Early Pleistocene soricomorphs and lagomorphs from the Xiaochangliang site in the Nihewan Basin, Hebei, Northern China

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This paper systematically describes soricomorph and lagomorph remains collected by a screen-washing procedure from the sediments of the Xiaochangliang site with the age of 1.36 Ma. The soricomorph remains described are assigned to the tribe Soricini in the subfamily Soricinae of the family Soricidae, on the basis of the detailed dental morphology. Among the genera of the tribe known from the Pliocene and Pleistocene of Asia, *Sorex* has morphological characters well coincident with those of the remains. Owing to their incompleteness, the specific determination can not be done, and thus they are assigned merely to *Sorex* sp. All the lagomorph remains belong to the family Ochotonidae. The family comprises two genera, *Ochotona* and *Ochotonoides*, in the Pliocene and Pleistocene of China. The remains are easily divided into a smaller and larger forms by their striking difference in size. The dental morphology and size of the smaller form indicate its allocation to *Ochotona*. The smaller form is compared with many species of *Ochotona* known from the Pliocene and Pleistocene as well as the present day of China, and is assigned to the extinct species, *O. youngi*. The larger form is, however, assigned merely to *Ochotona* or *Ochotonoides* sp., because of its limited specimens with poor preservation.

Keywords : soricomorph, lagomorph, systematics, Early Pleistocene, Xiaochangliang site, Nihewan Basin, China

I. Introduction

The Xiaochangliang site is one of the most important archaeological sites of Early Pleistocene age in China, and is situated in the Nihewan Basin about 150 km west-north-west of Beijing (see Fig. 1 of Zhang *et al.*, 2008). The artifact layer of the site is intercalated in fluvio-lacustrine sediments called the Nihewan Formation, and was dated as 1.36 Ma by paleomagnetic method (Zhu *et al.*, 2001). It was known that the layer had yielded mammalian remains in association with artifacts, but the

knowledge on small mammals from the layer had been quite limited, until we washed the sediments stratigraphically equivalent to the layer with fine-mesh screens in 2005. Our screen-washing successfully produced a large number of small mammal remains which included 10 forms identifiable at the generic or specific level (Zhang *et al.*, 2008). Among them, soricomorph and lagomorph remains are described systematically in this paper. The geological setting of the layer and the screen-washing procedure are explained in Zhang *et al.* (2008).

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II. Terminology and measuring method

Almost all the remains described herein are detached teeth. Figure 1 shows the terminology and measuring method used for the teeth of soricid soricomorphs, which follow those of Kawamura (1992, 1993). Figure 2 also shows those for the cheek teeth of ochotonid lagomorphs, which mainly follow those of Lopez-Martinez (1986). The measurements of the lagomorph teeth were taken parallel to their occlusal surfaces.

All the measurements were taken by using a measurescope (Nikon : MM-11) with an electric digital counter (Nikon : CM-65).

III. Systematic description

Order Soricomorpha Gregory, 1910

Family Soricidae Fischer de Waldheim, 1817

Subfamily Soricinae Fischer de Waldheim, 1817

Tribe Soricini Fischer de Waldheim, 1817

Genus *Sorex* Linnaeus, 1758

Sorex sp.

(Fig. 3)

Referred specimens—1 left first upper incisor (V15318.1); 1 right first upper incisor (V15318.2); 2 broken right M^1 (V15318.3-4); 1 left M^2 (V15318.5); 1 broken left M_1 (V15318.6); 1 right M_2 (V15318.7); 1 left M_3 (V15318.8).

Repository—All the specimens are stored in the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP), Chinese Academy of Sciences, Beijing.

Locality—Xiaochangliang site, about 0.5 km northwest of Guanting, Yangyuan County, Hebei Province (IVPP field locality number 78005). Geographic coordinates : 114°40'E, 40°13'N.

Horizon—Upper part of the Nihewan Formation defined by Wei (1997)

Age—Early Pleistocene ; dated paleomagnetically as 1.36 Ma.

Description—All the specimens are secondarily stained dark brown to brown, so that original pigmentation of their cusps cannot be detected.

First upper incisor : The anterior cusp has no medial cusplet, and thus this tooth is not fissident. The posterior cusp is well developed, and its apex reaches close to that of the anterior cusp in dorso-ventral level. On the labial

face of the crown, the posterior cingulum runs along the posterior margin of the crown. It is thick and not undulated. The cingulum continues to the ventral face of the crown, and forms a knob at the linguo-ventral corner of the crown. On the lingual face of the crown, however, it is absent or feeble. The root is long and stout, and extends postero-dorsally.

M^1 : In one of the two specimens described (V15318.3), the antero-buccal part of the crown is lost (3 in Fig. 3), but this part is observable in another specimen (V15318.4). The occlusal outline of the crown is squarish, and is not elongated linguo-buccally so that W is only little larger than L (Table 1). The anterior border of the crown is gently convex anteriorly in occlusal view. The buccal border of the crown is weakly emarginated both in its anterior and posterior halves. The V-shaped ridge formed by the parastyle, paracone and mesostyle has nearly the same size and shape as that formed by the mesostyle, metacone and metastyle. A postero-buccal protrusion of the metastyle is weak. In the lingual part of the crown, the protocone is well developed, and forms a broad-angled V-shaped ridge, whose posterior part (postprotocrista) runs posteriorly. This ridge is separated from the lingual base of the metacone, and thus the trigon basin opens posteriorly. The hypocone is much smaller and lower than the protocone, but shows a well-defined conical shape. It is separated from the postprotocrista by a shallow valley. The lingual border of the crown is gently emarginated, and a short cingulum is observed along its central part. The distocrista extends posteriorly from the apex of the hypocone to the postero-lingual corner of the crown, where it forms a feeble cusplet. Furthermore it continues to the postcingulum, which runs along the posterior border of the crown and reaches the postero-buccal corner of the crown. The posterior emargination is weak.

M^2 : This tooth can be regarded as a small version of M^1 , but the following minor differences are observed. W is almost equal to L (Table 1). The metastyle never protrudes postero-buccally. The postprotocrista bends at right angles, and extends buccally to the base of the metacone. The distocrista has no cusplet.

Fig. 1 Terminology and measuring method for the soricid soricomorph teeth described here, according to Kawamura (1992, 1993)

bl : base line for measurement, h : height of crown, L : length of crown, W : width of crown.

Fig. 2 Terminology and measuring method for the ochotonid lagomorph cheek teeth described here, according to Lopez-Martinez (1986)

All the measurements are taken on the occlusal surface of each tooth. L : maximum length of crown, W : maximum width of crown, Wa : width of anterior loph in P³.

Fig. 3 Detached teeth of *Sorex* sp. from the Lower Pleistocene of the Xiaochangliang site

1. left first upper incisor (V15318.1), 2. right first upper incisor (V15318.2), 3. right M^1 (V15318.3), 4. left M^2 (V15318.5), 5. right M_2 (V15318.7), 6. left M_3 (V15318.8). 1–2. labial view, 3–6. occlusal view.

M_1 : The trigonid is mostly lost in the only specimen described. The oblique cristid is connected to the posterior face of the protoconid. A well-marked cingulum is observed on the posterior base of the hypoconid. The postcristid extends from the hypoconid to the posterior base of the entoconid, but its lingual end is separated from the entoconid by a narrow groove extending postero-lingually from the talonid basin. The entoconid is a conical cusp, and separated from the metaconid by a depression between them. The entocristid is not recognized. A narrow cingulum runs from the postero-lingual base of the entoconid to the lingual base of the metaconid.

M_2 : The occlusal outline is trapezoidal. The trigonid is nearly as large as the talonid, but the former is slightly narrower than the latter. A distinct cingulum extends buccally from the anterior base of the paraconid along the anterior face of the crown. The morphology of the talonid is the same as that of M_1 except the following points. The oblique cristid has a weak incision on its central part, so that the mesoconid is recognizable. The entoconid is elongated antero-posteriorly to form the poste-

rior part of the entocristid. The anterior end of the entocristid is connected to the posterior base of the metaconid.

M_3 : The occlusal outline is also trapezoidal. The trigonid is larger than the talonid. A distinct cingulum starts at the anterior base of the paraconid, extends along the anterior and buccal faces of the crown, and terminates on the posterior base of the hypoconid. Another narrow cingulum runs along the lingual face of the crown. The talonid is longer than broad. It is not reduced, and shows nearly the same shape as those of M_1 and M_2 . But owing to the lack of the narrow groove between the lingual end of the postcristid and entoconid, the talonid basin becomes a closed depression surrounded by a continuous ridge formed by the oblique cristid, hypoconid, postcristid, entoconid and entocristid. The mesoconid is recognizable on the oblique cristid.

Measurements—The measurements of the teeth are given in Table 1.

Comparison and discussion—The specimens described here undoubtedly belong to the family Soricidae. Repenning (1967) divided the family into such four subfamilies as Heteroso-

Table 1 Measurements of the teeth of *Sorex* sp. from the Lower Pleistocene of the Xiaochangliang site in mm

Element/specimen no.	L	W	h
First upper incisor			
V15318.1	1.15	0.56	0.69
V15318.2	1.39	0.59	0.60
M ¹			
V15318.3	1.49±	1.63±	—
V15318.4	—	1.58±	—
M ²			
V15318.5	1.41	1.48	—
M ₁			
V15318.6	—	0.89±	—
M ₂			
V15318.7	1.16	0.67	—
M ₃			
V15318.8	0.91	0.50	—

h : height of crown, L : length of crown, W : width of crown.

ricinae, Crocidurinae, Limnoecinae and Soricinae, with the descriptions of morphological characters for each subfamily. According to him, Heterosoricinae differs from the present specimens in having no posterior emargination in M¹, a much thicker buccal cingulum in M₂ and M₃, and proportionately smaller talonid in M₃. Crocidurinae is also distinct in having a less developed posterior cusp in the first upper incisor, broader occlusal outline of M¹ elongating bucco-lingually, much stronger posterior emargination in M¹, and a much reduced talonid in M₃. Limnoecinae is different in having a proportionately shorter talonid in M₁ and much reduced talonid in M₃. Thus the members of the remaining subfamily, Soricinae, are compared with the present specimens.

Reumer (1984) revised the tribal classification of Soricinae by Repenning (1967), and recognized such seven tribes as Soricini, Blarinini, Notiosoricini, Soriculini, Beremendiini, Amblycoptini and Allosoricini. His descriptions indicate that Soriculini and Beremendiini are different from the present specimens in having a fissident first upper incisor. Blarinini and Allosoricini also differ in having no entocristid in M₂ and M₃, and a reduced talonid in M₃. Amblycoptini is easily distinguishable from the present specimens by its much better developed

parastyle in M¹ and extremely reduced M₃. As regards the members of Notiosoricini, Repenning (1967) gave their morphological characters. According to him, Notiosoricini differs in having a more reduced talonid of M₃ where the entocristid is lacking.

The remaining tribe, Soricini, is therefore compared with the present specimens. This tribe comprises such nine genera as *Sorex*, *Drepanosorex*, *Deinsdorfia*, *Petenya*, *Blarinella*, *Dimylosorex*, *Zelceina*, *Crocidosorex* and *Oligosorex* (Reumer, 1984). Among them, *Sorex*, *Deinsdorfia*, *Petenya* and *Zelceina* have been recorded from the Pliocene and Pleistocene of Asia (Storch *et al.*, 1998). Thus the four genera are compared with the present specimens on the basis of the descriptions by Reumer (1984).

Deinsdorfia differs from the present specimens in having a less developed posterior cusp of the first upper incisor, stronger posterior emargination in M¹ and M², proportionately smaller talonid in M₂, and strongly reduced talonid of M₃ which is usually single-cusped. *Petenya* is also distinct in having a dorso-ventrally shorter posterior cusp of the first upper incisor, no hypocone in M¹ and M², the entocristid situated close to the metaconid in M₁ and M₂, and a reduced talonid with a single cusp in M₃. *Zelceina* is distinguishable from the present specimens by its larger size, posterior emargination of M¹ and M² being weaker, tetrahedral hypocone of the same teeth, and strongly reduced talonid of M₃.

The remaining genus, *Sorex*, bears the main characters well coincident with those of the present specimens. They are as follows : The first upper incisor is fissident or not fissident, and has the posterior cusp being well-developed or moderately developed. M¹ and M² has a squarish outline, the posterior emargination being moderate or weak, and the hypocone being well-defined and normal in shape. M₂ and M₃ have the entocristid, and the talonid of M₃ is not reduced. The present specimens are therefore assignable to *Sorex*.

As stated by Reumer (1984), *Sorex* is a very large genus with many species. The present specimens are too incomplete to carry out any specific determination within the genus, and thus they are assigned merely to *Sorex* sp.

herein.

Order Lagomorpha Brandt, 1855

Family Ochotonidae Thomas, 1897

Genus *Ochotona* Link, 1795

Ochotona youngi Erbajeva and Zheng, 2005

(Figs. 4–5)

Ochotona nihewanica: Zheng and Cai, 1991: *Contr. XIII INQUA, Inst. Vert. Paleont. Paleoanthrop. Acad. Sinica*, 102–104.

Ochotona youngi Erbajeva and Zheng, 2005: *Acta Zool. Cracov.*, 48A, 100–103, 108.

Referred specimens—1 right P² (V15319.1); 5 left P³ (V15319.2–6); 8 right P³ (V15319.7–14); 8 left P⁴ or M¹ (V15319.15–22); 4 right P⁴ or M¹ (V15319.23–26); 1 left M² (V15319.27); 2 right M² (V15319.28–29); 1 right mandible with P₄ and M₁ (V15319.30); 4 left P₃ (V15319.31–34); 2 right P₃ (V15319.35–36)

Repository, locality, horizon and age—The same as *Sorex* sp. described above.

Description—

P²: This tooth is represented only by one specimen (1 in Fig. 4). It is shaped as a single-lobed curved shaft, which is convex antero-lingually. Its occlusal surface has an elliptical outline elongating bucco-lingually, and shows a simple pattern. The paraflexus, the only fold observed, separates the protocone from the metacone. The anterior wall of the protocone is arranged in the same bucco-lingual line as that of the metacone. Neither hypoflexus nor metaflexus is observed on these cusps. The paraflexus is filled with cementum, and extends postero-buccally from the anterior wall of the crown somewhat lingual to its center, and reaches near the posterior wall of the crown. The posterior wall is very slightly convex posteriorly. The enamel layer is thin, and its differentiation in thickness is not remarkable.

P³: This tooth is shaped as a bilobed curved shaft, which is convex lingually, as P⁴, M¹ and M² are. But it clearly differs from these cheek teeth in having the U-shaped paraflexus inside the crown (2–8 in Fig. 4). The protocone is coalescent with the paracone to form the anterior loph, whose anterior wall is slightly convex anteriorly. The anterior loph is much shorter than the posterior loph formed by the coalescence of the hypocone and metastyle.

The hypoflexus is relatively wide and shallow, and is usually filled with little cementum. The lingual wall of the hypocone protrudes more lingually than that of the protocone. The posterior wall of the posterior loph is nearly straight. The paraflexus is a long and narrow fold, which is initiated posteriorly to the paracone and terminates lingually to the metastyle. The metacone surrounded by the paraflexus remarkably protrudes out on the occlusal surface. The enamel thickens on the lingual walls of the metacone, protocone and hypocone.

P⁴ or M¹: Detached P⁴ and M¹ of ochotonids are generally indistinguishable from each other owing to their morphological similarity. Thus detached upper cheek teeth determined merely as P⁴ or M¹ are described here (9–13 in Fig. 4). In these teeth, the crown is composed of two elliptical lophs elongating bucco-lingually in occlusal view, which have nearly the same size and shape. The lingual ends of the lophs are always pointed, while their buccal ends vary from being pointed to blunt. The anterior wall of the anterior loph is slightly convex anteriorly. The hypoflexus is a narrow and long cement-filled fold without any crenulation on its anterior and posterior enamel walls. It extends buccally to reach near the buccal wall of the crown, which forms a shallow buccal fold. The posterior wall of the hypoflexus, in other words the anterior wall of the posterior loph, protrudes out on the occlusal surface. The posterior wall of the posterior loph is nearly straight. The enamel layer thickens on the anterior walls of the anterior and posterior lophs, while it is interrupted on the buccal wall of the crown.

M²: The morphology of this tooth is the same as that of P⁴ or M¹ described above, except for the presence of a process on the posterior wall of the posterior loph (14 in Fig. 4). This process is pointed posteriorly or postero-lingually, and is set considerably lingual to the center of the posterior wall. A shallow but remarkable fold is formed between the process and the lingual end of the posterior loph. The bucco-lingual width of the posterior loph is somewhat smaller than that of the anterior loph.

Mandible: The mandible is represented only

Fig. 4 Cheek teeth of *Ochotona youngi* from the Lower Pleistocene of the Xiaochangliang site (occlusal pattern)

by a poorly preserved horizontal ramus, whose lingual and buccal faces are smooth (Fig. 5). The buccal face is perforated by several small foramina, among which the most posterior one corresponding to the posterior mental foramen is the largest, and opens probably below the occlusal position of the talonid of M_2 . The maximum height of the ramus preserved (H in Fig. 5) measures 5.64 mm along its buccal face.

P_3 : This tooth is shaped as a curved trigonal prism which is convex buccally. Thus the occlusal surface has a triangular outline with rounded corners, and shows a relatively complicated pattern formed by one lingual and two buccal folds (15–20 in Fig. 4). These folds are filled with cementum. Among them, the paraflexid extends postero-buccally to the central

part of the crown, and has nearly the same length as the protoflexid which extends postero-lingually. These two folds separate the anteroconid from the remaining part of the crown, but a very narrow bridge connects the dentine field of the former with that of the latter. The bottom of the paraflexid is positioned somewhat posterior to that of the protoflexid. The anteroconid varies from trapezoidal to rectangular shapes with corners rounded in various degrees. No additional fold is observed on the antero-lingual and antero-buccal walls of the anteroconid. The buccal end of the protoconid protrudes more buccally than that of the anteroconid. The hypoflexid extends postero-lingually, and is somewhat longer than the protoflexid. The hypoconid remarkably

Fig. 5 Right fragmental mandible of *Ochotona youngi* from the Lower Pleistocene of the Xiaochangliang site (V15319.30; buccal view)

H: maximum height of the horizontal ramus measured along the buccal face.

elongates antero-buccally, and protrudes buccally far beyond the buccal end of the protoconid. The metaconid and entoconid are indistinguishable from each other and form a large dentine field continuous to the protoconid and hypoconid, because the lingual wall of the dentine field is almost straight, and no metaflexid is recognized. The posterior wall of the dentine field is also straight, and the postero-lingual corner of the field is nearly right-angled. The enamel layer thickens on the buccal walls of the protoconid and hypoconid as well as on the lingual wall of the metaconid.

M₁: The mandible described above (Fig. 5) bears the only M₁ worthy to describe here. This tooth is composed of the trigonid and talonid with rhombic to rhomboid shapes in occlusal view (21 in Fig. 4). The trigonid is as large as the talonid, but is higher than the talonid. The antero-buccal wall of the trigonid is weakly concave to form the protoflexid. The hypoflexid is somewhat deeper than the metaflexid. The posterior wall of the talonid is slightly convex posteriorly. The enamel layer thickens on the posterior walls of the trigonid and talonid, as well as their buccal ends.

Measurements—The measurements of the cheek teeth are given in Table 2.

Comparison and discussion—The lagomorph remains obtained from the Xiaochangliang site are easily divided into two forms by striking difference in size. The smaller form comprising much more specimens than the larger one is described here. The smaller form has the following dental characters: The U-shaped paraflexus is present in P³. The hypoflexus lacks enamel crenulation and reaches near the buccal wall of the crown in P⁴, M¹ and M². The lingual ends of the anterior and posterior lophs are pointed in the same teeth. The posterior process of the posterior loph is present in M². These characters indicate that the smaller form is referable to the family Ochotonidae.

Two ochotonid genera, *Ochotona* and *Ochotonoides*, have been known from the Pliocene and Pleistocene of China. *Ochotonoides* differs from *Ochotona* in its larger size and more complicate pattern of P₃. The size of the smaller form falls into the range of small species of *Ochotona*, and its P₃ pattern is simpler than that of *Ochotonoides*. The smaller form is, therefore, assignable to *Ochotona*.

Ochotona species from the Pliocene and Lower Pleistocene of China are represented by *O. lagreli*, *O. minor*, *O. nihewanica*, *O. plicodenta*, *O. magna*, *O. youngi*, *O. lingtaica* and *O. gracilis*. Among them, *O. lagreli* is well known by abundant materials from the uppermost Miocene and lowermost Pliocene of Inner Mongolia, which were first described by Schlosser (1924), and subsequently re-examined in detail by Qiu (1987). On the basis of the description by Qiu (1987), *O. lagreli* is easily distinguishable from the present form in having much larger size, the posterior mental foramen positioned more anteriorly, and such features of P₃ as the hypoflexid shallower and the bottom of the protoflexid opposite to that of the paraflexid.

O. minor was first discriminated as a new subspecies of *O. lagreli* by Bohlin (1942) in the remains assigned to *O. lagreli* by Schlosser (1924). The subsequent study on abundant remains by Qiu (1987) elevated the subspecies to a full species, *O. minor*. The data given by Qiu (1987) discriminate *O. minor* from the present form in the following features: 1) size usually

Table 2 Measurements of the cheek teeth of *Ochotona youngi* from the Lower Pleistocene of the Xiaochangliang site in mm

Element / specimen no.	L	W	Wa	Element / specimen no.	L	W	Element / specimen no.	L	W
P ²				P ⁴ or M ¹			M ²		
V15319.1	0.60	1.38	—	V15319.15	1.16	1.85	V15319.27	1.51	2.15
P ³				V15319.16	1.23	2.40	V15319.28	1.41	2.02
V15319.2	1.05	2.09	1.34	V15319.17	1.47	2.48	V15319.29	1.38	1.91
V15319.3	—	—	1.16±	V15319.18	1.29	2.37	P ₃		
V15319.4	0.96	—	—	V15319.19	1.31	2.21	V15319.31	1.06	1.18
V15319.5	1.12±	—	1.31	V15319.20	1.20	2.26	V15319.32	1.11	1.28±
V15319.6	1.03	2.18±	—	V15319.21	1.08	2.40	V15319.33	—	1.35±
V15319.7	1.05±	—	—	V15319.22	1.36	2.07	V15319.34	1.06	1.12
V15319.8	0.97	2.00	1.27	V15319.23	1.18	—	V15319.35	1.25	1.48
V15319.9	1.09±	—	1.29	V15319.24	1.40	2.19±	V15319.36	1.18	1.37
V15319.10	0.92	2.06	1.34	V15319.25	1.21	2.13	M ₁		
V15319.11	1.10	2.51	1.44	V15319.26	1.16	2.25	V15319.30	1.69	1.76
V15319.12	0.87	1.66	1.15						
V15319.13	1.15	—	—						
V15319.14	1.08	2.24	1.21						

L : maximum length of crown, W : maximum width of crown, Wa : width of anterior loph in P³.

smaller, although its size range partially overlaps that of the present form in some cheek teeth, 2) the protoflexid and paraflexid of P₃ shallower, so that the bridge between their bottoms is broader, 3) the metaflexid or a weak enamel fold on the postero-lingual wall usually present in P₃.

O. nihewanica was described by Qiu (1985) as a new species on the basis of the holotype only, which comprises a skull in association with left and right mandibles from the Lower Pleistocene of the Danangou section in the Nihewan Basin, about 15 km south-south-east of the Xiaochangliang site, and was originally allocated to "*O. lagrelii minor*" by Zheng (1981). Judging from the descriptions of the authors, *O. nihewanica* differs from the present form in having the hypoflexus and metaflexus in P², and the metaflexid in P₃, although there are no differences in the remaining cheek teeth, and although *O. nihewanica* is as large as larger specimens of the present form. Additionally, Zheng and Cai (1991) described 43 specimens including one P₃ (but no P²) from the Danangou section and allocated them to *O. nihewanica*. Their figure for P₃ (6 in Fig. 2) is different from that of the holotype, but is well coincident with P₃ of the present form in shape and size. Moreover, the measurements of the remaining teeth

by Zheng and Cai (1991) almost overlap the size ranges for the corresponding cheek teeth of the present form. Thus the specimens described by these authors probably belong to the same species as the present form, namely *O. youngi* as mentioned below.

O. plicodonta, *O. magna*, *O. youngi*, *O. lingtaica* and *O. gracilis* were recently described as new species by Erbaeva and Zheng (2005). The following comparisons are based on the data given by these authors.

O. plicodonta occurs from the Upper Miocene to Pliocene of Lingtai in Gansu. This species is larger than the present form in P² and P₃, while it is smaller in M². Additionally it is nearly as large as the present form in P³. This species is, however, different in having such features in P₃ as plication on the anterior wall of the paraflexid, the metaconid elongated more anteriorly, the paraflexid deeper, and the hypoconid shorter.

O. magna is obtained from the Lower Pleistocene of the Danangou section. This species is much larger than the present form, and differs in having larger anteroconid, deeper paraflexid and shorter hypoconid.

O. youngi occurs from the Lower Pleistocene of the Danangou section as well as that of Majuangou which is very near to the Xiao-

changliang site. The morphology and size of this species are well coincident with those of the present form, which leads to the allocation of the form to *O. youngi* (compare Fig. 4 and Table 2 of the present paper with Figs. 3, 4, 8 and Tables 6, 7 of Erbajeva and Zheng, 2005).

O. lingtaica known from the Pliocene of Lingtai is almost as large as the present form. It differs in P_3 with relatively larger anteroconid with a rhomboid shape, and with shorter hypoconid, but the differences are not so clear.

O. gracilis known also from the Pliocene of Lingtai has roughly the same size as the present form, but differs in having narrower P_3 , which is resulted from shorter hypoconid. It also differs in having shorter paraflexid in the same tooth, whose bottom is opposite to that of the protoflexid.

Additionally, Cai (1989) described remains of *Ochotona* from the Pliocene localities near the Danangou section, which were first reported by Cai (1987). Cai (1989) allocated them to "*O. cf. lagrelii*," *O. minor* and *O. erythrotis*. Unfortunately, Erbajeva and Zheng (2005) did not discuss the relationship among these forms and their new species mentioned above, but the allocation by Cai (1989) needs to be revised. At any rate, "*O. cf. lagrelii*" by Cai (1989) differs from the present form in having much larger size and the posterior mental foramen positioned more anteriorly. On the other hand, *O. minor* and *O. erythrotis* by Cai (1989) are more similar to the present form, but further discussion cannot be done owing to the shortage of the data.

Ochotona species have also recorded from the Middle and Upper Pleistocene of China. Erbajeva and Zheng (2005) described a new species, *O. zhangii*, from the Middle Pleistocene of Xiaoxishan in Shandong. This species is larger than the present form, and also differs in P_3 which has relatively larger anteroconid, narrower paraflexid and protoflexid, and somewhat shorter hypoconid.

Besides Xiaoxishan, several fossil localities of Middle and Late Pleistocene age yield remains of *Ochotona* which have been mostly assigned to such extant species as *O. koslowi*, *O. daurica* and *O. hyperborea*. Remains from Locality 3 of Zhoukoudian (=Choukoutien) in

Beijing are referred to *O. cf. koslowi* by Pei (1936). *O. cf. koslowi* from this locality seems to be considerably larger than the present form, and to have the posterior mental foramen positioned more posteriorly on the mandible, although the information on the cheek teeth is quite limited. Remains from the Upper Cave of Zhoukoudian are allocated to *O. daurica* by Pei (1940). Judging from his description, *O. daurica* from this locality differs from the present form in having much larger size, and shorter hypoconid and noticeable metaflexid in P_3 . Remains from Jinniushan are assigned to *O. hyperborea* by Zhang *et al.* (1993). Their description indicates that *O. hyperborea* from this locality differs from the present form in having a squarish outline of P^2 and remarkable metaflexid in P_3 , although the cheek teeth of the former are as large as those of the latter except P_3 .

Many species of *Ochotona* are known in present China. The main species are *O. thibetana* (including *O. cansus*), *O. roylei*, *O. macrotis*, *O. erythrotis* (including *O. gloveri*), *O. kamensis*, *O. daurica*, *O. curzoniae*, *O. koslowi*, *O. ladacensis*, *O. pallasii*, *O. alpina* and *O. hyperborea*. The present form is compared with these species on the basis of the descriptions of Gureev (1964) and Erbajeva (1988). Among the species, *O. macrotis*, *O. erythrotis*, *O. daurica*, *O. curzoniae*, *O. koslowi*, *O. ladacensis*, *O. pallasii* and *O. alpina* are larger than the present form, and have the posterior mental foramen positioned more posteriorly (below M_3 or more posteriorly). *O. roylei* and *O. hyperborea* differ from the present form in having larger size, and shallower protoflexid and paraflexid in P_3 so that the bridge between their bottoms is broader. Furthermore in P_3 , the hypoconids of these species are shorter than that of the present form. *O. kamensis* is much larger than the present form, and is different in having shallower protoflexid and paraflexid in P_3 which are opposite at their bottoms, and in having shallower hypoflexid also in P_3 . *O. thibetana* is as large as the present form, but differs in having the posterior mental foramen positioned more posteriorly, and in having P_3 whose paraflexid is longer and extends posteriorly, and whose hypoconid is shorter. The present form is, therefore, distinct from all the extant species compared.

Summarizing the comparison and discussion mentioned above, the present form differs from such Pliocene and Early Pleistocene extinct species as *O. lagreli*, *O. minor*, *O. nihewanica*, *O. plicodonta*, *O. magna*, *O. lingtaica* and *O. gracilis*, as well as the Middle Pleistocene extinct species of *O. zhangii*. It is also different from the Middle and Late Pleistocene *Ochotona* remains assigned or compared to such extant species as *O. koslowi*, *O. daurica* and *O. hyperborea*, and from the main extant species now distributed in China. On the other hand, the present form is coincident with the Early Pleistocene species, *O. youngi*, in morphology and size, and thus it is referable to *O. youngi*.

According to Erbajeva and Zheng (2005), *O. youngi* occurs from Layers 4 to 23 of the Danangou section. The geological ages of the layers are obscure within the Early Pleistocene, because chronological data obtained by non-faunal dating methods including paleomagnetism are lacking. On the basis of the faunal comparisons, Cai *et al.* (2004) concluded that the boundary between Layers 6 and 7, and that between Layers 18 and 19 were inferred to be 1.8 and 0.78 Ma, respectively. But their chronology is quite doubtful especially in the upper part of the section, because mammalian remains are few in Layers 19 to 27 which lack reliable time markers. Therefore we believe that the record of *O. youngi* from Layer 23 by Erbajeva and Zheng (2005) does not always indicate its occurrence in the Middle Pleistocene. In the paleomagnetically dated sections, the latest record of *O. youngi* is dated as 1.66 Ma at Majuangou (its age by Zhu *et al.*, 2004) except for the Xiaochangliang site described here (1.36 Ma). Thus the occurrence of *O. youngi* from the Xiaochangliang site is the latest in the reliably dated records. *O. youngi* had survived at least until 1.36 Ma in northern China.

***Ochotona* or *Ochotonoides* sp.**

(Fig. 6)

Referred specimens—1 right P³ (15320.1), 1 left P⁴ or M¹ (15320.2).

Repository, locality, horizon and age—The same as *Sorex* sp. described before in this paper.

Description—The two teeth described here

are much larger than the corresponding teeth of *O. youngi* described above.

P³: P³ is represented by the damaged tooth showing a shape of a curved shaft which is convex lingually. Its posterior loph is lost. In occlusal view, the anterior wall of the anterior loph is slightly convex anteriorly. The parafllexus is a U-shaped narrow and long fold which is filled with cementum. The metacone surrounded by the parafllexus protrudes out on the occlusal surface.

P⁴ or M¹: The tooth determined merely as P⁴ or M¹ is described here. The tooth is shaped as a bilobed curved shaft which is convex lingually. In occlusal view, the anterior and posterior lophs show nearly the same elliptical shape elongating bucco-lingually, and have nearly the same size. The lingual ends of the lophs are pointed, while the buccal ends are blunt. The anterior wall of the anterior loph is slightly convex anteriorly. The hypoflexus has no crenulation, and extends buccally to reach near the buccal wall of the crown. The posterior wall of the posterior loph is slightly convex posteriorly. The enamel layer becomes thick on the anterior walls of the anterior and posterior lophs, where it protrudes out on the occlusal surface.

Measurements—The width of the anterior loph (Wa) measures 2.09 mm in P³, while the length of the crown (L) measures 2.12 mm in P⁴ or M¹.

Discussion—The two teeth are assigned to the larger form of lagomorphs from the Xiaochangliang site. This form has the U-shaped parafllexus in P³, and lacks enamel crenulation of the hypoflexus in P⁴ or M¹, where the hypoflexus reaches near the buccal wall of the

Fig. 6 Detached cheek teeth of *Ochotona* or *Ochotonoides* sp. from the Lower Pleistocene of the Xiaochangliang site (occlusal pattern)

1. right P³ (V15320.1), 2. left P⁴ or M¹ (V15320.2).

crown, and the lingual ends of the anterior and posterior lophs are pointed. These characters indicate the allocation of the larger form to Ochotonidae, as in the case of the smaller form. Ochotonid genera known from the Pliocene and Pleistocene of China are represented by *Ochotona* and *Ochotonoides*, which are indistinguishable from each other by the morphology of P³ and P⁴ or M¹, but species of *Ochotona* are generally much smaller than those of *Ochotonoides*. Most species of *Ochotona* are, therefore, distinguishable from *Ochotonoides* by size difference. On the basis of the measurements given by Qiu (1987), and Erbaeva and Zheng (2005), however, larger individuals of *Ochotona lagreli*, the largest species of *Ochotona* in the Pliocene and Pleistocene of China, are as large as *Ochotonoides complicidens*, the only representative of *Ochotonoides* in the same age and area. The two teeth described here probably lie within this overlap of the size ranges of the two species, although the measurements of the present form are not sufficient owing to the poor preservation and shortage of material. Thus they cannot be determined whether to be *Ochotona* or *Ochotonoides*.

IV. Summary and conclusion

The detailed systematic descriptions given in this paper have brought a sufficient understanding of the soricomorph and lagomorph remains from the sediments of the Xiaochangliang site dated paleomagnetically as 1.36 Ma. All the soricomorph remains are isolated teeth which show morphological characters of the family Soricidae. The morphology of the teeth is well coincident with that of the tribe Soricini in the subfamily Soricinae, but is distinguishable from those of the other subfamilies as well as those of the other tribes of Soricinae. Among the genera of Soricini, such four genera as *Sorex*, *Deinsdorfia*, *Petenya* and *Zelceina*, are known from the Pliocene and Pleistocene of Asia, and thus they are compared with the present remains. The comparison reveals that the remains are allocated to *Sorex*. The remains are, however, too incomplete to carry out any specific determination within the genus. The remains are therefore assigned to *Sorex* sp.

All the lagomorph remains show the morphological characters of the family Ochotonidae. Almost all of them are isolated teeth. They are easily divided into a smaller and larger forms by their striking difference in size. Only two ochotonid genera, *Ochotona* and *Ochotonoides*, are known from the Pliocene and Pleistocene of China. The dental morphology and size of the smaller form coincide with those of *Ochotona*, which has a large number of species in the Pliocene and Pleistocene as well as the present day of China. The comparisons with the *Ochotona* species indicate that the smaller form is referred to *O. youngi* very recently described as a new extinct species. The occurrence of this species from the Xiaochangliang site is the latest in the reliably dated records, and thus this species had survived at least until 1.36 Ma in northern China. The larger form is referred merely to *Ochotona* or *Ochotonoides* sp., because it is very few in specimen number, and its morphological information is limited.

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中国河北省泥河湾盆地小長梁遺跡産の前期更新世 トガリネズミ形目化石および兎目化石

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〔要 旨〕

小長梁遺跡の 1.36 Ma とされる層準の堆積物から、篩による水洗法で得た小型哺乳類化石のうち、本論文ではトガリネズミ形目と兎目の化石を系統分類学的に記載した。トガリネズミ形目の化石は歯の形態の詳しい比較から、トガリネズミ科トガリネズミ亜科のトガリネズミ族に属することが明らかになった。この族を構成する多くの属のうち、アジアの鮮新統と更新統から知られる属と比較すると、今回の化石は *Sorex* に属することがわかったが、標本の不完全さから種の同定は行なえなかった。

兎目の化石は、すべてナキウサギ科に属し、それらは大きさが明らかに異なる 2 種類に分類できる。中国の鮮新統や更新統から知られるナキウサギ科の属は *Ochotona* と *Ochotonoides* のみで、今回の化石のうち小型の種類は形態や大きさから、*Ochotona* に属する。中国の鮮新世とそれ以降現在までの時期の多くの *Ochotona* の種と比較した結果、小型の種類は絶滅種の *O. youngi* に同定にできた。一方、大型の種類は標本が不十分で、*Ochotona* or *Ochotonoides* sp. とするにとどめた。

キーワード：トガリネズミ形目、兎目、系統分類、前期更新世、小長梁遺跡、泥河湾盆地、中国

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