than the typical Baode faunas that should all be later than 7 Ma by recent paleomagnetic dating (Yue et al., 2004). Study on the fauna from the Bahe formation, Lantian suggests that the Lamagou fauna should be later than Vallesian stage, and further can be correlated with early Turolian (Zhang et al., 2002; Zhang, in press). Hence, both *Dinocrocuta* and *Miotragocerus* from China are not strictly Vallesian equivalent indicators.

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