Three papers on the Late Miocene *Hipparion* Fauna of Tianzhu, Gansu Province

Some Pliocene* Lagomorphs and Rodents from Locality 1 of Songshan, Tianzhu, Gansu Province

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Introduction

In the summer of 1980, the authors of this text traveled to Songshan Commune of the Zang minority people in the Tianzhu Autonomous Region of Gansu Province to respond to a letter notifying the Institute of Vertebrate Paleontology and Paleoanthropology of three neighboring interrelated Pliocene fossil localities in the vicinity of Dihuajian. Quite a number of mammalian fossils had been excavated from two of the localities.[**] The fossil locality described in this text is at an elevation of 2640 m at Nanshanpo, Shangmiaogou Village, approximately 1.5 km southwest of Huaxing. The locality is located geographically at E Long. 103°16'18" and N Lat. 36°57'34", designated IVPP Locality No. 80006. Because the exposures were inadequate, a detailed cross section of the localities' fossil bearing sediments was not undertaken. However, from observations of the lithologic character and additional paleontological material produced from the other two localities, it is evident the fauna belongs to an assemblage equivalent to the North China Hipparion Red Clays (hereby designated the "Gansu Fauna"). These deposits are extremely well developed east of the Wushaoling Mts. with an estimated thickness of over 200 m. Accumulations of these red clays to this extent, to date, have rarely been observed in North China. These sediments compose a continuously red colored massif on the western side of Caotan at Songshan Commune. The elevation of this massif increases gradually westward. These topographic features preserve deposits that not only suggest that the climate during that time was hot and dry, lacking any appreciable large fluvial systems, but moreover sedimentation was derived from the restricted regions of the western side of the Wushao Mountains, the north face of Maomao Mt., and the south face of Nanshan Mt. Extensive research has been conducted upon the mammalian fossils within the *Hipparion* Red Clays (particularly the large mammals) by numerous endemic and foreign paleontologists. However, research upon the small mammals still appears deficient, such that it has been extremely difficult to make advanced continental temporal correlations. This text documents the first discovery of several rodent species in China that will undoubtedly contribute to the temporal correlation of the *Hipparion* Red Clays. The several species of small mammals in this text consist of:

Ochotonoides primitivus sp. nov.

Ochotona lagrelii minor Bohlin, 1942

Spermophilinus minutus sp. nov.

Kowalskia gansunica sp. nov.

Prosiphneus licenti tianzuensis subsp. nov.

Leptodontomys gansus sp. nov.

Description of Species

Lagomorpha Brandt, 1885
Ochotonidae Thomas, 1897
***Ochotonoides* Boule and Teilhard, 1928**
***O. primitivus* sp. nov.**[***]

Bohlin, B. 1942, pp. 113 153, fig. 14, E, F, G. (Plate I, Fig. 6)

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*Age of this fauna is now regarded Upper Miocene (WD).

[***]See Zheng, S.H., 1982; Some Pliocene mammalian fossils from Songshan 2 and 3 (Tianzhu, Gansu Province) and the Songshan Fauna. *Vertebrata PalAsiatica,* Vol. XX, No. 3, pp. 216-227.

[***] See also Qiu, Z.D., 1987; *Senckenbergina Lethaea* Vol. 67, pp. 390-391 (L.J. Flynn pers. com.).

Type: One right mandible with p3-m3, V6277 (Fig. 1).

Figure 1. Occlusal view of right p3-m3 *Ochotonoides primitivus* sp. nov. (V6277, Type)

Hypodigm: One right mandible containing p4-m2, V6278; One right mandible containing m1-m3, V6278 1; a section of right mandible containing m1-m3, V6278 2; a section of right mandible containing m1-m2, V6278 3; a section of left mandible containing m1-m3, V6278 4.

Diagnosis: A slightly smaller individual than *O. complicidens.* The first labial reentrant is relatively deep and the second labial salient angle is relatively small.

Description: The labial side of the p3 possesses 4 salient angles and 3 reentrant folds. The sizes of the first, third, and fourth salient angles are approximately equivalent. The second salient angle is relatively smaller, but projected further out than the third angle. The first reentrant fold is shallower than both the second and third reentrants. The third and fourth salient angles display portions of relatively thick enamel. Absent are accessory enamel plications within the reentrant folds. The lingual side of the p3 possesses 3 salient angles and 3 reentrant folds. The first and third reentrants are both relatively diminished, but the second reentrant fold is cut relatively deeply into the premolar to lie close to the second reentrant. Consequently, the premolar is divided into two sections with the anterior section small and the posterior large. The anterior section is slightly shorter than the posterior section. The p4-m2 display a narrower talonid than trigonid and there is a slight posteriorly directed projection at the center of the talonid. The enamel is relatively thicker on the posterior walls of the talonids and trigonids. The anterior region of the p4 does not come into direct contact with the p3, which is a character similar to *O. complicidens* found at localities such as Qingyang and Nihewan. The m3 has not only lost the talonid, but has correspondingly reduced its existing trigonid.

Table 1. Dental measurements of *Ochotonoides primitivus* sp. nov (mm).

	V6277	V6278	V6278.1	V6278.2	V6278.3	V6278.4
p3 length	1.89					
Trig. width	1.47					
Tal. width	1.80					
p4 length	1.86	1.86	1.77			
Trig. width	1.92	1.83	1.86			
Tal. width	1.98	1.95	1.89			
m1 length	1.95	1.92	1.74	1.86	1.92	1.95
Trig. width	1.98	1.95	1.92	2.04	1.86	2.10
Tal. width	1.89	1.98	1.95	2.10	1.95	2.04
m2 length	1.80	1.95	1.77	1.86	1.89	1.95
Trig. width	1.95	2.01	1.89	1.95	1.89	2.10
Tal. width	1.89	1.95	1.71	1.86	1.92	1.95
m3 length	0.90			0.87		0.90
Breadth	1.50			0.81		1.35
Mand. ht. at m2	7.45	7.50		7.36	6.72	7.24
m1-3 length	4.92			4.90		4.82
p3-m3 length	8.96					

Comparison: This taxon has an occlusal morphology similar to *Ochotona*, but is a larger individual with a more projected second labial salient angle. To date, there has been only one comparable species, *O. complicidens*, found from Quaternary deposits of North China. In contrast, the current specimen is discovered from the much older *Hipparion* Red Clays, being slightly smaller with a relatively deep first reentrant fold on the labial side of the p3, a relatively small second salient angle, and a corresponding relatively long anterior section that has been separated by the second lingual and labial reentrant folds. Bohlin (1942, Fig. 14. E , F, G) described three lower premolars from Olan Chorea, Ertemte, Inner Mongolia, with a basic morphology identical to the Tianzhu specimen. He gave careful consideration to the character of the second salient angle being relatively smaller than that of *O. complicidens*, and hence described them as Ochotonidae sp. It is believed here that as this character is consistent with the Tianzhu specimens, and with careful consideration given to these specimens being stratigraphically older, a new species assignment is warranted.

Ochotona Link, 1795
O. lagrelii minor Bohlin, 1942

(Plate I, Fig. 7)

Bohlin, B., 1942, pp. 143-153, figs. 14-21.

Material: A section of right mandible with p3-m3, V6279 (Fig. 2); a section of right mandible with a p3, V6279-1; a section of right mandible with p4-m3, V6279-2.

Table 2. Dental measurements of *Ochotona lagrelii minor* (mm).

	V6279	V6279.1	V6279.2
p3 length	1.26	1.47	
Trig. width	0.63	1.20	
Tal. width	1.14	1.47	
p4 length	1.02		1.26
Trig. width	1.05		1.14
Tal. width	1.11		1.29
m1 length	1.11		1.20
Trig. width	1.08		1.20
Tal. width	1.17		1.29
m2 length	1.17		1.29
Trig. width	1.11		1.24
Tal. width	1.05		1.32
m3 length	0.45		0.60
Breadth	0.75		0.90
Mand. ht. at m1	3.64		4.20
p3-m3 length	5.20		
m1-3 length	2.88		3.24

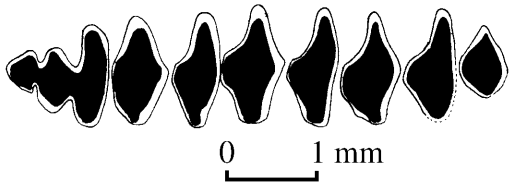

Figure 2. Occlusal view of *Ochotona lagrelii minor* Bohlin, 1942, right p3-m3 (V6297)

Description: Size equivalent to that illustrated in Schlosser (1924) Plate IV, Fig. 19, but on the juvenile specimen (V6279) the first reentrant on the lingual side of the p3 is broad and shallow, and second reentrant is relatively deep and narrow. An adult individual (V6279-1) possesses a first reentrant on the lingual side that is deep and long and a second reentrant that has become lost. Nevertheless, the juvenile and adult individuals are the same species maintaining two individual labial reentrant folds throughout their ontogeny. The p4-m2, as indicated by Schlosser, maintains an accessory projection on the anterior side of the trigonid, thereupon causing the trigonid to be larger than the talonid. The talonid on the m3 has become lost and the trigonid is smaller than its preceding tooth. Bohlin (1942) believed the aforementioned *O. lagrelii* specimens illustrated by Schlosser, as well as two additional specimens of the same size, belonged to fully adult individuals with a large size discrepancy that should be redesignated as different species or subspecies. He therefore reassigned them to *O. lagrelii minor*, emphasizing that the i2 and p4 could be distinguished by their "comparatively great breadth at the alveolar knobs." The appearance of these taxa in Gansu and other regions is further confirmation of the subspecies.

Rodentia

Sciuromorpha Brandt, 1885

Sciuridae Gray, 1821

***Spermophilinus* de Bruijn and Mein, 1968**

***S. minutus* sp. nov.**

Type: One right m2-3, V6280 (Fig. 3)

Hypodigm: One right m2, V6281; one right m3, V6281-1

Diagnosis: Smallest species known. The protoconid is not connected to the metalophid, a metastylid is absent, and the entoconid is unclear.

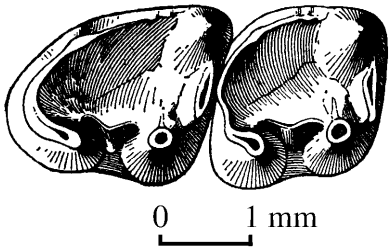

Figure 3. Occlusal view of *Spermophilinus minutus* sp. nov. right m2-3 (V6280-Type)

Description: A small individual. The occlusal surface of the m2 has a breadth greater than width. The metaconid is the highest cusp, and the protoconid and hypoconid are of an equivalent size. An entoconid is unclear, thereupon creating a relatively rounded angle at the posterolingual section of this molar. The loph composing the posterior face is not directly connected to the

metaconid as there is a deep groove separating them. The metaconid is connected to the anterior cingulum, but a paraconid is absent. The protoconid is triangular in shape and is isolated from the metalophid. The ectolophid is weak and a mesoconid is not clearly defined.

The occlusal surface of the m3, due to the expansion of the talonid basin, has a length greater than its width. The metalophid is weaker than on the m2. The protoconid is rather large and due to a deep groove is separated from the metalophid. There is an incipient mesoconid, and the four roots and other characteristics are similar to the m2.

Comparison: In 1968, de Bruijn and Mein reassigned the nomenclature of the type species *Sciurus bredai* v. Meyer by adopting the species name from *Sciurus spermophilinus* (=*S. bredai*) and elevating it to the generic status of *Spermophilinus.* In the same paper they also described *S. turolensis* produced from the *Hipparion*-bearing deposits of the Catalayud-Teruel Basin, Spain. Three additional species were also assigned to this genus: S. cf. *bredai* from Vieux Collonges, *S. bredai* from La Grive, France; and *S. gigantus* from the Island of Rhodes, Greece. The distribution of these species is confined to Europe. Precisely as de Bruijn and Mein indicated, regardless of which single character one selects from either the dentition or skull, it is very difficult to exclude this genus from any of the other genera in the subfamily Sciurinae, and it is merely a composite of characters from each species that allows the exclusion of the genus. It is possible here to assign this restricted specimen to this genus principally upon the basis of the diagnostic characters that coincide completely with the definition of the genus. The geologic age appears also to be consistent.

The most characteristic features are that it is a smaller individual than any of the aforementioned species, the protoconid and metalophid are disconnected, and the m2 is compressed anteroposteriorly.

Table 3. Dental measurements of *Spermophilinus minutis* sp. nov. (mm).

V6280	m2 L/W: 1.50/1.77
	m3 L/W: 2.01/1.74
V6281	m2 L/W: 1.56/1.86
V6281.1	m3 L/W: 1.95/1.80

Cricetidae Rochebrune, 1883
Cricetinae Murray, 1866
***Kowalskia* Fahlbusch, 1969**
***K. gansunica* sp. nov.**

Type: A section of right mandible containing m1-3, V6282 (Fig. 4).

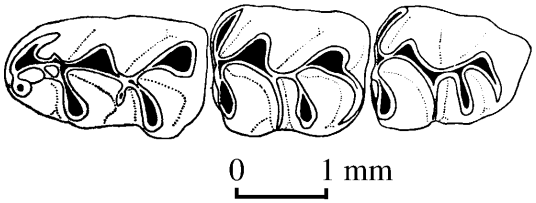

Figure 4. Occlusal view of *Kowalskia gansunica* sp. nov. Right ml-3 (V6282-Type).

Diagnosis: Size of the individual lies between *K. polonica* and *K. magna.* The anterior face of the ml possesses two united cusps. All three molars possess a long and fine mesolophid

disconnected from the metaconid. A mesostylid is not clearly defined. The m2 and M/3 possess and anterolabial cingulum that extends to the margin of the tooth.

Description: The ml is long and narrow. There are two unseparated cusps anteriorly which form an anteriorly projected wall causing the anterior outline to be blurred. At the center of the molar a small lingual cusp is connected to the metaconid by an extremely thin loph. At the labial aspect there is a sharp posteriorly directed anterolophid connected primarily to the protoconid that also forms a delicate branch which contacts metaconid, such that at the point of convergence between the protocone and metacone, there is a small anterior square vacuity. The mesolophid is perpendicular to the tooth's axis, obliquely inclined toward the lingual side, and disconnected from the metaconid. A mesostylid is absent.

The m2 is rectangular with an elongated anterior cingulum on the labial side which reaches the margin of the molar. On the lingual side it is relatively shorter, terminating at the anterior lingual corner of the molar. The mesolophid is both higher and longer than on the ml, and a mesostylid is absent.

The m3 is correspondingly reduced. The branch of the anterior cingulum on the lingual side is slightly shorter than on the m2 but is still very conspicuous. On the labial side it also reaches the margin of the molar. The mesolophid is the most well developed of all the molars and may extend to the lingual margin of the molar. The entoconid is extremely notable.

Comparison: This taxon is found principally in the Pliocene deposits of Podlesice, Poland. When Fahlbusch (1969) erected this genus he described the two different sized species as *K. polonica* (small individual) and *K. magna* (large individual). With regard to size, the Gansu species lies between the two. Morphologically it resembles the large species from Poland in characters such as the untapered anterior end of the ml, with the two anterior cusps bifurcated from two small lophs that connect to the metaconid and protoconid; the undeveloped ml mesostylid; and the relative reduction of the m

Table 4. Dental measurements of *Kowalskia* gansunica sp. nov. (mm).

	m1	m2	m3
Length	1.98	1.41	1.56
Width	1.17	1.26	1.20

Prosiphneus Teilhard, 1926
Prosiphneus licenti tianzuensis subsp. nov.

(Plate I, Figs. 1, 2, 3, 4)

Holotype: One right M3, V6283; Paratype: One left M3, V6284; Hypodigm: One left mandible containing m1-3, V6285; one right mandible containing m2-3, V6285-1; a section of right mandible containing m1-2, V6285-2; a section of right mandible containing m1, V6285-3; a section of right mandible containing m1-2, V6285-4; a section of right mandible containing m1, V6285-5; one right m1, V6285-6; one right m2, V6285-7; four left m1, V6285-8,9,10,11; one right M1, V6285-12; and one right M2, V6285-13.

Diagnosis: Morphology and size rather close to *P. licenti* Teilhard, only the m3 posterolabial reentrant contracts and narrows to alter into a circle such that on its surface there is a small constant enamel ring.

Description: This taxon begins to bifurcate its tooth roots from the time it is a juvenile. Relatively advanced Prosiphneus juvenile taxa from later stages are hypsodont with unbifurcated roots and upon gradual wear of the tooth crown, in adult individuals, the roots gradually lengthen but still do not bifurcate. On aged individuals, where the crown is very worn, the roots are lengthened and bifurcated.

The M1 labial and lingual sides each contain two individual reentrants folds, with the folds on the labial side deep and long, and on the lingual side shallow and short, with the first lingual fold particularly weak, such that after tooth wear it becomes lost, and generally does not form into an enamel ring. Paired roots are present with the anterior large and posterior small.

The M2 is orthomegodont. The two lingual reentrants are deep and long, cutting deeply into and exceeding the midline of the tooth. The labial side has one reentrant that is short and shallow. It maintains paired roots with the anterior large and posterior small.

The M3 is greatly reduced, particularly noticeable is the posterolabial reentrant fold which has been reduced to alter into a circle and within its center there is a noticeable enamel ringlet. On the type specimen there are paired roots, the anterior large and posterior small, but on the paratype there are four roots, two anteriorly, one posteriorly, and the fourth situated between the posterior root and the anterolingual root. The root count discrepancy is due to individual variation, but the aforementioned small enamel ring is a autapomorphy.

The mandible's ascending ramus initiates at the anterior margin of the m2. A mental foramen is situated directly beneath the anterior margin of the m1 alveolae. On the labial side of the mandible there is no projected swelling at the lower region of the masseteric fossa. The cross-section of the lower incisor is triangular. The lingual side of the mandible maintains many nutrient foramina.

The ml is long and thin with three long, thin, and deep lingual reentrant folds that far exceed the long axis of the tooth crown. Two labial reentrant folds are comparatively more shallow, short, and do not reach the midline of the tooth. On several specimens there is a well-developed small accessory cusp at the base of the valley entrance in the second labial reentrant fold, but on several other specimens this cusp has become lost. There are two roots, with the anterior small and the posterior large.

The m2 anterior wall is straight but inclined lingually. There are two lingual and two labial reentrant folds with the lingual side being relatively short but equivalent in length. After undergoing wear they become two isolated enamel rings. The depth penetration is equivalent to those on the m1. There is a small accessory cusp at the base of the second labial reentrant valley mouth on all the specimens. This cusp is lost only when occlusal wear reaches the base of the valley mouth. There are two roots, with the anterior small and the posterior large.

The m3 anterior wall is not inclined lingually. The first labial reentrant valley penetrates the tooth crown shallower than the second reentrant. Here also, the second labial reentrant valley possesses a well-developed accessory cusp at its valley mouth.

Comparison: The size and morphology of the material described above are generally consistent with *Prosiphneus licenti* described from the *Hipparion* Red Clays of Qingyang, Gansu, by Teilhard (1926). The only difference lies in the m3, where there is the conspicuous presence of a small enamel ringlet due to the posterolingual salient angle being rounded. This character is not known on any other known *Prosiphneus* specimens. Although the current material at hand is fragmentary, it is still possible to erect a new taxon on the basis of this single character.

Table 5. Dental measurements of *Prosiphneus licenti tianzuensis* subsp. nov. (mm).

		M1	M2	M3	m1	m2	m3
Specimen count		5	1	2	5	5	1
Length	Max	3.48		2.48	3.54	3.20	
	Avg.	3.26	2.62	2.35	3.42	3.16	1.86
	Min.	2.88		2.22	3.28	3.06	
Width	Max	2.64		2.10	2.36	2.76	
	Avg.	2.47	2.60	2.06	2.26	2.49	2.12
	Min.	2.26		2.02	2.16	2.36	

Eomyidae Deperet and Douxami, 1902
Leptodontomys Shotwell, 1956 .
L. gansus sp. nov.

(Plate I, Figures 5 and 5a)

Holotype: One right mandible containing p4-m3, V6286 (Figure 5).

Diagnosis: An individual of the same size or slightly smaller than *L. quartzi* (Shotwell). Lower molars maintain anterior and posterior cingula lower than the crown surface. A mesolophid is absent, but there is a noticeable mesostylid. The p4 maintains a transverse loph connecting the protoconid and metaconid, thereupon forming a metalophid.

Discussion: The p4 protoconid and metaconid are bunodont with a narrow ridge connecting the two that forms a metalophid. There is a small isolated cusp precisely between and anterior to these two cusps. There is a low and short anterior cingulum in front of the metaconid and small cusp. The obliquely shaped mesoconid is situated precisely in the center of the tooth crown and there is a weak ridge projecting anteriorly from it that contacts the metaloph to form a "T" configuration. The protoconid posteriorly projects a short but relatively high ridge to connect with the hypoconid. A mesolophid is absent, but there is a conspicuous mesostylid that is connected to the entoconid by a weak ridge. The posterior cingulum is more well developed than the anterior. There are two roots.

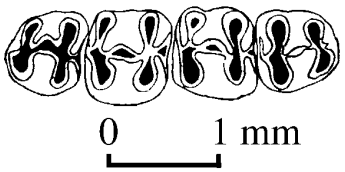

Figure 5. Occlusal view of left p4-m3 *Leptodontomys gansus* sp. nov (type V6286

The m1 and m2 are almost equivalent in both their size and cusp morphology, and both are square in configuration. The anterior cingulum is lower than the occlusal surface but upon undergoing occlusal wear becomes connected to the midpoint of the metalophid. The labial branch of the cingulum is slightly longer. A mesolophid is absent but there is a weak mesostylid. The ectolophid and protoconid are connected to the hypoconid. The distance between the mesoconid and hypoconid is shorter than the distance between the mesoconid and protoconid. The hypoconid and hypoconulid are both well developed. The posterior cingulum is weaker than the anterior cingulum and is situated extremely low. There are three roots present, two small anteriorly and one large posteriorly.

The m3 is relatively smaller with a relatively narrow posterior section. Due to deep occlusal wear, the characteristics of the entoconid, hypoconid, and hypoconulid are obliterated, however, the structure of the anterior cusps is equivalent to that on the m1 and m2. Generally, the tooth wear is more intense posteriorly than anteriorly.

The mandible displays a large mental foramen situated anterior to the p4 on the labial side at the midpoint of the diastema. The length of the diastema is equivalent to the length of the tooth row. The lower incisor intersects the posterior dentition beneath the m3 where it projects and terminates at the level of the m3 alveolae. The incisor cross section is nearly elliptical. The masseteric fossa is shallow and there is a conspicuous masseteric crest that descends and attenuates just below the posterior margin of the p4. On the lingual side of the mandible there is a shallow sulcus initiating as the anterior margin of the m1, passing beneath the p4 and extending into the diastema. Observing the labial aspect, the ascending ramus intersects the tooth row at the posterior margin of the m2. The inferior dental foramen, posterior to the tooth row and beneath the ascending ramus, is projected posteriorly and opens at the height of the occlusal surface. Precisely beneath this foramen lies another secondary inferior dental foramen that opens posteriorly. Additionally, there is another small foramen opening posteriorly at the lingual side of the mandible near the angular process.

Comparison: Since the erection of the genus *Leptodontomys* by Shotwell in 1956, this taxon has been discovered in close succession within Tertiary and Quaternary deposits of North America and Europe. The two species discovered consecutively from North America are *L. oregonensis* Shotwell (1956) and *L. quartzi* Shotwell (1967). The most extensively distributed taxa in Europe are the Miocene and Pliocene *L. catalaunicus* Hartenberger (1966) and its related species; as well as *L. bodvanus* Janossy (1972) from the Miocene and Pliocene of Hungary.

Table 6. Dental measurements of *Leptodontomys gansus* sp. nov. (mm).

	p4		m1		m2		m3	
	W	W	L	W	L	W	L	W
L. gansus sp. nov	0.66	0.69	0.66	0.78	0.66	0.78	0.57	0.64
L.catalaunicus Can Llobateres (CL. 1365) (from Hartenberger, 1966)	0.75	0.72	0.85	0.85	0.92	0.92		
L.catalaunicus Podlesice (MF/1580/1) (from Fahlbusch, 1978)	0.70	0.65	0.82	0.83	0.77	0.85	0.68	0.75
L.catalaunicus La Grive-Saint-Alban (from Hugueney and Mein, 1968)	#65345		#65344					
	0.66	0.76	0.80	0.80	0.83	0.80		
L. bodvanus Janossy (Osztramos, Loc. 1, V7152) (from Janossy, 1972)			0.80	0.78	0.86	0.80		
L. quartzi (Shotwell) (UO. 22689) (from Shotwell, 1967)	0.60	0.64	0.78	0.72	0.72	0.77		
L. oregonensis Shotwell (UO F-3633) (from Shotwell, 1956 Fig. Meas.)	0.76	0.69						

From the perspective of size, the Gansu specimen is closest to the small species *L. quartzi* from North America, and is unlike the relatively large species *L. catalaunicus* from Europe. However, from the characters of tooth morphology, among which are the absence of a mesolophid, the acute shape of the protoconid and metaconid on the p4, and the development of the anterior and posterior cingula, the Gansu species is closer to *L. catalaunicus*. The Hungarian *L. bodvanus* is a relatively large individual maintaining relatively well-developed anterior posterior cingula and a conspicuous mesolophid.

In addition to *Leptodontomys*, the general morphology of the Gansu specimen is also comparable to the North American genus *Adjidaumo* Hay (1899) as well as the European *Eomys* Schlosser (1884), but differs totally in characters such as the morphology of the metalophid and the degree of development of the anterior and posterior cingula, as well as the presence of a mesolophid. Moreover, the geologic age of these two genera is comparatively older, such that it is more appropriate that the Gansu specimens be assigned to the derived North American and European genus *Leptodontomys*.

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Middle Pliocene Micromammals from the Tianzhu Locality 80007 (Gansu Province)

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Introduction

During the summer of 1980, in response to written communication, the author of this text traveled to Songshan Commune, in the Tianzhu Tibetan Minority Autonomous Region of Gansu Province. There, several bone bearing red clay concretions were collected from Locality 80007. These samples were disaggregated upon return to the laboratory where they produced several fragmentary but relatively significant small mammalian fossils. The discovery of these fossils not only further documents the small mammal fauna previously described from Tianzhu Locality 80006, but is moreover significant in relation to extending the comprehension of the North China Hipparion Fauna.

The fossil locality lies on the north slope of Dihuajian at Songshan Commune, lying geographically at east longitude 103° 17' 26" and North latitude 36° 57' 53", at an elevation of 2660m (7980 ft). The locality is approximately equivalent to the stratigraphic position of Locality 80006 and produces the following taxa: *Paralactaga minor* sp. nov., *Heterosminthus gansus* sp. nov., *Heterosminthus simplicidens* sp. nov., *Protalactaga* cf. *tungurensis* Wood (1936), Spalacinae gen. et sp. indet., and *Ochotona lagrelii minor* Bohlin (1942).

Description of Specimens

Dipodidae Waterhouse, 1842

Allactaginae Vinogradov, 1930

Paralactaga Young, 1927

Paralactaaga minor sp. nov.

Type: A section of right mandible containing m1-2, V6302 (Fig. 1A)

Paratype: One right M1 or M2, V6303 (Fig. 1B).

Hypodigm: One left m2, V6304 (Fig. 1C)

Diagnosis: A small form. The m1 mesoconid and metaconid are connected. The entoconid is isolated and displays a distinct "G" angle. The m2 maintains a relatively deep groove separating the mesoconid and entoconid. The M1 or M2 maintains a greatly inflated metacone that is not bisected by a shallow groove on its labial side.

Description: The M1 or M2 maintains two lingual cusps, the protocone and hypocone, and three labial cusps, the paracone, mesocone and metacone, as well as an anteroloph formed from the anterior cingulum. Both the hypocone and metacone are more inflated than the protocone and paracone. The paracone is almost isolated. The mesocone is long, thin, recurved, and extends posteriorly to nearly contact the metacone. The groove between the paracone and mesocone is long and thin. The metacone is a single cusp that is not bisected by a groove labially. A posterior cingulum is absent.

Only the anterior section of the mandible is preserved. The height of the mandible beneath the m1 is 5.4 mm. There is a relatively large mental foramen situated at the anteroventrolabial margin of the m1. The curvature of the diastema is not intense such that the anterior margin of the m1 alveolus is nearly perpendicular to it. The masseteric crest on the labial side of the mandible extends anteriorly to directly beneath the m1 protoconid and forms a robust dorsally curved projection that gradually attenuates posteriorly.

The lower incisors are flat and thin. The lingual side is straight and lacks enamel, while the labial side is rounded with a thick layer of enamel. The lower incisor diameter is 1.76 x 0.78 mm.

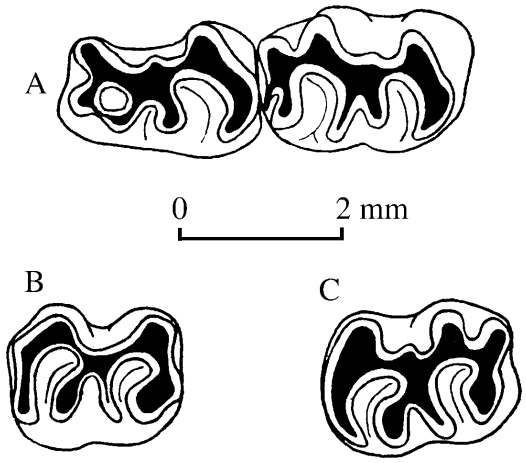

Figure 1. *Paralactaga minor* sp. nov. occlusal morphology. A. right m1 and m2 (V6302, type); B. right M1 or M2 (V6303 paratype); C. left m2 (V6304).

The m1 has two principal cusps on the labial side representing the protoconid and hypoconid. Between them is a small "G" angle. The hypoconid is the most well developed of the cusps. There are four principal cusps on the labial side, being the metaconid, mesoconid, entoconid, and hypoconulid. The labial side of the mesoconid connects to the metaconid such that between them there is formed an enamel ringlet. The entoconid and mesoconid are separated from one another by a broad and shallow groove. An anteroconid is absent.

The M2 has three principal cusps, the anteroconid, protoconid, and hypoconid. On the type specimen there is a relatively clear anterior cingulum and a weak "G" angle as described by Schaub (1930), but on specimen V6304 the anterior cingulum is lost and the G angle is relatively projected. This may indicate that the type specimen is rather immature. Lingually there are four individual cusps: the metaconid, mesoconid, entoconid, and hypoconulid. The mesoconid is relatively thin and weak, situated rather distantly from the metaconid, and close to the entoconid.

Comparison: Since the erection of this genus by C.C. Young (1927), specimens of this genus are still relatively sparse, being restricted to several fragmentary molars. However, with the exception of a single m2 discovered from the western Soviet Union, the remaining material of this rather interesting dipodid is all known from the *Hipparion* Red Clays of North China and the earliest Pleistocene sandstones.[*]

The most abundant material of this genus is represented by the type species *P. anderssoni* Young from Jinchuan in Gansu, which is represented by a complete upper and lower dentition such that it is thereupon possible to make advanced and relatively detailed comparisons with the Tianzhu material. The differences are absolutely clear. The Jingchuan M1 and M2 maintains a complicated metacone that is cut by a shallow groove on its posterolabial side, whereas the Tianzhu specimen is inflated and complete. The mesocones on the Jinchuan M1 and M2 are thick and straight with a shallow groove separating them from the paracones, whereas the Tianzhu specimen's mesocone is thin and posteriorly curved. The Jingchuan M1 maintains an isolated metaconid whereas the Tianzhu species maintains a connection between the

[*] Zheng, S.H.; A Plio-Pleistocene mammalian fauna from Ningxian Co., Gansu Province (in preparation).

metaconid, protoconid, and mesoconid. The Jingchuan specimens have a cusp arrangement (particularly the M2) that are conspicuously oblique to the tooth's longitudinal axis, whereas the Tianzhu specimens tend to be perpendicular to this axis. The clearest difference is the larger size of the Jingchuan specimens.

The material of *P. suni* discovered at Shenmu, Shaanxi Province, consists of one left M1-2 and one right M2-3 (Teilhard and Young, 1931, pp. 8-9, Pl. V, Figs. 22 and 23). Teilhard and Young believed the paracone and metacone of *P. suni* to be more well developed than on *P. anderssoni* as well as the M3 being reduced. Aside from these distinctions, it is difficult differentiate the two species' cusp morphology. Therefore, it is not necessary to make further comparisons with the Tianzhu specimens.

There is merely a single right m1 representing the material of *P. major* Young (1927) from Jingchuan, Gansu. This is a particularly large species, being almost twice the size of the Tianzhu specimens (see Table I). The occlusal morphology displays an anteroconid, a single well developed G angle, an anteroconid metaconid, protoconid mesoconid, and a G angle and entoconid that are all aligned in pairs perpendicularly along the tooth axis. The points of similarity with the Tianzhu specimens are the connected metaconid mesoconid protoconid, and the broad separation of the mesoconid and entoconid.

In 1978 Shaohua Zheng discovered a single m1 in the sandstones interbedded between the "*Hipparion* Red Clays" and the "Wucheng Loess" at Ningxian, Gansu, that has a size intermediate between *P. major* and *P. anderssoni.* It maintains a weak anteroconid and its metaconid, protoconid, and mesoconid are separated. These characters clearly resemble the Tianzhu specimens. In view of the Tianzhu specimens being the smallest speciens as well as the aforementioned character differences, the erection of the new species *Paralactaga minor* is warrented.

Heterosminthus Schaub, 1930

Heterosminthus gansus sp. nov.

Type: One left m1-2, V6305 (Fig. 2A).

Hypodigm: One left m2, V6306 (Fig. 2B)

Diagnosis: The m1 is longer than the m2. The metaconid is basically isolated, the m2 has a well developed anteroconid, and there is a low longitudinal ridge connecting the anteroconid, protoconid, entoconid, and hypoconid.

Discussion: The crown of the m1 is composed of eight principal elements: the anteroconid, metaconid, protoconid, mesoconid, entoconid, hypoconid, hypoconulid, and a G angle. The anteroconid is situated at the most anterior end of the tooth as a small isolated cusp, positioned relatively low, and possessing a small spur projected posteriorly, but does not contact either the metaconid or protoconid. The metaconid is basically isolated with a small spur on its posterolabial side that projects toward the protoconid. The protoconid is positioned relatively close to the posterior side of the metaconid. There is a vertical ridge projecting posteriorly to connect with the mesoconid. The mesoconid maintains a vague G angle that lies obliquely to the labial side. Lingually there is a well developed transverse loph connecting the mesoconid to the entoconid. The mesoconid also maintains a low ridge directed posterior to the anterior margin of the hypoconid. The entoconid possesses an accessory lingual inflected fold. The entoconid, mesoconid, hypoconid, and hypoconulid are all mutually connected anteroposteriorly and lingually to form a nearly enclosed sulcus. There are two roots.

The m2 is shorter and more broad than the m1 with the tooth crown composed of seven elements: the anterolingual cingulum, anteroconid, metaconid, protoconid, entoconid, hypoconid, and hypoconulid that, as in the same manner as the m1, has a low perpendicular ridge connecting them (in occlusal view the

anterior section of the tooth is inflated with the posterior section narrowing). There are three roots: two anterior and one posterior.

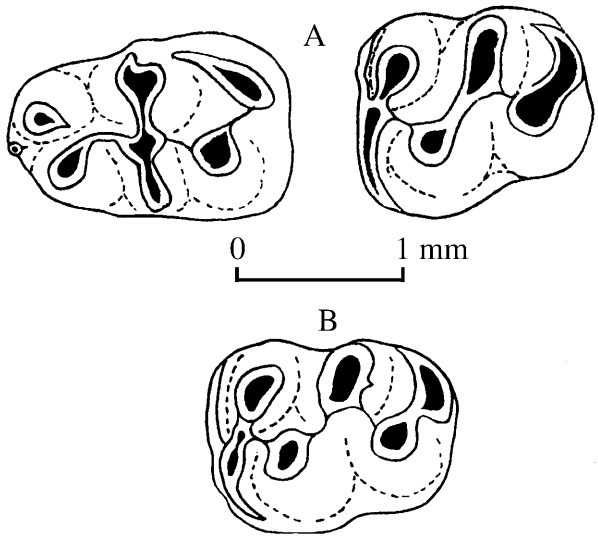

Figure 2. Crown morphology of *Heterosmithus gansus* sp. nov.
A. Left m1-2 (V6305, type); B. Left m2 (V6306.

Table 2. Dental measurements of several speceis of *Hetreosmithus* (mm).

	m1		m2		m3	
	L	W	L	W	L	W
H. gansus sp. nov	1.47	0.99	1.29	1.14		
H. simplicidens sp. nov.	1.35	0.96	1.17	0.96	0.81	0.78
H. orientalis Schaub	1.30		1.40		0.90	

Comparison: *Heterosmithus* was established by Shaub (1930) based upon the reevaluation and comparisons of a mandible with a complete tooth row described initially as *Paracricetulus schaubi* Young (1927, Pl. 1, Fig. 8 9). Precisely as Schaub indicated, the lower dentition of this dipodid from one aspect clearly resembles *Plesiosminthus.* From another aspect it maintains characters of *Protalactaga*; however, the mesostylids of both are structurally different. *Plesiosminthus* and *Protalactaga* both maintain well developed mesolophids on the m2 and mesolophs on the M2 which have been lost in *Heterosminthus.* However, regardless of this condiditon, there is no question that *Heterosminthus* is a member of the Dipodidae.

A comparison with *H. orientalis* from Yongdeng, Gansu, shows the principal differences as being the m1 and m2 are longer and relatively shorter. The m1 maintains a basically isolated metaconid, unlike that on *H. orientalis* where it is in contact with the protoconid. Its G angle is also relatively weak. The m2 protoconid is unlike *H. orientalis*, which maintains a wandering posterior arm of the protoconid formed from a small spur transversly and lingually directed and that converts to form a loph with the entoconid. The new species has a well developed anterolingual cingulum that is absent on *H. orientalis*.

Heterosminthus simplicidens sp. nov.

Type: One left m2, V6703 (Fig. 3A)

Paratype: One right m1, V6308 (Fig. 3B)

Hypodigm: One left M3, V6309 (Fig. 3C)

Diagnosis: The m1 is short and wide. Anteroconid is lost on the m2 and there is a low ridge connecting the protoconid, entoconid, and hypoconid.

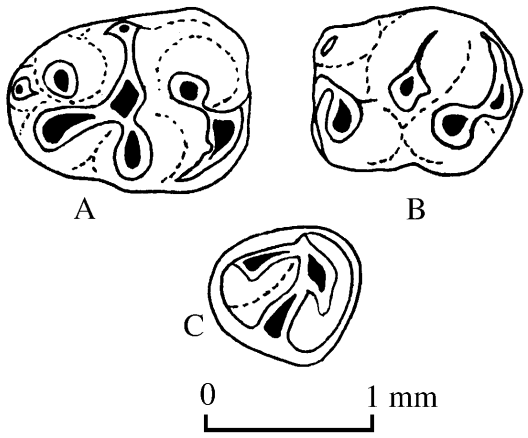

Figure 3. *Heterosminthis simplicidens* sp. nov. occlusal morphology.
A. Left m2 (V6307 Type); B. Right m1 (V6308 Paratype); C. Left M3 (V6309).

Description and Comparison: Compared to *Heterosminthus gansus* described above, the m1 is shortened but still longer than the m2. This is different from *H. orientalis*, whose M2 is longer than the M1. The principal number of cusps and their morphological alignment, in addition to the number of roots, are all consistent with *H. gansus*; however, there is an even better developed mesolophid and mesoconid. Supplementary inflections are absent on the lingual side of the entoconid.

The M2 maintains a more simple structure than *H. orientalis* or *H. gansus*. Possibly as a result of anteroposterior compression, the anteroconid has become lost and the metaconid has become reduced. In the position of the anteroconid and in place of it there is formed a metalophulid II (vorjochkante). The protoconid is still connected with this metalophulid II. The diagnostic character of a directly connected protoconid entoconid is shared between *H. simplicidens* and *H. orientalis*, but a posterior arm of the protoconid has not been developed. The position of the entoconid is extremely close to the labial side and there is an arm projecting from the posterolabial region toward the lingual side, but it does not connect to the hypoconid. There are three roots: two small ones anteriorly and one large posterior root.

The M3 is reduced. The protocone is particularly well developed and comes in contact with the hypocone and metacone posteriorly. The metacone is relatively low and lies parallel to the margin of the tooth. The paracone is relatively weak. A cingulum encircles the molar. Three roots are preesent: two anteriorly and one posteriorly (see Table 2 for measurements).

Protalactaga Young, 1927

Protalactaga cf. *tunggurensis* Wood, 1936

Material: One left P4, M1, V6310 (Fig. 4A); one left M1 V6310 1 (Fig. 4B).

Description: The P4 is extremely small with a single root and a central principal cusp at the anterolabial side. There are many low radiating ridges from this central cusp which terminate at the margin of the premolar where they become small accessory cuspules.

The M1 protocone is clearly anterior to the paracone with a well developed anterocone connected to it at the anterolabial side. There is a robust mesocone lying between the paracone and hypocone. On specimen V6310, the mesocone projects a cusp angle only to the labial side, whereas on V6310 1 this feature reaches the margin of the molar to become a mesoloph. The protocone is genuinely not isolated, as a short transverse loph passes through it to connect with the paracone. Both upper molars possess an extremely well developed posterior cingulum. There are four roots: two anterior and two posterior. Compared to *P. tunggurensis* from Tunggur, Inner Mongolia, the Tianzhu specimens have a more well developed anteroconid and posterior cingulum. There is no way to make an adequate comparison as the type specimen for this taxon, *P. grabaui* Young (1927), is a mandible containing the m1-3.

Table 3. Dental measurements of *Protolactaga* (mm).

	P4		M1	
	L	W	L	W
P. cf. *tunggurensis*	0.49	0.55	1.32-1.47	1.02-1.08
P. tunggurensis Wood, 1936	0.36	0.52	1.40	1.00

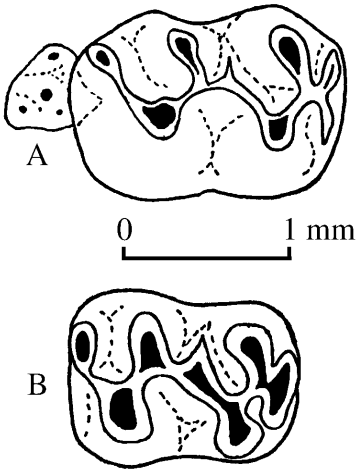

Figure 4. Occlusal morphology of *Protalactaga* cf. *tunggurensis* Wood, 1936. A. Left P4-M1 (V6310); B. Left M1 (V6310.1)

Spalacidae Gray, 1821

Spalacinae Gray, 1821

Spalacinae gen. et sp. indet.

Material: One left M3, V6311 (Fig. 5)

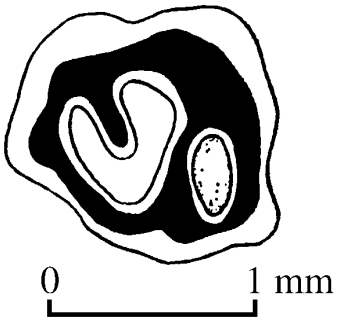

Figure 5. Occlusal view of Spalacinea gen. et sp. indet. left M3 (V6311).

Description: A small individual (M3 length 1.32 mm and width 1.35 mm) with a nearly square occlusal surface. The molar has been worn relatively deeply such that the reentrant folds appear to have been lost, although their existence may still be clearly distinguished. Reentrant fold I on the labial side has become lost; reentrant fold II is relatively deep and long, forming an elliptical enamel ringlet. There are still weak vestiges of reentrant folds III and IV on the labial side but on the occlusal surface they have been lost. The remnants of these have only been preserved as enamel rings on the occlusal surface. These enamel rings still preserve communication with the lingual reentrant fold and are "V" shaped. There are three roots: two anteriorly and one posteriorly.

To date, genuine fossil spalacines have still not been recovered in China. Teilhard and Young (1931, P.12, Pl.V, Figs. 36 36b) described a mandible containing m2-3 from the top of the *Hipparion* Red Clays in the vicinity of Shawanzi at Baode volcanic crater, Shanxi Province. This specimen is not named because the m1 is missing, the m2 is worn completely flat, and only on the m3 is it possible to distinguish one labial and two lingual reentrant folds (enamel ringlets). This is a relatively large individual (m2 m3 occlusal length approximately 5.3 mm) that may possibly bear no relationship whatever to the Tianzhu specimens. From the perspective of size, the Tianzhu specimen approaches the European taxon *Pliospalax*; however, because the specimen has been worn too deeply, and the material is too restricted, the possibility of making any more advanced diagnosis is relatively difficult. It may however possibly be established that this subfamily truly appears to exist in China.

Ochotonidae Thomas, 1897

Ochotona Link, 1795

Ochotona lagrelii minor Bohlin, 1942

Figure 6. Occlusal view of *Ochotona lagrelii minor* Bohlin, 1942 left P3 (V6321-4)

Material: One left P2, V6312; two left P3 V6312 1,2; one left M1-2 V6312 3; one left P3 4, V6312 4 (Fig. 6); one right m1 2, V6312 5.

Description: The P2 is small with the anterior reentrant fold extended posterolabially. The anterior lobe of the P3 is narrow and the posterior lobe is broad. At the center of the crown there is an open mouthed, crescentic shaped enamel reentrant fold directed toward the labial side. The M1 has an anterior lobe broader than the posterior lobe with enamel layers thicker on the anterior walls of these lobes than the posterior walls. The thickest enamel occurs near the lingual angles. The hypostria may reach the labial margin of the tooth. The M3 has anterior posterior lobes of generally equivalent breadth. There is a weak accessory projection on the posterolingual side of the posterior lobe. The hypostria does not extend to the tooth margin.

There are two reentrant folds on the labial side of the P3 with the posterior reentrant being relatively deep. The anterolingual and anterolabial reentrants are juxtaposed and relatively broad. The posterolingual reentrant has already been lost. The enamel is thicker on the projected salient angles than within the reentrants (see Fig. 6). The P4-M2 possess broad anteriorly directed projections on the anterior side of the anterior lobes and there are weak posteriorly directed projecting angles on the posterior walls. The projected section on the anterior side of the posterior lobe lies very close to the posterior wall of the anterior lobe.

Table 1. Dental measurements of various species of *Paralactaga* (mm).

	M1		M2		M3		m1		m2		m3	
	W	W	L	W	L	W	L	W	L	W	L	W
P. minor sp. nov (Tianzhu)	2.01	1.02					2.34	1.56	2.22	1.62		
P. anderssoni (Jingchuan)	2.70	1.70	2.50	1.70	1.20	1.20	2.80	1.80	2.80	2.00	2.20	1.60
P. major (Jingchuan)							4.80	2.80				
P. suni (Shenmu)	3.30	2.20	3.30	2.20	1.70	1.80						
P. sp. (Ningxian)							3.10	2.30				

Table 4. Dental measurements of *Ochotona lagrelii minor* Bohlin, 1942 (mm).

	P2	P3	M1	M2	p3	p4	m1	m2
Length	0.69	1.02	1.71	1.53	1.44	1.29	1.23	1.14
Anterior width	1.26	1.56	2.82	2.22	0.81	1.47	1.11	1.11
Posterior width		2.31	2.31	2.19	1.23	1.41	1.14	1.14

Conclusions

Several taxa of small mammals have previously been described from another locality in the same region, Locality 80006. The stratigraphic positions of the 80006 small mammal fauna and the fauna described in this text are generally equivalent, and together constitute a small mammal fauna that may be considered Pliocene* in aspect. This fauna includes the assemblage of 11 taxa: *Leptodontomys gansus* Zheng and Li, *Spermophilinus minutus* Zheng and Li, *Kowalskia sunshanensis* Zheng and Li, *Prosiphneus licenti tianzhuensis* Zheng and Li, *Paralactaga minor* sp. nov., *Heterosminthus gansus* sp. nov., *H. simplicidens* sp. nov., *Protalactaga* cf. *tunggurensis* Wood, 1936, Spalacinae gen. et sp. indet., *Ochotonoides primitivus* Zheng and Li, and *Ochotona lagrelii minor* Bohlin, 1942.

Within the aforementioned fauna are the relatively abundant endemic forms of the North China region, such as *Prosiphneus, Heterosminthus, Protalactaga, Ochotonoides, Ochotona lagrelii minor*, and others. In addition there are first records of elements that may be correlated to Pliocene faunas of Europe and North America. These include *Leptodontomys, Kowalskia*, the Spalacinae, and others. The discovery of these taxa not only fills a vacancy in the East Asian fossil record, but moreover is evidence contributing to the direct faunal correlation between each of the North China Pliocene faunas, as well as those of North America and Europe. This consequently also clarifies the position of the North China *Hipparion* Fauna.

Despite the occurrence of elements such as *Protalactaga* cf. *tunggurensis*, a species previously recorded from the Miocene, the remaining elements are all attributable to the Pliocene. Moreover, as this collection appears in the *Hipparion* Red Clays, the geologic age of this small mammal fauna should correspond to the age of the North China *Hipparion* Fauna, being approximately equivalent to the European Turolian or the North American Hemphillian stages. Advanced evidence for this correlation is also displayed in the large mammal faunas to be described in the future from Localities 80007 and 80008. It may be observed that from the relatively large proportion of dipodids within the fauna, the environmental conditions of that time were under a relatively hot and xeric grassland environment.

* Now regarded Upper Miocene (WD).

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Some Pliocene Mammalian Fossils from Songshan 2 and 3 (Tianzhu, Gansu) and the Songshan Fauna

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Abstract

The description of material in this text from Localities 80007 and 80008 of Songshan is a continuation of the paleontological documentation of this region. A third collection of material is described subsequent to the first locality (80006) and the second locality (80007). A relatively detailed description is conducted on taxa including *Chilotherium tianzhuense* sp. nov., the rare *Percrocuta gigantea*, *Indarctos atticus*, *Chalicotherium* sp., and others. A taxonomic list from these localities is also presented (containing 5 orders, 17 families, 27 genera, and 33 species and subspecies). A brief discussion is conducted regarding the age of the Tianzhu fauna and its associated paleoecology.

Introduction

The material described in this text represents a continuation of reports on the third collection of fossil mammals subsequent to the rodents and lagomorphs from Locality 1 (80006) and Locality 2 (80007). In addition to the small mammals from Locality 3 (80008), there are important faunal elements acquired from a Songshan drug store. Because this material was produced from two neighboring localities in close proximity, these specimens supplement comprehension of the Tianzhu Pliocene* mammalian assemblage. Based upon the preservation of the specimens, the two localities may be distinguished as representing two taphonomic conditions. Locality 2 is predominantly a calcareous concretionary unit with specimens generally being white. Locality 3 is composed of red clays, with the color of the specimens black. The geographic position of Locality 3 is lat. 3657"37" N, long. 103 16'46" E, at Yingpanju, Nanshanpuo, at an elevation of 2660m (7980 ft).

Description of Specimens

Rodentia

Prosiphneus licenti tianzhuensis Zheng and Li, 1982

Material: Two right m1 (V6404.1, V6404 2) and one right M1 (V6404.3).

Prosiphneus sinensis Teilhard and Young, 1931

Material: One left m1 (V6405.1), one right m1 (V6405.2), one left m2 (V6405.3), and one right M1 (V6405 4).

Castoridae gen. et sp. indet.

Material: A single distal piece of incisor (V6406) only represents the presence of this family.

Lagomorpha

Ochotona lagrelii minor Bohlin, 1942

Material: One left ramus containing p3-m3 (V6407 1) and three isolated p3 (V6407 2,3,4).

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* Age is now regarded Upper Miocene (WD).

Carnivora

Ictitherium hipparionum hyaenoides (Zdansky, 1924)

Material: includes one left P4 M1 (V6408.1) and one right P4 (V6408.2), one left m1 (V6408.3), and four right P3 (V6408.4,5,6,7).

Table 1. Dental measurements of *Ictitherium hipparionum hyaenoides* (Zdansky, 1924) (mm)

	P3	P4	M1	m1
Length	17.5-18.2	26.5-27.0	7.8	23.0
Width	9.0-9.9	14.2	15.3	10.8

Adcrocuta eximia variabilis (Zdansky, 1924)

Material: one left P2 (V6409.1); three right P2 (V6409.2,3,4); one left P3 (V6409.5); three right P3 (V6409.6,7,8); two right P4 (V6409.9,10); two left p3 (V6409.12,13), one left p4 (V6409.14); one right p4 (V4609.15); and one right m1 (V4609.16).

Table 2. Dental measurements of *Adcrocuta eximia variabilis* (Zdansky, 1924) (mm).

		P2	P3	P4	p3	p4	m1
Count		4	4	3	2	2	1
Length	Max.	18.0	21.0	39.0	20.2	22.9	
	Mean	17.7	20.0	27.3	19.9	22.0	29.3
	Min.	17.3	19.3	35.4	19.5	21.1	
Width	Max.	12.2	14.4	16.5	13.3	13.1	
	Mean	11.9	13.6	16.3	12.9	13.0	13.4
	Min.	11.6	12.5	16.0	12.5	12.9	

Referring to the size and morphological characters of *Adcrocuta eximia variabilis* described by Zdansky (1924), variation in size appears as presented in Table 2, such that it may encompass *A. henanensis* (Pei 1934; Kurten 1957). This species was first considered to lie belong to the genus *Hyaena*. In 1931 Pilgrim reassigned it to the genus *Crocuta*. Kurten (1957) erected it as a subspecies based only upon the minute dental differences between this species and the European *Crocuta eximia*, and began applying the subgenus designation *Crocuta* (*Percrocuta*) initiated by Kretzoi (1938). Schmidt Kittler (1976) also adopted the nomenclature of *Adcrocuta* Kretzoi (1938) based upon *C.* (*Percrocuta*) *eximia.* Zhanxiang Qiu (1979) initially adopted the concept of a Chinese species, or a local species of the European taxon. This is the nomenclature adopted here.

Percrocuta (*Dinocrocuta*) *gigantea* (Schlosser, 1903)

(Plate I fig. 1,1a)

Represented by a section of left mandible containing the p2-p4 (V6410); the p2 crown is quadrilateral with the anterior section more narrow than the posterior section. An anterior cusp is absent but there is a conspicuous anterior cingulum and shallow anterior angle. The posterior cusp

appears in the form of a vertical ridge and a posterior cingulum is not very well developed. The p3 is also quadrilateral in form, however, the anterior section is relatively broader. It maintains a conical shaped anterior cusp equivalent in size to the posterior cusp of the p2. The posterior cusp is broken but there is a well developed posterior cingulum on the posterior lingual side. There is an approximate 150° obtuse angle between the p3 and p4. The p4 is narrower than both the p2 and p3 with an anterior cusp larger than the posterior cusp and both appearing as vertical ridges. The labial morphology of the molar is precociously trifoliate. There exists a relatively expansive region on the lingual side of the posterior cusp with an extremely well developed cingulum at its posterior side. This taxon exceeds the size of all other known fossil hyaenids as well as extant species. Specimens are extremely rare and to date, a precise locality and understanding of its exact stratigraphic position is unknown. Unfortunately the specimens from Tianzhu are inadequate with respect to solving this difficulty. Schlosser (1903) erected this genus on the basis of several fragmentary teeth (these specimens are currently housed in the Institute of Paleontology and Historical Geology, Munich, West Germany). With regard to other related material, Kurten (1957) cited Chinese specimens in a collection of G.H.R. von Koenigswald that includes a P3, p3 and m1 (currently housed in Utrecht, Holland). A single m1 is also housed in the British Museum (Natural History). The current author described a mandible collected from the Bulong Basin, Tibet, (Zheng, 1980) maintaining a canine and the first and second premolar that have well developed anterior and posterior cusps, equivalent lengths of the p2 and p3, and the p4 and m1 correspondingly narrow. However, because of such characters as being a small individual, the cingulum being not well developed, and the presence of a single cusped talonid basin, it was considered a justifiable subspecies. It is also appropriate to note here that the nomenclature of the prior literature should be amended to conform to the nomenclature of this text.

Table 3. Dental measurements of *Percrocuta* (*Dinocrocuta*) *gigantea* (Schlosser, 1903) (mm)

	p2		p3		p4	
	L	W	L	W	L	W
Tianzhu	29.2	19.1	30.5	21.3	34.3	18.4
Schlosser	24.0?	17.5	28.0	19.0	34.0	19.0
Kurten			28.0-28.3	19.3-19.5		
Bulong	25,5	16.0	25.5	17.5	30.5	17.5

Machairodus sp.

Specimens include a section of upper canine (V6412.1). The length at the base is approximately 35 mm and width 15.5 mm. There is also one right DP3 (V6412.2) with a length of 24.5 and width of 9.9 mm.

***Indarctos atticus lagrelii* (Zdansky, 1924)**

Material: One right M2 (V6413.1), one left m/1 (V6413.2), one left m2 (V6413.3), and one left m3 (V6413.4) which may represent a single individual.

Description: The Tianzhu specimens are assigned to *I. lagrelii*, a small individual described by Zdansky (1924). Particularly notable is the general consistency of the m2 trigonid/talonid ratio (7:5) which differs from that of the large species *I. sinensis*, with a ratio of 1:1. There are differing hypotheses regarding the relationships of the two species of *Indarctos* in China. Pilgrim (1931) chose to use recognize *I. lagrelii*, but Erdbrink (1953) believed there were sufficient differences to describe two species. Tobien (1955) believed certain characters of the two species, such as the style lying between the protoconid and hypoconid in the m1, corresponded to *I. arctoides* from Samos, Greece, whereupon he erected the *I. arctoides* complex. Kurten (1952) initially recognized both species, but later, based upon sexual dimorphic characters in other species

of ursids, and particularly upon the close proximity of the fossil localities, decided the differences were due to sexual dimorphism. The small form represented the female and the large form the male. He moreover regarded them as a subspecies of the European taxon *I. ponticus*. Thenius (1959) agreed with Kurten's sexual dimorphic hypothesis, but disagreed with the taxonomic assignment to the *arctoides* clade, regarding it as a subspecies of *I. atticus.* Thus, the specimens from Wenquan, Xinjiang (Li and Qi 1964) and those from Ningxian, Gansu* should be considered male individuals, while the Tianzhu specimens should be considered female individuals.

Perissodactyla
Chalicotherium sp.

(Plate I, Fig. 2,3)

Material: One left M2(?) with a damaged protoloph and paracone (V6414 1), one-third of a posterior right M3(?) (V6414 2), and one left DP1-DP3 (V6415).

Description: The molars are square and brachydont with the labial side higher than the lingual side. The ectoloph is sinuous and exceeds the long axis of the tooth to descend abruptly to the base of the molar at the lingual side. There is a robust mesostyle, but a metastyle is absent. Well developed ribbing occurs on the lingual side of the metacone. There is a small spur projected off the lingual side of the ectoloph that is directed toward the medifossette. The hypocone is thin, narrow, and is directly connected to the metaloph. The protocone is conical and isolated. There is a well developed cingulum at the base of the labial side. The M2(?) width is 41.7 mm, and the M3(?) is 44 mm. The DP1-3 are deeply worn and the permanent molars have begun to erupt. The DP1 is triangular. The protocone is small and loph shaped but not connected to the protoloph. The hypocone is large. The anterior and posterior curvature of the ectoloph is not well developed. Molar length is 13.8 mm and width is 14.4 mm. The DP2 is quadrilateral with a relatively more observable anterior and posterior curving ectoloph. The molar length is 18.3 mm and width is 21.3 mm. DP3 initiates molariform morphology on the dentition with a length of 25.3 mm. The DP1-3 has a length of 55.6 mm. All three premolars maintain three roots. Judging from the condition of the erupting permanent molars, this species of chalicothere will have lost the P1 upon maturity.

Chilotherium (*Acerorhinus*) *tianzhuensis* sp. nov.

(Plate I, Figs. 5, 6; Plate II, Fig. 1)

Type: One damaged maxilla containing left and right P2-M2 (V6416).

Paratype: One left M3 (V6417).

Hypodigm: One right P2-P4 (V6418.1), one left P4-M1 (V6418.2), one right M1-M2 (V6418.3), one left DP2 (V6418.4), one left DP2-DP4 (V6418.5), one right DP1 (V6418.6), two left M1 (V6418.7,8), one left M2 (V6418.9), two right P3 (V6418.10,11), one left P3 (V6418.12), one left P4 (V6418.13), and one right P4 (V6418.14).

Diagnosis: The protocone is more robust than the hypocone, the protoloph is longer than the metaloph, and there is a deep anterior protocone fold. The lingual cingulum on the premolars is not continuous; a well developed crochet and antecrochet surround the medifossette and there is a secondary inflection within this fossette. The molars lack a lingual cingulum but maintain an

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* Zheng, S.H. (in preparation); A Plio-Pleistocene mammalian fauna from Ningxian Co., Gansu Province.

antecrochet that is even with the ectoloph. The M3 maintains a flat and thin triangular shaped talon basin, and the lengths of the protoloph and ectoloph are equivalent. The length of the DP1-DP4 is equivalent to the length of the M1-M3.

Description: DP1: This molar is relatively brachydont, maintaining a weak protoloph, strong antecrochet, and lacking a crochet. The metaloph is correspondingly well developed with a large and deep postfossette. There are two roots.

DP2: The parastyle is strong with a broad and shallow parastyle fold. There is conspicuous ribbing on the metacone. The protocone and hypocone faces are reduced and the hypocone is relatively weak. The lingual wall of the anterior fold on the hypocone intersects the posterior fold of the protocone. The crochet is long, flat, and level with the ectoloph and there is a crista descended from the ectoloph and intersecting the medifossette. There is a well developed secondary inflection within this fossette. The anterior, lingual, and posterior cingula are connected.

DP3: Aside from a relatively narrow and deep anterostyle fold and relatively weak lingual cingulum, this premolar is similar to the DP2.

DP4: There is a relatively spacious entosinus, the lingual cingulum is nearly lost, the metacone lacks conspicuous ribbing, and the secondary inflections within the medifossette are weak.

P2: The anterostyle is projected with a weak anterostyle fold. The degree of protocone reduction is weaker than on the teeth succeeding it. The protoloph is shorter than the metaloph. The crochet and crista are well developed to form a medifossette. An antecrochet is absent.

P3 and P4: There is a well developed parastyle fold and paracone ribbing. The protocone is larger than the hypocone but still strongly reduced. The anterior fold of the protocone is large and deep, which together with the anterior cingulum unites to form an accessory fossette. The protoloph is much longer than the metaloph. There is a well-developed crochet and crista, and some specimens possess a secondary crista. Within the fossette are inflections of varying degrees. The lingual cingulum breaks open at the protocone and forms a thin wall at the mouth of the entosinus. There is a high and broad bridge connecting the protocone and hypocone.

M2 and M2: The labial wall is slightly elongated. The anterostyle fold is relatively conspicuous. The crochet and antecrochet are short, thick, level with the ectoloph, and additionally block the entosinus. The protoloph is longer than the metaloph, both being at equivalent levels and both perpendicular to the ectoloph. The crista and lingual cingulum have become lost.

M3: The anterostyle fold is relatively weak. The crochet is relatively strong but does not come in direct contact with the protoloph. The crista is flat and thin but does not connect with the crochet to form a medifossette. The lengths of the protoloph and ectoloph are generally consistent. There is a flat and thin talon that is triangular in shape. The boundary between the ectoloph and metaloph is manifested by the appearance of a thin and weak angle.

Comparison: The Tianzhu specimens share certain dental characters with "*Chilotherium*" *xizangensis* (Ji et al. 1980) from Jilong, Tibet and *C.* (*Acerorhinus*) *cornutum* (Qiu and Yan 1982) from the Yushe I Zone of Shanxi. These characters include molariform premolars, extremely well-developed crochet and crista that unite to form a medifossette, labial wall of the molars slightly extended, a relatively weak parastyle and parastyle fold, protoloph and metaloph perpendicular to the ectoloph, a robust crochet and antecrochet that are level with the ectoloph, M3 with a generally equivalent protoloph and ectoloph length, and a flat and thin triangular-shaped talon.

K. Heissig reevaluated the species of *Chilotherium* in 1975, distinguishing and assigning them to three genera: *Aprotodon, Chilotherium,* and *Hispanotherium*. He also distinguished three subgenera of *Chilotherium*: *Ch.* (*Chilotherium*), *Ch.* (*Acerorhinus*), and *Ch.* (*Subchilotherium*). He also preserved the species names of *Diceratherium palaeosinense, Aceratherium hipparionum,* and *Diceratherium tsaidamense,* but placed them in the subgenus *Ch.* (*Acerorhinus*). *Ch. habereri laticeps* and *Ch. planifrons* were synonymized with the species *Ch. anderssoni.*. While *Ch. gracile,* and *Ch. wimani* were synonymized with *Ch. habereri,* and together with the genus *Rhinoceros brancoi* were placed into the subgenus *Ch.* (*Chilotherium*). *Diceratherium palaeosinense* var. *minus* was assigned to the species *Ch. intermedium* and together with *Rhinoceros pygmaeus* were placed in the subgenus *Ch.* (*Subchilotherium*).

Ch. (*Acerorhinus*) from the Yushe I Zone is possibly a horned subgenus (Qiu and Yan 1982); as indicated by the aforementioned characters, the Tianzhu specimens and Tibetan specimens should also be included into this subgenus.

Compared to *Ch.* (*A.*) *cornutum* the DP1-P4 length of the Tianzhu specimens and Tibetan specimens are equivalent but not smaller than the M1-M3 tooth row length as found in the Yushe specimens (see Table 5). The lingual cingulum of the premolars on the Tianzhu specimens is not continuous, while it is continuous on the Yushe specimens. The Tianzhu specimens maintain a protocone larger than the hypocone with a deep anterior protocone fold, but the Yushe species is correspondingly relatively small with a shallow anterior protocone fold. The Tianzhu specimens display more well-developed secondary inflections with the premolar fossettes than the Yushe species.

Ch. (*A*).*xizangensis* is a small individual with a DP1-P4 length smaller than the M1-M3 length. The premolars maintain a continuous lingual cingulum and lack well-developed secondary inflections.

Ch. (*A*) *tsaidamense* maintains an unreduced premolar protocone with a weak crochet and undeveloped crista. The M3 has relatively well-pronounced paracone ribbing and a broad parastyle fold. The DP1-P4 length is smaller than the M1-M3 length.

Ch. (*A.*)*palaeosinense* has slightly broadened premolars, the protocone is not strongly reduced, the lingual cingulum is well developed and united, and there is an isolated enamel pillar at the mouth of the medisinus. The DP1-P4 length is longer than the M1-M3 length.

Ch (*A.*) *hipparionum* material consists of several isolated teeth. The lingual cingulum on the upper premolars is united and well developed. The protocone is strongly reduced. *Ch.*(*A.*) *zernowi* has a well-developed cingulum on the upper molars, the protocone fold and hypocone fold are slightly weak, but the paracone ribbing and parastyle fold are very conspicuous.

Table 5. *Ch.* (*Acerorhinus*) comparative dental measurements (mm).

	DP1-M3	DP1-P4	M1-M3	DP1-P4/ M1-M3 x 100
Ch. (A) tianzhuense sp. nov.	241	120	120	100
Ch. (A) cornutum	250	120	137	87.6
Ch. (A) palaeosinense	240-246	126-130	124-128	101.6
Ch. (A) tsaidamense	237-254	123-130	125-138	94.2-98.4
Ch. (A) xizangensis	197(?)	92(?)	106	86.8(?)

Discussion: As stated above, shared characters between the Tianzhu species, the Yushe species, and the Jilong species are noted; however, even though the skull of the Tianzhu species is

not known, it maintains genuinely valid individual characters. Moreover, a consideration of the extreme geographic distances between the three localities warrants the establishment of a new species. If complete skulls are excavated in the future that would display consistent diagnostic characters with the Yushe species, the possibility would then exist for the synonymy of these three species.

Chilotherium (*Chilotherium*) *anderssoni* (Ringstrom, 1924).

(Plate II, Fig. 2)

Material: One right M2 (V6419.1), one left M3 (V6419.2), one left P2 (V6419.3), one left P3 (V6419.4), and one left DP3-P4 (V6419.5). These items correspond exactly to the diagnostic characters of Ringstrom (1924) that define this species.

Table 6. Dental measurements of *Chilotherium* (*Chilotherium*) *anderssoni* (Ringstrom, 1924) (mm).

	DP3	DP4	P2	P3	M2	M3
Length	40.0	----	35.0	41.0	63.0	53.(?)
Width at protoloph	44.5	49.5	38.5	53.5	58.0	66.5
Width at metaloph	44.0	48.5	42.0	48.5	52.0	----

Ch. (*Ch.*) *habereri* (Schlosser, 1903)

(Plate I, Fig. 4)

Material: One left DP3-DP4 (V6420.1), one left P2-P3 (V6420.2), and one left P4 (V6420.3).

Table 7. Dental measurements of *Chilotherium* (*Ch.*) *habereri* (Schlosser, 1903) (mm).

	DP3	DP4	P2	P3	P4
Length	39.0	43.3	34.0	38.5	42.5
Width at protoloph	37.2	42.1	35.5	46.0	47.5
Width at metaloph	37.9	40.6	36.5	42.0	46.5

Chilotherium sp.

Material: One right P2 (V6421.1) and one right P3 (V6421.2). This is a small individual with a P2 length of 27.5 mm, breadth at the protoloph is 27.5 mm, and breadth at the metaloph is 32.5 mm. The P3 length is 28.0 mm, breadth at the protoloph is 31.0 mm, and breadth at the metaloph is 33.5 mm

Hipparion sp. 1

(Plate II, Fig. 3)

There is one right P4-M3 (V6422.1), one left M2-3 (V6422.2), and one left P4-M1 (V6422.3).

Hipparion sp. 2

Material consists of one left P3/ (V6423.1), one right P3 (V6423.2), one left P4 (V6423.3), and one left M1 (V6423.4).

Artiodactyla

Paleotragus microdon (Koken, 1885)

(Plate II, Fig. 5)

There is a left maxilla containing P4-M2 (V6424.1) and one left M3/ (V6424.2) representing this taxon.

Paleotragus coelophrys (Polder and Weithofer. 1890)

(Plate II, Fig. 6)

Material consists of one right M1-M2 (V6425.1), one left M1-M2 (V6425.2), one left M2 (V6425.3), and one right DP3-DP4 (V6425.4).

Samotherium sp.

There is one right p4 (V6426.1) and one right m1 (V6426.2).

Sinotragus sp.

There is one right M2-3 (V6427.1), three left M2 (V6427.2,3,4), and one left M3 (V6427.5).

Antilope sp.

(Plate II, Fig. 7,7a)

Material consists of one left tooth row containing P4-M3 (V6428.1), one left P2-P4 (V6428.2), one left M1-M2 (V6428.3) and one left m3 (V6428.4).

Dorcadoryx triquetriconris Teilhard and Trassaert, 1938

There is a piece of left basal horn core (V6429.1) and a piece of the right basal horn core (Y6429.2).

Gazella gaudryi Schlosser, 1903

There is one basal section of right horn core (V6430.1), one right m1-3 (V6431.2), a maxilla containing P3-M3/ (V6431.1), one right m1-3 (V6431.2), and a right m1-2 (V6431.3).

Pachygazella cf. *grangeri* Teilhard and Young, 1931

There is one right basal section of a horn core (V6432).

Gazella sp.

There is one right basal section of a horn core (V6433).

Muntiacus cf. *lacustris* Teilhard and Trassaert, 1937

(Plate II, Fig, 4)

Material consists of a fragmentary base of left horn at its bifurcation with its antler bracelet (V6434).

The Tianzhu Miocene-Pliocene mammalian fauna

A taxonomic list of the fossil mammals occurring at the three localities of Songshan, Tianzhu, is present in Table 8. Because the stratigraphic positions of these three localities are in close proximity, and as there are a number of commonly occurring elements among them, from a macroscopic perspective they may be considered as a single fauna.

This fauna is composed of 5 orders, 17 families, 27 genera (subgenera), and 33 species (subspecies). There are many species of small mammals concentrated within this fauna that previously have not been noted from the Chinese "*Hipparion* fauna". Among these are the first occurrences of the eomyid, *Leptodontomys* and the cricetid *Kowalskia*.. *Ochotonoides* and *Protalactaga* are also now confirmed to exist in the *Hipparion* Red Clays. In this manner, it is not only possible to correlate the Tianzhu fauna to other Chinese Miocene-Pliocene faunas, but moreover these elements may be utilized to compare and correlate the fauna to its contemporaneous assemblages in Europe and North America. Its geologic age is equivalent to the Chinese Baode Stage, the European Turolian Stage, and the North American Hemphillian Stage.

The exposures at Songshan, Tianzhu, are extremely thick (approximately 200 m). These red clay deposits, indicating the presence of a *Hipparion* fauna, are relatively complicated. The distribution pattern of multistoried carbonate concretion deposits reflects alternate numerous drying and wetting climatic fluctuations. Locality 80008 described above was relatively wet, with a faunal complexion suggesting a dense forest. Localities 80006 and 80007 are relatively dry with a faunal complexion indicating dense forest to grasslands. Therefore, as expressed by Dongshen Liu et al. (1978), the suggestion that Kurten's (1952) observations of the North China *Hipparion* Red Clays being a single stratigraphic position with three environments represented by a dense forest, grasslands, or a mixed model between the two, solely upon the presence of hypsodont or brachydont bovids, is oversimplified. Therefore, from the complexion of each Chinese *Hipparion* fauna it is very possible that different stratigraphic positions at the same locality represent different ecological environments.

Table 8. Species distribution among the three localities at Tianzhu

Taxon	Locality		
	80006	80007	80008
Leptodontomys gansus Zheng and Li	x		
Spermophilinus minutus Zheng and Li	x		
Kowalskia gansunica Zheng and Li	x		
Prosiphneus licenti tianzhuensis Zhang and Li	x		x
P. sinensis Teilhard and Young			x
Paralactaga minor Zheng		x	
Heterosmitnthus gansus Zheng		x	
H. simplicidens Zheng		x	
Protalactaga cf. *tunggurensis* Wood		x	
Spalacinae gen. et sp. indet.		x	
Castoridae gen et sp. indet.			x
Ochotonoides primitivus Zheng and Li	x		
O. lagrelii minor Bohlin	x	x	x
Ictitherium hipparionum hyaenoides (Zdansky)		x	x
Adcrocuta eximia variabilis (Zdansky)		x	x
Percrocuta (*Dinocrocuta*) *gigantea* (Schlosser)		x	
Metailurus major Zdansky			x
Machairodus sp.		x	x
Indarctos atticus lagrelii (Zdansky)			x
Hipparion sp. 1			x
H. sp. 2			x
Chalicotherium sp.		x	
Chilotherium (*Acerorhinus*) *tianzhuense* sp. nov.		x	x
Ch. (*Chilotherium*)*anderssoni* (Ringström)		x	x
Ch. (*Ch.*) *habereri* (Schlosser)		x	x
Ch. sp.		x	
Paleotragus microdon (Koken)			x
P. coelophrys (Rodler and Weithofer)		x	x
Samotherium sp.		x	
Dorcadoryx triquetricornis Teilhard and Trassaert		x	
Gazella gaudryi Schlosser		x	x
G. sp.			x
Pachygazella cf. *grangeri* Teilhard and Young			x
Sinotragus sp.		x	x
Antilope sp.		x	x
Muntiacus cf. *lacustris* Teilhard and Trassaert		x	

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