Mammal Study 27: 31–63 (2002)

Morphological variation and geographical and altitudinal distribution in *Eothenomys melanogaster* and *E. mucronatus* (Rodentia, Arvicolinae) in China, Taiwan, Burma, India, Thailand, and Vietnam

Yukibumi Kaneko

Biological Laboratory, Faculty of Education, Kagawa University, Takamatsu 760-8522, Japan

Abstract. I classified about 600 museum specimens of Père David's vole and examined its distribution. In a restricted area of Burma (25.70–26.13°N, 98.13–98.70°E; Myanmar, Area V), 150 individual specimens sampled during the same period could be classified into two groups on the basis of the relationship between the hind foot length (HFL) and tail length (TL): the large (L) and small (S) types. Group L was distributed at altitudes above 2460 m, whereas Group S was found below 2460 m. The distance between the incisor and third upper molar (I-M3) exceeded 14.3 mm in Group L, and was less than 15.2 mm in Group S. Except for young individuals, specimens from Groups L and S from Area V differed in two external and 14 cranial measurements. The molar pattern of the third upper molar ranged from simple to complex types, and varied both within and between Groups L (Types B, C, and D) and S (Types B and C), indicating that it is inadequate as a primary diagnostic character. The relationship between TL and HFL differentiated the groups in Areas III, IV (Yunnan Province, China), VI (India, Thailand, Vietnam, and northern Burma), and VII (the provinces of Zhejiang and Fujian in China, and Taiwan), but did not differentiate them in Areas I (the provinces of Hubei and Guizhou) or II (the provinces of Gansu and Sichuan), where histograms of I-M3 distinguished Groups L and S. Proportional likeness was represented using a ratio diagram; the lines for 11 cranial dimensions distinguished Group L from Group S, indicating that they are two distinct species. Group L was identified as *Eothenomys mucronatus* (Allen, 1912); it was distributed in Areas II, III, V, and VI. Group S was identified as *E. melanogaster* (Milne-Edwards, 1872); it was distributed in Areas I, II, IV, V, and VII. The elevations at which *E. melanogaster* occurred decreased from southwest to northeast, whereas no clear altitudinal tendency was seen in *E. mucronatus*.

Key words: distribution, *Eothenomys melanogaster*, *E. mucronatus*, morphology, variation.

The genus *Eothenomys* Miller, 1896 (Arvicolinae, Rodentia) has a palatal shelf construction like that of the genus *Clethrionomys* Tilesius, 1850, but the molars are rootless, even in old age. Within the genus *Eothenomys*, Père David's vole (the *E. melanogaster* group) has a prominent postero-internal salient angle on the first upper molar. This group occurs in central and southern China, Taiwan, Burma (Myanmar), India, Thailand, and Vietnam (Corbet 1978; Corbet and Hill 1992; Musser and Carleton 1993).

Historically, this group has included 14 named species and subspecies, as described by Milne-Edwards (1872), Thomas (1911a, c, 1914, 1921), Allen (1912), Cabrera (1922), Hinton (1923), Tokuda and Kano (1937), and Wang and Li (2000). These taxa have been reclassified into one to four distinct species by several authors (Hinton 1926; Allen 1940; Ellerman 1941; Ellerman and Morrison-Scott 1951; Gromov and Polyakov 1977; Corbet 1978; Honacki et al. 1982; Corbet and Hill 1992; Musser and Carleton 1993; Wang and Li 2000). Those authors that consider the group a single distinct species call it *Eothenomys melanogaster*. Other authors consider the group two species, *E. melanogaster* and either *E. fidelis* or *E. miletus*; three species, *E. melanogaster*, *E. eleusis*, and *E. miletus*; or four species, *E. melanogaster*, *E. eleusis*, *E. miletus*, and *E. cachinus*.

E-mail: kaneko@ed.kagawa-u.ac.jp

The lack of agreement about the classification of this group has generated confusion in biological studies. The taxonomical disagreement may stem from the wide variation found in this group, as well as its broad distribution. Studies of geographical variation are difficult, unless they can make use of many specimens housed in many different museums. This study reviewed the geographic variation in morphological characters of Père David's vole, including a reexamination of 10 holotypes, and the group's altitudinal distribution; on this basis, a revised classification is presented.

Taxonomic history and problems

Fourteen species and subspecies of Père David's vole (*Eothenomys melanogaster* group) have been described from specimens from China, Taiwan, Vietnam, Burma, and India, based on differences in coat color and sizes of the skull, teeth, and tympanic bulla. Milne-Edwards (1872) first described Père David's vole as *Arvicola melanogaster*, using specimens collected from Moupin (Locality #17 in this study), Szechwan (= Sichuan), China. He noticed variation in skin color ranging between "bistre" (black) and "mummy-brown" (brown). Miller (1896) revised the classification of the Microtinae (now Arvicolinae), recognizing seven genera; he called *Eothenomys* a new subgenus of *Microtus* that included *Arvicola melanogaster* Milne-Edwards, 1872, because *Eothenomys* (even when adult) lacks molar roots.

After the generic and subgeneric names were revised by Miller (1896), Thomas (1911a) described *Microtus* (*Eothenomys*) *melanogaster colurnus* from Kuatun (Locality #59 in this study), Fukien (= Fujian), China, which has a slightly darker and richer "hazel" coat color. Thomas (1911c, 1912) further described *Microtus* (*Eothenomys*) *melanogaster eleusis* from Cha-tung-fu (Locality #33 in this study), north of Yunnan and southeast of Szechwan, China. The vole differs from others in the group in having slightly grayish-brown skin, a decidedly longer tail, and a complicated molar pattern on the third upper molar.

Allen (1912) described the species *Microtus* (*Eothenomys*) *aurora* as distinct from *M.* (*E.*) *melanogaster*, collected from Changyang-hsien (Locality #3 in this study), Hupeh (= Hubei) Province, China. This species has a larger body, is reddish brown in color, and has a larger, heavier skull with a complicated molar pattern on the third upper molar. In the same paper, Allen (1912) described another species, *Microtus* (*Eothenomys*) *mucronatus*, collected from Tachiao (Locality #21 in this study), western Szechwan, China. The vole has a larger skull and teeth than *M.* (*E.*) *aurora* and a small additional angle on the inner side of the posterior heel of the third upper molar.

Thomas (1914) described a new subspecies, *Microtus* (*Eothenomys*) *melanogaster miletus*, collected 10 miles west of Yangpi (Locality #47 in this study), western Yunnan, China. This vole differs from *M.* (*E.*) *melanogaster eleusis* in its somewhat larger skull with a smaller tympanic bulla, although the two subspecies have the same complicated molar pattern on the third upper molar. Later Thomas (1921) described *Microtus* (*Eothenomys*) *cachinus*, collected from Imaw Bum (Locality #70 in this study), Burma. He noted that the vole has a larger and heavier skull with a smaller tympanic bulla than *M.* (*E.*) *melanogaster eleusis* but has the same complicated molar pattern on the third upper molar.

Without comparing his specimens collected from Fu-Chou, Fukien (= Fujian), China, with the other species hitherto described, Cabrera (1922) described *Microtus* (*Eothenomys*) *bonzo*; this species has four salient angles on the outer side of the third upper molar but three angles on the inner side.

Hinton (1923) regarded *Eothenomys* as a distinct genus and described *Eothenomys fidelis*, collected from the Lichiang Range (Locality #34 in this study), northwestern Yunnan, China. He mentioned that the vole has a large skull with a smaller tympanic bulla and teeth with three outer and four inner salient angles on the third upper molar, as does *M.* (*E.*) *melanogaster eleusis*. Hinton (1923) described another subspecies, *Eothenomys melanogaster confinii*, collected from the Kiu-chiang-Salwin Divide (Locality #28 in this study) at 28°N latitude, Yunnan, China; this vole has a slightly smaller skull and tympanic bulla than does *M.* (*E.*) *melanogaster miletus* and three outer and four inner salient angles on the third upper molar. Adding to these two subspecies, Hinton (1923) further described *Eothenomys melanogaster libonotus*, collected from Dreyi (Locality #65 in this study), Mishmi Hills, Assam, India. This vole has a similarly sized skull with a small tympanic bulla and large teeth, like *M.* (*E.*) *mucronatus*, with three outer and three inner salient angles on the third upper molar.

Tokuda and Kano (1937) described *Eothenomys kanoi*, from His-ko-Yueh, Taiwan, as having a smaller skull and three inner and outer salient angles on the third upper molar.

Wang and Li (2000) described *Eothenomys eleusis*

yingjiangensis, collected from Yingjiang Xiang, Yunnan, China. This vole has a shorter tail, about 35% of the head and body length, with four inner salient angles on the third upper molar. They also described *E. melanogaster chenduensis*, collected from Chengdu Shi, Sichuan, China; this vole has a larger skull (more than 27 mm in total skull length) with three inner salient angles on the third upper molar.

Due to the number and inconsistency of the proposed scientific names, several taxonomists have revised the classification of Père David's vole, resulting in the following five systems.

Many recognize a single valid species, called *Eothenomys melanogaster* (Ellerman 1941; Ellerman and Morrison-Scott 1951; Corbet 1978; Honacki et al. 1982; Musser and Carleton 1993), although Corbet (1978) and Musser and Carleton (1993) considered the species provisional until a large museum series could be reexamined.

Hinton (1926) proposed that two species should be recognized: *Eothenomys melanogaster* and *E. fidelis*. The two species differ in the number of salient angles on the third upper molar and the size of tympanic bulla. According to his classification, *E. melanogaster* is synonymous with *E. colurnus*, *eleusis*, *aurora, mucronatus*, *miletus*, *cachinus*, *confinii*, and *libonotus*, whereas *E. fidelis* has no synonym. Although Hinton (1926) did not examine the type specimen of *E. bonzo,* he assumed that it was a synonym of *E. melanogaster.*

Emphasizing that their proposal was a tentative classification, Corbet and Hill (1992) identified two species using the lengths of the head and body, hind foot, and skull; the tail ratio; and the number of salient angles on the third upper molar. However, they studied only the holotypes housed in the Natural History Museum, London. They recognized *Eothenomys melanogaster*, listing *E. colurnus*, *mucronatus, bonzo, confinii*, *libonotus*, and *kanoi* as synonyms, with possible synonyms of *E. eleusis* and *E. aurora*. In addition, they recognized *E. miletus*, with *E. fidelis* as a synonym, with *E. cachinus* as a possible synonym.

Allen (1940), Gromov and Polyakov (1977) and Hu and Wang (1984) recognized three species. According to Allen (1940), one is *Eothenomys melanogaster*, with *E. colurnus*, *mucronatus, cachinus*, *bonzo,* and *libonotus* as synonyms; the second is *Eothenomys eleusis*, with *E. confinii* as a synonym; and the third is *Eothenomys miletus*, with *E. aurora* and *E. fidelis* as synonyms. Taxonomically this procedure is incorrect (Ellerman 1949), because the senior synonym is not *E. miletus* but *E. aurora*, since the name *aurora* was given by Allen (1912) and *miletus* by Thomas (1914). These three vole species differ primarily in the number of salient angles on the third upper molar and secondarily in skull length.

Wang and Li (2000) recognized four species based on differences in the number of salient angles on the third upper molar, although they did not examine the holotypes housed in the Natural History Museum, London, the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, or the Muséum National d'Histoire Naturelle, Paris. One species is *Eothenomys melanogaster*, with three inner and outer salient angles on the molar; this species has *E. colurnus, mucronatus, bonzo,* and *kanoi* as synonyms. The second is *Eothenomys eleusis*, with four inner and three outer salient angles on the molar and a synonym *E. aurora*. The third is *Eothenomys miletus*, with four inner and three outer salient angles on the molar and a larger skull than *E. eleusis*; *E. fidelis* and *E. confinii* are synonyms. The fourth species is *Eothenomys cachinus*, which has four inner and four outer salient angles on the molar.

Therefore, the number of salient angles on the third upper molar has been emphasized as a primary diagnostic character (Hinton 1926; Allen 1940; Ellerman 1941; Gromov and Polyakov 1977; Hu and Wang 1984; Wang and Li 2000). However, some authors have reported collecting specimens with four inner salient angles along with specimens with three angles (Allen 1912; Howell 1929; Pen et al. 1962; Lu et al. 1965). The large number of specimens from Burma showed continuous variation in the molar pattern, from three to four salient angles through intermediate forms, and one specimen had three on one side and four on the other (Anthony 1941). Therefore, the specimens should be reclassified using other characters to reevaluate whether using the number of salient angles as a primary diagnostic character is suitable.

Materials and methods

I examined approximately 600 specimens of this group, consisting of conventional museum skins accompanied with skulls, as well as the following ten holotypes by author: *Arvicola melanogaster* Milne-Edwards, 1872; *Microtus* (*Eothenomys*) *melanogaster colurnus* Thomas, 1911; *Microtus* (*E.*) *melanogaster eleusis* Thomas, 1911; *Microtus* (*E.*) *aurora* Allen, 1912; *Microtus* (*E.*) *mucronatus* Allen, 1912; *Microtus* (*E.*) *melanogaster miletus*

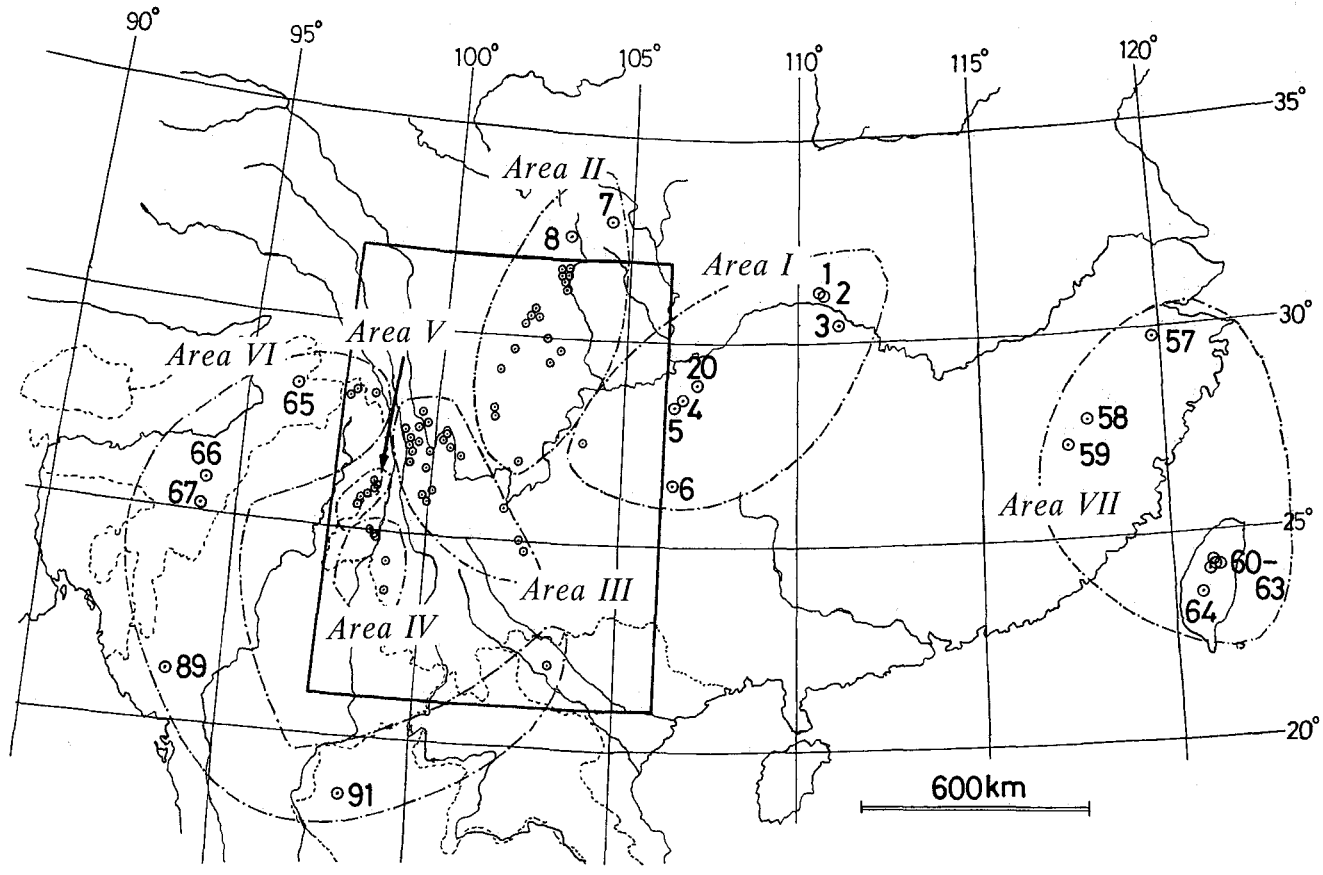

Fig. 1. Localities of specimens examined in China, Taiwan, Burma, India, Thailand, and Vietnam in the present study. Locality numbers in the rectangular area are shown in Fig. 2, which is enlarged.

Thomas, 1914; *Microtus* (*E.*) *cachinus* Thomas, 1921; *E. fidelis* Hinton, 1923; *E. melanogaster confinii* Hinton, 1923; and *E. melanogaster libonotus* Hinton, 1923. The following three holotypes could not be accessed directly: *Microtus* (*E.*) *bonzo* Cabrera, 1922; *Eothenomys eleusis yingjiangensis* Wang and Li, 2000; and *Eothenomys melanogaster chenduensis* Wang and Li, 2000. The holotype for *Eothenomys kanoi* Tokuda and Kano, 1937 was not designated; the authors described the new scientific name based on 37 specimens. The location of these syntypes is not known.

The specimens examined, including types, are housed in the following institutions: the Natural History Museum, London (BM); the United States National Museum of Natural History (USNM); the Museum of Comparative Zoology, Harvard University (MCZ); the American Museum of Natural History (AMNH); the Field Museum of Natural History (FMNH); the Muséum National d'Histoire Naturelle (MHNM); and Hokkaido University Museum (HUM-HAno).

Some of these specimens have been studied previously (Milne-Edwards 1872; Thomas 1899, 1911a, b, c, 1912, 1914, 1921, 1923; Allen 1912, 1924, 1940; Hinton 1923, 1926; Hinton and Lindsay 1926; Howell 1929; Osgood 1932; Anthony 1941; Ellerman 1941, 1961; Stager 1949; Ellerman and Morrison-Scott 1951; Cranbrook 1960-61; Pen et al. 1962; Lu et al. 1965; Lawrence 1982).

The localities from which specimens were collected and their reference numbers are shown in Figs. 1 and 2. Appendix 1 lists the geographical coordinates, altitude, collection date, museum, and registration numbers for all specimens examined. The geographical coordinates of each locality were determined from gazetteers (Zhuang 1983; Su 1984) and from an account of a collecting expedition (Kingdon Ward 1921). Altitude was obtained from labels attached to skins, and those recorded in feet were converted to meters (m) by multiplying by 0.3. The great variation exhibited by specimens from the 91 collecting localities makes it difficult to appreciate broad morphological patterns. These localities were arbitrarily grouped into seven geographic areas (Figs. 1 and 2). Area I (Localities #1–6) covers Hubei and the southeast-

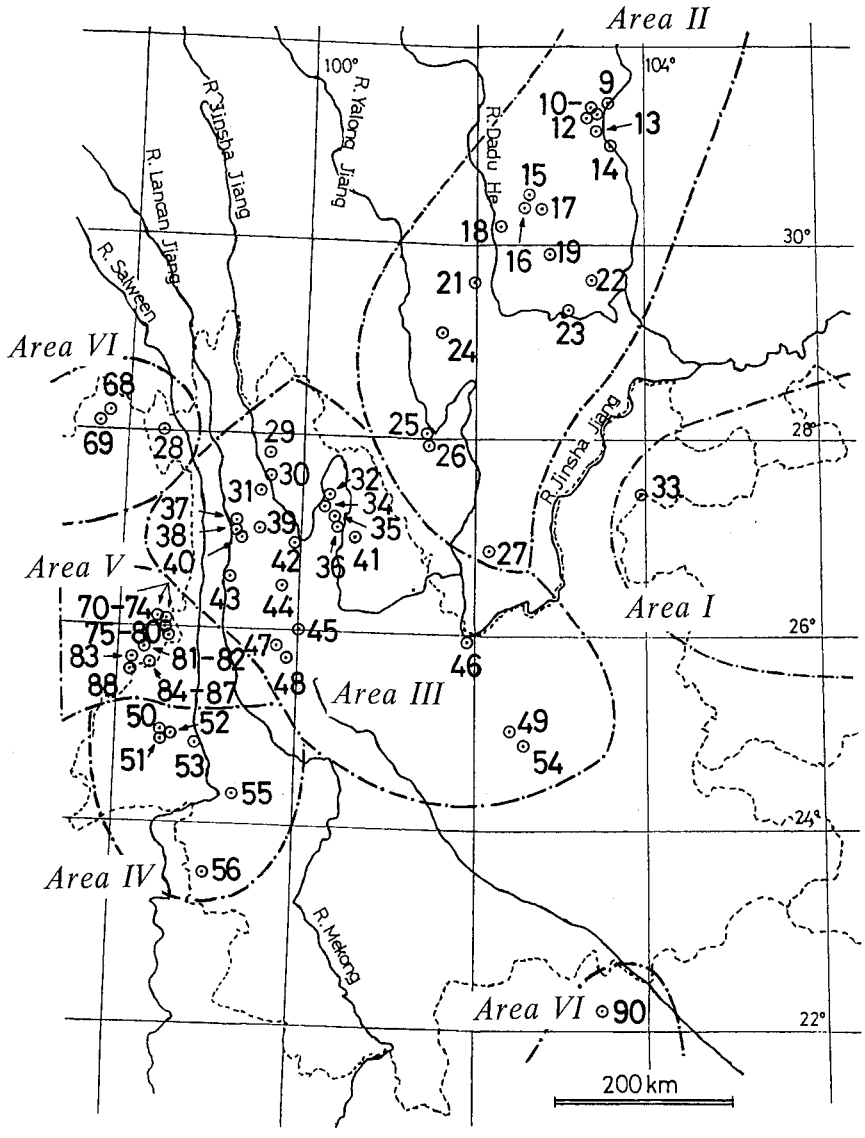

Fig. 2. Localities of specimens examined in a rectangle area, which is shown in Fig. 1.

ern parts of Sichuan and Guizhou provinces, China. Area II (Localities #7–27) consists of the western parts of Sichuan and Gansu provinces, China. Area III (Localities #29–49 and 54) is northeastern Yunnan Province, China. Area IV (Localities #50–56) is southwestern Yunnan Province, China. Area V (Localities #70–88) is extreme northeastern Burma. Area VI (Localities #28, 65–67, 68–69, 89, and 90–91) includes northern Yunnan Province, northern and western Burma, northeastern India, northern Thailand, and northern Vietnam. Area VII (Localities #57–59 and 60–64) consists of Zhejiang and Fujian provinces, China, and Taiwan.

Adult females were identified by mammae on the skin and males by a report of descended testes on the label attached to the skin. Young were identified either by the presence of minute perforations on or the absence of full ossification of the skull. For external measurements, head and body length (H&BL), tail length (TL), and hind foot length (HFL) were recorded from labels attached to skins. I measured the following 15 skull measurements (abbreviation followed by measurement definition) to the nearest 0.1 mm with dial calipers (minimum accuracy = 0.05 mm): condylobasal length (CBL), distance between the occipital condyle and the anterior point of premaxilla; condyle-zygomatic length (C-Z), distance between the occipital condyle and the antero-superior edge of the premaxilla; condyle-first upper molar length (C-M1), distance between the occipi-

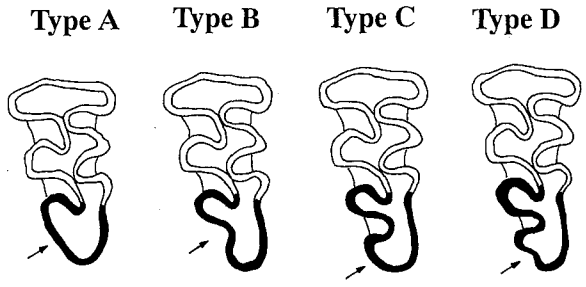

Fig. 3. Dental patterns (Types A, B, C and D) of the third upper molars on the left side. These patterns differ in the number of reentrant angles and the shape of the posterior loop (arrow).

tal condyle and the anterior edge of the first upper molar; incisor-third upper molar length (I-M3), distance between the anterior-most point of the incisor and the posterior-most edge of the third upper molar; diastema length (Dias), distance from the posterior edge of the upper incisive alveolus to the anterior edge of the alveolar space in the upper molar row; length of incisive foramen (IFL), maximum length of the palatine slit; nasal length (NL), maximum length of the nasal bone; molar length (ML), distance from the anterior edge of the alveolus of the first upper molar to the posterior edge of the third upper molar; molar width (MW), maximum distance between the lateral border of the first upper molar on both sides; width of the first molar (M1w), maximum width of the first upper molar; interorbital width (IOW), minimum diameter of the frontal bones between the orbits; zygomatic width (ZW), maximum spread of the zygomatic arches; condyle-bullae length (C-Bull), distance between the occipital condyle and the anterior point of the tympanic bullae; length of tympanic bulla (BL), maximum length of the tympanic bulla; and tympanic bulla width (BW), the maximum width of the tympanic bulla.

Differences in proportions can be graphically illustrated in the form of the ratio diagram described by Simpson (1941) and Musser (1970). For each external and cranial measurement, the absolute value of the mean of a given sample is divided by the mean of the sample used as the standard. The quotient is converted into a logarithm. Measurements greater than the standard are represented on the diagram by positive values, and those smaller than the standard are represented by negative values. A sample with the same proportions as the standard is represented by a line parallel to that of the standard. Any two samples with like proportions are shown by lines of like form, even if neither is a straight line parallel to the standard.

Table 1. Frequencies of the relationship between HFL and TL classes in Area V, classifying two separate clusters: large type (Group L) and small type (Group S). Group L was identified as *Eothenomys mucronatus*, and Group S as *E. melanogaster*.

Area V	HFL(mm)										
TL (mm)	13-	14-	15-	16-	17-	18-	19-	20-	21-	22-	Total
20-			1	1							2
25-	2	2	5	1	1						11
30-	8	6	25	17	5	2					63
35-	1	1	1	7	1			2			13
40-							1				1
45-							4	6	1		11
50-								19	1		20
55-							1*	7	5		13
60-								1			1
Total	11	9	32	26	7	2	6	35	7		135

* the holotype of *Microtus* (*Eothenomys*) *cachinus*.

The enamel patterns of the occlusal surface of the upper molar were drawn from close-up photographs taken with a Nikon SMZ-10 stereomicroscope at 6.6× magnification. The original photographs of the museum specimens were taken using an accessory close-up lens (1.75×magnification) attached to an Olympus camera. The enamel patterns of the third upper molar were classified into four types (Types A–D; see Fig. 3). Type A has three salient and two reentrant folds on the lingual side with a posterior loop where the enamel lamella forms either a straight or concave outline on the lingual side. Type B has four salient and three reentrant folds on the lingual side with convex enamel lamella on the third reentrant fold. Type C has four salient and three reentrant folds on the lingual side with a posterior loop, which has either a straight or concave outline of the enamel lamella, as found in Type A. Type D has five salient and four reentrant folds on the lingual side with a small posterior loop, which forms a convex enamel lamella of the fifth reentrant fold, as in Type B.

Results

Discrimination of two size groups (S and L) in specimens from Area V

In 1939, the Vernay-Cutting Burma Expedition (Anthony 1941) collected 150 museum specimens from Area V (Localities #70–88); 147 were obtained between January and March, and the remaining 3 were collected in April (from Localities #81 and 83). These localities lie within a limited area between 25.70 and 26.13°N and 98.13 to 98.70°E, at altitudes from 1200 to 3000 m (Figs.

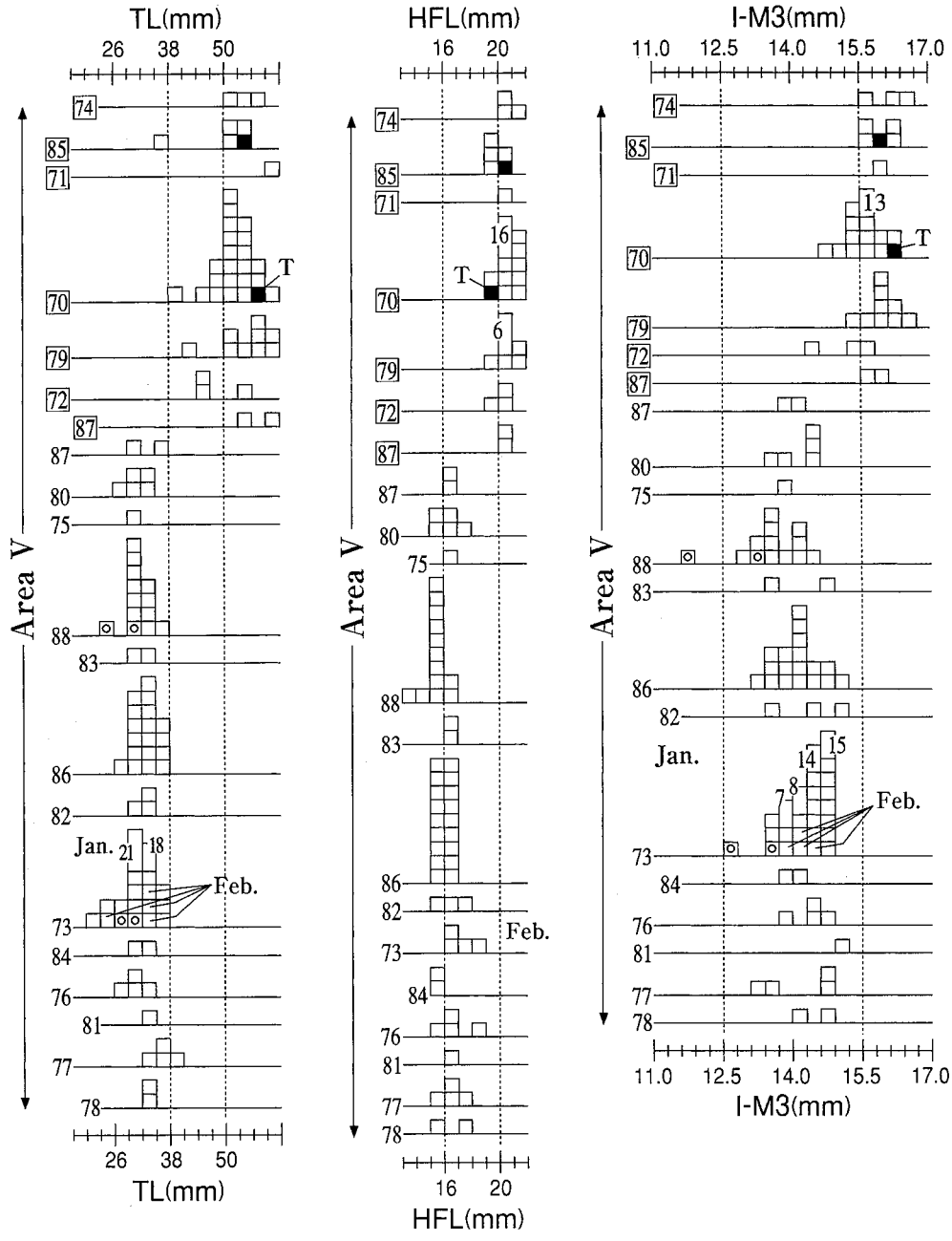

Fig. 4. Geographical variation of frequencies of TL, HFL and I-M3 in Area V. The number indicates localities listed in Appendix 1. Locality numbers in a rectangle indicate places where Group L (later identified as *Eothenomys mucronatus)* was collected, and Group S (later identified as *E. melanogaster*) was collected from other localities. One rectangle shows one specimen, except for the number at the top of the column indicating the total number of specimens in respective bars. Symbols: adult = closed rectangle; young = small circle within a rectangle; T = holotype. The scientific name of the holotype is given by referring the locality numbers listed in Appendix 1. Localities arranged from the upper to the bottom were drawn from higher to lower elevation. Figs. 5–9 were arranged from the northeast to the southwest direction in respective areas shown in Figs. 1 and 2.

1 and 2, and Appendix 1). Therefore, these results are directly comparable without considering differences in sampling period or geographic location.

Based on the relationship between TL and HFL, these specimens were classified into two separate clusters (Table 1). In one cluster, TL was 35 to 64 mm and HFL was 19 to 21 mm (large type, Group L); this cluster was composed of specimens from Localities #70 to 72, 74, 79, 85, and 87. In the other cluster, TL was 20 to 39 mm and HFL was 13 to 18 mm (small type, Group S);

Table 2. External and cranial measurements of Groups L and S in Area V. Group L (L) is identified as *Eothenomys mucronatus* and Group S (S) is as *E. melanogaster*. In each measurement, mean ± standard deviation, range and number of specimens in parentheses are shown.

	E. mucronatus	*E. melanogaster*		*E. mucronatus*	*E. melanogaster*
Area Measurements*	Area V (L)	Area V (S)	Area Measurements*	Area V (L)	Area V (S)
H&BL	109.2 ± 4.93 98 – 120 (46)	109.6 ± 18.21 81 – 138 (99)	NL	7.44 ± 0.336 6.8 – 8.2 (41)	6.81 ± 0.262 6.1 – 7.5 (88)
TL	51.6 ± 5.28 35 – 61 (46)	31.7 ± 2.75 21 – 39 (100)	ML	6.06 ± 0.227 5.6 – 6.6 (46)	5.58 ± 0.219 4.8 – 6.3 (101)
HFL	20.02 ± 0.58 19.0 – 21.0 (46)	15.66 ± 0.86 13.0 – 18.0 (59)	MW	5.19 ± 0.189 4.7 – 5.6 (46)	4.62 ± 0.314 3.9 – 5.3 (98)
CBL	25.36 ± 0.651 23.7 – 26.4 (43)	22.79 ± 0.672 21.2 – 23.9 (69)	Mlw	1.08 ± 0.064 0.9 – 1.2 (46)	1.03 ± 0.055 0.9 – 1.2 (101)
C-Z	19.87 ± 0.555 18.5 – 21.1 (43)	18.19 ± 0.493 16.9 – 19.1 (68)	IOW	4.42 ± 0.181 4.1 – 4.8 (46)	4.45 ± 0.150 4.1 – 4.8 (99)
C-M1	16.03 ± 0.375 15.1 – 16.7 (43)	14.65 ± 0.432 13.6 – 15.6 (68)	ZW	15.11 ± 0.463 13.7 – 16.0 (45)	13.79 ± 0.436 12.6 – 14.7 (94)
I-M3	15.69 ± 0.421 14.4 – 16.6 (46)	13.98 ± 0.443 12.8 – 15.0 (101)	C-Bull	7.60 ± 0.301 7.0 – 8.2 (38)	7.14 ± 0.245 6.5 – 7.6 (60)
Dias	7.81 ± 0.296 7.1 – 8.3 (46)	6.83 ± 0.274 6.2 – 7.3 (100)	BL	6.62 ± 0.313 5.9 – 7.2 (38)	6.04 ± 0.285 5.3 – 6.5 (65)
IFL	5.04 ± 0.248 4.5 – 5.6 (46)	4.04 ± 0.243 3.4 – 4.6 (100)	BW	5.54 ± 0.255 4.9 – 6.1 (40)	5.00 ± 0.187 4.5 – 5.5 (65)

* Measurements except for H&BL and IOW differ statistically between *mucronatus* and *melanogaster*.

Table 3. Frequencies of dental patterns on the third upper molars in Area V of Groups L and S.

Group L (*Eothenomys mucronatus*)

Locality	#74	#85	#71	#70	#79	#72	#87	Total	%
Month	Feb.	Mar.	Jan.	Jan. Jun.	Feb.	Jan.	Mar.		
Type A	0	0	0	0	0	0	0	0	0.0
Type B	0	0	0	1	0	0	0	1	2.2
Type C	2	2	0	19	5	2	0	30	65.2
Type D	1	3	1	3	4	1	2	15	32.6
Total	3	5	1	23	9	3	2	46	100

Group S (*Eothenomys melanogaster*)

Locality	#87	#80	#75	#88	#83	#86	#82	#73	#84	#76	#81	#77	#78	Total	%
Month	Mar.	Feb.	Feb.	May	Mar. Apr.	Mar.	Mar.	Jan. Feb.	Mar.	Feb.	Apr.	Feb.	Mar.		
Type A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Type B	0	4	1	1	0	8	0	28	0	3	0	1	0	46	43.8
Type C	2	1	0	12	2	10	3	20	2	1	1	3	2	59	56.2
Type D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Total	2	5	1	13	2	18	3	48	2	4	1	4	2	105	100

this cluster was composed of specimens from Localities #73, 75 to 78, 80 to 84, and 86 to 88. Two specimens from Locality #87 belonged to Group L and another two to Group S. When the localities were arranged from lower to higher elevation, it was clear that Group L was collected at altitudes above 2460 m, whereas Group S was collected at altitudes below 2460 m (Fig. 14; Area V).

The histograms demonstrate that TL and HFL did not change with elevation (Fig. 4). Voles in Group L had a TL ≥ 35 mm and an HFL ≥ 19 mm. By contrast, voles in Group S had a TL < 41 mm and an HFL < 19 mm. Histograms depicting I-M3 data arranged by elevation

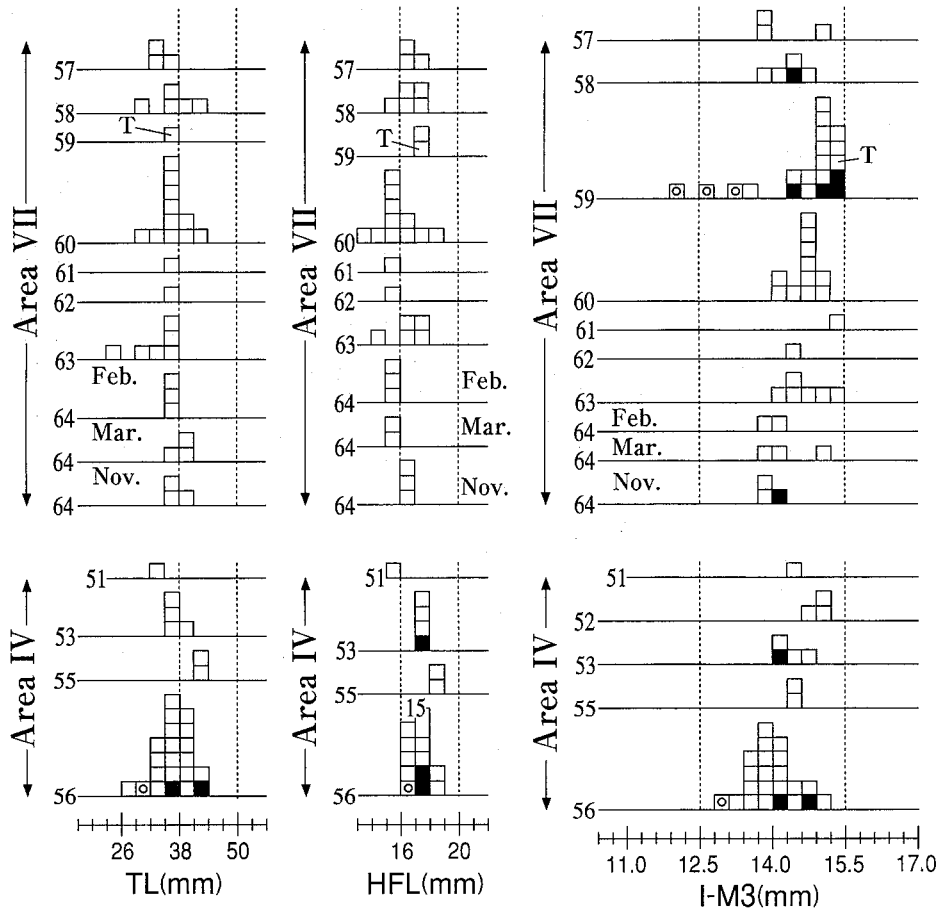

Fig. 5. Geographical variation of frequencies of TL, HFL and I-M3 in Areas IV and VII. The number indicates localities listed in Appendix 1. Locality numbers in a rectangle indicate places where Group L (later identified as *Eothenomys mucronatus*) was collected, and Group S (later identified as *E. melanogaster*) was collected from other localities. Further explanation is given in Fig. 4.

indicated that Group L consisted of I-M3 values ≥ 14.3 mm, whereas Group S consisted of values < 15.2 mm (Fig. 4).

The means, standard deviations, and ranges of three external and 15 cranial measurements were calculated for Groups L and S specimens except for young from Area V (Table 2). Group L was statistically different ($p < 0.001$) from Group S for all sizes (TL, $t = 29.948$, $df = 144$; HFL, $t = 29.531$, $df = 103$; CBL, $t = 19.920$, $df = 110$; C-Z, $t = 15.189$, $df = 109$; C-M1, $t = 17.234$, $df = 109$; I-M3, $t = 22.034$, $df = 145$; Dias, $t = 19.571$, $df = 144$; IFL, $t = 22.950$, $df = 144$; NL, $t = 11.594$, $df = 127$; ML, $t = 12.182$, $df = 145$; MW, $t = 11.371$, $df = 142$; M1w, $t = 4.850$, $df = 145$; ZW, $t = 16.369$, $df = 137$; C-Bull, $t = 8.280$, $df = 96$; BL, $t = 9.610$, $df = 101$; and BW, $t = 12.481$, $df = 103$) except H&BL ($t = 0.015$, $df = 143$, $p > 0.1$) and IOW ($t = 1.048$, $df = 143$, $p > 0.1$).

Table 3 shows the frequencies of the patterns of the third upper molar in Groups L and S with decreasing ele-

Table 4. Frequencies of the relationship between HFL and TL classes in Areas IV and VII, showing Group S (*Eothenomys melanogaster*).

Area IV	HFL (mm)										
TL (mm)	13-	14-	15-	16-	17-	18-	19-	20-	21-	22-	Total
25-					1						1
30-			1	4	1						6
35-					11	2					13
40-				1	5	2					8
Total			1	5	18	4					28

Area VII	HFL (mm)										
TL (mm)	13-	14-	15-	16-	17-	18-	19-	20-	21-	22-	Total
25-				1							1
30-	1		1	2	1	1					6
35-		1	11	8	5*						25
40-			1		1						2
Total	1	1	13	11	7	1					34

* the holotype of *Microtus* (*Eothenomys*) *melanogaster colurnus*.

Table 5. External and cranial measurements of *Eothenomys melanogaster* (Group S, S) in Areas I, II, IV and VII. In each measurement, mean ± standard deviation, range and number of specimens in parentheses are shown.

	Eothenomys melanogaster			
Area Measurements	Area I (S)	Area II (S)	Area IV (S)	Area VII (S)
H&BL	95.7 ± 10.082 71 – 115 (22)	97.9 ± 6.11 70 – 112 (173)	96.2 ± 7.25 80 – 110 (35)	96.2 ± 7.251 80 – 110 (35)
TL	43.6 ± 6.84 27 – 55 (22)	36.9 ± 4.59 30 – 46 (170)	37.0 ± 3.44 28 – 43 (27)	35.4 ± 3.11 25 – 42 (37)
HFL	17.48 ± 1.592 15.0 – 21.0 (22)	16.80 ± 0.922 14.0 – 19.0 (174)	17.05 ± 0.685 15.0 – 18.5 (28)	15.77 ± 1.095 13.0 – 18.0 (36)
CBL	23.78 ± 1.065 21.7 – 25.4 (13)	23.71 ± 0.757 22.0 – 25.8 (57)	23.07 ± 0.621 21.7 – 24.6 (24)	24.06 ± 0.942 21.8 – 25.5 (42)
C-Z	18.98 ± 0.876 17.6 – 20.4 (13)	18.66 ± 0.657 17.1 – 20.5 (59)	18.26 ± 1.075 13.9 – 20.0 (25)	19.00 ± 0.807 17.0 – 20.5 (42)
C-M1	15.55 ± 0.812 14.2 – 16.8 (13)	15.35 ± 0.507 14.2 – 16.6 (59)	14.96 ± 0.441 14.2 – 16.1 (25)	15.51 ± 0.661 14.0 – 16.9 (42)
I-M3	14.33 ± 0.517 13.1 – 15.1 (22)	14.40 ± 0.524 12.9 – 15.7 (181)	14.17 ± 0.487 13.2 – 15.1 (31)	14.58 ± 0.512 13.4 – 15.4 (52)
Dias	6.85 ± 0.297 6.1 – 7.4 (22)	7.00 ± 0.327 6.1 – 7.7 (181)	6.84 ± 0.249 6.3 – 7.3 (29)	7.10 ± 0.291 6.4 – 7.7 (53)
IFL	4.27 ± 0.297 3.8 – 4.9 (22)	4.26 ± 0.351 3.4 – 5.1 (181)	4.16 ± 0.219 3.8 – 4.6 (29)	4.39 ± 0.206 3.9 – 4.8 (53)

	Eothenomys melanogaster			
Area Measurements	Area I (S)	Area II (S)	Area IV (S)	Area VII (S)
NL	7.03 ± 0.392 6.2 – 7.8 (23)	6.86 ± 0.418 5.7 – 7.9 (165)	6.78 ± 0.357 6.3 – 7.6 (28)	7.26 ± 0.420 6.6 – 8.2 (50)
ML	5.69 ± 0.343 5.0 – 6.3 (25)	5.69 ± 0.234 5.2 – 6.3 (191)	5.58 ± 0.212 5.1 – 6.0 (32)	5.71 ± 0.259 5.1 – 6.4 (52)
MW	4.65 ± 0.309 3.8 – 5.2 (24)	4.88 ± 0.243 4.3 – 5.7 (187)	4.73 ± 0.211 4.3 – 5.2 (32)	4.88 ± 0.273 4.3 – 5.6 (53)
Mlw	1.02 ± 0.074 0.9 – 1.1 (23)	1.03 ± 0.068 0.9 – 1.2 (191)	1.01 ± 0.068 0.9 – 1.2 (31)	0.99 ± 0.070 0.9 – 1.1 (53)
IOW	4.51 ± 0.211 3.9 – 4.8 (20)	4.35 ± 0.189 3.9 – 4.9 (166)	4.44 ± 0.177 4.1 – 4.9 (30)	4.59 ± 0.222 3.9 – 5.1 (51)
ZW	14.37 ± 0.581 12.9 – 15.1 (21)	14.23 ± 0.482 13.1 – 15.5 (135)	13.84 ± 0.412 13.1 – 14.6 (31)	14.43 ± 0.669 13.1 – 15.8 (50)
C-Bull	8.15 ± 0.366 7.2 – 8.5 (12)	7.80 ± 0.310 7.0 – 8.5 (56)	7.35 ± 0.236 7.0 – 7.9 (27)	7.64 ± 0.433 6.7 – 8.3 (35)
BL	7.25 ± 0.396 6.4 – 7.9 (15)	6.83 ± 0.297 6.2 – 7.5 (60)	6.21 ± 0.213 5.8 – 6.7 (27)	6.39 ± 0.345 5.6 – 7.1 (38)
BW	5.56 ± 0.217 5.3 – 5.9 (14)	5.47 ± 0.293 4.9 – 6.6 (56)	6.21 ± 0.213 5.8 – 6.7 (27)	5.29 ± 0.032 4.9 – 5.7 (34)

vation. Group L had Types B, C, and D, with Type C dominant (65.2%), whereas Group S had 43.8% Type B and 56.2% Type C. The frequencies of these types differed statistically between Groups L and S (*Gadj* = 48.08, *df* = 3, $p < 0.005$). The molar pattern varied continuously from three to four salient angles through an intermediate form. I was able to reconfirm that one specimen had three on one side and four on the other side at Locality #73 (AMNH 114951), as was reported by Anthony (1941).

In the following results, the frequencies of the TL/HFL relationship are used to differentiate between the two size groups in each area.

Identifying Group S in Areas IV and VII and Group L in Areas III and VI

Table 4 shows the frequencies of the HFL/TL relationship for Areas IV (southern Yunnan) and VII (Zhejiang and Fujian provinces, and Taiwan). In both areas, there was only one cluster, in which TL was 25 to 44 mm and HFL was 13 or 15 to 18 mm, indicating that the cluster was Group S. There was no clinal trend in TL or HFL (Fig. 5). The values of I-M3 were less than 15.5 mm in both areas, also indicating that these specimens belonged to Group S (Fig. 5).

Table 5 shows the values for three external and 15 cranial measurements in Group S specimens except for young for Areas IV and VII. Table 7 shows the frequencies of the molar patterns in Areas IV and VII. There was no Type A in Area IV, whereas Type A was present in 17.0% of specimens from Area VII. Type B occurred in 30.3% of specimens from Area IV and was dominant in Area VII (81.1%). Type C was dominant in Area IV (69.7%), whereas it represented less than 2% of the samples from Area VII. Type D did not appear in Area IV or VII. The frequencies of these molar patterns differed statistically between Areas IV and VII (*Gadj* = 26.63, $df = 2$, $p < 0.005$).

Table 8 shows the data for the HFL/TL relationship for Areas III (Yunnan Province) and VI (northern Burma, India, Vietnam and Thailand). In both areas, there was only one cluster, in which TL was 30 to 60 mm and HFL was 14 to 22 mm, which demonstrate that these specimens are Group L. There was no clinal trend in TL or HFL in Areas III and VI (Figs. 6 and 7), although specimens from Locality #28 were larger in TL (53–64 mm) (Fig. 7). Except for young, I-M3 ranged from 14.0 to 17.5 mm in Area III and from 14.0 to 16.3 mm in Area VI, also indicating that these specimens belonged to Group L (Figs. 6 and 7).

The means, standard deviations, and ranges for three external and 15 cranial measurements for Group L are

Table 6. External and cranial measurements of *Eothenomys mucronatus* (Group L, L) in Areas II, III and VI. In each measurement, mean ± standard deviation, range and number of specimens in parentheses are shown.

	Eothenomys mucronatus				*Eothenomys mucronatus*		
Area Measurements	Area II (L)	Area III (L)	Area VI (L)	Area Measurements	Area II (L)	Area III (L)	Area VI (L)
H&BL	113.0 ± 13.63 95 – 140 (13)	112.3 ± 10.43 79 – 134 (52)	104.6 ± 7.053 92 – 122 (53)	NL	7.60 ± 0.446 6.8 – 8.4 (15)	7.74 ± 0.533 6.4 – 8.8 (51)	7.40 ± 0.499 6.1 – 8.3 (53)
TL	38.9 ± 4.87 31 – 48 (14)	43.5 ± 4.61 33 – 51 (50)	42.9 ± 5.36 32 – 59 (52)	ML	6.34 ± 0.203 5.9 – 6.6 (17)	6.37 ± 0.301 5.6 – 7.0 (54)	6.07 ± 0.258 5.5 – 6.7 (54)
HFL	17.77 ± 2.127 14.0 – 20.0 (13)	19.44 ± 1.471 15.0 – 22.0 (52)	17.35 ± 0.002 15.0 – 20.0 (53)	MW	5.19 ± 0.238 4.6 – 5.8 (15)	5.31 ± 0.306 4.8 – 5.9 (52)	5.08 ± 0.275 4.5 – 5.6 (54)
CBL	25.70 ± 0.699 24.0 – 26.5 (11)	26.30 ± 1.174 23.0 – 28.5 (40)	24.83 ± 0.893 22.3 – 26.3 (46)	Mlw	1.09 ± 0.075 1.0 – 1.2 (17)	1.10 ± 0.069 0.9 – 1.2 (54)	1.09 ± 0.010 1.0 – 1.2 (54)
C-Z	20.47 ± 0.659 19.0 – 21.2 (11)	20.91 ± 0.924 18.3 – 22.6 (39)	19.74 ± 0.635 18.1 – 20.9 (45)	IOW	4.42 ± 0.283 4.0 – 4.9 (15)	4.55 ± 0.194 4.2 – 5.0 (52)	4.44 ± 0.338 3.6 – 5.1 (54)
C-M1	16.63 ± 0.529 15.5 – 17.4 (11)	16.99 ± 0.735 15.1 – 18.4 (39)	15.91 ± 0.550 14.4 – 16.9 (46)	ZW	15.28 ± 0.128 14.2 – 15.8 (14)	15.37 ± 0.758 12.9 – 17.0 (51)	14.65 ± 0.564 13.3 – 15.7 (49)
I-M3	15.79 ± 0.442 14.5 – 16.3 (15)	16.09 ± 0.733 14.0 – 17.4 (54)	15.35 ± 0.547 14.0 – 16.2 (54)	C-Bull	8.18 ± 0.524 7.2 – 9.0 (12)	8.40 ± 0.505 7.4 – 9.7 (35)	7.52 ± 0.370 6.0 – 8.0 (43)
Dias	7.54 ± 0.238 6.9 – 7.9 (15)	7.85 ± 0.465 6.7 – 8.8 (53)	7.50 ± 0.302 6.7 – 8.0 (54)	BL	7.15 ± 0.488 6.1 – 7.9 (13)	7.17 ± 0.456 6.0 – 8.4 (39)	6.44 ± 0.277 5.8 – 6.9 (43)
IFL	4.75 ± 0.250 4.4 – 5.2 (15)	5.12 ± 0.371 4.0 – 5.7 (53)	4.71 ± 0.305 4.0 – 5.4 (54)	BW	5.79 ± 0.291 5.3 – 6.2 (14)	5.76 ± 0.239 5.0 – 6.4 (37)	5.27 ± 0.225 4.8 – 5.7 (44)

Table 7. Frequencies of dental patterns on the third upper molars in Areas IV and VII of Group S (*Eothenomys melanogaster*). A question mark (?) means the collecting date unknown.

Area IV

Locality	#51	#52	#53	#55	#56	#50	Total	%
Month	May	?	Apr.	Feb.	Feb.	?		
Type A	0	0	0	0	0	0	0	0.0
Type B	1	0	3	0	6	0	10	30.3
Type C	0	3	1	2	16	1	23	69.7
Type D	0	0	0	0	0	0	0	0.0
Total	1	3	4	2	22	1	33	100

Area VII

Locality	#57	#58	#59	#60	#61	#62	#63	#64	#64	#64	Total	%
Month	Dec. Feb. Mar.	May Jun.– Aug.	Mar. Apr. Oct.	Jan. Oct. Nov.	Jan.	Jan.	Oct.	Feb.	Mar.	Apr.		
Type A	1	1	4	2	0	0	1	0	0	0	9	17.0
Type B	2	4	13	9	1	1	5	2	3	3	43	81.1
Type C	0	0	1	0	0	0	0	0	0	0	1	1.9
Type D	0	0	0	0	0	0	0	0	0	0	0	0.0
Total	3	5	18	11	1	1	6	2	3	3	53	100

Table 8. Frequencies of the relationship between HFL and TL classes in Areas III and VI, showing Group L (*Eothenomys mucronatus*).

Area III	HFL (mm)										
TL (mm)	13-	14-	15-	16-	17-	18-	19-	20-	21-	22-	Total
25-						1					1
30-							3				3
35-					1	1	2	2			6
40-				1	1	3	6	7	6		24
45-				1		2*	6**	4	2		15
50-								3	2	1	6
Total				2	2	7	17	16	10	1	55

* the holotype of *Eothenomys fidelis*.
** the holotype of *Microtus* (*Eothenomys*) *melanogaster miletus*.

Area VI	HFL (mm)									
TL (mm)	13-	14-	15-	16-	17-	18-	19-	20-	21-	22-	Total
30-				1	2*						3
35-				1	10	1					12
40-				4	9	6					19
45-		1		2	5	5	4				17
50-			1	1		3					5
55-								1**			1
Total		1	1	9	26	15	4	1			57

* the holotype of *Eothenomys melanogaster libonotus*.
** the holotype of *Eothenomys melanogaster confinii*.

shown for specimens except for young from Areas III and VI (Table 6). Table 9 shows the frequencies of the molar patterns found in Areas III and VI. Type A was not present in Area III or VI. Type C was dominant in both areas (52.5%, Area III; 58.3%, Area VI).

Discriminating between Groups S and L in Areas I and II

The HFL/TL data did not yield two clusters in Area I (Hubei and Guizhou provinces) or II (Gansu and Sichuan provinces) (Table 10). TL ranged from 25 to 59 mm in Area I, and from 15 to 49 mm in Area II. HFL varied from 15 to 21 mm in Area I and from13 to 20 mm in Area II. Here, both TL and HFL showed a wider range than in other areas. This was because the values increased clinally from northeast to southwest (Figs. 8 and 9).

By contrast, histograms of I-M3 distinguished Groups L and S in Areas I and II in comparison with the other areas (Table 11; Figs. 8 and 9). In Area I, for which there were no young specimens, the histograms identified one group, because the size of adults and other specimens (13.1–14.9 mm) agreed well with values for Areas IV, V, and VII (Table 11). In Area II, by contrast, the histograms indicate that adults and other specimens formed two size groups (Table 12 and Fig. 9). Groups S and L consisted of the adults and other specimens with I-M3 ranged from 12.8 to 15.7 mm and from 14.3 to 16.3 mm, respectively. Group S occurred in Localities #7 to 13, 15 to 19, 22 to 23, 25, and 27, and Group L in Localities #14, 21, 24, and 26 (Fig. 9). In Group L, TL varied from 31 to 48 mm and HFL from 14 to 20 mm, whereas in Group S, TL varied from 30 to 46 mm and HFL from 14

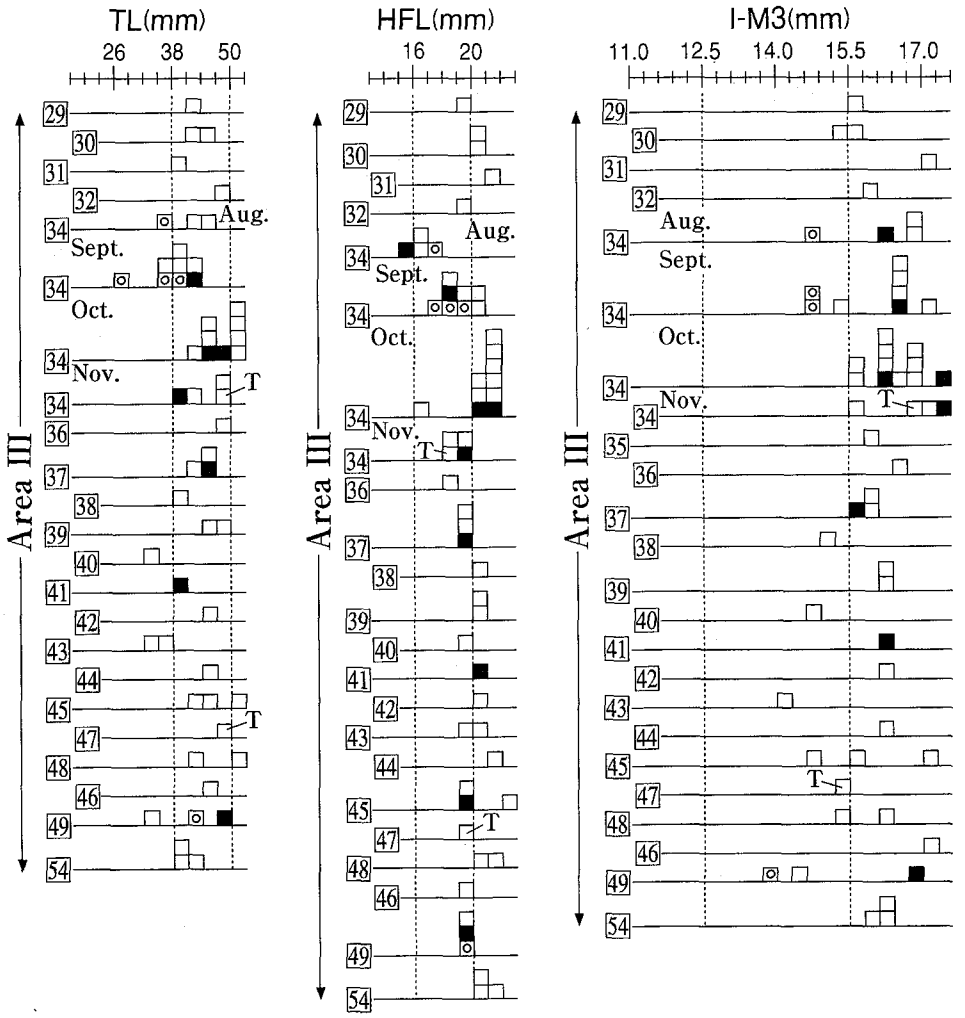

Fig. 6. Geographical variation of frequencies of TL, HFL and I-M3 in Areas III. The number indicates localities listed in Appendix 1. Locality numbers in a rectangle indicate places where Group L (later identified as *Eothenomys mucronatus)* was collected, and Group S (later identified as *E. melanogaster*) was collected from other localities. Further explanation is given in Fig. 4.

to 19 mm (Tables 5 and 6).

The means, standard deviations, and ranges of three external and 15 cranial measurements were calculated for adults and other specimens from Group S in Area I and Groups L and S in Area II (Tables 5 and 6). In Area II, Group L differed statistically from Group S in all characters ($p < 0.01$)(H&BL, $t = 7.658$, $df = 184$; HFL, $t = 3.234$, $df = 185$; CBL, $t = 8.073$, $df = 66$; C-Z, $t = 8.385$, $df = 68$; C-M1, $t = 7.638$, $df = 68$; I-M3, $t = 9.977$, $df = 194$; Dias, $t = 6.253$, $df = 194$; IFL, $t = 5.291$, $df = 194$; NL, $t = 6.529$, $df = 178$; ML, $t = 11.081$, $df = 206$; MW, $t = 4.761$, $df = 200$; M1w, $t = 3.458$, $df = 206$; ZW, $t = 8.099$, $df = 147$; C-Bull, $t = 3.367$, $df = 66$; BL, $t = 3.104$, $df = 71$; and BW, $t = 3.660$, $df = 68$) except TL ($t = 1.560$, $df = 182$, $p > 0.1$) and IOW ($t = 1.343$, $df = 179$, $p > 0.1$).

Table 13 shows the frequencies of the molar patterns seen in Areas I (Group S) and II (Groups L and S). In Group S, Type A did not occur in Area I but was present in Area II (9.7%). Type B occurred in 28.7% of specimens in Area I, and was dominant in Area II (84.7%). Type C was dominant in Area I (72.0%) but scarce in Area II (5.6%). Type D did not occur in Areas I or II. On the contrary, in Group L in Area II, Types A and D did not appear, Type B was dominant (63.2%), and Type C was next most frequent (36.8%).

Taxonomic conclusions

The number of salient angles on the third upper molar gave little diagnostic information for discriminating

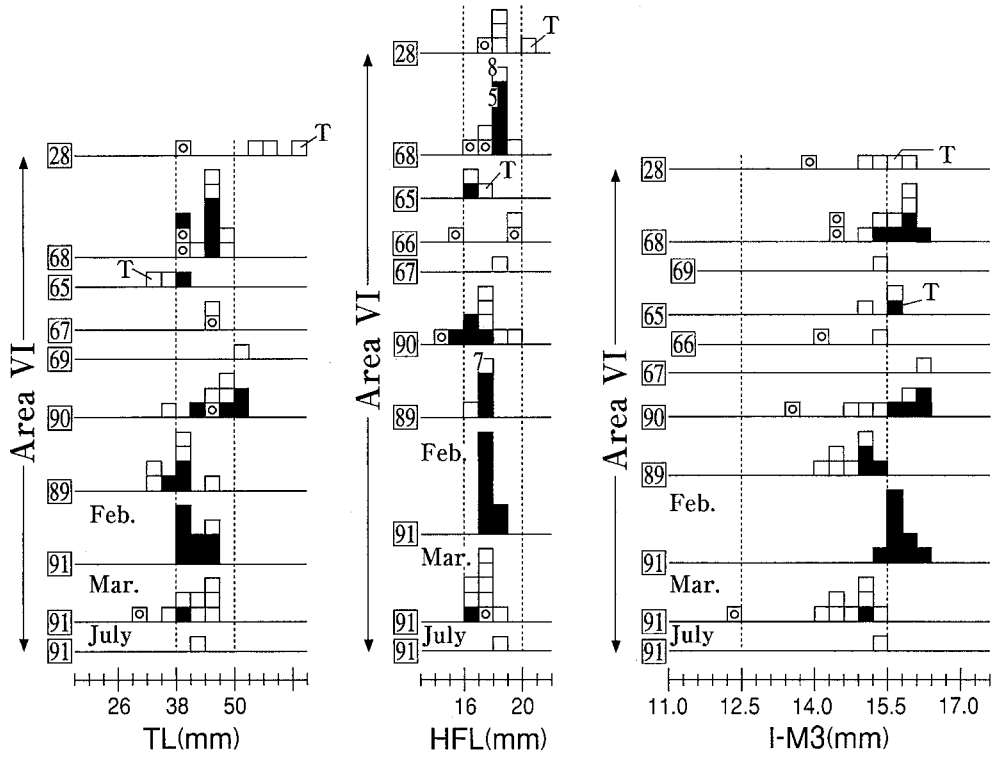

Fig. 7. Geographical variation of frequencies of TL, HFL and I-M3 in Areas VI. The number indicates localities listed in Appendix 1. Locality numbers in a rectangle indicate places where Group L (later identified as *Eothenomys mucronatus*) was collected, and Group S (later identified as *E. melanogaster*) was collected from other localities. Further explanation is given in Fig. 4.

between the two groups. The frequencies of the molar pattern of the two groups from northeast to southwest were as follows (Areas I to VII) (Tables 3, 7, 9, and 13). In Group S, Type A only occurred in 17.0% of molars in Area VII and in 9.7% of molars in Area II. Type B occurred in 81.1, 28.0, 84.7, 30.3, and 43.8% in Areas VII, I, II, IV, and V, respectively. Type C was found in 1.9, 72.0, 5.6, 69.7, and 56.2% in Areas VII, I, II, IV, and V, respectively. Type D did not appear. Therefore, there was no clinal tendency in Group S from northeast to southwest.

On the contrary, the frequencies in Group L were as follows. Type A was not found. Type B occurred in 63.2, 33.9, 41.7, and 2.2% in Areas II, III, VI, and V, respectively; Type C in 36.8, 52.5, 58.3, and 65.2 %, respectively; and Type D in 13.6% in Area III and 32.6% in Area V. There was a clinal tendency from northeast to southwest in Type C in Group L.

As mentioned above, there were statistical differences in the means of 14 cranial dimensions between Groups S and L where the two groups are recognized, although there was no difference for IOW in Areas II and V (Tables 2, 5, and 6). The differences in proportions of the means of the respective groups in each area are graphically illustrated using ratio diagrams (Simpson 1941; Musser 1970) (Fig. 10). The means of 15 cranial measurements for Group L in three areas (Areas II, III, and VI) were compared with those of Group L in Area V as the standard. Similarly, the means of the 15 measurements for Group S in five areas (Areas I , II, IV, V, and VII) were compared with those for Group L of Area V as the standard.

Of the nine parallel lines, the means of IOW are similar in absolute size as indicated by their close proximity in the diagram. The means of the length and width of the auditory bullae (C-Bull, BL, and BW) varied greatly and did not differentiate Groups S and L, indicating that these are inadequate diagnostic characters. The lines for I-M3, Dias, IFL, and ML differed greatly in scale between Group L in Area VI and Group S in Area VII, reflecting the differences in absolute size. The proportional likeness of the lines for CBL, C-Z, C-M1, I-M3, Dias, IFL, NL, ML, MW, M1w, and ZW seen in Groups L and S distinguished the groups, indicating that they represent two distinct species. The differences in the sizes and proportions of the two groups were reflected principally

in the molar and frontal regions of the skull.

Within Group L, except for IOW, C-Bull, BL, and BW, the line for Area III is the largest, and that for Area VI is the smallest, indicating differences in absolute size. On the contrary, within Group S, the line for Area VII is the largest, and that for Area V is the smallest. Except for IOW, the parallel lines of Groups L and S indicate marked differences in absolute size in Areas II and V, respectively, where Groups L and S both occur.

The upper molar patterns of the 11 holotypes exam-

Table 9. Frequencies of dental patterns of the third upper molar on the left side in Areas III and VI of Group L (*Eothenomys mucronatus*). A question mark (?) means the collecting date unknown.

Area III

Locality	#29	#30	#31	#32	#34	#34	#34	#34	#35	#36	#41	#42	#37
Month	Dec.	Nov.	Nov.	Nov.	Aug.	Sept.	Oct.	Nov.	Mar.	Feb.	May	Dec.	Dec.
Type A	0	0	0	0	0	0	0	0	0	0	0	0	0
Type B	0	2	1	0	1	4	3	1	1	0	0	0	2
Type C	1	0	0	1	3	4	6	3	0	1	0	0	1
Type D	0	0	0	0	0	0	2	0	0	0	1	1	0
Total	1	2	1	1	4	8	11	4	1	1	1	1	3

Area III (continued)

Locality	#38	#40	#39	#43	#44	#45	#47	#48	#46	#49	#54	Total	%
Month	Dec.	Dec.	Dec.	Dec.	Dec.	Dec.	Feb.	Jan.	Jan.	Feb.	Aug.		
Type A	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Type B	0	1	1	0	0	0	0	1	0	1	1	20	33.9
Type C	1	0	1	2	1	1	1	1	0	1	2	31	52.5
Type D	0	0	0	0	0	2	0	0	1	1	0	8	13.6
Total	1	1	2	2	1	3	1	2	1	3	3	59	100

Area VI

Locality	#28	#68	#69	#65	#66	#67	#90	#89	#91	#91	#91	Total	%
Month	Jul. Dec.	May Jun.	?	Jun.	Aug. Sept.	Dec.	Nov. Dec.	Mar.– Jun.	Feb.	Mar.	Jul.		
Type A	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Type B	1	1	0	3	1	1	2	8	2	5	1	25	41.7
Type C	4	11	1	0	1	0	7	0	7	4	0	35	58.3
Type D	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Total	5	12	1	3	2	1	9	8	9	9	1	60	100

Table 10. Frequencies of the relationship between HFL and TL classes in Areas I and II, not classifying the two clusters of Group S or L.

Area I	HFL (mm)										
TL (mm)	13-	14-	15-	16-	17-	18-	19-	20-	21-	22-	Total
25-			1								1
30-							1				1
35-								2			2
40-			1	2		1*	1				5
45-				3	5	1			1		10
50-					1	1					2
55-					1**						1
Total			2	5	7	3	2	2	1		22

* the holotype of *Microtus* (*Eothenomys*) *aurora*.

** the holotype of *Microtus* (*Eothenomys*) *melanogaster eleusis*.

Area II	HFL (mm)										
TL (mm)	13-	14-	15-	16-	17-	18-	19-	20-	21-	22-	Total
15-	1										1
20-		1									1
25-				3							3
30-		2	3	47	12	2	1				67
35-		2	1	12	29	9	2*	1			56
40-			4	3	28	32	2	1			70
45-					1	3	2				6
Total	1	5	8	65	70	46	7	2			204

* the holotype of *Microtus* (*Eothenomys*) *mucronatus*.

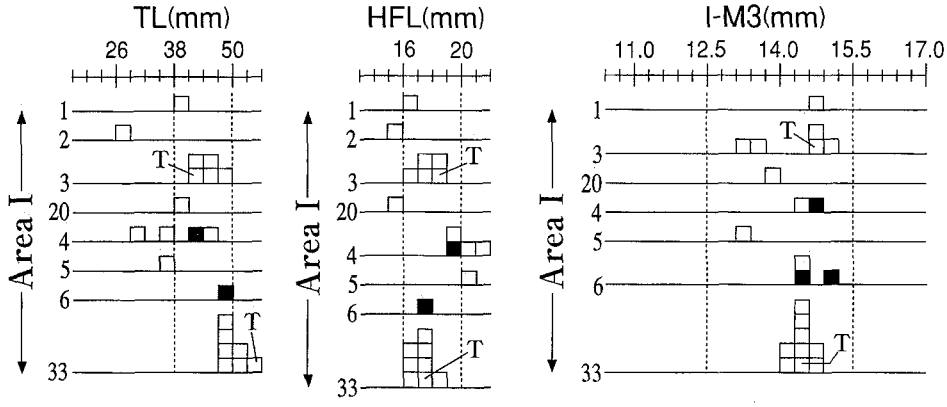

Fig. 8. Geographical variation of frequencies of TL, HFL and I-M3 in Areas I. The number indicates localities listed in Appendix 1. Locality numbers in a rectangle indicate places where Group L (later identified as *Eothenomys mucronatus*) was collected, and Group S (later identified as *E. melanogaster*) was collected from other localities. Further explanation is given in Fig. 4.

ined are shown in Fig. 11, which includes figures for the holotype of *Microtus* (*Eothenomys*) *bonzo* and two syntypes of *E. kanoi* redrawn from Cabrera (1922) and Tokuda and Kano (1937), respectively. These patterns are classified into Types A through C. The pattern of one specimen collected from Locality #79 in Area V is shown as an example of Type D (Fig. 11).

The following four holotypes are included in Group S: *Arvicola melanogaster* Milne-Edwards, 1872, collected from Locality #17 in Area II (Tables 11 and 12); *Microtus* (*Eothenomys*) *melanogaster colurnus* Thomas, 1911, from Locality #59 in Area VII (Tables 4 and 11); *Microtus* (*Eothenomys*) *melanogaster eleusis* Thomas, 1911, from Locality #33 in Area I (Tables 10 and 11); and *Microtus* (*Eothenomys*) *aurora* Allen, 1912, from Locality #3 in Area I (Tables 10 and 11).

I was unable to access two holotypes, which were predicted to be Group S specimens: *Microtus* (*Eothenomys*) *bonzo* Cabrera, 1922, and *E. eleusis yingjiangensis* Wang and Li, 2000. The holotype of *Microtus* (*Eothenomys*) *bonzo* Cabrera, 1922, was collected in Fu-Cho, Fujian Province located in Area VII. The measurements of TL (30 mm) and HFL (15.5 mm) for the holotype are identified as Group S, based on the relationship between HFL and TL in Area VII (Table 4). The I-M3 of the holotype was estimated as 11.3 mm by summing Dias (6 mm) and ML (5.3 mm) values (Cabrera 1922). The size lies within the range of I-M3 values for Group S in Area VII (Table 11). The holotype has three inner and four outer salient angles on the third upper molar (Fig. 11; Cabrera 1922); this type, Type B, is predominant in Area VII (Table 7).

The collecting locality of the holotype of *E. eleusis yingjiangensis* Wang and Li, 2000 (KIZ 76286), in Yingjiang Xiang (altitude 800 m), Yunnan, China, was determined to be 24.6°N and 97.9°E (Zhuang 1983), in Area IV. The measurements of TL (34 mm) and HFL (15 mm) for the holotype are identified as Group S, based on the relationship between HFL and TL in Area IV (Table 4). The CBL of the holotype was estimated as 24.1 mm (by adding 1 mm to the basal length of 23.1 mm), because the authors did not list the measurements of CBL, I-M3, or Dias. One millimeter is approximately the distance between the posterior margin of the occipital condyle and the mid-point of the lower margin of the foramen magnum. This length (24.1 mm) lies within the range of CBL of Group S in Area IV (Table 5). Wang and Li (2000) identified the holotype as the subspecies of *E. eleusis*, since it had four inner salient angles on the third upper molar; this type, Type C, is predominant in Area IV (Table 7).

By contrast, the holotype of *E. kanoi* Tokuda and Kano, 1937, was not designated. The collecting locality for 37 syntypes of *E. kanoi* Tokuda and Kano, 1937, is near His-Ko-Yueh, Taiwan, determined as 24.3°N and 121.3°E (Jones 1975), in Area VII. The measurements of TL (38 mm) and HFL (15 mm) for one syntype identified it as Group S in Area VII (Table 4). The value of I-M3 for one syntype was approximated as 12.1 mm by summing Dias (6.7 mm) and ML (5.4 mm) (Tokuda and Kano 1937). This length lies within the range of I-M3 for Group S in Area VII (Table 11). The two syntypes illustrated by Tokuda and Kano (1937) (Fig. 11) show Type B on the upper molar patterns, which is dominant

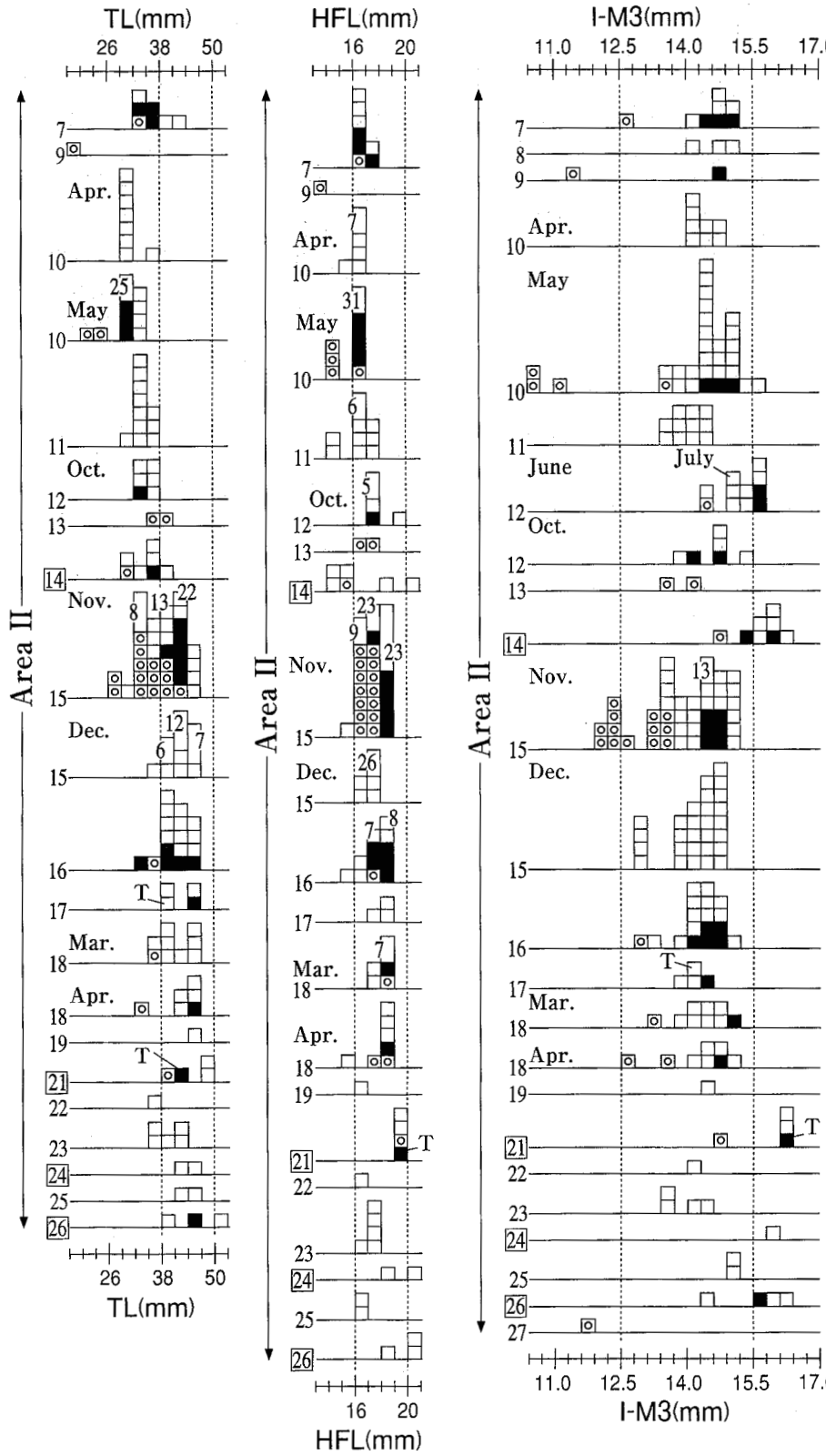

Fig. 9. Geographical variation of frequencies of TL, HFL and I-M3 in Areas II. The number indicates localities listed in Appendix 1. Locality numbers in a rectangle indicate places where Group L (later identified as *Eothenomys mucronatus*) was collected, and Group S (later identified as *E. melanogaster*) was collected from other localities. Further explanation is given in Fig. 4.

Table 11. Frequencies of I-M3 classes in Areas I-VII. S or L indicates Groups S or L, respectively. Y: young, A: adults, O: other specimens, T: total number of specimens. The holotype examined in each Area is shown with locality number and I-M3 size class in parentheses.

I-M3 (mm)	Area V (S)			Area V (L)			Area IV (S)				Area VII (S)				Area III (L)				Area VI (L)				Area I (S)			Area II			
	Y	O	T	A	O	T	Y	A	O	T	Y	A	O	T	Y	A	O	T	Y	A	O	T	A	O	T	Y	A	O	T
10.4-																										2	0	0	2
10.7-																										0	0	0	0
11.0-																										1	0	0	1
11.3-																										1	0	0	1
11.6-	1	0	1																							2	0	0	2
11.9-	0	0	0								1	0	0	1												2	0	0	2
12.2-	0	0	0								0	0	0	0					1	0	0	1				4	0	0	4
12.5-	1	0	1								1	0	0	1					0	0	0	0				3	0	0	3
12.8-	0	1	1				1	0	0	1	0	0	0	0					0	0	0	0				1	0	4	5
13.1-	1	3	4				0	0	1	1	1	0	0	1					0	0	0	0	0	2	2	4	0	1	5
13.4-	1	13	14				0	0	4	4	0	0	1	1					1	0	0	1	0	1	1	6	0	9	15
13.7-	0	16	16				0	0	6	6	0	0	7	7	1	0	0	1	1	0	0	1	0	1	1	0	0	18	18
14.0-	0	20	20				0	2	5	7	0	1	6	7	0	0	1	1	1	0	2	3	0	2	2	1	2	31	34
14.3-	0	23	23	0	1	1	0	0	6	6	0	2	6	8	0	0	1	1	2	0	4	6	1	7	8	1	8	42	51
14.6-	0	22	22	0	1	1	0	1	3	4	0	0	10	10	3	0	2	5	0	0	3	3	1	5	6	2	10	26	38
14.9-	0	3	3	0	1	1	0	0	3	3	0	1	11	12	0	0	1	1	0	3	7	10	1	1	2	0	3	20	23
15.2-				0	6	6					0	2	5	7	0	0	4	4	0	3	7	10				0	1	4	5
15.5-				0	19	19									0	1	6	7	0	8	3	11				0	3	5	8
15.8-				1	8	9									0	0	5	5	0	5	4	9				0	1	4	5
16.1-				1	6	7									0	3	10	13	0	4	1	5				0	1	4	5
16.4-				0	2	2									0	1	5	6											
16.7-															0	1	6	7											
17.0-															0	0	5	5											
17.3-															0	2	0	2											
Total	4	101	105	2	44	46	1	3	28	32	3	6	46	55	4	8	46	58	6	23	31	60	3	19	22	30	29	168	227
Names of the types examined (locality no., I-M3 class)	—			*cachinus* (#70, 16.1-)			—				*colurnus* (#59, 15.2-)				*miletus* (#47, 15.2-) *fidelis* (#34, 16.7-)				*confinii* (#28, 15.5-) *libonotus* (#65, 15.5-)				*aurora* (#3, 14.6-) *eleusis* (#33, 14.3-)			*melanogaster* (#17, 14.0-) *mucronatus* (#21, 16.1-)			
Names of the types unexamined	—			—			*yingjiangensis*				*bonzo kanoi*				—				—				—			*chenduensis*			

Table 12. Frequencies of I-M3 classes in Area II. Groups S (S) or L (L) are discriminated by histograms of I-M3 as shown in Fig. 9. Y: young, A: adults, O: other specimens, T: total number of specimens.

I-M3 (mm)	Area II (S)				Area II (L)			
	Y	A	O	T	Y	A	O	T
10.4-	2	0	0	2				
10.7-	0	0	0	0				
11.0-	1	0	0	1				
11.3-	1	0	0	1				
11.6-	2	0	0	2				
11.9-	2	0	0	2				
12.2-	4	0	0	4				
12.5-	3	0	0	3				
12.8-	1	0	4	5				
13.1-	4	0	1	5				
13.4-	6	0	9	15				
13.7-	0	0	18	18				
14.0-	1	2	31*	34				
14.3-	1	8	41	50	0	0	1	1
14.6-	0	10	26	36	2	0	0	2
14.9-	0	3	20	23	0	0	0	0
15.2-	0	0	4	4	0	1	0	1
15.5-	0	2	3	5	0	1	2	3
15.8-					0	1	4	5
16.1-					0	1**	4	5
Total	28	25	157	210	2	4	11	17

* the holotype of *Arvicola melanogaster* (Locality #17).
** the holotype of *Microtus* (*Eothenomys*) *mucronatus* (Locality #21).

in Area VII (Table 7).

Consequently, Group S belongs to the species *Arvicola melanogaster* Milne-Edwards, 1872, which is the senior scientific name. Junior synonyms of *A. melanogaster* Milne-Edwards, 1872, are *Microtus* (*E.*) *m. colurnus* Thomas, 1911; *Microtus* (*E.*) *m. eleusis* Thomas, 1911; *Microtus* (*E.*) *aurora* Allen, 1912; *Microtus* (*E.*) *bonzo* Cabrera, 1922; *E. kanoi* Tokuda and Kano, 1937; and *E. eleusis yingjiangensis* Wang and Li, 2000. Hereafter, Group S is called *Eothenomys melanogaster* (Milne-Edwards, 1872).

By contrast, the following six holotypes were included in Group L: *Microtus* (*Eothenomys*) *mucronatus* Allen, 1912, collected from Locality #21 in Area II (Tables 10 to 12); *Microtus* (*E.*) *melanogaster miletus* Thomas, 1914, from Locality #47 in Area III (Tables 8 and 11); *Microtus* (*E.*) *cachinus* Thomas, 1921, from Locality #70 in Area V (Tables 1 and 11); *E. fidelis* Hinton, 1923, from Locality #34 in Area III (Tables 8 and 11); *E. m. confinii* Hinton, 1923, from Locality #28 in Area VI (Tables 8 and 11); and *E. m. libonotus* Hinton, 1923, from Locality #65 in Area VI (Tables 8 and 11).

I was unable to access the holotype of *E. melanogaster chenduensis* Wang and Li, 2000 (KIZ 63242), which was predicted to be part of Group L. The collecting locality for the holotype was Chengdu Shi, Sichuan, China, located at 30.6°N and 104.1°E (Zhuang 1983), 1982 feet (594.6 m) above sea level (Dolan 1938), in Area II. Measurements of TL (35 mm) and HFL (17 mm) for the holotype fit those for Area II (Table 10), but do not clearly identify the holotype as Group S or L because of the variation in TL and HFL in Area II, mentioned above. Wang and Li (2000) did not measure the I-M3 of the holotype. The ML (6.6 mm) measured for the holotype is in the range of that for Group L in Area II (Table 6). The CBL for the holotype was estimated as 27.1 mm (by adding 1 mm to the basal length of 26.1 mm; 1 mm was added for reasons mentioned above for *E. eleusis yingjiangensis*). The CBL for the holotype exceeds the range of CBL for Group L in Area II, but is within the range of CBL for Group L in Area III (Table 6). The holotype has three inner and outer salient angles (Wang and Li 2000), which place it in Group L for Area II, as shown in Type B (Table 13).

Consequently, Group L belongs to the species *Microtus* (*Eothenomys*) *mucronatus* Allen, 1912, which is the senior scientific name. Junior synonyms of *Microtus* (*E.*) *mucronatus* Allen, 1912, are *Microtus* (*E.*) *melanogaster miletus* Thomas, 1914; *Microtus* (*E.*) *cachinus* Thomas, 1921; *E. fidelis* Hinton, 1923; *E. m. confinii* Hinton, 1923; *E. m. libonotus* Hinton, 1923; and *E. m. chenduensis* Wang and Li, 2000. Hereafter, Group L is called *Eothenomys mucronatus* (Allen 1912).

Distribution of Eothenomys melanogaster *and* E. mucronatus

Both species are broadly distributed (Figs. 12 and 13). *Eothenomys melanogaster* occurs in the Chinese provinces of Zhejiang, Fujian, Hubei, Guizhou, Gansu, Sichuan, and southern Yunnan, and in northern Burma and Taiwan (Areas I, II, IV, V, and VII). By contrast, *E. mucronatus* is distributed in the Chinese provinces of Sichuan and Yunnan, and in the northeastern parts of India, northern Burma, Thailand, and Vietnam (Areas II, III, V, and VI). Both species are distributed in Sichuan Province, China, and northern Burma (Areas II and V). Summarizing their geographic distribution, *E. melanogaster* occurs in eastern and northern districts, whereas *E. mucronatus* is distributed in western and southern districts.

The distributions of *E. melanogaster* and *E. mucronatus* are separated at an elevation of 2460 m in Area V; the former species lives at lower elevations than the latter

Table 13. Frequencies of dental patterns on the third upper molars in Areas I and II of Groups S and L.

Group S (*Eothenomys melanogaster*)
Area I

Locality	#1	#2	#3	#3	#20	#4	#5	#6	#33	Total	%
Month	Apr.	Apr.	Feb.	Oct.–Nov.	Sept.	May	May	Aug. Sept.	Mar.		
Type A	0	0	0	0	0	0	0	0	0	0	0.0
Type B	0	0	0	0	1	1	1	0	4	7	28.0
Type C	1	1	1	4	0	3	0	3	5	18	72.0
Type D	0	0	0	0	0	0	0	0	0	0	0.0
Total	1	1	1	4	1	4	1	3	9	25	100

Area II

Locality	#7	#8	#9	#10	#10	#11	#12	#12	#13	#15	#15
Month	May	Aug.	Oct.	Apr.	May	Oct.–Dec.	Jun.	Oct.	Mar.	Nov.	Dec.
Type A	0	0	0	3	6	1	0	0	0	6	2
Type B	7	2	1	5	25	10	9	6	2	49	26
Type C	0	1	0	0	2	0	3	0	0	1	0
Type D	0	0	0	0	0	0	0	0	0	0	0
Total	7	3	1	8	33	11	12	6	2	56	28

Area II (continued)

Locality	#16	#17	#18	#18	#19	#22	#23	#25	#27	Total	%
Month	Jan.–Feb.	Jul. Aug.	Mar.	Apr.	Jul.	Aug.	Sept.–Nov.	Apr.	Apr.		
Type A	1	1	1	0	0	0	0	0	0	21	9.7
Type B	16	3	8	6	1	1	5	0	1	183	84.7
Type C	1	0	0	2	0	0	0	2	0	12	5.6
Type D	0	0	0	0	0	0	0	0	0	0	0.0
Total	18	4	9	8	1	1	5	2	1	216	100

Group L (*Eothenomys mucronatus*)
Area II

Locality	#14	#21	#24	#26	Total	%
Month	Nov.	Aug. Sept.	Apr.	Mar. Apr.		
Type A	0	0	0	0	0	0
Type B	8	4	0	0	12	63.2
Type C	1	0	2	4	7	36.8
Type D	0	0	0	0	0	0
Total	9	4	2	4	19	100

(Fig. 14). Both species occur at 2460 m.

The elevation at which *E. melanogaster* occurs decreases from southwest to northeast (Fig. 14): 1800 to 3000 m in southern Yunnan Province (Area IV, 23–25°N, 98–99°E), 1600 to 2500 m in northern Burma (Area V, 25–26°N, 98–99°E), 1200 to 2400 m in Sichuan Province (Area II, 26–32°N, 101–104°E), 1200 to 1800 m in the provinces of Sichuan, Hubei, and Guizhou (Area I, 27–32°N, 104–112°E), and 700 to 1800 m in the provinces of Zhejiang and Fujian, and in Taiwan (Area VII, 23–28°N, 117–122°E).

By contrast, the altitudinal distribution of *E. mucronatus* did not show a clear trend from southwest to northeast as was found in *E. melanogaster*. *Eothenomys mucronatus* (Fig. 14) is found from 1300 to 3600 m in northeastern India, northern Burma, Thailand, and Vietnam (Area VI, 18–29°N, 98–104°E), 2500 to 3000 m in northern Burma (Area V, 25–26°N, 98–99°E), 1500 to 4200 m in Yunnan Province (Area III, 24–28°N, 99–103°E), and 900 to 3900 m in Sichuan Province (Area II, 26–32°N, 101–104°E). In Area II, *E. mucronatus* was collected at 900 m in Kuan shien (Locality #14), which is

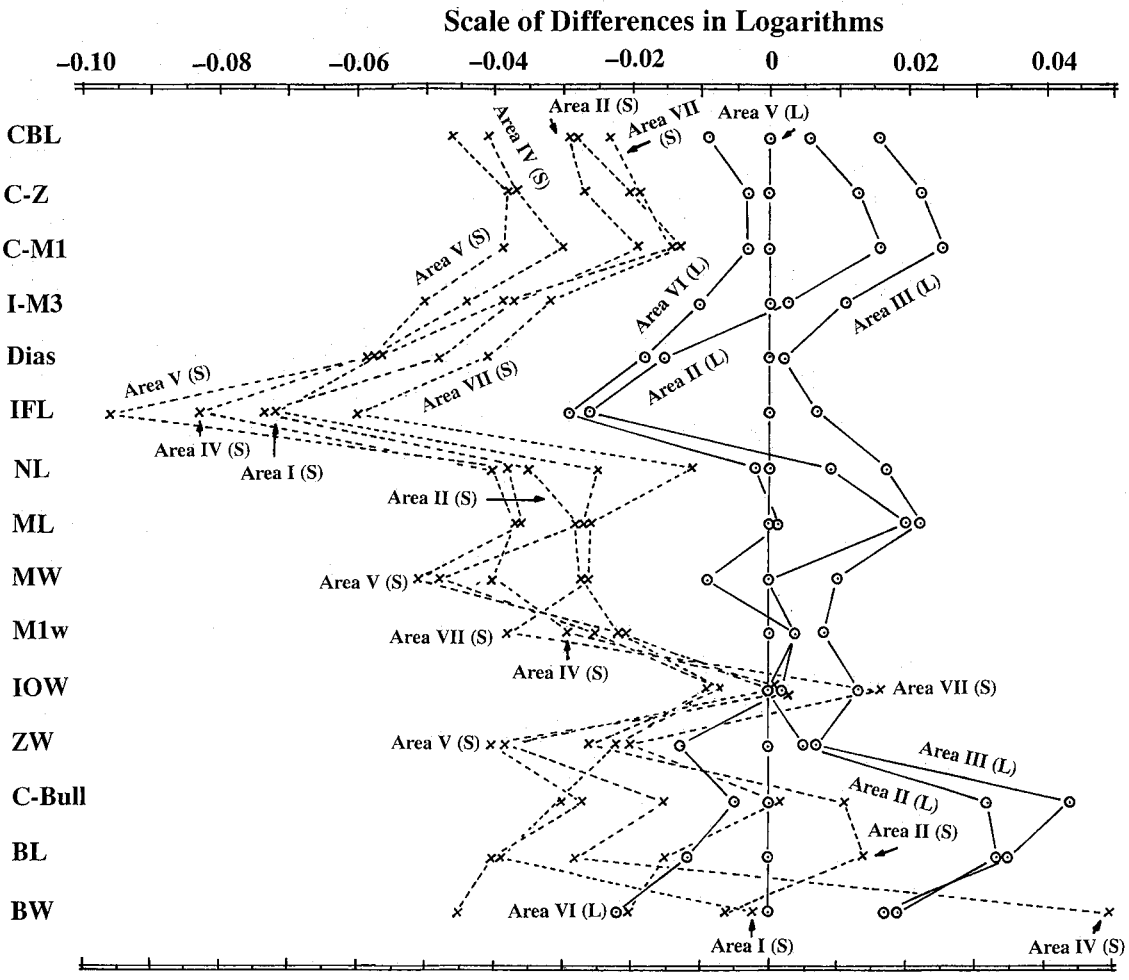

Fig. 10. Ratio diagram of 15 cranial dimensions, comparing among the samples of Areas II, III and VI (Group L; L) and those of Areas I, II, IV, V and VII (Group S; S). Group L of Area V is the standard. See text, Simpson (1941) and Musser (1970) for explanations of the ratio daigram. Lines of CBL, C-Z, C-MI, I-M3, Dias, IFL, ML, MW, and M1w show the resemblance between Groups L and S.

markedly lower in elevation than the collection sites in the other areas. An altitude of Kuan shien (900 m, 3000 feet) recorded on the specimen label was confirmed in Dolan's (1938) map, which indicates the elevation of "Kwanshien" as 2697 feet (809 m). The type locality of *E. melanogaster chenduensis* Wang and Li, 2000, was 594.6 m in Chengdu, Sichuan, which is near Kuan shien. Therefore, in Sichuan, *E. mucronatus* occurs at much lower elevations and with a much more fragmented geographic distribution than in other areas.

Discussion

Distribution of Eothenomys melanogaster and E. mucronatus

The altitudinal distribution of *E. melanogaster* decreased from southwest to northeast, suggesting that the distribution depends on climatic factors. In northern Burma (Area V), *E. melanogaster* occurs at lower altitudes (less than 2460 m) and *E. mucronatus* at higher ones (more than 2460 m) compared with the distribution in northeastern India and Vietnam (Area VI). This difference suggests that *E. mucronatus* is forced to live at higher elevations in northern Burma where *E. melanogaster* occurs, which in turn suggests a competitive relationship.

The results of the geographic and elevational distribution allow postulation about the history of the distributions as follows. First, both species originated at the border between southern Yunnan, China and northern Burma, near the Hengduan Shan Mountains. Subsequently, *E. mucronatus* spread south into northern

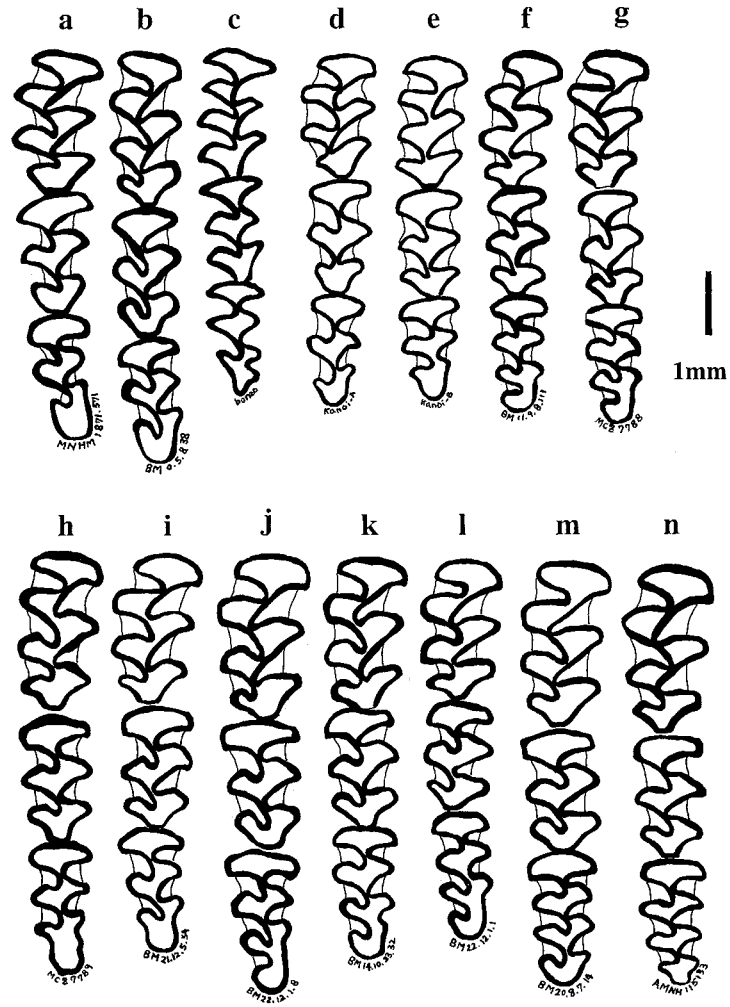

Fig. 11. Upper molar patterns of holotypes (a–c and f–m), syntypes (d and e) and one specimen (n) in *Eothenomys melanogaster* (Group S: a–g) and *E. mucronatus* (Group L: h–n) identified in the present study. Patterns of the third upper molar are classified into Types A–D (Fig. 3). a, the holotype of *Arvicola melanogaster* (MNHM 1871. 571, Type A); b, the holotype of *Microtus* (*Eothenomys*) *melanogaster colurnus* (BM 0.5.8.38, Type A); c, the holotype of *M.* (*E.*) *bonzo* (redrawn from Cabrera 1922, Type B); d, one syntype of *E. kanoi* (redrawn from Tokuda and Kano 1937, Type B); e, one syntype of *E. kanoi* (redrawn from Tokuda and Kano 1937, Type B); f, the holotype of *M.* (*E.*) *melanogaster eleusis* (BM 11.9.8.111, Type C); g, the holotype of *M.* (*E.*) *aurora* (MCZ 7788, Type C); h, the holotype of *M.* (*E.*) *mucronatus* (MCZ 7789, Type B); i, the holotype of *E. melanogaster libonotus* (BM 21.12.5.54, Type B); j, the holotype of *E. fidelis* (BM 22.12.1.8, Type C); k, the holotype of *M.* (*E.*) *melanogaster miletus* (BM 14.10.23.32, Type C); l, the holotype of *E. melanogaster confinii* (BM 22.12.1.1, Type C); m, the holotype of *M.* (*E.*) *cachinus* (BM.20.8.7.14); n, the specimen of AMNH 115133 (Type D).

Burma, Thailand, Vietnam, and northeastern India; it was followed into southern Yunnan and Burma by *E. melanogaster*, which forced *E. mucronatus* to higher altitudes. Concurrently, after *E. mucronatus* spread from Yunnan to Sichuan, *E. melanogaster* extended its range into northern and eastern China, where *E. mucronatus* now has a fragmented distribution and occurs at lower altitudes, like a relic, in Sichuan (Area II). *Eothenomys mucronatus* excluded *E. melanogaster* from northern Yunnan, where the species are now allopatric.

In the Early and Later Pleistocene, mainland China and Taiwan were connected via the Taiwan Strait (The Committee of Natural Geography of China 1984). *Eothenomys melanogaster* probably occupied Taiwan at that time. Early Pleistocene fossils of *E. melanogaster* have been discovered in Yunnan and the Guizhou Plateau (Zheng 1993). However, because these fossils were identified by molar patterns, the identification of these specimens needs to be reexamined using molar measurements in different populations to establish the population size and distribution of these species at that time.

Carleton and Musser (1984) showed that the southernmost boundary of the Arvicolinae is approximately 22.5°N in the Palaearctic Region but approximately

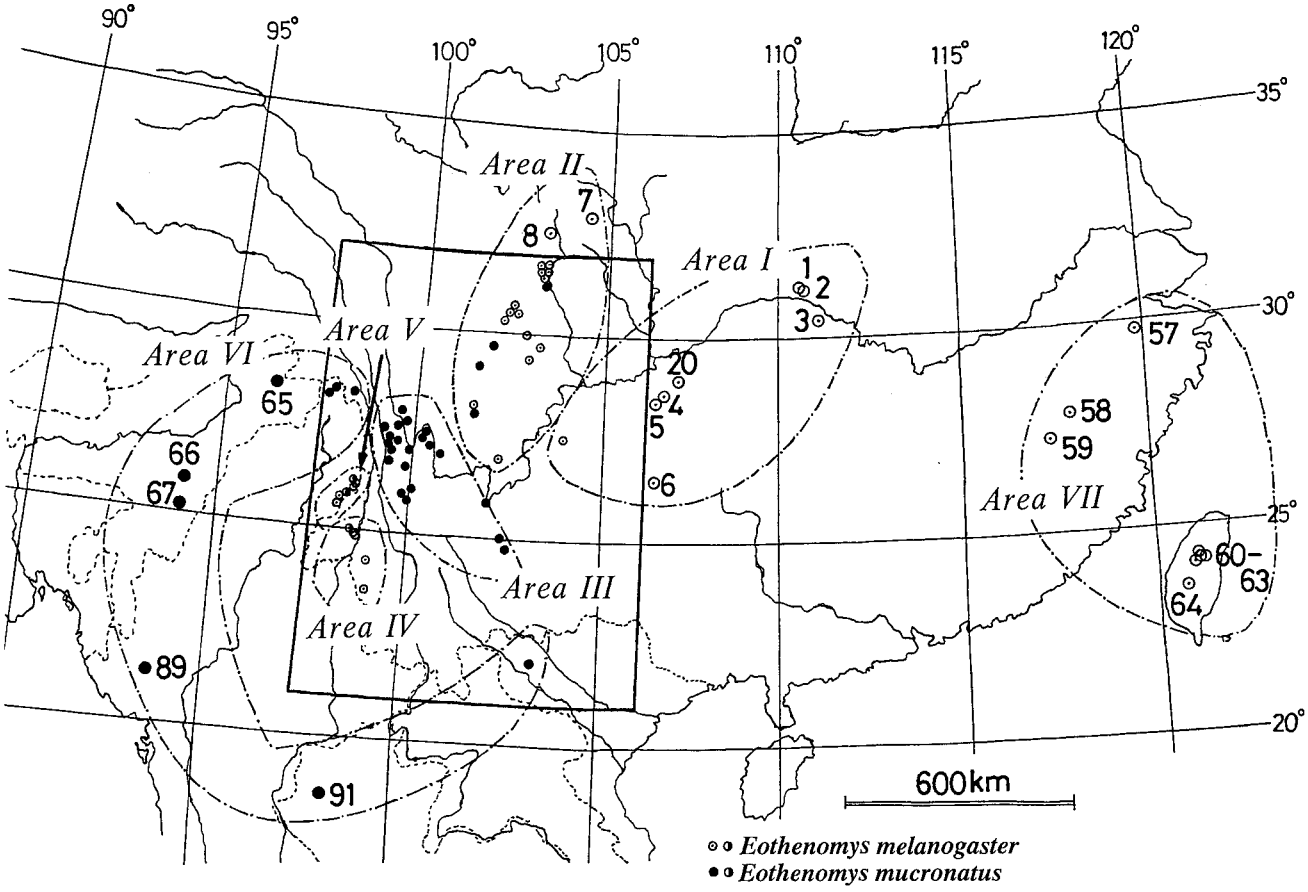

Fig. 12. Geographical distribution of *Eothenomys melanogaster* (Group S) and *E. mucronatus* (Group L). The rectangle area is enlarged in Fig. 13.

15°N in North America. *Microtus oaxacensis, M. umbrosus*, and *M. guatemalensis* occur in mountain cloud forest near 15°N in Mexico and Guatemala, and are regarded as relicts of early arvicolid invasions of the New World (Hoffmann and Koeppl 1985). In this study, the southern boundary of the distribution of *E. mucronatus* was more southerly than that of *E. melanogaster*, and *E. mucronatus* now occurs near 18°N in alpine habitats. The summit of Doi Inthanon (Locality #91), Thailand, where *E. mucronatus* occurs, is isolated, and a "sea" of drier lowland forests has surrounded this "island" of moist mountain forest since the end of the last glaciation (Bernard 1991). This observation suggests that during the ice ages the southernmost arvicolid invasions were represented by the genus *Eothenomys* in the Old World, especially by *E. mucronatus*, and by the genus *Microtus* in the New World.

This study shows that *E. mucronatus* is distributed in northeastern India, northern Burma, and northwestern Thailand (Fig. 12). Regarding zoogeography, Blanford (1901) recognized that the fauna of Assam is distinct from that of other parts of India, and considered this a transitional area between the Palaearctic and Oriental regions. He named the area including Assam, Burma, and east of the Bay of Bengal as one of five subregions in the Oriental region. This area is comprised of Assam, northern Burma, southern Burma around Rangoon, western Thailand, the northern part of the Malay Peninsula, and the Andaman and Nicobar Islands. Kurup (1966, 1974) considered that most genera characteristic of Assam are not found in the rest of India, but are widely distributed in the Indochina region, and India forms the westernmost boundary of their range. His biogeographic interpretation is confirmed by the distribution of *E. mucronatus* in the Assam subregion.

Reexamination of the literature on inaccessible specimens

I was unable to examine three specimens directly. Blanford (1891) stated that Thomas identified one specimen collected from the Kakyen Hills, near Bhámo,

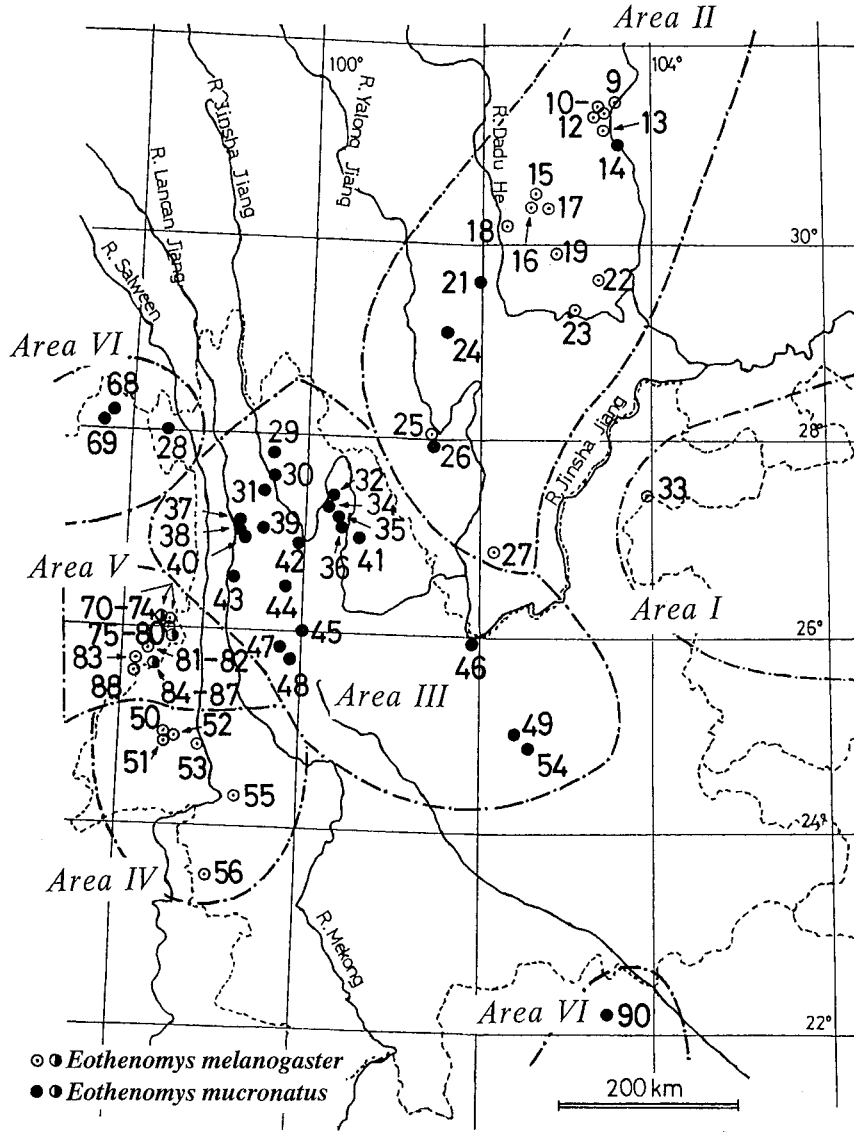

Fig. 13. Geographical distribution of *Eothenomys melanogaster* (Group S) and *E. mucronatus* (Group L) in the rectangle area exhibited in Fig. 12.

northern Burma, as *Microtus melanogaster*. The geographic coordinates of Bhámo are 24.15°N and 97.15°E (The Times Atlas of the World 1994). For the specimen, Blanford (1891) recorded a TL of 1.4 inches (35 mm) and an HFL of 0.65 inches (16.51 mm). It is reasonable to identify this specimen as *E. melanogaster* (Group S) on the basis of the relationship between TL and HFL in Area V (Table 1). This categorization suggests that *E. melanogaster* is distributed further southwest in Burma than shown on the distribution map presented here.

Ho (1935) reported collecting 47 specimens of *E. melanogaster* at several localities in Sichuan Province, China. His report included measurements of three specimens, with external and cranial dimensions, collected from Ganyango (Locality # 16 in Area II) (6650–6900 feet, or 1995–2070 m). The dental length (I-M3) of these three specimens agrees with those for *E. melanogaster* (Fig. 9).

Lekagul and McNeely (1977) reported collecting *E. melanogaster* on the summit of Doi Inthanon (Locality #91) and recorded measurements TL as 40 mm and HFL as 18.7 mm, for which this study identifies *E. mucronatus* only. These measurements agree with the TL/HFL relationship for *E. mucronatus* in Area VI (Table 8). Although the reported skull length was 26.1 mm, the authors did not indicate whether they measured the greatest

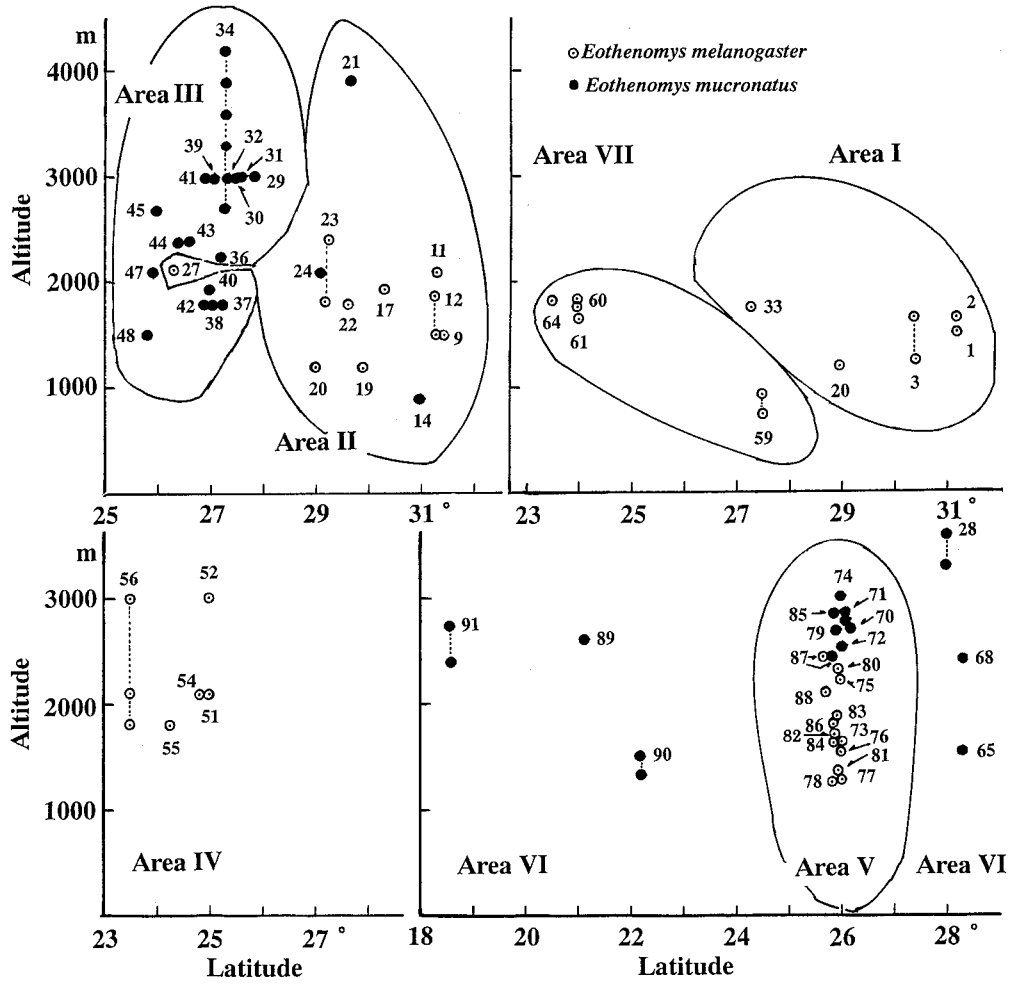

Fig. 14. Altitudinal distribution of *Eothenomys melanogaster* (Group S) and *E. mucronatus* (Group L) in Areas I–VII.

skull length or the condylobasal length. Calculating I-M3 as either 17.2 or 16.2 mm from a picture of the ventral view of the skull, this I-M3 value is within the range of those for *E. mucronatus* (Fig. 4). It is reasonable to conclude that only *E. mucronatus* occurs on the summit of Doi Inthanon.

Ho (1979) reported collecting one specimen of *E. melanogaster* with five adult specimens of *E. miletus* at Kunming, Yunnan Province, China (Locality #54 in Area III, approximately 1890–2300 m above sea level). He used the molar pattern on the third upper molar as described by Allen (1940) as the key for identification. This specimen is *E. mucronatus*, not *E. melanogaster*, since the measurements of TL (47 mm) and HFL (17 mm) (Ho 1979) agree well with those of *E. mucronatus* in Area III (Table 8). Therefore, it appears that only *E. mucronatus* occurs at Kunming.

Referring to many collecting reports, Zhang (1997) first reviewed and then presented a small-scale distribution map for Père David's vole in China, although he did not mention how to identify these voles. Zhang (1997) misread *E. melanogaster* as being collected at Zayü, Xizang Zizhiqu, China (Ellerman and Morrison-Scott 1951) and the Liupan Shan Mountains, Ninqxia Huizu Zizhiqu, China (Qin 1991). The two misread sources do not report collecting *E. melanogaster*. Zhang's map does not give the full geographic distribution of the vole in China. This incompleteness is why, except in the few cases mentioned above, specimens examined by many Chinese researchers have not been sufficiently described for identification and the keys used for identification probably differ for each original author.

I was unable to reexamine some collecting localities by accessing specimens directly, because the reports do not state where the specimens are kept. These localities are the Qinling Mountains, Shanxi Province (Wu and Li

1982; Wang 1990); the Tai-bai Shan Mountains, Shanxi Province (Wu and Li 1982; Wang 1990); Zoige, Sichuan Province (Hu and Wang 1984); and the Yunkai Dashan Mountains, Guangdong Province (Liu and Liu 1983). Reexamination of the identification of these specimens is needed to establish the full geographic distribution of this vole.

Studies on altitudinal distribution reported to date are not accurate, since the descriptions are inadequate for identifying and determining the geographic distribution of the specimens. However, the following three reports suggest some distributions. *Eothenomys melanogaster* was collected from 1500 to 2700 m (Kano 1940) and from 1400 to 2700 m (Yu 1994) in Taiwan, and from 600 to 1400 m in Zhejiang Province, China (Bao and Zhuge 1986). Since only *E. melanogaster* is distributed in Zhejiang Province and Taiwan, these studies confirm our results for the range of elevation.

Reports that describe collecting *E. mucronatus* on mountains in northern Yunnan Province (Area III) might be reliable, because only *E. mucronatus* is distributed in this area. Yang and Yang (1985) collected *E. miletus* (now *E. mucronatus*) from 1200 to 3550 m, but not from 3550 to 4200 m in this district. Yang and Tao (1986), however, collected *E. miletus* at altitudes of 2500 to 4000 m in the Laojun Mountains, Yunnan. Therefore, the elevation at which *E. mucronatus* occurs changes with mountain range in southern Yunnan, and these results confirm our overall results.

Habitats of Eothenomys melanogaster *and* E. mucronatus

The habitats of *E. melanogaster* and *E. mucronatus* can be inferred from the descriptions in the collection data. Anthony (1941) described the habitat of *E. melanogaster libonotus* (now *E. melanogaster*), although the scientific names differ from those in this study. Except for specimens of both species collected from the Hpare-Saulang Road (Locality #87), he clearly distinguished the two voles in the same manner as in this paper (Fig. 13). *Eothenomys melanogaster* was not collected in dense forest but in foothills, in grassy meadows under cultivation, or occasionally in stands of trees and shrubs along streams (Anthony 1941). Yu (1994) also reported that *E. melanogaster* occurred in grasslands more often than in forest in Taiwan, where only *E. melanogaster* occurs. According to Bao and Zhuge (1986), however, *E. melanogaster* was abundant in pine forest, common in meadows, and rare in Chinese fir forests in Zhejiang Province, where only *E. melanogaster* is distributed. Therefore, *E. melanogaster* habitat differs with geographic area.

Eothenomys mucronatus was common on the banks of small streams, slopes, meadows, rocks, or logs in Burma, where only *E. melanogaster cachinus* (now *E. mucronatus*) is distributed (Anthony 1941). In the Adung Valley, Burma, *E. mucronatus* was mainly collected in coniferous forests, and occasionally collected in open scrubland and bamboo thickets at 2400 m in elevation (Cranbrook 1960–61). According to Yang and Yang (1985), *E. miletus* (now *E. mucronatus*) was more common in cultivated fields or bushes than in mixed forest, pine and cedar forest, or bushy bamboo. The vole, however, was not collected in alpine grasslands in northern Yunnan Province, where only *E. mucronatus* is distributed. Therefore, the habitat of *E. mucronatus* differs between Burma and Yunnan.

Classification

The historical usage of the sub-specific and specific names of *E. melanogaster* and *E. mucronatus* in relation to associated taxa, their distribution, type locality, and type specimens can be summarized as follows:

Eothenomys melanogaster (Milne-Edwards, 1872)

- Distribution: Chinese provinces of Zhejiang, Fujiang, Hubei, Guizhou, Gansu, Sichuan, and Yunnan; Taiwan.
- Type locality: Moupin, SéTchuan (= Sichuan), China.
- Holotype: MNHM 1871. 571

Arvicola melanogaster; Milne-Edwards 1872, p. 93 (footnote). Blandford 1881, p. 114.

Microtus melanogaster; Blandford 1891, p. 434. Thomas 1899, p. 775.

Microtus (*Eothenomys*) *melanogaster*; Miller 1896, p. 45. Thomas 1911b, p. 176. Allen 1912, p. 211.

Microtus (*Eothenomys*) *melanogaster colurnus*; Thomas 1911a, p. 209 [Type locality: Kuatun, N. W. Fokien (= Fujian), China].

Microtus (*Eothenomys*) *melanogaster eleusis*; Thomas 1911c, p. 50 [Type locality: East of Chatungfu, N. Yunnan, China; 5,800']. Thomas 1912, p. 139.

Microtus (*Eothenomys*) *aurora*; Allen 1912, p. 211 [Type locality: Changyanghsien, Hupeh (= Hubei), China].

Microtus (*Eothenomys*) *bonzo*; Cabrera 1922, p. 168 [Type locality: Fu-Chou (= Fuzhou), China].

Eothenomys melanogaster; Jacobi 1922, p. 15. Tanaka 1936, p. 308. Kuroda 1938, p. 54. Ellerman 1941,

p. 576 (in part). Aoki and Tanaka 1941, p. 141. Ellerman and Morrison-Scott 1951, p. 668 (in part). Gromov and Polyakov 1977, p. 237. Corbet 1978, p. 101 (in part). Lawrence 1982, p. 5. Honacki et al. 1982, p. 486. Hu and Wang 1984, p. 257. Corbet and Hill 1992, p. 401 (in part). Musser and Carleton 1993, p. 514 (in part).

Eothenomys melanogaster melanogaster; Hinton 1926, p. 285. Ho 1935, p. 146. Allen 1940, p. 806. Ellerman and Morrison-Scott 1951, p. 668. Pen et al. 1962, p. 126. Wang and Li 2000, p. 440.

Eothenomys melanogaster eleusis; Hinton 1926, p. 286. Ellerman and Morrison-Scott 1951, p. 668. Pen et al. 1962, p. 126 (in part). Lu et al. 1965, p. 294.

Eothenomys melanogaster aurora; Hinton 1926, p. 287. Ellerman and Morrison-Scott 1951, p. 668.

Eothenomys melanogaster colurnus; Hinton 1926, p. 288. Allen 1940, p. 810. Ellerman and Morrison-Scott 1951, p. 668. Von Lehmann 1955, p. 166. Wang and Li 2000, p. 444.

Microtus (*Eothenomys*) *melanogaster melanogaster*; Howell 1929, p. 51.

Microtus (*Eothenomys*) *melanogaster colurnus*; Howell 1929, p. 52.

Eothenomys kanoi; Tokuda and Kano 1937, p. 1118 [Type locality: His-ko-Yueh, Taiwan: 24°19'N, 121°17'E (referring Jones, 1975)].

Eothenomys miletus aurora; Allen 1940, p. 814.

Eothenomys melanogaster kanoi; Kuroda 1940, p. 274. Tokuda 1941, p. 52. Ellerman and Morrison-Scott 1951, p. 669. Wang and Li 2000, p. 447.

Eothenomys eleusis; Allen 1940, p. 815. Gromov and Polyakov 1977, p. 237. Hu and Wang 1984, p. 259.

Eothenomys miletus miletus; Stager 1949, p. 70.

Eothenomys eleusis eleusis; Wang and Li 2000, p. 430.

Eothenomys eleusis aurora; Wang and Li 2000, p. 431.

Eothenomys eleusis yingjiangensis; Wang and Li 2000, p. 434 [Type locality: Yingjiang Xiang, Yunnan, China; 800 m].

Eothenomys melanogaster mucronatus; Wang and Li 2000, p. 442.

Eothenomys melanogaster libonatus; Wang and Li 2000, p. 443.

Eothenomys mucronatus (Allen, 1912)

■ Distribution: Chinese provinces of Sichuan and Yunnan; northeastern India; northen Burma (= Myanmar); northern Thailand; northern Vietnam.

■ Type locality: Tachiao, western Szechwan (= Sichuan), China; 12,000'.

■ Holotype: MCZ 7789.

Microtus (*Eothenomys*) *mucronatus*; Allen 1912, p. 214.

Microtus (*Eothenomys*) *melanogaster miletus*; Thomas 1914, p. 474 [Type locality: 10 miles of W. of Yangpi, W. Yunnan, China; 7,000'].

Microtus (*Eothenomys*) *cachinus*; Thomas 1921, p. 504 [Type locality: Imaw Bum, Burma; 9,000'].

Eothenomys fidelis; Hinton 1923, p. 150 [Type locality: Lichang Range N.W. flank in 27°37'N, Yunnan, China; 14,000']. Thomas 1923, p. 661. Hinton 1926, p. 290.

Eothenomys melanogaster confinii; Hinton 1923, p. 151 [Type locality: Kiu-chiang-Salween divide, 28°N, China; 11,000' to 12,000']. Allen 1924, p. 3. Hinton 1926, p. 288. Osgood 1932, p. 323.

Eothenomys melanogaster libonotus; Hinton 1923, p. 151 [Type locality: Dreyi, Mishmi Hills, Assam, India; 5,140']. Hinton 1926, p. 289. Hinton and Lindsay 1926, p. 400. Anthony 1941, p. 99. Ellerman 1961, p. 442. Kurup 1968, p. 98.

Microtus (*Eothenomys*) *fidelis*; Allen 1924, p. 4.

Eothenomys melanogaster cachinus; Hinton 1926, p. 286. Anthony 1941, p. 98 (in part). Ellerman and Morrison-Scott 1951, p. 669. Ellerman 1961, p. 441.

Eothenomys melanogaster miletus; Hinton 1926, p. 287. Ellerman and Morrison-Scott 1951, p. 669.

Eothenomys melanogaster mucronatus; Hinton 1926, p. 289.

Eothenomys melanogaster fidelis; Osgood 1932, p. 323.

Eothenomys miletus miletus; Allen 1940, p. 811. Pen et al. 1962, p. 127. Ho 1979, p. 145. Wang and Li 2000, p. 453.

Eothenomys melanogaster; Ellerman 1941, p. 576 (in part). Ellerman and Morrison-Scott 1951, p. 668 (in part). Lekagul and McNeely 1977, p. 418. Corbet 1978, p. 101 (in part). Corbet and Hill 1992, p. 401 (in part). Musser and Carleton 1993, p. 514 (in part).

Eothenomys melanogaster eleusis; Pen et al. 1962, p. 126 (in part).

Eothenomys miletus; Gromov and Polyakov 1977, p. 237. Hu and Wang 1984, p. 259. Corbet and Hill 1992, p. 401.

Eothenomys melanogaster melanogaster; Ho 1979, p. 145.

Eothenomus melanogaster chenduensis; Wang and Li 2000, p. 447 [Type locality: Chengdu Shi, Sichuan, China].

Eothenomys miletus confinii; Wang and Li 2000, p. 455.

Eothenomys cachinus; Wang and Li 2000, p. 457 (in part?).

Acknowledgements: I gratefully acknowledge H. Abe and the curators who allowed me to examine specimens in their care, particularly: J. M. Ingles, P. D. Jenkins and D. M. Hills (BM); M. E. Rutzmoser (MCZ); G. G. Musser, the late W. K.-H. Fuchs, and F. Brady (AMNH); M. D. Carleton (USNM); B. B. Patterson (FMNH); Wang Sung, Wang Zongren and Quan Guoqing (AZSI). Michel Tranier (MNHN) photographed, measured the holotype specimen in his care, and copied a part of the book written by Milne-Edwards for me. M. E. Rutzmoser sent the maps of W. R. Zappey. M. Terayama taught the names of locations in Taiwan. M. D. Carleton, M. Motokawa, H. Abe, and Paul G. Batten carefully improved the draft of this manuscript. T. Saitoh and H. Suzuki encouraged me to prepare this manuscript. This work was partly supported by a Short Term Visitor Grant from the Smithsonian Institution, by the Karl P. Schmidt Fund of FMNH, and by an "Overseas Scientific Grant for 1987 (62041089) and 1988 (63043061) given by the Ministry of Education, Science and Culture of Japan.

References

Allen, G. M. 1912. Some Chinese vertebrates. Mammalia. Memoirs of the Museum of Comparative Zoology of Harvard College 40: 201–247.

Allen, G. M. 1924. Microtines collected by the Asiatic Expeditions. American Museum Novitates 133: 1–13.

Allen, G. M. 1940. Mammals of China and Mongolia. The Natural History of Central Asia. Vol. 11, Part 2. American Museum of Natural History, New York, pp. 621–1350.

Aoki, B. and Tanaka, R. 1941. The rats and mice of Formosa illustrated. Memoirs of the Faculty of Science and Agriculture, Taihoku Imperial University, Zoology 23: 121–191.

Anthony, H. E. 1941. Mammals collected by the Vernay-Cutting Burma Expedition. Field Museum of Natural History, Zoological Series 27: 37–123.

The Atlas Publication Cooperative Society. 1979. The Atlas of the People's Republic of China. Beijing, 75 pp. (in Chinese)

Bao, Y.-X. and Zhuge, Y. 1986. An ecological study on *Eothenomys melanogaster*. Acta Theriologica Sinica 6: 297–305 (in Chinese with English abstract).

Bernard, H.-U. 1991. Southeast Asia, Wildlife. APA Publications, Hong Kong, 430 pp.

Birckhead, H. 1937. The birds of the Sage West China Expedition. American Museum Novitates 966: 1–17.

Blandford, W. T. 1881. On the vole (*Arvicola*) of the Himalayas, Tibet, and Afghanistan. Journal of the Asiatic Society of Bengal 50: 88–117.

Blandford, W. T. 1891. The Fauna of British India, including Ceylon and Burma. Mammalia, Part 2. Taylor and Francis, London, 251–617 pp.

Blandford, W. T. 1901. The distribution of vertebrate animals in India, Ceylon, and Burma. Philosophical Transactions of the Royal Society of London, (B) 194: 355–436.

Cabrera, A. 1922. Sobre algunos mamíferos de la China oriental. Boletín de la Real Sociedad Española Historia Natural 22: 162–170.

Carleton, M. D. and Musser, G. G. 1984. Muroid rodents. In (S. Anderson and J. Knox Jones, Jr., eds.) Orders and Families of Recent Mammals of the World. Pp. 289–379. John Wiley & Sons, New York.

Chengdu Geographical Institution, Academia Sinica. 1983. Geographic Expedition in the Gongga Mountain. Chongqing Branch of the Publication for Science and Technology, Chongqing, 108 pp. (in Chinese with English abstract)

The Committee Natural Geogrphy of China (ed.) 1984. Natural Geography of China. Paleogeography. 1. Science Publication, Beijing, 262 pp. (in Chinese)

Corbet, G. B. 1978. The Mammals of the Palaearctic Region: a Taxonomic Review. British Museum (Natural History) and Cornell University Press, London and Ithaca, 314 pp.

Corbet, G. B. and Hill, J. E. 1992. The Mammals of the Indomalayan Region: Systematic Review. Natural History Museum Publication, Oxford University Press, 488 pp.

Cranbrook, The Earl of. 1960–61. Notes on the habitats and vertical distribution of some insectivores from the Burma-Tibetian frontier. Proceedings of the Linnean Society of London 173: 121–127.

Dolan, B. II. 1938. Zoological results of the second Dolan Expedition to western China and eastern Tibet, 1934–1936. Part II, Introduction. Proceedings of the Academy of Natural Sciences of Philadelphia 90: 159–184.

Ellerman, J. R. 1941. The Families and Genera of Living Rodents. Vol. II. Family Muridae. British Museum (Natural History), London, 690 pp.

Ellerman, J. R. 1949. The Families and Genera of Living Rodents. Vol. III. British Museum (Natural History), London, 210 pp.

Ellerman, J. R. 1961. The Fauna of India including Pakistan, Burma and Ceylon. Mammalia, 2nd ed., Vol. 3 Rodentia, Part 1. Manager Publications, Delhi, 482 pp.

Ellerman, J. R. and Morrison-Scott, T. C. S. 1951. Checklist of Palaearctic and Indian Mammals 1758 to 1946. British Museum (Natural History), London, 810 pp.

Gromov, I. M. and Polyakov, I. Ya. 1977. Fauna of the USSR. Mammals, Vol. III, No. 8, Voles (Microtinae). (English edition was translated from Russian in 1992 by Smithsonian Institution Libraries, Washington, D. C., 725 pp.)

Hinton, M. A. C. 1923. On the voles collected by Mr. G. Forrest in Yunnan; with remarks upon the genera *Eothenomys* and *Neodon* and upon their allies. Annals and Magazine of Natural History, Ser. 9, 11: 145–162.

Hinton, M. A. C. 1926. Monograph of the Voles and Lemmings (Microtinae), Living and Extinct. Vol. 1. British Musum (Natural History), London, 488 pp.

Hinton, M. A. C. and Lindsay, H. M. 1926. Bombay Natural History Society's mammal survey in India, Burma and Ceylon. Report No. 41, Assam and Mishmi Hills. Journal of the Bombay Natural History Society 31: 383–403.

Ho, J.-H. 1935. Study of some mammals from Szechuan. Contribution of Biological Laboratory of Science Society of Nanking, Zoological Series 11: 123–164.

Ho, X.-R. 1979. A list, reproductive conditions and taxonomy of small rodents at Kunming. Bulletin of theYunnan University 2: 143–152 (in Chinese).

Hoffmann, R. S. and Koeppl, J. W. 1985. Zoogeography. In (R. H. Tamarin, ed.) Biology of New World *Microtus*. Pp. 84–115. Special Publication No. 8. The American Society of Mammalogists.

Honacki, J. H., Kinman, K. E. and Koeppl, J. W. 1982. Mammal Species of the World. Allen Press, Incorporated and the Association and Systematic Collections, Lawrence and Kansas, 694 pp.

Howell, A. B. 1929. Mammals from China in the collections of the United States National Museum. Proceedings of the United States National Museum 75: 1–82.

Hu, J.-Z. and Wang, Y.-Z. (eds.) 1984. Sichuan Fauna Economica. Vol. 2. Mammalia. Sichuan Sciences and Tech. Publication, 365 pp. (in Chinese).

Jacobi, A. 1922. Zoologische Ergebniss der Walter Stölznerschen Expedition nach Szetschwan, Osttibet und Tschli auf Grund der Sammlungen Dr. Hugo Weigolds. Abhandlungen und Berichte des Museum fur Tierkunde und Völkerkunde zu Dresden 16: 1–22.

Jameson, E. W., Jr. and Jones, G. S. 1977. The Soricidae of Taiwan. Proceedings of the Biological Society of Washington 90: 459–482.

Jones, G. S. 1975. Catalogue of the type specimens of mammals of Taiwan. Quarterly Journal of the Taiwan Museum 28: 183–217.

Kano, T. 1940. Zoogeographical Studies of the Tsugitaka Mountains of Formosa. The Shibusawa Institute for Ethnographical Researches, Tokyo, 145 pp.

Kingdon Ward, F. 1921. Some observations on the birds and mammals of Imaw Bum. Journal of the Bombay Natural History Society 27: 754–758.

Kingdon Ward, F. 1924. The Snow Mountains of Yunnan. Geographical Journal 64: 222–231.

Kingdon Ward, F. 1930. Plant Hunting on the Edge of the World. Victor Gollancez, London, 383 pp. (reprinted by Cadogan Books, London, in 1985)

Kuroda, N. 1938. A List of the Japanese Mammals. Published by the author, Tokyo, 122 pp.

Kuroda, N. 1940. A Monograph of the Japanese Mammals, exclusive of Sirenia and Cetacea. Sanseido, Tokyo, 311 pp.

Kurup, G. U. 1966. Mammals of Assam and adjoining areas. 1. An analytical study. Proceedings of the Zoological Society of Calcutta 19: 1–21.

Kurup, G. U. 1968. Mammals of Assam and adjoining areas. 2. A distributional list. Proceedings of the Zoological Society of Calcutta 21: 79–99.

Kurup, G. U. 1974. Mammals of Assam and the mammal-geography of India. In (M. S. Mani, ed.) Ecology and Biogeography in India. Pp. 585–613. Dr. W. Junk, The Hague.

Lawrence, M. 1982. Western Chinese Arvicolines (Rodentia) collected by the Sage Expedition. American Museum Novitates 2745: 1–19.

Lekagul, B. and McNeely, J. A. 1977. Mammals of Thailand. Sahakarnbhat Company, Bangkok, 758 pp.

Liu, M.-Q. and Liu, Z.-H. 1983. Preliminary report on the collection and ecology in *Eothenomys melanogaster* in Guangdong province. Journal of Zoology 3: 17–19 (in Chinese).

Lu, C.-K., Wang, T.-Y., Qyan, G.-Q., Gin, S.-K. and Ma, T.-H. 1965. On the mammals from the Lin-tsang Area, western Yunnan. Acta Zootaxonomica Sinica 2: 279–295 (in Chinese with English abstract).

Miller, J. S., Jr. 1896. Genera and subgenera of voles and lemmings. North American Fauna 12: 1–85.

Milne-Edwards, A. 1872. Description of mammals—footnotes. Pp. 91-93. In (A. David) Rapport adressé à Mm. les Professeurs-Adminstrateurs du Museum d'Histoire Naturelle. Nouvelles Archives du Muséum d'Histoire Naturelle de Paris 7: 73–100.

Moore, J. C. and Tate, G. H. H. 1965. A study of the diurnal squirrels, Sciurinae, of the Indian and Indochinese subregions. Fieldiana Zoology 48: 1–351.

Musser, G. G. 1970. Species-limits of *Rattus brahma*, a murid rodents of northeastern India and northern Burma. American Museum Novitates 2406: 1–27.

Musser, G. G. and Carleton, M. D. 1993. Family Muridae. In (D. E. Wilson and D.-A. M. Reeder, eds.) Mammal Species of the World: A Taxonomic and Geographic Reference. 2nd ed. Pp. 501–755. Smithsonian Institution Press, Washington and London.

Musser, G. G. and Chiu, S. 1979. Notes on taxonomy of *Rattus andersoni* and *R. excelsior*, murids endemic to western China. Journal of Mammalogy 60: 581–592.

Osgood, W. H. 1932. Mammals of the Kelley-Roosevelts and Delacour Asiatic Expeditions. Field Museum of Natural History, Zoological Series 18: 193–339.

Pen, H.-S., Kao, Y.-T. and Lu, C.-K. 1962. Report on mammals from southwestern Szechwan and northwestern Yunnan. Acta Zoologica Sinica 14 (Supplement): 105–132 (in Chinese with English abstract).

Pope, C. H. 1935. The Reptiles of China. The Natural History of Central Asia. Vol. X. American Museum of Natural History, New York, 604 pp.

Qin, C.-Y. 1991. On the faunastics and regionalization of glires in Ningxia Autonomous region, China. Acta Theriologica Sinica 11: 143-151 (in Chinese with English abstract).

Roosevelt, T. and Roosevelt, K. 1929. Trailing the Giant Panda. Charles Scribner's Sons, New York and London, 278 pp.

Sasaki, K. 1951. The Atlas of the World. The Main Area of Asia. Toseishya, Tokyo, 44 pp. (in Japanese)

Sheldon, W. G. 1975. The Wilderness Home of the Giant Panda. University of Massachusetts Press, Amherst, 196 pp.

Simpson, G. G. 1941. Large Pleistocene Felines of North America. American Museum Novitates 1136: 1–27.

Stager, K. F. 1949. Notes of the mammals of Kweichow province, China. Journal of Mammalogy 30: 68–71.

Su, D.-R. (ed.) 1984. Gazetteer of the World. Vol. 2. Pp. 1519–2808. China Encyclopedia Publication Cooperative Soc., Beijing and Shanghai (in Chinese).

Tanaka, R. 1936. A form of *Eothenomys melanogaster* from Taiwan. Transactions of the Taiwan Museum of Natural History 26: 305-309 (in Japanese with English résumé).

Thomas, O. 1899. On mammals collected by Mr. J. D. La Touche at Kuatun, N. W. Fokien, China. Proceedings of the Zoological Society of London 1898: 769–775.

Thomas, O. 1911a. New Asiatic Muridae. Annals and Magazinne of Natural History, Series 8, 7: 205–209.

Thomas, O. 1911b. The Duke of Bedford's Zoological Exploration of eastern Asia. XIII. On mammals from the provinces of Kan-su and Sze-chwan, western China. Proceedings of the Zoological Society of London 1911: 158–180.

Thomas, O. 1911c. On mammals collected in the provinces of Szechwan and Yunnan, W. China, by Malcolm Anderson, for the Duke of Bedford's Exploration. Abstracts of the Proceedings of the Zoological Society of London No. 100: 48–50.

Thomas, O. 1912. The Duke of Bedford's Zoological Exploration of eastern Asia. XV. On mammals from the provinces of Sze-chwan and Yunnan, western China. Proceedings of the Zoological Society of London 1912: 127–141.

Thomas, O. 1914. Second list of small mammals from western Yunnan collected by Mr. F. Kindon Ward. Annals and Magazine

of Natural History, Series 8, 114: 472–475.
Thomas, O. 1921. On small mammals from Kachin province, northern Burma. Journal of the Bombay Natural History Society 27: 499–505.
Thomas, O. 1923. On mammals from Li-kiang Range, Yunnan, being a further collection obtained by Mr. George Forrest. Annals and Magazine of Natural History, Series 9, 11: 655–663.
The Times Atlas of the World. 1994. 9th ed., Times Books/ Random House, New York, 218 pp.
Tokuda, M. 1941. A revised monograph of the Japanese and Manchou-Korean Muridae. Transactions of the Biogeographical Society of Japan 4: 1–155.
Tokuda, M. and Kano, T. 1937. The alpine Murid of Formosa. Botany and Zoology 5: 1115-1122 (in Japanese).
Traylor, M. A., Jr. 1967. A collection of birds from Szechwan. Fieldiana Zoology 53: 3–67.
Von Lehmann, E. 1955. Die Säugetiere aus Fukien (SO-China) im Museum A. Koenig, Bonn. Bonner Zoologische Beiträge 3–4: 147–170.
Wang, T.-Z. 1990. On the fauna and the zoogeographical regionalization of glires (including rodents and lagomorphs) in Shaanxi province. Acta Theriologica Sinica 10: 128–136 (in Chinese with English abstract).
Wang, Y.-X. and Li, C. 2000. Genus *Eothenomys* Miller, 1896. In (Z. Luo, W. Chen and W. Gao, eds.) Fauna Sinica, Mammalia, Vol. 6 Rodentia, Part III Cricetidae. Pp. 388–462. Science Press, Beijing (in Chinese with English abstract).
Wu, J.-Y. and Li, G.-H. 1982. A report on the mammals of Ankang region, Shanxi Province. Zoological Research 3: 59–68 (in Chinese with English abstract).
Wilson, E. H. 1913. A Naturalist in Western China with Vasculum, Camera, and Gun. Vol. 1. Methuen & Co., London, 251 pp.
Yang, G.-R. and Tao, K.-H. 1986. The vertical distribution of rodents of Laojun Mountain, Yunnan. Zoological Research 7: 311–316 (in Chinese with English abstract).
Yang, G.-R. and Yang, Z.-S. 1985. A study on biology in *Eothenomys miletus miletus*. Journal of Zoology 5: 38–44 (in Chinese).
Yu, H.-T. 1994. Distribution and abundance of small mammals along a subtropical elevational gradient in central Taiwan. Journal of Zoology (London) 234: 577–600.
Zhang, Y. (ed.) 1997. Distribution of Mammals in China. China Forestry Publishing House, 280 pp. (in Chinese with English)
Zheng, S. 1993. Quaternary Rodents of Sichuan-Guizhou Area, China. Science Publication, Beijing, 270 pp. (in Chinese with English abstract)
Zhuang, J.-N. (ed.) 1983. Gazetteer of China. An Index to the Atlas of the People's Republic of China. Atlas Publication Cooperation Society, Shanghai, 315 pp. (in Chinese)

Received 4 September 2000. Accepted 15 April 2002.

Appendix 1. Localities and specimens examined

(Altitude was listed in front of the number of specimens registered as well as the date of collection, because there are many specimens collected without recording altitude.)

China

Hubei Province

1. Quong Pow (=Luong Pow): circa 31.2°N, 110.5°E; This locality was not able to find out on the map made by W. R. Zappey housed in the MCZ. However, the collecting date of Quong Pow (April 15, 1907) is near to that of Hsiatienze (MCZ 7193/ April 6, 1907). Thus, I tentatively regarded the coordinates as Hsiatientze; *E. melanogaster*, 5000', April 1907, MCZ 7188.
2. Hsien Tien Tsze: 31.2°N, 110.5°E; the NE of the Wansonshan mountain; *E. melanogaster*, 5500', April 1907, MCZ 7193.
3. Changyang-hsien (=Changyang Xian): 30.4°N, 111.1°E; *E. melanogaster*, February 1909, the holotype of *Microtus* (*Eothenomys*) *aurora* Allen, 1912 (MCZ 7788)/5500', October 1907, MCZ 7185/4150' and 5500', November 1907, MCZ 7187, 7195, BM 13.9.13.8.

Guizhou Province

4. Shuan Lung Chang (=Hsing lungshan), 110 li SE of Wen Shui: 28.8°N, 106.8°E (Trayer 1967); *E. melanogaster*, May 1932, FMNH 40529–32.
5. Hsiang Liao Pa (=Shung Liao Pa), 60 li SE of Wen Shui: 28.4°N, 106.6°E; *E. melanogaster*, May 1932, FMNH 40535.
6. Kweiyang (=Guiyang): 26.6°N, 106.7°E, Stager (1949) originally noted the location as 22°N and 107°E. His description, however, seems to be mistaken; *E. melanogaster*, August 1945, USNM 279308/August or September 1945, USNM 284995/the date of collecting is unknown, USNM 284996.

Gansu Province

7. Wen Xian: 33.0°N, 104.6°E; *E. melanogaster*, May 1910, BM 11.2.1.227–234.

Sichuan Province

8. Tai Pin Yi (=Tai Ping), Tao Kuan: 32.1°N, 103.7°E; *E. melanogaster*, August 1938, BM 55.566–568.
9. Wen Chuan (=Wenchuan Xian): 31.4°N, 103.6°E, following Birckhead (1937) and Sheldon (1975); *E. melanogaster*, 5000', September 1933, USNM 258705/5000', October 1933, USNM 258704/November 1934, USNM 259365.
10. Goan She Dwe: about 31.3°N, 103.3°E. I regarded the coordinates as Gan tang Go in Traylor (1967), because the collecting date of this locality (from April 17 to May 19, 1934) is quite near to that of Gan tang Go (May 7–9, 1934;Traylor 1967); *E. melanogaster*, April 1934, FMNH 45718–25/May 1934, FMNH 45726–59.
11. Chengon Creek, Cheng Wei, 25 miles WE Wenchwan (2100 m): 31.25°N, 103.60°E following the map of Sheldon (1975); *E. melanogaster*, 7000', October 1934, AMNH 111549–51, 111567/ 7000', November 1934, AMNH 111554–55, 111559–62/7000', December 1934, AMNH 111568.
12. Tsaq Po (=Caopo): 31.25°N, 103.33°E; *E. melanogaster*, 5000' and 6200', October 1934, AMNH 111542, 111544–48/June 1938, BM 55.552–562/July 1938, BM 55.563.
13. Lu Er Cheh: 31.08°N, 103.58°E. I regarded the coordinates as Lao Chun Ya in Traylor (1967), because the date of collecting at this locality is quite near to that of Lao Chun Ya (March 28, 1932; Traylor 1967); *E. melanogaster*, March 1932, FMNH 40536–37.
14. Kuan shien (=Guan Xian): 31.00°N, 103.62°E (Traylor 1967); *E. mucronatus*, 3000', November 1932, USNM 258147–55.
15. Ping Yang Goh: 30.42°N, 102.58°E (Traylor 1967); *E. melanogaster*, November 1932, FMNH 45658–45676, 45678–45714/ December 1932, FMNH 45770–96, 45798.
16. Gan Yang Go: 30.33°N, 102.50°E (Traylor 1967); *E. melano-*

gaster, January 1931, FMNH 36447/February 1931, FMNH 36450–57, 36459–61, 36463–65, 36468–69, USNM 259915–16.

17. Moupin (=Baoxing Xiang): 30.3°N, 102.8°E; *E. melanogaster*, the holotype of *Arvicola melanogaster* Milne-Edwards, 1872 (MNHM 1871. 571)(the collecting date is unknown)/6500', July 1929, USNM 254841–42/April 1931, USNM 259914.
18. Luan Shi Gow: 30.25°N, 102.25°E (Traylor 1967); *E. melanogaster*, March 1931, FMNH 36502–05, 36508–11, USNM 259913/April 1931, FMNH 36513–17, 36520–22.
19. Ya-chow (=Ya'an Xian), 45m SW: 29.9°N, 102.9°E; *E. melanogaster*, 4000', July 1910, BM 11.2.1.271.
20. Chin-fu-san (=Jinfo Sahn), near Nan-chwan (=Nanchuan): 29.0°N, 107.1°E; *E. melanogaster*, 4000', September 1910, BM 11.9.8.120.
21. Tachiao (=Taquiao): 29.73°N, 102.01°E; The collecting locality of the holotype was fixed in Appendix 2; *E. mucronatus*, 12000', August 1908, the holotype of *Microtus* (*Eothenomys*) *mucronatus* Allen, 1912 (MCZ 7789)/13000', September 1908, BM 13.9.13.7, MCZ 7791, 7803.
22. Omei-shan or Omei-san (=Emei Sahn): 29.6°N, 103.4°E; *E. melanogaster*, 6000', August 1910, BM 11.2.1.270.
23. Washan: 29.2°N, 103.0°E; *E. melanogaster*, 6000', May 1908, MCZ 7799/6000', September 1908, MCZ 7804/8000', November 1908, MCZ 7798, 7800–7801.
24. Chu Liang Shian or Chu Lung shien (=Jiulong Xian), Ta Pu Tze, Tong Ku or Chung Ku: 29.1°N, 101.6°E; *E. mucronatus*, 7000', April 1934, AMNH 113557–58.
25. Ku-lu (=Kulu): 28.0°N, 101.3°E; *E. melanogaster*, April 1929, FMNH 33065–66.
26. Mili (=Muli): 27.9°N, 101.3°E; *E. mucronatus*, March 1928, FMNH 33061–62/April 1929, FMNH 33063, 33086.
27. Yunnan border: near Paikuowan; 26.8°N, 102.2°E, following the collecting date of Roosevelt and Roosevelt (1929); *E. melanogaster*, 7200' (Roosevelt and Roosevelt 1929), April 1929, USNM 254694.

Yunnan Province

28. Gomba La (=Gompa La), Kiu-chiang-Salwin Divide, Lat. 28°N or Salween Riu Riang Divide: 28.0°N, 98.5°E (from the map of Kingdon Ward 1924); *E. mucronatus*, 11000', July 1921, the holotype of *Eothenomys melanogaster confinii* Hinton, 1923 (BM 22.12.1.1)/11000'–12000', July 1921, BM 22.12.1.2–3. 22.12.1.5/12000', October 1922, BM 23.3.7.21.
29. To-mulang, Cheng Tien (=Zhongdian Xian): 27.8°N, 99.7°E; *E. mucronatus*, 10000', December 1916, USNM 259933.
30. Pehti (=Petai), 30 miles S of Chung-tien (=Zhongdian Xian): 27.5°N, 99.7°E; *E. mucronatus*, 10000', November 1916, MCZ 21298, AMNH 44233.
31. Tugannsha, 20 miles S of Chungtien (=Zhongdian Xian): 27.5°N, 99.4°E; *E. mucronatus*, 10000', November 1916, MCZ 21299.
32. Ha-pa, 20 miles N of Taku: 27.4°N, 100.4°E; *E. mucronatus*, 10000', November 1916, FMNH 30555.
33. 21 miles E of Cha-tung-fu (=Zhangtong Xian): 27.3°N, 104.0°E; *E. melanogaster*, 5800', March 1911, the holotype of *Microtus* (*Eothenomys*) *eleusis* Thomas, 1911 (BM 11.9.8.111), BM 11.9.8.109–110, 11.9.8.118–119, 11.9.8.114–116
34. Lichiang Range, NW flank, Lat. 27.4°N: 27.3°N, 100.2°E; *E. mucronatus*, 14000', November 1921, the holotype of *Eothenomys fidelis* Hinton, 1923 (BM 22.12.1.8)/13000' and 14000', November 1921, BM 22.12.1.6–7, 22.12.1.9/8200', October 1916, AMNH 44074, USNM 259932, MCZ 21296–97, 21300–01, FMNH 30550, 30552–54/12000' and 14000', August 1922, BM 23.10.11.15, 23.10.11.17, 75.641, FMNH 28966/9000', 11000', 12000', 13000' and 14000', September 1922, FMNH 28965, BM 23.10.11.16, 23.10.11.18–20, 75.642–644/October 1922, BM 23.10.11.21.
35. Yang-tze River (near Nguluko): 27.2°N, 100.3°E (from the map of Stevens housed in the FMNH); *E. mucronatus*, March 1929, FMNH 33191.
36. Nguluko: 27.2°N, 100.3°E; *E. mucronatus*, 7500' (Roosevelt and Roosevelt 1929), February 1929, FMNH 33008.
37. Chung-lu (=Zhongku), Mekong River: about 27.2°N, 99.2°E; *E. mucronatus*, 6000', December 1916, FMNH 30560–61, USNM 259934.
38. Waita (=Weiodeng), Mekong River: 27.1°N, 99.2°E; *E. mucronatus*, 6000', December 1916, FMNH 30563.
39. Li-tien (=Ludian), Yangtze-Mekong Divide: 27.1°N, 99.4°E; *E. mucronatus*, 10000', December 1916, FMNH 30558–59.
40. Hsio-tien (=Xiaotien), Mekong River: 27.0°N, 99.2°E; *E. mucronatus*, 6500', December 1916, FMNH 30538.
41. Yung-Ning (=Yongning), 50 m S of: 27.0°N, 100.7°E; *E. mucronatus*, 10000', May 1922, BM 23.3.7.20.
42. Shi-ku (=Shiqu), Yangtse River: 26.9°N, 99.9°E; *E. mucronatus*, 6000', December 1916, FMNH 30557.
43. Thiao-he-la or Hsia-ke-la (=Xiaogola), Mekong River: 26.6°N, 99.1°E; *E. mucronatus*, 8000', December 1916, FMNH 30564, AMNH 44036.
44. Chiang-wei (=Xunwei or Xunnan), Mekong River: 26.4°N, 99.8°E; *E. mucronatus*, 8000', December 1916, FMNH 30565.
45. Yang-tsen, Mekong Drainage, and Yang Cheng Fu, 20 miles S (near Lang Qiong ?): 26.0°N, 100.0°E; *E. mucronatus*, 9000', December 1916, FMNH 30566, 30568/January 1917, AMNH 44053.
46. Lung Kai, Wu Ting Hsien: 25.95°N, 101.90°E (Moore and Tate 1965); *E. mucronatus*, January 1927, MCZ 24440.
47. 10 miles W of Yangpi: 25.9°N, 99.7°E; *E. mucronatus*, 7000', February 1914, the holotype of *Microtus* (*Eothenomys*) *melanogaster miletus* Thomas, 1914 (BM 14.10.23.32).
48. Yang-pi River (=Yangbi Jiang), Tengyeuh Road: 25.8°N, 99.8°E; *E. mucronatus*, 5000', January 1917, FMNH 30569, USNM 259935.
49. Kao Chiao: 25.02°N, 102.33°E (Moore and Tate 1965); *E. mucronatus*, February 1927, MCZ 24437–39.
50. Tengyueh (=Tengchong Xian): 25.0°N, 98.5°E; *E. melanogaster*, BM 12.6.26.4 (the date of collecting is unknown).
51. Ching Ts'ai Fang, Tengyueh: 25.00°N, 98.5°E; *E. melanogaster*, 7000' (not determined and used Tengyueh), May 1912, BM 13.12.8.16.
52. Shwelli Valley: circa 25.00°N, 98.67°E; *E. melanogaster*, 10000', the date of collecting is unknown, BM 25.10.5.26–28.
53. Ho-mewr-shee Pass (=Ho-mu-shy Pass): 24.92°N, 98.75°E (Moore and Tate 1965); *E. melanogaster*, 8000', April 1917, AMNH 44063–64, 44066, FMNH 30549.
54. Kungming (=Kunming), 15 miles SW: 24.9°N, 102.5°E; *E. mucronatus*, 7000', August 1945, USNM 279305–7.
55. Ta-shui-tang (=Tashutang), Salween Drainage: 24.28°N, 99.25°E (Moore and Tate 1965); *E. melanogaster*, 6000', February 1917, AMNH 44045–46.
56. Mucheng-Salween Drainage (=Mengdiangie or Mengdingie): 23.5°N, 99.0°E; *E. melanogaster*, 6000', 7000', and 10000', February 1917, MCZ 21286–91, FMNH 30540, 39542–44, 30546–48, BM 29.3.17.111, USNM 259919–20, AMNH 44172–73, 44175, 44186, 44199–200.

Zhejiang Province

57. Tung-lu: about 29.9°N, 119.6°E; *E. melanogaster*, December 1925, MCZ 34303/February 1926, MCZ 24303/March 1928,

MCZ 24305.

Fujian Province

58. Chung Hsien (=Chunganhsian): 28.03°N, 117.88°E (Moore and Tate 1976); *E. melanogaster*, June 1925, AMNH 60327/July 1925, MCZ 24441/May 1926, AMNH 84766/July 1926, AMNH 84776/August 1926, AMNH 84777.
59. Kuatun (=Huaqiao): 1300 km NW of Showa near Bohea Mountain (Thomas, 1899), about 27.5°N, 117.2°E; *E. melanogaster*, 2400', October 1899, the holotype of *Microtus* (*Eothenomys*) *melanogaster colurnus* Thomas, 1911 (BM 0.5.8.38)/October 1896, BM 97.3.2.14/April 1898, BM 98.11.1.27/March 1899, BM 75.639–40/the dates of collecting are unknown, BM 5.6.1.11, 8.7.25.41, 8.8.11.101–103, 96.12.2.16, 98.11.1.28, 0.5.8.37, 0.5.8.39; USNM 141496 (3000'), 141497–500, 252186.

Taiwan

60. Chuei-feng, Nanton (=Nantow) Hsien: 24.08°N, 121.18°E (Jameson and Jones 1977); *E. melanogaster*, October 1961, USNM 332945/November 1961, USNM 332946–49, 332961/5900' and 6000', January 1962, USNM 332940–44.
61. Mei-feng, Nanton (=Nantow) Hsien; circa 24.07°N, 121.20°E (personal information of Dr. Terayama); *E. melanogaster*, 5500', January 1961, USNM 332957.
62. Lung Yuen Bridge, Wu-Sheh, Nan Ton (=Nantow) Hsien: 24.03°N, 121.13°E (Jameson and Jones 1977); *E. melanogaster*, January 1962, USNM 332950.
63. Wu-Sheh, Nan Ton (=Nantow) Hsien: 24.03°N, 121.03°E (Jameson and Jones 1977); *E. melanogaster*, October 1961, USNM 332951–56.
64. Mt. Alisan, Alishan, or Alishan St., Chiaai Hsien: 23.53°N, 20.80°E (Jameson and Jones 1977); *E. melanogaster*, November 1936, USNM 261037–39/March 1969, USNM 358357–59/6000', February 1962, USNM 332958–60.

India

65. Dreyi (=Delei), Mishmi Hills, Assam: near Minutang (=Chibaon), 28.25°N, 96.50°E (Kingdon Ward 1930); *E. mucronatus*, 5140', June 1921, the holotype of *Eothenomys melanogaster libonotus* Hinton, 1923 (BM 21.12.5.54), BM21.12.5.55–56.
66. Tokubama, Naga Hills (=Nagaland), Assam: about 26°N, 94°E; *E. mucronatus*, August 1950, FMNH 76434/September 1950, FMNH 76728, 76433.
67. Karong, Manipur, Manipur Hills, Assam: 25.1°N, 94.0°E; *E. mucronatus*, December 1950, FMNH 76432.

Burma (=Myanmar)

68. Adung Valley: 28.25°N, 97.67°E (Cranbrook 1960-61); *E. mucronatus*, 8000', May 1931, BM 32.11.1.123/8000', June 1931, BM 32.11.119–121, 32.11.1.124, 32.11.1.128, FMNH 40955–60.
69. Seinghku, near Haita: 28.10°N, 97.55°E (Kingdom Ward 1930); *E. mucronatus*, BM 25.3.7.18 (the date of collecting is unknown but probably in 1928, following Kingdom Ward 1930).
70. Imaw Bum, Kashin (=Kachin) Province: 26.13°N, 98.38°E (from the map of Anthony 1941); *E. mucronatus*, 9000', June 1919, the holotype of *Microtus* (*Eothenomys*) *cachinus* Thomas, 1921 (BM 20.8.7.14)/9000', January 1939, AMNH 115046–67.
71. Above Nyetmaw River: about 26.1°N, 98.5°E; *E. mucronatus*, 9200'- 9700', January 1939, AMNH 115074.
72. Nyetmaw River: 26.1°N, 98.5°E; *E. mucronatus*, 8600', January 1939, AMNH 115068–69, 115075.
73. Gangfang (=Kangfang): 26.1°N, 98.6°E (from the map of Anthony 1941); *E. melanogaster*, 5200', January 1939, AMNH 114939–82/5200', February 1939, AMNH114983–85, 115077.
74. Road to Chimeli Pass: about 26.1°N, 98.7°E; *E. mucronatus*, 10000', February 1939, AMNH 115108, 115115–16.
75. Hpawti (=Hpawte, near Gangfang): 26.01°N, 98.58°E (from the map of Anthony 1941); *E. melanogaster*, 7400', February 1939, AMNH 114987.
76. Tanatung (=Tangtung, near Gangfang): 26.01°N, 98.58°E (from the map of Anthony 1941); *E. melanogaster*, 5077' (Anthony 1941), February 1939, AMNH 114990–93.
77. Phyinlawska (=Hpinlawkha): about 26°N, 98.4°E (from the map of Anthony 1941); *E. melanogaster*, 4200', February 1939, AMNH 114988–89, 115127–28.
78. Hkamkawn: 25.98°N, 98.40°E (from the map of Anthony 1941); *E. melanogaster*, 4000', March 1939, AMNH 115001–02.
79. Hpimaw Road: 25.97°N, 98.60°E (from the map of Anthony 1941); *E. mucronatus*, 9000', February 1939, AMNH 114998, 115000, 115129, 115132–34, 115138–40.
80. Hpimaw: 25.97°N, 98.60°E (from the map of Anthony 1941); *E. melanogaster*, 7600', February 1939, AMNH 114994–97, 114999.
81. Langyang: 25.92°N, 98.25°E (from the map of Anthony 1941); *E. melanogaster*, 4600'(Anthony 1941), April 1939, AMNH 115043.
82. Htawgaw: 25.92°N, 98.33°E (from the map of Anthony 1941); *E. melanogaster*, 5600', March 1939, AMNH 115003,115041–42.
83. Pyepat: 25.88°N, 98.13°E (from the map of Anthony 1941); *E. melanogaster*, 6300' (Anthony 1941)/April 1939, AMNH 115044–45.
84. Luksuk (near Hpare): 25.83°N, 98.40°E; *E. melanogaster*, 5200', March 1939, AMNH 115004–05.
85. Hpare Pass: 25.83°N, 98.40°E (from the map of Anthony 1941); *E. mucronatus*, 9500', March 1939, AMNH 115146–48, 115151–52.
86. Hapare: 25.83°N, 98.40°E (from the map of Anthony 1941); *E. melanogaster*, 6000', March 1939, AMNH 115007, 115024–40.
87. Hapre-Saulang Road: 25.75°N, 98.40°E (from the map of Anthony 1941); 8200', March 1939, *E. melanogaster*, AMNH 115022–23, *E. mucronatus*, AMNH115044–45.
88. Changyinku: 25.70°N, 98.27°E (from the map of Anthony 1941); *E. melanogaster*, 7000', March 1939, AMNH 115009–115020/May 1939, AMNH 115008.
89. Mt. Victoria, Pakokku, Chin Hills: 21.12°N, 93.55°E; *E. mucronatus*, 2600 m, March 1938, AMNH 163651/2600 m, April 1938, AMNH 163650, 163652–55/2600m, May 1938, AMNH 163656/2600 m, June 1938, AMNH 163657.

Vietnam

90. Chapa, Tonkin, Lao Cai Province: 22.2°N, 103.5°E; *E. mucronatus*,1320 m, February 1929, MCZ 38226, FMNH 32307/5000', November 1929, BM 33.4.1.474–475, FMNH 32980–82/5000', December 1929, BM 33.4.1.476–477.

Thailand

91. The Summit of Doi Intheron, (Doi Inthanon-Angka Peak, 8452'), Chiangmai province: 18.58°N, 98.50°E; *E. mucronatus*, 8000', 8100', and 9000', March 1937, MCZ 35533–34, 35537–34543/July 1972, USNM 533346/2400 m, February 1979, HUM-HAno 230–234, 255, 257–258, 276.

Appendix 2. Fixing localities of Mt. Washan and the holotypes of *Microtus* (*Eothenomys*) *mucronatus* Allen, 1912 and *Microtus* (*Eothenomys*) *aurora* Allen, 1912

The holotype of *Microtus* (*Eothenomys*) *aurora* Allen, 1912 (MCZ 7788) was collected from Changyanshien, Hupeh (=Hubei), China. The location of Changyanshien (=Cahngyan Xian) has been deter-

mined as at either 30°25'N and 111°13'E (Moore and Tate 1965), 30°24'N and 110°06'E (Zhuang 1983), or 30°30'N and 111°12'E (Su 1984). I read the longitude and latitude of Changyan Xian as 30°29'N and 111°12'E from the Atlas Publication Cooperative Society (1979). Therefore, I adopt 30°30'N and 111°12'E (Su 1984) for Changyanshien.

The holotype of *Microtus* (*Eothenomys*) *mucronatus* Allen, 1912 (MCZ 7789) was collected from Tachiao, western Szechwan (=Sichuan) by W. R. Zappey. Moore and Tate (1965) determined Ta Chiao as circa 30°03'N and 103°13'E. Wang and Li (2000) noted that Daqiao is localted in Ganluo Xian (28°54'N, 102°54'E; Zhuang 1983). From the Library of MCZ, however, I was able to obtain the copy of the map figured by W. R. Zappey. The map reveals that Ta-chaio is located at about 15 miles south from Ta-chien-Lu (=Kangding; 30°00'N, 101°54'E, Su 1984) and between Liang-ho-kou and Mo-hsi-mien. According to Sasaki (1951) and Chengdu Geograph Institution, Academia Sinica (1983), the following is the coordinate of the localtion. Tachiao (=Taquiao) is located at the northeast side of Mt. Gonngaa Shan (=Mt. Minya Konka in English; 29°41'N, 101°54'E; Su 1984), and Linang-ho-kou is Lianghokow (29°48'N, 102°06'E); read from the Atlas Publication Cooporation Society (1979) and Mo-hsi-mien is Moxi (29°36'N, 102°06'E; Zhuang 1983). Therefore, Tachiao can be determined as 29°44'N, 102°06'E.

At Washan (Locality #23), five specimens of *Eothenomys melanogaster* examined in this study were collected by W. R. Zappey. Two holotypes of *Epimys zappey* Allen, 1912 (MCZ 7607) and *Sciurotamias davidanus thayri* Allen, 1912 (MCZ 8008) were collected also on the same locality as "Washan Mountains, western Szechwan (=Sichuan), China". On the fixation, however, there has been disagreement among four researchers. Wilson (1913: p. 245), who went to Hubei and Sichuan with Zappey, described Mt. Washan as 29°12'N and 103°14'E. Pope (1935) determined Washan as 29°12'N and 103°30'E. Moore and Tate (1965) listed it as circa 29°25'N and 104°20'E. Musser and Chiu (1979) only referred it in Sichuan province for the taxonomic revision of the type of *Epimys zappey*. Washan Mountains are located at about 30 miles southwest from Mt. Omei (= Mt. Emei Shan) and at five miles west-north west of the Chin-kou-hou along River Dadu He by one of the maps figured by Zappey and housed in the Library of MCZ. The location of the map accords with that of Guancunba (29°12'N, 103°00'E; Zhuang 1983), though this mountain is not marked on the Atlas Publication Cooperative Society (1979). I, therefore, determined Washan as 29°12'N, 103°00'E.