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New material of *Hispanotherium matritense* (Rhinocerotidae, Perissodactyla) from Laogou of Hezheng County (Gansu, China), with special reference to the Chinese Middle Miocene elasmotheres

Hispanotherium matritense (Rhinocerotidae, Perissodactyla) de Laogou de Hezheng County (Gansu, Chine) : matériel nouveau et rapports avec les élasmothères chinois du Miocène moyen

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Abstract

New rhinocerotid teeth from Laogou in Hezheng (Gansu, China) are described and identified as *Hispanotherium matritense*. Comparing the other Chinese Middle Miocene elasmotheres with material of *H. matritense* from Iberian localities and Laogou, we confirm the synonymy proposed previously for the species *Hispanotherium lintungensis*, *Tesselodon fangxianensis*, *Caementodon tongxinensis* and *Huaqingtherium qiui*. The larger size of *Hispanotherium tungurense* proves that it is a different species from *H. matritense*. The age of Laogou fauna corresponds to MN6. Paleoenvironments of *H. matritense* in China include rivers and lakes, which are somewhat different from the arid environment in the Iberian Peninsula. The origin of the *Hispanotherium* lineage may be in southwestern Europe. After that, it dispersed eastward to Asia.

Résumé

Des dents inédites de Rhinocerotidae de Laogou de Hezheng (Gansu, Chine) sont décrites et attribuées à *Hispanotherium matritense*. La comparaison des autres élasmothères chinois du Miocène moyen avec l'*Hispanotherium* de Laogou et de sites ibériques permet de confirmer les synonymies précédemment proposées pour *Hispanotherium lintungensis*, *Tesselodon fangxianensis*, *Caementodon tongxinensis* et *Huaqingtherium qiui*. La plus grande taille d'*Hispanotherium tungurense* le différencie spécifiquement d'*H. matritense*. La faune de Laogou peut être placée en zone MN6. Les paléoenvironnements d'*H. matritense* en Chine se composent de rivières et de lacs et sont différents de l'environnement ibérique aride. *Hispanotherium* pourrait être originaire du Sud-Ouest de l'Europe et s'être dispersé ultérieurement vers l'Est jusqu'en Asie.

Keywords: Systematics; Rhinocerotidae; Middle Miocene; China

Mots clés : Systématique ; Rhinocerotidae ; Miocène moyen ; Chine

1. Introduction

Laogou is a small gully on the north bank of the River Guangtong in Hezheng County (Gansu, China) (Fig. 1), where late Cenozoic deposits are well exposed. A mammalian fauna represented by abundant fossil remains was discovered from the lower part of the Laogou section. *Platybelodon* and *Gomphotherium* are the dominant elements of the fauna. About 500 isolated teeth of theirs were collected. Other fossils include *Pliopithecus* sp., *Hemicyon teilhardi*,

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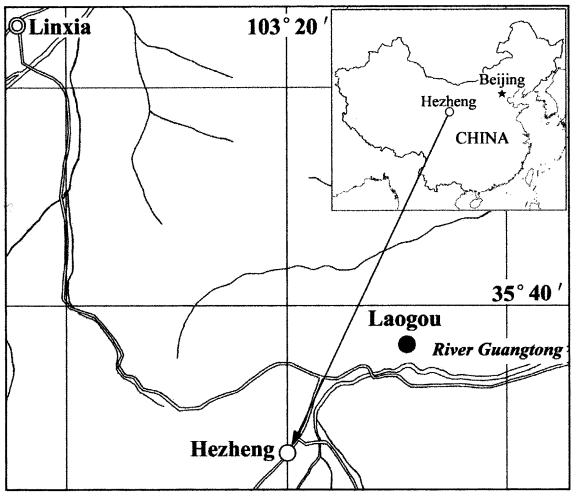

Fig. 1. Location map.
Fig. 1. Carte de localisation.

Amphicyon tairumensis, *Percrocuta tungurensis*, *Anchitherium gobiensis*, *Alicornops* sp., *Hispanotherium matritense*, *Listriodon mongoliensis*, *Kubanochoerus gigas*, and *Palaeotragus tungurensis*. This fauna is within the Tunggurian Stage of Middle Miocene in the Chinese Neogene mammalian sequence. The specimens of *Hispanotherium matritense* are second only to those of *Platybelodon* and *Gomphotherium* in terms of abundance.

In this paper, the material of *H. matritense* is studied. This is the first recognition of this species in China, although several elasmothere species had been described from the Chinese Middle Miocene.

H. matritense was named by de Prado (1864) as *Rhinoceros matritensis* based on a few teeth from Puente de Toledo (Madrid, Spain). Crusafont and Villalta (1947) established the genus *Hispanotherium* based on that species, which was found later in other localities of Spain, Portugal and France (Hernández-Pacheco and Crusafont, 1960; Antunes, 1979; Alférez et al., 1982; Cerdeño and Alberdi, 1983; Antunes and Ginsburg, 1983; Ginsburg et al., 1987; Cerdeño, 1992; Cerdeño and Iñigo, 1997). Iñigo and Cerdeño (1997) referred a number of the elasmothere forms to *H. matritense*, including *Caementodon oettingenae*, *Begertherium grimmi*, *B. tekkayai* and *B. borissiaki* from localities in Turkey, Pakistan and Mongolia. On the basis of a cladistic analysis of the family Rhinocerotidae, Cerdeño (1995) considered that *Hispanotherium* and related forms were included in the Subtribe Iranotheriina within the Tribe Rhinocerotini. I think that it is a result without enough and efficient synapomorphies; so I support the opinion of Antoine (2000) to retain all elasmotheres within the monophyletic Tribe Elasmotheriini.

In China, several Middle Miocene elasmotheres have been described, including *Hispanotherium lintungensis* from Lintong (Zhai, 1978), *Tesselodon fangxianensis* from Fangxian (Yan, 1979), *Shennongtherium hyposodontus* from Shennongjia (Huang and Yan, 1983), *Caementodon tongxinensis* and *Huaqingtherium qiui* from Tongxin (Guan, 1988, 1993). Cerdeño (1996) described a new species, *Hispanotherium tungurense* from Tunggur, Inner Mongolia, China, and discussed some Middle Miocene elasmotheres of China. The new material of *H. matritense* from Laogou provides us with a better knowledge of the geographic distribution and characters of this species, and also the range of morphological and metrical variation within a single population. Furthermore, these new remains allow us to discuss anew the controversial synonymy problems of the Chinese Middle Miocene elasmotheres, *Hispanotherium lintungensis*, *Tesselodon fangxianensis*, *Caementodon tongxinensis*, and *Huaqingtherium qiui*.

2. Systematic paleontology

Order: PERISSODACTYLA Owen, 1848
Family: RHINOCEROTIDAE Gill, 1872
Subfamily: RHINOCEROTINAE Gill, 1872
Tribe: ELASMOTHERIINI Dollo, 1885
Genus: ***Hispanotherium*** CRUSAFONT and VILLALTA, 1947
Hispanotherium matritense PRADO (1864)
Figs. 2–5 and Tables 1 and 2

Synonymy:
1952 *Chilotherium quintanelensis* ZBYSZEWSKY
1971 *Begertherium borissiaki* BELIAJEVA
1972 *Caementodon oettingenae* HEISSIG
1974 *Hispanotherium grimmi* HEISSIG
1974 *Beliajevina tekkayai* HEISSIG
1978 *Hispanotherium alpani* SARAC
1978 *Hispanotherium lintungensis* ZHAI
1979 *Tesselodon fangxianensis* YAN
1980 aff. *Aceratherium platyodon* BONE et al.
1983 *Huaqingtherium lintungensis* HUANG and YAN
1988 *Caementodon tongxinensis* GUAN
1989 *Begertherium grimmi* FORTELIUS and HEISSIG
1989 *Begertherium tekkayai* FORTELIUS and HEISSIG
1993 *Huaqingtherium qiui* GUAN

Holotype: Right M^2 in Crusafont and Villalta (1947; Fig. 1). Stored in the Museo Geominero (Madrid, Spain).

Geographical distribution: Western Europe (Iberian Peninsula and France) and Asia (Turkey, Pakistan, Mongolia and China).

Stratigraphical distribution: Middle Miocene to Upper Miocene, Lower Aragonian to Lower Vallesian, MN4 to MN9 of Europe and Tunggurian of East Asia.

Diagnosis: Small rhinocerotid with one nasal horn, maybe with sexual dimorphism. Subhypsodont cheek teeth, with very thick cement cover as well as deeply constricted protocone and lightly constricted metaconid. Upper premolars with closed median valley. Secondary folds of the enamel developed. I_2 like small tusks, with sexual dimorphism in size. Postcranial skeleton slender, with the McV reduced, not functional.

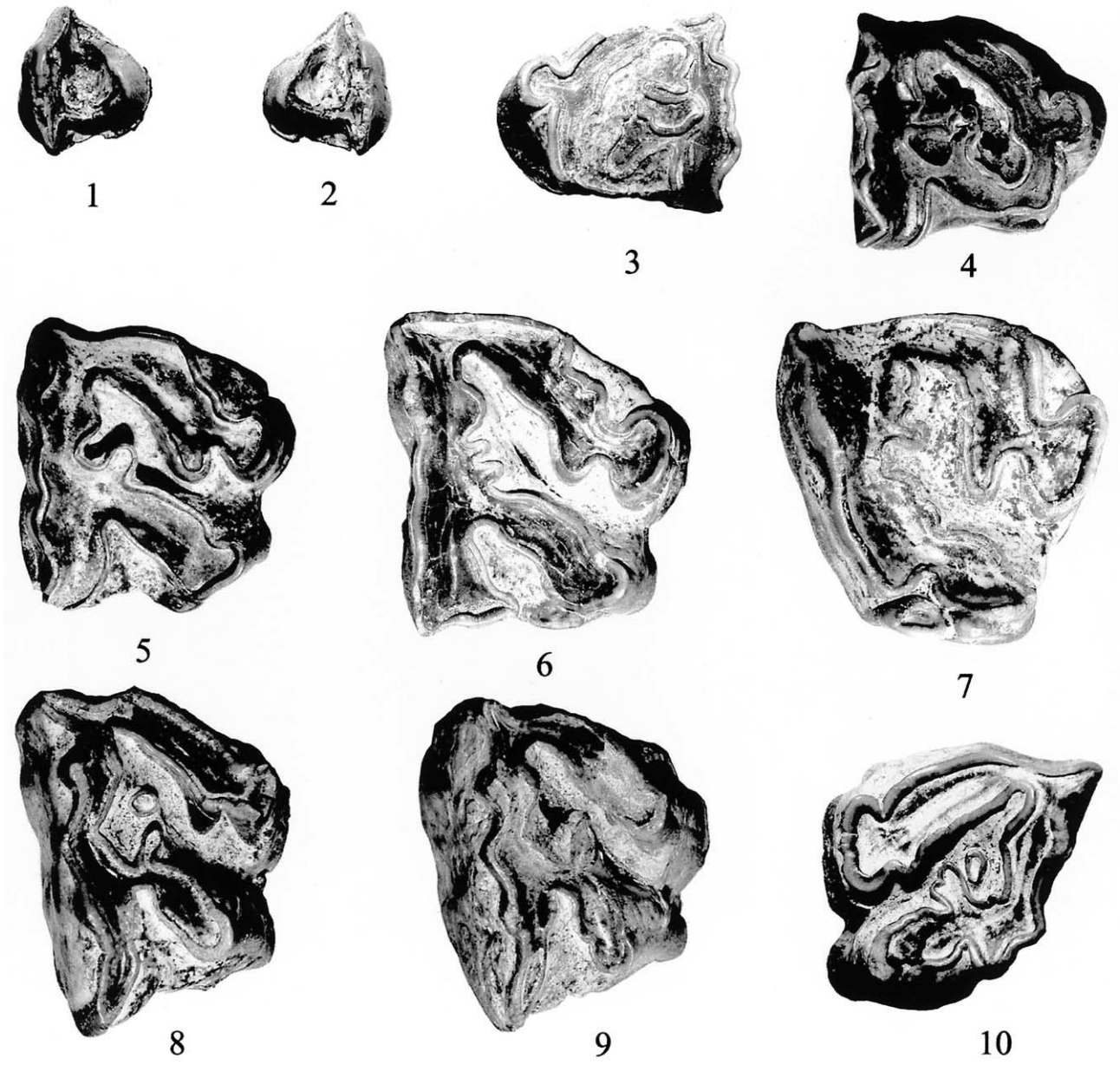

Fig. 2. Upper teeth of *Hispanotherium matritense* from Laogou, Hezheng (Gansu, China), occlusal view, × 1. **(1)** V 12649.5, right P^1. **(2)** V 12649.1, left P^1. **(3)** V 12649.2, left P^3. **(4)** V 12649.6, right P^4. **(5)** V 12649.7, right M^1. **(6)** V 12649.8, right M^2. **(7)** V 12649.11, right M^3. **(8)** V 12649.9, right M^2. **(9)** V 12649.10, right M^2. **(10)** V 12649.3, left M^3.

Fig. 2. Dents supérieures d'*Hispanotherium matritense* de Laogou, Hezheng (Gansu, Chine) en vue occlusale, × 1. **(1)** V 12649.5, P^1 droite. **(2)** V 12649.1, P^1 gauche. **(3)** V 12649.2, P^3 gauche. **(4)** V 12649.6, P^4 droite. **(5)** V 12649.7, M^1 droite. **(6)** V 12649.8, M^2 droite. **(7)** V 12649.11, M^3 droite. **(8)** V 12649.9, M^2 droite. **(9)** V 12649.10, M^2 droite. **(10)** V 12649.3, M^3 gauche.

Materials studied: V 12649.1, left P^1; V 12649.2, left P^3; V 12649.3, left M^3; V 12649.4, left M^3; V 12649.5, right P^1; V 12649.6, right P^4; V 12649.7, right M^1; V 12649.8, right M^2; V 12649.9, right M^2; V 12649.10, right M^2; V 12649.11, right M^3; V 12649.12, right I_2; V 12649.13, right M_2; V 12649.14, left I_2; V 12649.15, left P_3; V 12649.16, left P_4; V 12649.17, left M_1; V 12649.18, left M_1; V 12649.19, left M_2; V 12649.20, left M_3. These 20 teeth correspond to a minimum number of three adult individuals. All are from the Tunggurian of the Middle Miocene (MN6) at Laogou in Hezheng (Gansu, China).

Abbreviations used in the tables are the following: *L*, length; *W*, width, *H*, height.

Description: The upper cheek teeth have a strongly undulated labial border of ectoloph with marked paracone and metacone but weak mesostyle ribs, wrinkled enamel surrounding the median valley, and a rather thick cement layer, but no lingual cingulum.

P^1—Triangular in crown view, and double rooted. The anterior and posterior cingula are low. The protoloph is narrow and low, ascending lingually. The metaloph is well

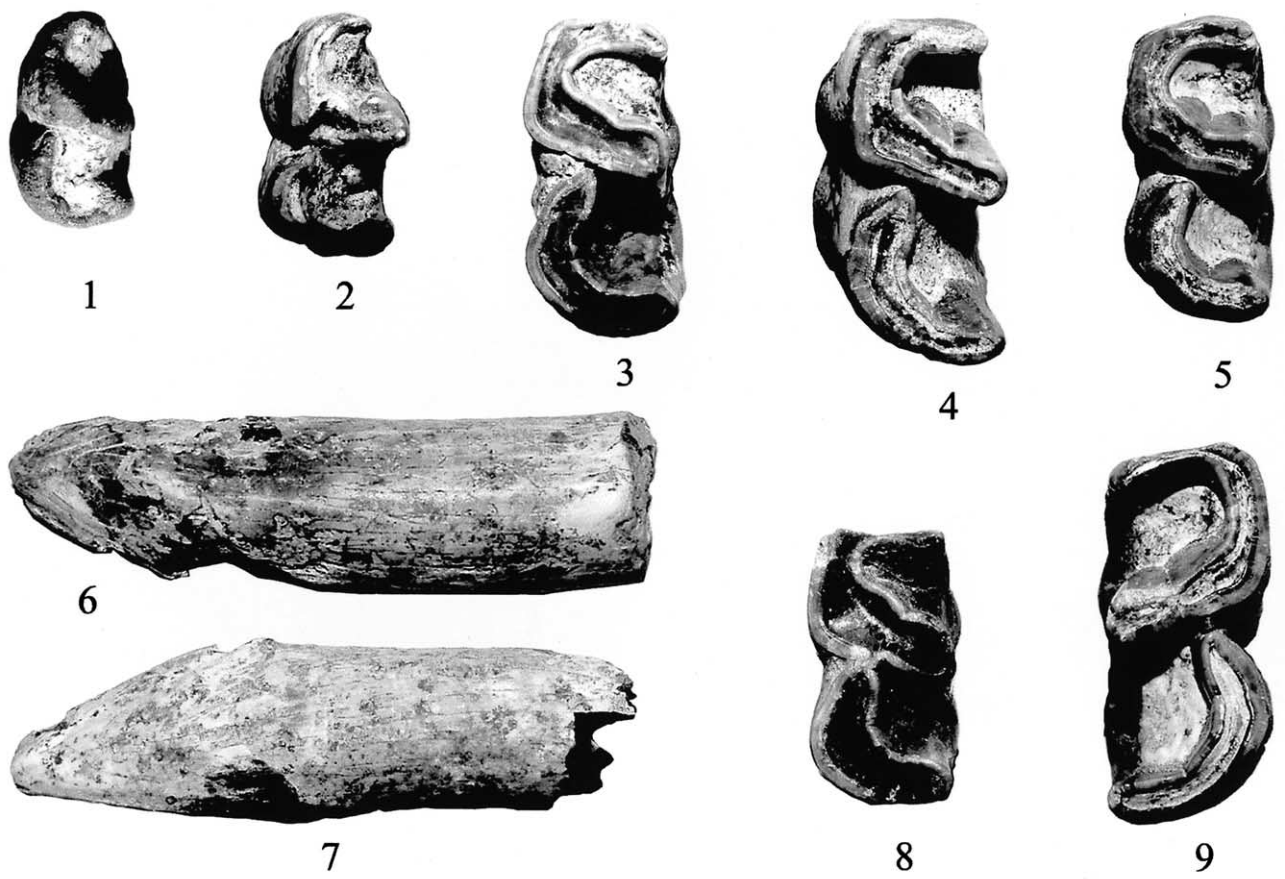

Fig. 3. Lower teeth of *Hispanotherium matritense* from Laogou, Hezheng (Gansu, China), occlusal view, × 1. **(1)** V 12649.15, left P_3. **(2)** V 12649.16, left P_4. **(3)** V 12649.17, left M_1. **(4)** V 12649.19, left M_2. **(5)** V 12649.20, left M_3. **(6)** V 12649.12, right I_2. **(7)** V 12649.14, left I_2. **(8)** V 12649.18, left M_1. **(9)** V 12649.13, right M_2.

Fig. 3. Dents inférieures d'*Hispanotherium matritense* de Laogou, Hezheng (Gansu, Chine) en vue occlusale, × 1. **(1)** V 12649.15, P^3 gauche. **(2)** V 12649.16, P^4 gauche. **(3)** V 12649.17, M^1 gauche. **(4)** V 12649.19, M^2 gauche. **(5)** V 12649.20, M^3 gauche. **(6)** V 12649.12, I^2 droite. **(7)** V 12649.14, I^2 gauche. **(8)** V 12649.18, M^1 gauche. **(9)** V 12649.13, M^2 droite.

developed and bends forward to connect the protoloph. The crochet and crista are very small.

P^3—The protocone is round, with well developed anterior and posterior constriction grooves. The protoloph is wide, and bends backward to connect the metaloph. The metaloph is very narrow, and its posterior wall is lost on the worn surface. The posterior valley is absent. Double cristae: the anterior one forms a narrow and long bar, but the posterior one is a large triangle with a wrinkled enamel. The posterior cingulum is absent.

P^4—The protocone is similar to that of P^3. The protoloph, metaloph and bridge are of the same width. The crochet and crista are narrow and long, with a wrinkled enamel. A small enamel ring is formed between the ends of crochet and crista. The parastyle is narrow while the metastyle is wide. The posterior valley is deeply V-shaped. The anterior cingulum is weak, but the posterior one is well developed.

M^1—The crown surface is square. The protocone is round, with anterior and posterior constriction grooves. The protoloph and metaloph are wide. The crochet and antecrochet are thick and short. The median valley is open. The posterior cingulum is well developed but the anterior one is absent. The metastyle is wide and long; correspondingly, the posterior valley is wide and deep.

M^2—Similar to M^1. The protocone is oval, with deep anterior and posterior constriction grooves. The antecrochet and crista become stronger towards the base, but the crochet is weaker or absent. The anterior cingulum is weak.

M^3—The protocone is flat lingually and deeply constricted. The development of the crochet, antecrochet and crista is similar to that of M^2. The posterior cingulum forms two well developed pillars. The lightly worn specimen is very different from the heavily worn one. Since the labial wall is well undulated, the ribs are well developed. A well marked ridge is present on the metacone, forming a small but obvious posterior valley.

I_2—Small tusk with a triangular worn surface and an oval root section.

The crowns of the lower cheek teeth are high, and become short towards their bases. Cement cover is present mainly in the valleys and the labial grooves. The labial wall has a well marked ridge on the protoconid. The labial groove is deep. The paralophid is short in the premolar but long in the molar. The constricted metaconid declines backwards. There are

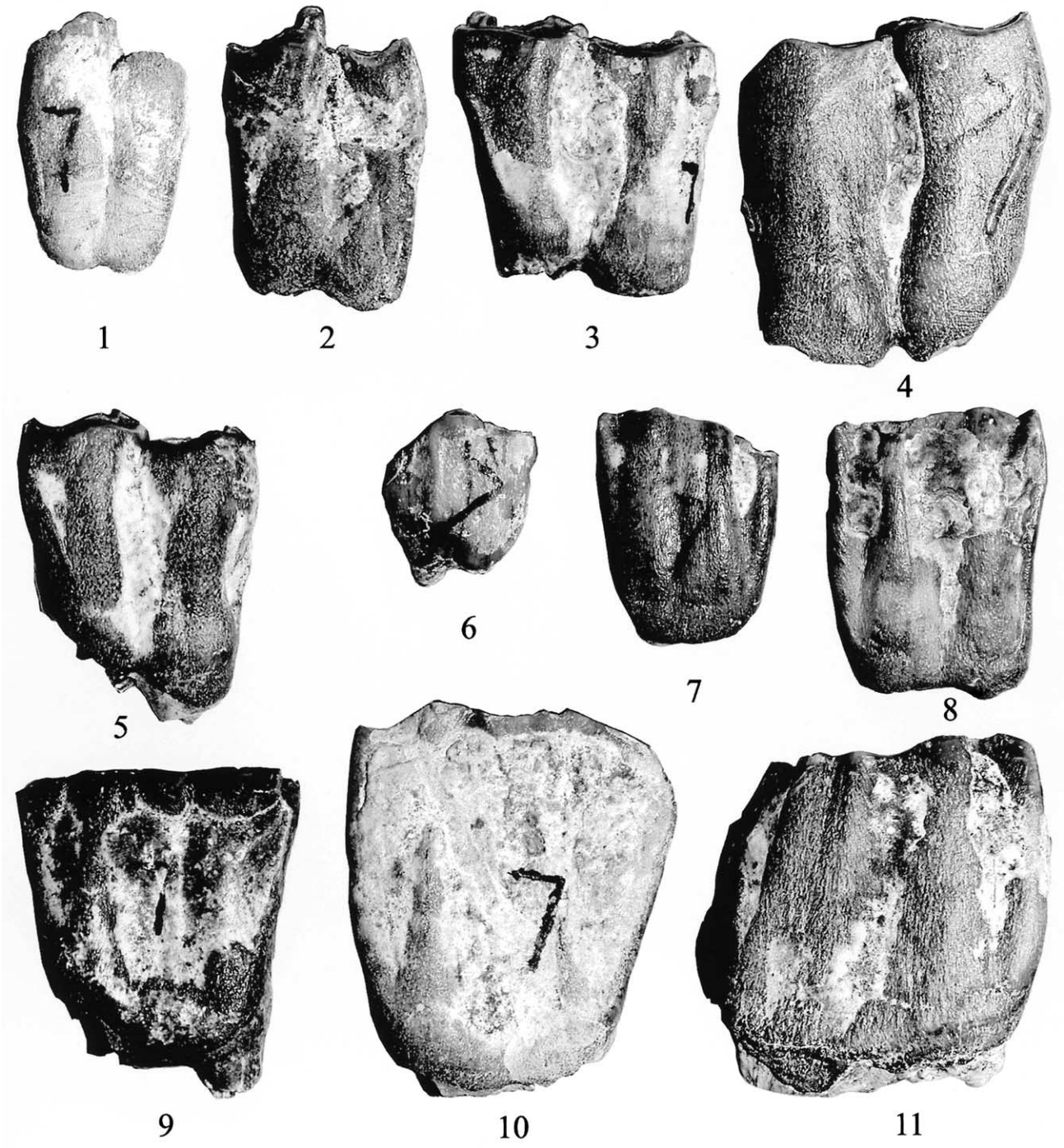

Fig. 4. Cheek teeth of *Hispanotherium matritense* from Laogou, Hezheng (Gansu, China), labial view, × 1. **(1)** V 12649.15, left P_3. **(2)** V 12649.16, left P_4. **(3)** V 12649.17, left M_1. **(4)** V 12649.13, right M_2. **(5)** V 12649.20, left M_3. **(6)** V 12649.5, right P^1. **(7)** V 12649.2, left P^3. **(8)** V 12649.6, right P^4. **(9)** V 12649.7, right M^1. **(10)** V 12649.10, right M^2. **(11)** V 12649.3, left M^3.

Fig. 4. Dents jugales d'*Hispanotherium matritense* de Laogou, Hezheng (Gansu, Chine) en vue labiale, × 1. **(1)** V 12649.15, P^3 gauche. **(2)** V 12649.16, P^4 gauche. **(3)** V 12649.17, M^1 gauche. **(4)** V 12649.13, M^2 droite. **(5)** V 12649.20, M^3 gauche. **(6)** V 12649.5, P^1 droite. **(7)** V 12649.2, P^3 gauche. **(8)** V 12649.6, P^4 droite. **(9)** V 12649.7, M^1 droite. **(10)** V 12649.10, M^2 droite. **(11)** V 12649.3, M^3 gauche.

weak anterior and posterior cingula, but no lingual and labial ones. The anterior and posterior valleys are U-shaped. The enamel is weakly wrinkled. The anterior lobe is flat labially and the posterior one is rounded. Both buccally and lingually, the conids have small but distinct basal swellings.

Discussion: The studied material from Laogou is generally similar to the specimens of *Hispanotherium matritense* from other localities in Eurasia, with minor differences.

This new material has the more variable enamel folds in the median valley on the upper cheek teeth than all the other

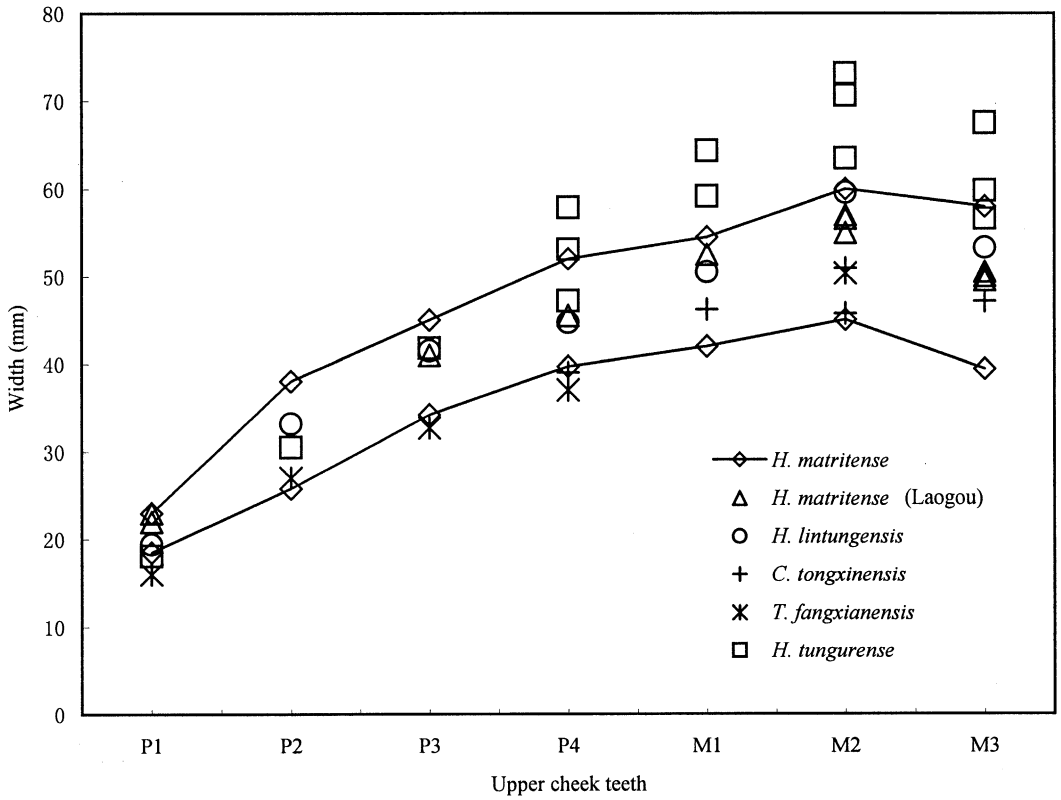

Fig. 5. Comparative relationship of the width of the upper teeth of *Hispanotherium matritense* and the Chinese Middle Miocene elasmothere species.
Fig. 5. Comparaison des largeurs des dents supérieures d'*Hispanotherium matritense* et d'espèces chinoises d'élasmothères du Miocène moyen.

known species. The specimens of *H. matritense* from the Iberian Peninsula usually have very simple enamel folds on their upper cheek teeth, such as those from Puente de Toledo (de Prado, 1864), Torrijos (Cerdeño and Alberdi, 1983), Corcoles (Iñigo and Cerdeño, 1997).

The lower molar described by de Prado (1864; Pl. 3a, Fig. 6) has marked constriction grooves of metaconid. However, Iñigo and Cerdeño (1997) excluded the constriction of the metaconid from the diagnosis of *H. matritense*, because this character was observed at a low frequency within the sample

Table 1
Measurements and comparisons of upper teeth of *Hispanotherium matritense* from Laogou, Hezheng (Gansu, China) in millimeters
Mesures et comparaisons en millimètres des dents supérieures d'*Hispanotherium matritense* de Laogou, Hezheng (Gansu, Chine)

Teeth		*H. matritense* (Laogou)	*H. lintungensis* (Zhai, 1978)	*T. fangxianensis* (remeasure)	*C. tongxinensis* (Guan, 1988,1993)	*H. tungurense* (Cerdeño, 1996)
P^1	L	22.5/24	19.5	17		20.5
	W	23/22	19.4	16		18.1
	H	25/25		21		
P^3	L	30	25.5	29		34.2
	W	41	41.5	32.7		41.8
	H	38		30.5		
P^4	L	33.5	26	30	29.6	36.1–39.4
	W	45.5	44.7	37	39	47.2–57.9
	H	44.5		49	36.3	
M^1	L	44	33.3		38.9	42.5–48.9
	W	52.5	50.5		46.2	59.2–64.4
	H	44			33.8	
M^2	L	49/56/54. 5	49		45.7	60.9–64.6
	W	57/55/56. 5	59.6	50.3	45.7	63.5–73.1
	H	44/58.5/6 3.6		56		
M^3	L	49.5/47/4 8	45.7		45.7	46.4–60
	W	50/49.5/5 0.5	53.3		47.1	56.6–67.5
	H	30/50/70 (unworn)			60	

Table 2
Measurements and comparisons of lower teeth of *Hispanotherium matritense* from Laogou, Hezheng (Gansu, China) in millimeters
Mesures et comparaisons en millimètres des dents inférieures d'*Hispanotherium matritense* de Laogou, Hezheng (Gansu, Chine)

Teeth		*H. matritense* (Laogou)	*C. tongxinensis* (Guan, 1993)	*H. qiui* (Guan, 1993)	*H. tungurense* (Cerdeño, 1996)
I_2	L	25/23			
	W	18/17			
	H	39/35			
P_3	L	30			27.7–31.9
	W	20			21.7–23.2
	H	44 (unworn)			
P_4	L	34.5	26.4	38.1	29.8–37.6
	W	24	21.4	26.3	23.7–33.7
	H	46.5			
M_1	L	43/39	32.1	40.6	41.1–41.9
	W	24.5/25	25.7	26.6	27.5–34.6
	H	39/37.5			
M_2	L	48/51	48.6	45	44.3–57.5
	W	28.5/29	30	26.3	27.3–39
	H	44/52			
M_3	L	42	48.6		46.6–60.6
	W	23	27.1		25.7–36.9
	H	45	45		

from Corcoles. On the other hand, this character is observed in each lower cheek tooth of *H. matritense* from Laogou.

The upper cheek teeth from Laogou have more undulated labial border of ectoloph than from other localities, and the lower cheek teeth have higher crown. The boundary between the ectoloph and metaloph of M^3 is well defined.

The size of the teeth from Laogou is very close to that of *H. matritense* from different localities in Europe and Asia (Iñigo and Cerdeño, 1997). Among the upper cheek teeth, the P^1 is a little wider than the Iberian specimens (Iñigo and Cerdeño, 1997), but it is similar to the specimens from Turkey (=*B. grimmi* HEISSIG, 1976) and Mongolia (=*B. borissiaki* BELIAJEVA, 1971). Among the lower dentition, the two I_2s are as wide as the male specimens but as long as the female ones of *H. matritense* from Corcoles (Iñigo and Cerdeño, 1997). The M_3 is slightly narrower than any known M_3 from other localities.

The length of the rhinocerotid cheek teeth becomes shorter towards the base. Therefore, it is not very effective to compare the lengths of rhinocerotid cheek teeth in different degrees of wear. On the other hand, the largest width of the rhinocerotid cheek teeth is at the base, so the width is a better character for comparative purpose.

A number of elasmothere genera and species were described from the Middle Miocene in Europe and Asia. Antunes and Ginsburg (1983) suggested to synonymize *Begertherium*, *Caementodon* and *Beliajevina* with *Hispanotherium*. Iñigo and Cerdeño (1997) confirmed the synonymy of *Caementodon oettingenae*, *Begertherium grimmi*, *B. tekkayai* and *B. borrissiaki* with *H. matritense*. They compared the mean lengths of the upper teeth between *H. matritense* and *B. caucasica*. They still retained *B. caucasia* as a separate species because of its larger size, but considered that its validity as a distinct genus can hardly be justified. On the other hand, the width of the cheek teeth of *B. caucasica* falls well within the observed range of variation of *H. matritense* from the Iberian Peninsula. The length of the upper cheek teeth of *B. caucasica* is very close to *B. grimmi*, but the latter was referred to *H. matritense* by Iñigo and Cerdeño (1997).

An elasmothere skull of old age with complete upper cheek tooth rows from Lengshuigou in Lintong (Shaanxi, China) was described as a new species, *Hispanotherium lintungensis* (Zhai, 1978). Zhai stated that the enamel fold and crochet of this species are weaker than those of *H. matritense*, and that the M^2 of *H. lintungensis* has only an anterior groove on the hypocone while *H. matritense* has both anterior and posterior grooves. Cerdeño (1996) indicated that the dental characters of the type material of *H. lintungensis* hardly differ from those of *H. matritense*. The development of the enamel fold and crochet becomes weaker towards the base. The Lintong specimen is an old individual with heavily worn teeth. The posterior groove on the hypocone of M^2 can be very little developed, as the type material of *H. matritense* (Crusafont and Villalta, 1947) and the Corcoles specimens of *H. matritense* (Iñigo and Cerdeño, 1997). The width of the upper cheek teeth of *H. lintungensis* falls completely within the variation range of *H. matritense* from Iberia, Turkey, Pakistan and Mongolia as well as *H. matritense* from Laogou. Consequently, *H. lintungensis* is a junior synonym of *H. matritense*. Huang and Yan (1983) erected a distinct genus, *Huaqingtherium* for *H. lintungensis*, because of the differences stated by Zhai (1978) from *H. matritense*. Guan (1993) said that *Huaqingtherium* has a relatively wider skull. But Cerdeño (1996) did not agree with Guan's statement, and indicated that *Huaqingtherium* should be a subjective synonym.

Yan (1979) established a new elasmothere, *Tesselodon fangxianensis* on an incomplete left upper cheek tooth row from Erlanggang in Fangxian (Hubei, China). He considered that *Tesselodon* has three characters different from *Hispanotherium*: smaller size, four upper premolars, and no enamel fold. We measured the Fangxian specimens again. The new measurement shows that the tooth size of *T. fangxianensis* is very close to that of *H. matritense* from Iberia (Iñigo and Cerdeño, 1997). Only the P^3 and P^4 are slightly narrower than the Iberian specimens. *H. matritense* also has four upper cheek teeth (Iñigo and Cerdeño, 1997; Fig. 2). Two P^1s of *H. matritense* are also discovered from Laogou. The enamel fold of *H. matritense* from Corcoles is not stronger than that of Fangxian specimens. The developed cement cover, undulated labial border of ectoloph, constricted protocone and closed median valley on the premolar of the Fangxian specimens are very similar to *H. matritense* from the Iberian localities, and also similar to the Laogou specimens. Cerdeño (1996) indicated that *T. fangxianensis* does not differ fundamentally from *Hispanotherium*. Therefore, *T. fangxianensis* is also a junior synonym of *H. matritense*.

Huang and Yan (1983) described a new elasmothere, *Shennongtherium hyposodontus* based on an incomplete left upper jaw with P^2-M^1 from Sunjiapo in Shennongjia (Hubei, China). Fortelius and Heissig (1989) considered that *Shennongtherium* belongs to the tribe Rhinocerotiini. It is true that *Shennongtherium* has no developed cement cover, wrinkled enamel, and undulated ectoloph. We agree to exclude *Shennongtherium* from the tribe Elasmotheriini.

Guan (1988) established a new elasmothere, *Caementodon tongxinensis* from Tongxin (Ningxia, China). He stated that the new species is smaller than *Hispanotherium matritense*. On measuring the materials of Guan (1988; Pl. II, III; 1993, Pl. II), however, the size of *C. tongxinensis* falls well within the variation range of *H. matritense*. Guan (1988) listed the differences between *C. tongxinensis* and *H. matritense*, and considered that on the upper cheek teeth of the former, the mesostyle is not marked, the hypocone is not constricted, the crochet and crista are well developed, but the antecrochet is very weak. *H. matritense* has both marked paracone and metacone folds, but a weak mesostyle. The crochet and crista of *C. tongxinensis* are not stronger than those of *H. matritense*. In Tongxin specimens, however, the hypocone is constricted and the antecrochet is well developed (Guan, 1988; Pl. II, 4). Cerdeño (1996) indicated that *C. tongxinensis* is not different from *H. matritense*, taking into account the great intraspecific variation. The genus *Caementodon* was previously considered a synonym of *Hispanotherium* (Antunes and Ginsburg, 1983; Cerdeño, 1992; Iñigo and Cerdeño, 1997).

Guan (1993) established another new elasmothere, *Huaqingtherium qiui* from Tongxin. As discussed above, *Huaqingtherium* is just a junior synonym of *Hispanotherium*. He stated the different characters of *Huaqingtherium qiui* from *Hispanotherium*: larger size, greater tooth width relative to its length, well developed antecrochet, and distinctly constricted hypocone. But measurements of the upper jaw of *Huaqingtherium qiui* of Guan (1993; Pl. I) indicate that the size is not larger than the largest value of *Hispanotherium matritense* from Iberia (Iñigo and Cerdeño, 1997; Table 1). The antecrochets of *H. matritense* from the Iberian localities and Laogou are also well developed. In *H. matritense*, the antecrochet becomes stronger, the tooth length shorter, and hypocone constriction more distinct towards the base. The specimen of *Huaqingtherium qiui* is an old individual with heavily worn upper cheek teeth, so it has well developed antecrochet, great tooth width and distinctly constricted hypocone. As for the lower teeth of *Huaqingtherium*, Cerdeño (1996) indicated that they belong to an acerathere. We support her opinion.

Cerdeño (1996) studied the rhinocerotid material from Tunggur (Inner Mongolia, China), which was discovered in 1928 by the Central Asiatic Expeditions of the American Museum of Natural History, and stored in this museum now. She established a new species, *Hispanotherium tungurense*. She considered that this species is larger than the other species of the genus *Hispanotherium*, its premolar series is relatively shorter than that in *Hispanotherium matritense*. Indeed, the tooth width of *H. tungurense* is obviously larger than that of *H. matritense* (Fig. 5); especially its M^2 and M^3. Therefore, *H. tungurense* is a separate species in the genus *Hispanotherium*.

3. Biostratigraphy and paleoecology

The Laogou fauna is very similar to the Dingjiaergou fauna from Tongxin (Qiu et al., 1999). In the Laogou site, the fossiliferous sandstone bearing *H. matritense* underlies the sandstone bearing *Platybelodon grangeri*. Between the two fossiliferous beds, there is a bed of red clay. The Dingjiaergou fauna corresponds to MN6 of Europe, and the Tunggur fauna corresponds to MN7-8. As a result, the Laogou fauna also corresponds to MN6. The faunas with *H. matritense* from Lengshuigou in Lintong (=*Hispanotherium lintungensis*, Zhai, 1978) and Erlanggang in Fangxian (= *Tesselodon fangxianensis*, Yan, 1979) should also be correlated with MN6. The larger *H. tungurense* from Tunggur in Mongolia belongs to MN7-8 (Qiu et al., 1999).

H. matritense is a characteristic species of MN4-5 in Europe (Iñigo and Cerdeño, 1997). This species was considered to live in dry and warm conditions because of its hypsodont with thick cement cover and slender limbs (Cerdeño and Nieto, 1995; Iñigo and Cerdeño, 1997). In China, on the other hand, *H. matritense* is always found together with members of Amebelodontidae, as in Laogou and Dingjiaergou. *H. tungurense* also lived with *Platybelodon grangeri* in Tunggur. Amebelodonts with shoveled tusks might have preferred to live near waters. The fossils of *H. matritense* in Laogou and Dingjiaergou came from fluvial gray-yellowish sandstones with gravel. Therefore, the paleoenvironment of *H. matritense* in China is somewhat different from that of Europe. The climate was probably not very dry during MN6

in the Linxia and Tongxin Basins, and there were some rivers and lakes.

Iñigo and Cerdeño (1997) indicated that *H. matritense* is distributed in the Iberian Peninsula during MN4-5, and it is distributed in some Asian localities during MN6-8, such as Turkey, Pakistan and Mongolia. The new material from Laogou proves that *H. matritense* also lived in China during MN6. In addition, *H. tungurense* was discovered from Inner Mongolia during MN7-8.

Antoine (1997) established a new elasmothere, *Aegyrcitherium beonensis*, from the Lower Miocene of Montréal-du-Gers (Gers, France). He considered that this new elasmothere is more derived than *Caementodon* and *Hispanotherium*. On the contrary, Heissig (1999) considered that *Aegyrcitherium beonensis* is the ancestor of the more evolved *Hispanotherium matritense*. We supported Heissig's opinion because *A. beonensis* has a thinner cement cover, flatter ectoloph and weaker enamel fold than *H. matritense*. The discontinuous protoloph on the P^3-P^4 and the unconstricted protocone on the P^1-P^3 in *A. beonensis* are more primitive than in the latter. Although the evolutionary center of the tribe Elasmotheriini remains in Asia, the origin of this tribe is unknown. As mentioned above, however, the origin of the *Hispanotherium* lineage may be in southwestern Europe. The earliest known species, *Aegyrcitherium beonensis*, appeared in MN4. The next earlier species *Hispanotherium matritense* was distributed widely in Spain, Portugal and southern France in MN5. *H. matritense* dispersed into Turkey, Pakistan, China and Mongolia in MN6. The more evolved species *Hispanotherium tungurense* lived in northern China in MN7-8, and it has more developed cement cover, stronger enamel fold, more undulated ectoloph, and more constricted protocone.

4. Conclusions

New rhinocerotid teeth from Laogou, Hezheng (Gansu, China) are described and identified as *Hispanotherium matritense*. The specimens have a thick layer of cement, well developed enamel fold, undulated labial border of ectoloph, constricted protocone, and closed median valley of premolar. In comparison with the Iberian remains of *H. matritense*, the Laogou material has higher frequency of a constricted metaconid on the lower cheek teeth.

Comparing the other Middle Miocene elasmotheres from China with the material of *H. matritense* from the Iberian localities and Laogou, we confirm the synonymy proposed previously for the species *Hispanotherium lintungensis*, *Tesselodon fangxianensis*, *Caementodon tongxinensis* and *Huaqingtherium qiui*. The larger size of *Hispanotherium tungurense* proves that it is a different species from *H. matritense*.

The age of Laogou fauna from Hezheng is contemporaneous to that of the Dingjiaergou fauna from Tongxin; both of them correspond to MN6. *H. matritense* lived together with members of Amebelodontidae in Laogou and Tongxin, which implies that the environment of *H. matritense* in northern China during MN6 is somewhat different from the arid environment in the Iberian Peninsula during MN4-5, being characterized in terms of having more rivers and lakes.

The origin of the *Hispanotherium* lineage may have taken place in southwestern Europe. *Aegyrcitherium beonenensis* in MN4 is the most primitive species. *Hispanotherium matritense* was distributed in the Iberian Peninsula in MN5 and then dispersed back eastward to Asia. *Hispanotherium tungurense* is a more advanced species in northern China in MN7-8.

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