

## Some Fossil Arvicolid Rodents from the Pinza-Abu Cave, Miyako Island, the Ryukyu Islands, Japan

Yukibumi Kaneko and Yoshikazu Hasegawa

**Abstract.** A total of 680 isolated molars and three lower jaws with molars aged as of the late Pleistocene (25,800±900 y.B.P. and 26,800±1,300 y.B.P.) were recovered from the Pinza-Abu Cave, Miyako Island, the Ryukyu Islands, Japan, in 1982-83. All fossil molars with a prismatic enamel pattern are rootless. Among them 82 specimens of the first lower molars were identified as *Microtus fortis*, five ones as *M. oeconomus*, and seven unidentified first lower molars were recorded. Without being assigned to genus, 74 specimens of the third upper molars have an intermediate form with four internal salient angles and with open dentine spaces between the first and second triangles following the anterior loop. Two specimens of the second upper molars were identified as *M. oeconomus* because of the occurrence of an additional reentrant fold in the second external closed triangles. The discovery of the fossil from the Miyako Island indicates the most southern distribution of *M. fortis* and *M. oeconomus* in the late Pleistocene, and disagrees with paleobotany and paleogeography previously reported.

### Introduction

The Ryukyu Islands belongs to the most southern part of the Nansei Islands, which lie from Kyushu, Japan, to Taiwan in the East China Sea. The recent mammal fauna of the Ryukyu Islands differs from that of Kyushu and Honshu, Japan, and the Watase Line between the two faunae demarcates the Palaearctic from the Oriental Region (Kuroda, 1939; Imaizumi, 1970). From the Islands of Miyako and Okinawa, the Ryukyu Islands, however, only small fossil rodents of *Diplothrix legata* and *Tokudaia osimensis* have been reported (Takai and Hasegawa, 1971; Hasegawa *et al.*, 1973; Kowalski and Hasegawa, 1976; Kawamura, 1989). Thus, zoogeographical studies on small fossil rodents have been little known in the Ryukyu Islands.

From the Pinza-Abu Cave, the Miyako Island of the Ryukyu Islands, some kinds of Arvicolidae fossil molars and lower jaws were recovered in large numbers in 1982-83, though none of the living arvicolid rodents is distributed now in the Ryukyu

Islands. The purpose of this paper is to describe and identify some fossils of the arvicolid molars, comparing with the recent arvicolids of Japan and neighboring countries, and discusses the meaning of the discoveries with other studies of fossils, paleobotany and paleogeography on the Ryukyu Islands. We acknowledge the Division of Culture, Department of Education, Okinawa Prefecture, and the Agency of Culture, the Ministry of Education, Science and Culture, Japan for loaning fossil materials to the present study, and the Yamashina Institute for Ornithology for allowing me to examine the specimens of *Microtus* in China.

### Materials

Fossil molars were recovered from the Pinza-Abu Cave (24°44'50" N, 125°20'08" E), which locates at Ueno Village, Miyako County (Miyako Island), Okinawa Prefecture. The altitude of the entrance of the cave is 53 m from the sea level.

The collection was carried out during November

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20-27, 1982 (the first Division) and from July 25 to August 5, 1982 (the second and third Divisions). The environmental condition of these Divisions was described by Kishimoto (1985). The deposits in the cave were estimated to have been formed at  $25,800 \pm 900$  y.B.P. and  $26,800 \pm 1,300$  y.B.P. by the  $^{14}\text{C}$  method (Hamada, 1985), i.e. the later part of Pleistocene by the F-contents (Matsuura, 1985).

The number of arvicolid fossils was 680 isolated molars, one lower jaw with two molars, and two lower jaws with one molar with a prismatic enamel patterns. For identification and description we examined two specimens of the second upper molars, 74 ones of the third upper molars, and 82 ones of the first lower molars, one of which one molar puts together with the second lower molar on a lower jaw. Others are 151 specimens of the first upper molars, 64 ones of the second upper molars, 119 ones of the second lower molars and 41 ones of the third lower molars.

The fossils were compared with the following

specimens of ten living species of *Microtus* for the identification: *Microtus montebelli* = 22 (Kyoto, Japan), *M. agrestis* = 8 (six from Finland and two from France), *M. oeconomus* = 15 (the Kola (=Kol'skii) Peninsula and the Kurile Islands, Russia), *M. fortis* = 15 (Jilin and Anhui Provinces, China), *M. maximowiczii* = 1 (Heilongjiang Province, China), *M. kikuchii* = 10 (Taiwan), *M. mandarinus* = 2 (Shanxi Province, China), and *M. brandti* = 10 (Inner Mongolia, China). The enamel pattern of *M. sachalinensis* was referred to the figures of Vasin (1955) and Meyer (1978).

The molars were measured following Meyer (1978; Fig. 1). The measurements were taken to the nearest 0.01 mm under a stereomicroscope (Nikon SMZ-10) with levels of 40 magnification attached an objective micrometer produced by Kogaku. Enamel patterns were drawn using the microscope with an accessory drawing apparatus by 14 magnifier.

Enamel patterns on the third upper molars were classified into three types according to Miyao (1961):

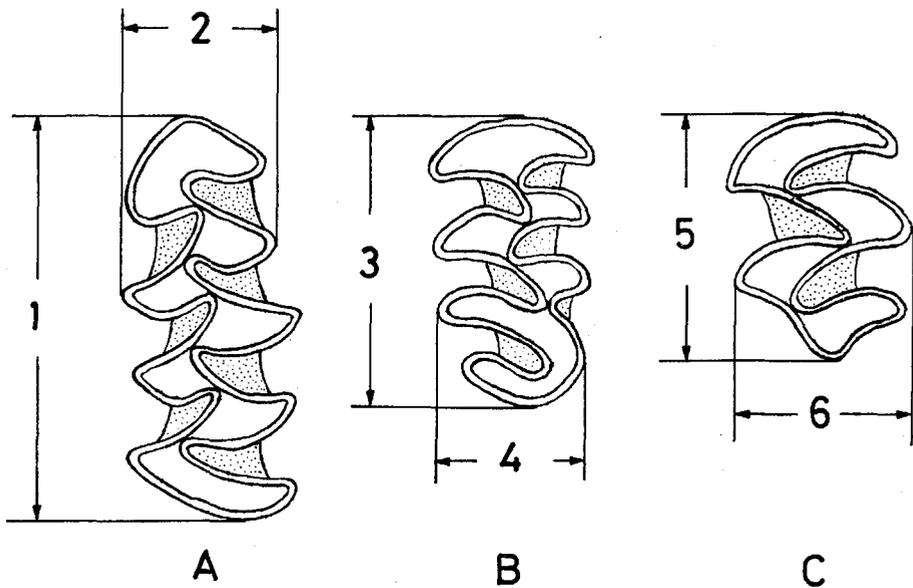


Fig. 1. Six measurements (1-6) of Arvicolidae molars. A, the first lower molar (1=length and 2=width); B, the third upper molar (3=length and 4=width); C, the second upper molar (5=length and 6=width).

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the complex form with three reentrant folds on the lingual side and with posterior concavity on the posterior loop; the intermediate form with three reentrant folds on the lingual side and without posterior concavity on the posterior loop; the simple form with two reentrant folds on the lingual side.

The scientific names followed Honacki *et al.* (1982) and the terminology of the molar morphology followed Carleton (1985). Registration numbers are shown as the collections of the Okinawa Prefecture Museum (OPM).

## Results

### 1) The first lower molars

All examined molars have no root. The first lower molar has four to five closed triangles in front of the posterior loop in 82 specimens. The molar with five closed triangles is a diagnostic character for the genus *Microtus* except for *M. oeconomus*, *M. millicens*, *M. musseri*, and variant of *M. nivalis* (Lawrence, 1982).

Among 82 specimens of the first lower molars, 69 isolated molars and one molar with a lower jaw (OPM 3.4.4.18) were identified as *M. fortis*, which has five closed triangles and a round anterior loop with a small anteroexternal concavity. *M. fortis* slightly resembles *M. kikuchii* in the shape of the anterior loop among the species of *Microtus* living in eastern Asia, but *M. kikuchii* has the loop with a deeper fold anteriorly, the shape of which is a reverse V- or U-like form (Kaneko, 1987). Six examples of *M. fortis* are exhibited in Fig. 2 (a-f). Table 1 shows measurements of 63 undamaged specimens among 70 fossil specimens of *M. fortis*. The fossil molars show significantly longer and wider than those of living *M. fortis* ( $t = 5.343$ ,  $p < 0.001$  and  $df = 76$  in the length;  $t = 5.244$ ,  $p < 0.001$  and  $df = 76$  in the width). No significant difference between the two regression lines of the fossil and living ones (Fig. 3;  $t = 0.665$ ,  $p > 0.5$  and  $df = 74$ ).

Five molars could be identified as *M. oeconomus* (Fig. 2; g-k), because the first lower molar has four

closed triangles in front of the posterior loop and three internal salient angles. Living *M. oeconomus* has three internal salient angles in contrast to four angles in living *M. nivalis* (Hinton, 1907; Kowalski, 1957), though the dental space of *M. nivalis* is sometimes confluent between the fifth triangle and the anterior loop, which looks like *M. oeconomus*. No significant difference was found in the length and width between the fossil and living *M. oeconomus* (Table 1;  $t = 2.025$ ,  $0.05 < p < 0.1$  and  $df = 18$  in the length;  $t = 0.553$ ,  $p > 0.5$  and  $df = 18$  in the width). The measurements of the fossils are included in a cluster composed of those of the living ones except for one specimen (POM 2.3.1.4.13 indicated as g in Fig. 3). No significant difference between the two regression lines of the fossil and living *Microtus* (Fig. 3;  $t = 0.662$ ,  $p > 0.6$  and  $df = 16$ ).

Six fossil molars could not be assigned to any of the known species (Fig. 2; m-r). These molars have characteristics in which the triangles meet at the median longitudinal axis and the anterior loop has both external and internal concavities, which are observed in *M. montebelli*, *arvalis*, *agrestis*, *maximowiczii*, and *sachalinensis*. Four of them (Fig. 2; m-p) are larger and wider than two other fossil molars (Fig. 2; q-r) and specimens of two living species, *M. montebelli* and *M. agrestis* (Fig. 3).

One example could not be identified (Fig. 2; l). The molar has following characteristics: a sharp salient angle appears on the right and left, the dentine space of the fifth salient angle is confluent to the anterior loop, the shape of the anterior loop looks like a mushroom, and the enamel lamellae is thinner than the fossils examined here.

### 2) The third upper molars

The third upper molar usually is not useful for the identification of the vole species except for a few cases, because it has individual, age and geographical variations. We, therefore, only describe some characteristics found in 74 specimens. Forty-one molars are of the right and 33 are of the left. They have an anterior loop followed by three alternating

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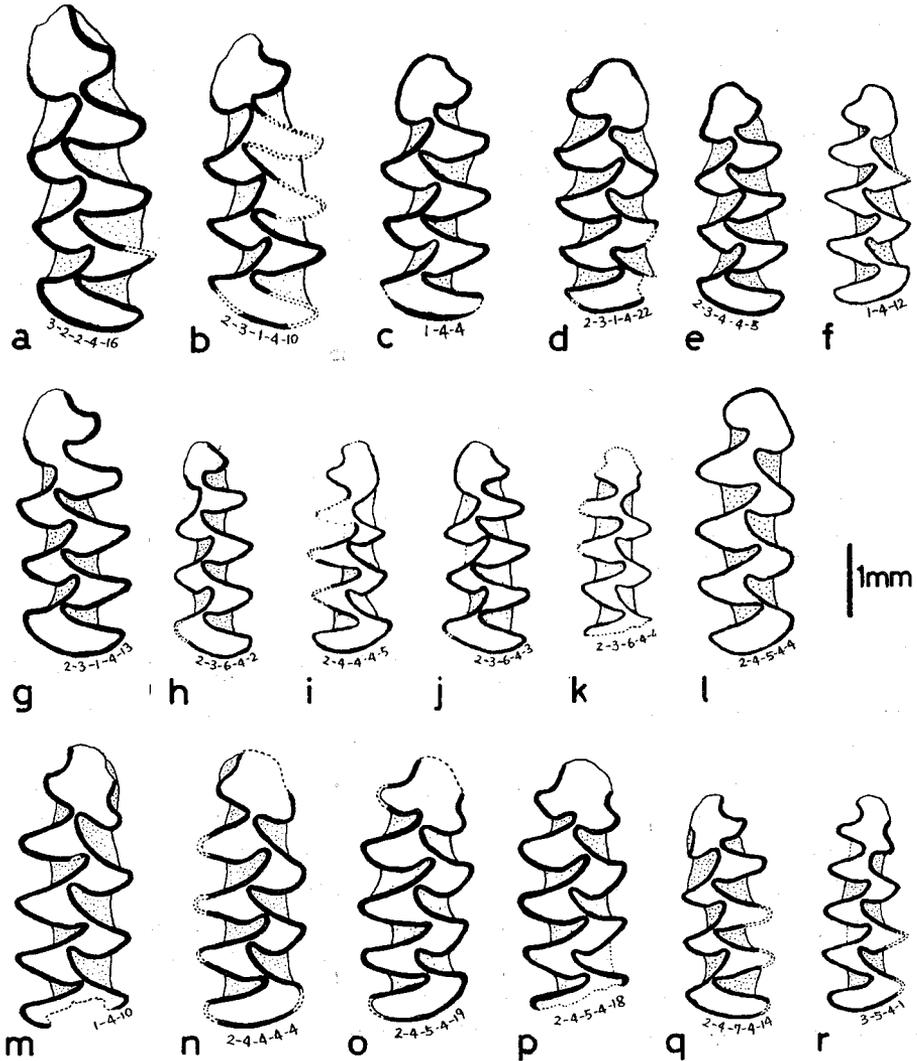


Fig. 2. The first lower molars of six specimens (a-f) of *Microtus fortis*, five specimens (g-k) of *M. oeconomus*, and not identified specimens (l-r). a, OPM 3.2.2.4.16; b, OPM 2.3.1.4.10; c, OPM 1.4.4; d, OPM 2.3.1.4.22; e, OPM 2.3.4.4.5; f, OPM 1.4.12; g, 2.3.1.4.13; h, OPM 2.3.6.4.2; i, OPM 2.4.4.4.5; j, OPM 2.3.6.4.3; k, OPM 2.3.6.4.4; l, OPM 2.4.5.4.4; m, OPM 1.4.10; n, OPM 2.4.4.4.4; o, OPM 2.4.5.4.19; p, OPM 2.4.5.4.18; q, OPM 2.4.7.4.14; r, OPM 3.5.4.1.

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Table 1. Measurements of the length and width of the first lower molars and regression equations in fossil (F) and living (L) species of *Microtus*. Mean  $\pm$  standard deviation and range in parentheses.

Species name	N	Molar length(X)	Molar width(Y)	Regression equation
<i>M. fortis</i> (F)	63	3.56 $\pm$ 0.27 (2.86-4.31)	1.42 $\pm$ 0.11 (1.00-1.74)	Y=0.30+0.31X
<i>M. oeconomus</i> (F)	5	2.95 $\pm$ 0.35 (2.65-3.55)	1.11 $\pm$ 0.15 (1.00-1.36)	Y=-0.09+0.41X
<i>M. fortis</i> (L)	15	3.17 $\pm$ 0.20 (2.80-3.45)	1.26 $\pm$ 0.07 (1.10-1.35)	Y=0.69+0.18X
<i>M. oeconomus</i> (L)	15	2.71 $\pm$ 0.20 (2.47-3.07)	1.08 $\pm$ 0.09 (0.90-1.26)	Y=0.43+0.24X
<i>M. kikuchii</i> (L)	10	3.03 $\pm$ 0.16 (2.76-3.35)	1.25 $\pm$ 0.06 (1.10-1.32)	Y=0.77+0.16X
<i>M. montebelli</i> (L)	22	2.92 $\pm$ 0.15 (2.69-3.20)	1.14 $\pm$ 0.08 (1.00-1.30)	Y=0.24+0.31X
<i>M. agrestis</i> (L)	7	2.76 $\pm$ 0.15 (2.56-3.05)	1.07 $\pm$ 0.07 (0.95-1.15)	Y=0.39X

closed triangles, i.e. one internal and two outer. Some molars, however, have the second and third triangles, and/or the third and fourth triangles between which they have a confluent dentine space, respectively (Table 2). No statistical independence was shown in the dentine confluence between both sides by the *G*-test with Williams' adjustment (Sokal and Rohlf, 1973;  $G_{adj} = 4.830$ ,  $0.1 < p < 0.25$  and  $df = 3$ ). Molars with the confluence between the third and fourth triangles are the most common among the total molars including those of both sides.

No simple form of the enamel pattern was found in 74 specimens (Table 3). No statistical independence of the patterns between the two intermediate and complex forms was shown between the both sides by the *G*-test with Williams' adjustment (Sokal and Rohlf, 1973;  $G_{adj} = 0.380$ ,  $0.5 < p < 0.75$  and  $df = 1$ ). The intermediate form is the most common among the total specimens consisting of those of both sides.

Among 74 specimens of the third upper molars, 44 specimens are able to measure because others cannot measure due to damage. Five examples of 44 specimens are shown in Fig. 4 (a-e). A regression line between the length and the width was drawn by 40 specimens, excluding four molars which are

exceptional form having slightly short length, or one or two confluent dentine spaces (Figs. 4 and 5; f-i). The 40 specimens are slightly longer and wider than living species of *Microtus* except for the width in *M. kikuchii* (Table 4).

### 3) The second upper molars

Two examples of the molars were identified as those of *M. oeconomus* (Fig. 3; j-k), because the second external closed triangle has a small additional reentrant fold at the anterior edge. This additional fold has been reported in both living *M. nivalis* (Kowalski, 1957) and living *M. oeconomus* (Ruprecht, 1967) among *Microtus* species. But, we identified them as the molars of *M. oeconomus* because living *M. nivalis* is distributed from southwest of Europe to Iran (Corbet, 1978). They are 2.30 mm long and 1.43 mm wide (POM 2.2.2.2.6), and 2.03 mm and 1.30 mm (POM 3.2.2.1), respectively. The two fossil molars are larger than those of living *M. oeconomus* (Fig. 6; j-k) and other living species of *Microtus* (Table 5).

## Discussion

First, we discuss the reason why we do not refer the scientific names of fossil *Microtus* in the results. As

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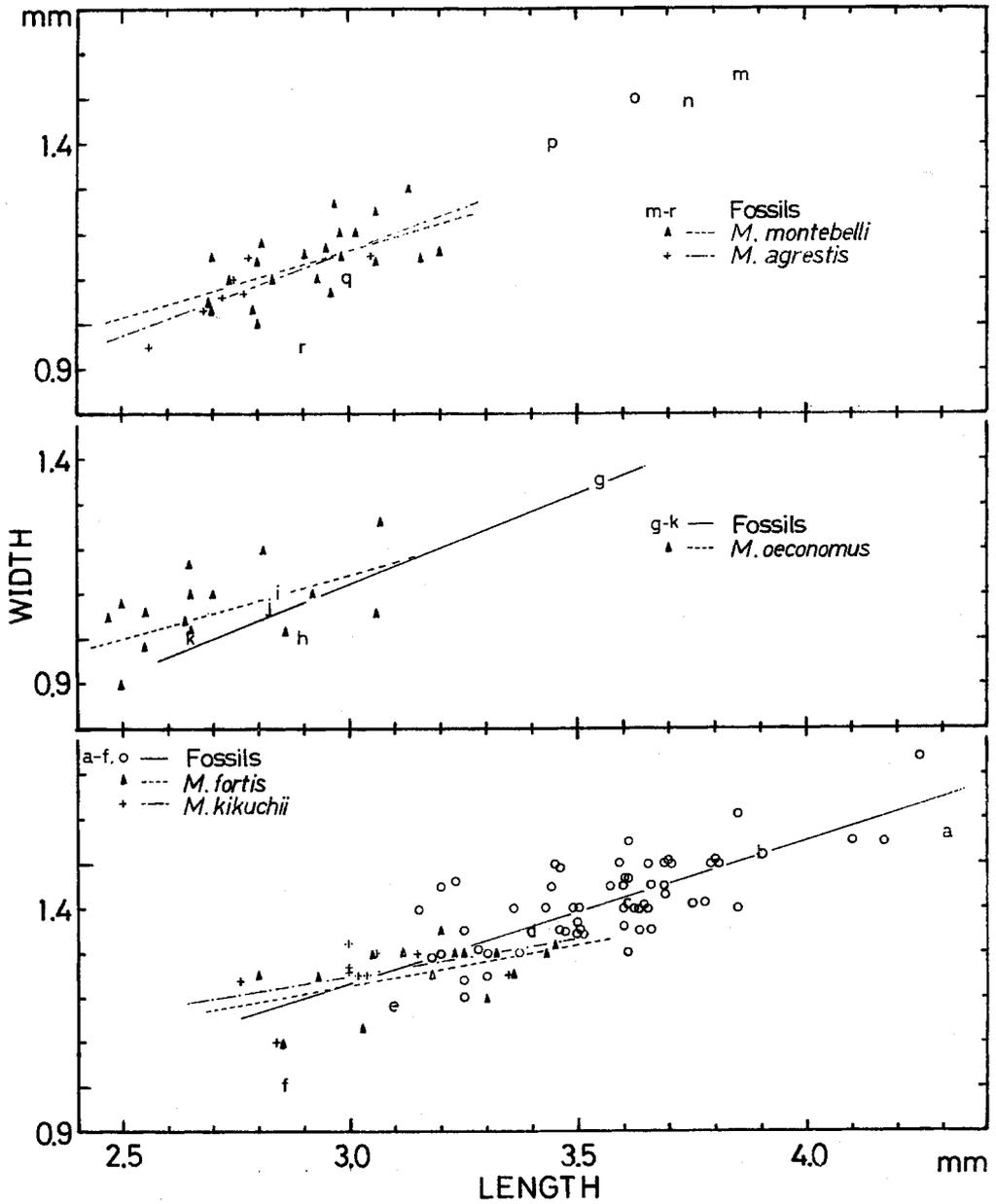


Fig. 3. Scatter diagrams of the length and width of the first lower molar. The registration number for the specimens (a-r) is shown in Fig. 2.

regards fossil species of *Microtus* at the middle and late Pleistocene in China and Japan, *Microtus epiratticeps* (Young, 1934), *M. brandtioides* (Young, 1934), and *M. complicidens* (Pei, 1936) from China, and *M. epiratticepoides* (Kawamura, 1988) from Japan have been described. Young (1934) and Pei (1936), however, did not designate the holotypes of *M. epiratticeps*, *M. brandtioides*, *M. complicidens*, respectively, and figured some enamel patterns on the first lower molars in respective species, which resemble those of living *M. oeconomus*, *M. fortis*, *M. mandarinus*, and/or *M. brandti*. Because we cannot decide what characters can be qualified for these species of *Microtus*, we consider that the descriptions done by Young (1934) and Pei (1936) are problematic and we need to reexamine the type series and designate the lectotypes.

Kawamura (1988) identified many fossil species of Arvicolidae from Japan in the middle and late Pleistocene and recognized *Microtus epiratticepoides* as a new species referring *M. epiratticeps* described by Young (1934). In describing the diagnostic characters of the new species, Kawamura (1988) gave both characters of the third upper and first lower molars, though he designated the third upper isolated molar as the holotype and did not show a fact that the third upper and first lower molars are combined together as one specimen. Furthermore, some enamel patterns of the anterior loop of the first lower molar in *M. epiratticepoides* shown by Kawamura (1988) coincide with those of fossil *M. epiratticeps* (Young, 1934).

Therefore, we suspend the validity of *M. epiratticeps*, *M. brandtioides*, *M. complicidens*, and *M. epiratticepoides* until the reexamination of these type series to prevent taxonomic confusion.

In this study we deal with *M. epiratticeps* Young, 1934 as a synonym of *M. oeconomus*. Young (1934) gave the following three characters for the species: 1) the posterior transverse loop of the third lower molar is wider in *epirratticeps* than in *oeconomus* and other two transverse loops are less alternating in

*epirratticeps* in position; 2) the internal convexity develops very faintly in the anterior loop of the first lower molar; 3) the anterior transverse loop of the first lower molar lacks a fold or is faintly developed. Tokuda (1939), however, remarked that the characters of 1) and 3) are not sufficient for discriminating the two species. Hasegawa *et al.* (1977) said that *M. epiratticeps* would be a synonym of *M. oeconomus* in spite of the size difference in the molar length. Kowalski and Hasegawa (1976) and Kawamura and Kajiura (1990), however, used the name of *M. epiratticeps* without comments. Because some specimens of *M. epiratticeps* shown by Young (1934) could be identified as *M. fortis* as mentioned above and the figures drawn by Young (1934) did not accord with his given characters, we cannot confirm his diagnostic characters. We agree with Tokuda (1939) who regarded *M. epiratticeps* as a junior synonym of *M. oeconomus*.

Referring to localities in eastern Asia, fossils identified as *M. oeconomus* have been reported both in Japan and China. Fossil *M. oeconomus* has been found in Manchuria (Tokuda, 1939) and Beijing (Pei, 1940), China, and in Honshu, Japan (Kowalski and Hasegawa, 1976; Hasegawa *et al.*, 1977; Kawamura and Kajiura, 1980) in the late Pleistocene; in Beijing, China (Young, 1934; Pei, 1931, 1936) and in Honshu, Japan (Kowalski and Hasegawa, 1976) in the middle Pleistocene. *M. cf. brandti* reported by Pei (1931) and *M. complicidens* by Pei (1936) also appear to correspond with fossil *M. oeconomus* (= *M. ratticeps*). Living *M. oeconomus* occurs throughout the entire tundra and taiga zones of the northern Palaearctic (Corbet, 1978), and the fossil *M. oeconomus* on the Miyako Island is the southernmost record beyond the known range of the distribution of both the fossil and living *M. oeconomus*.

As regards fossil *M. fortis*, only Tokuda (1939) has reported it from Harbin, northeast China, though he called it as *M. cf. pelliceus* (= now *M. fortis*; Corbet, 1978). The figured enamel pattern of the anterior loop of the first lower molar agrees well with that of fossil

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Table 2. Frequency on the occurrence of the dentine space separated or in confluent in the third upper fossil molars.

Dentine spaces	Confluent			Separated	Total
	2nd-3rd	3rd-4th	2nd-3rd-4th		
The left	1 (3.0%)	17 (51.5%)	6 (18.2%)	9 (27.3%)	33
The right	2 (4.9%)	18 (43.9%)	2 (4.9%)	19 (46.3%)	41
Total	3 (4.1%)	35 (47.3%)	8 (10.8%)	28 (37.3%)	74

Table 3. Frequency of three enamel patterns in the third upper fossil molars. Three patterns were determined following Miyao (1961).

	Three enamel patterns				Damaged	Total
	Simple	Intermediate	Complex	Total		
The left	0	24 (72.7%)	1 (3.0%)	25	8	33
The right	0	38 (92.7%)	1 (2.4%)	39	2	41
Total	0	62 (96.9%)	2 (3.1%)	64	10	74

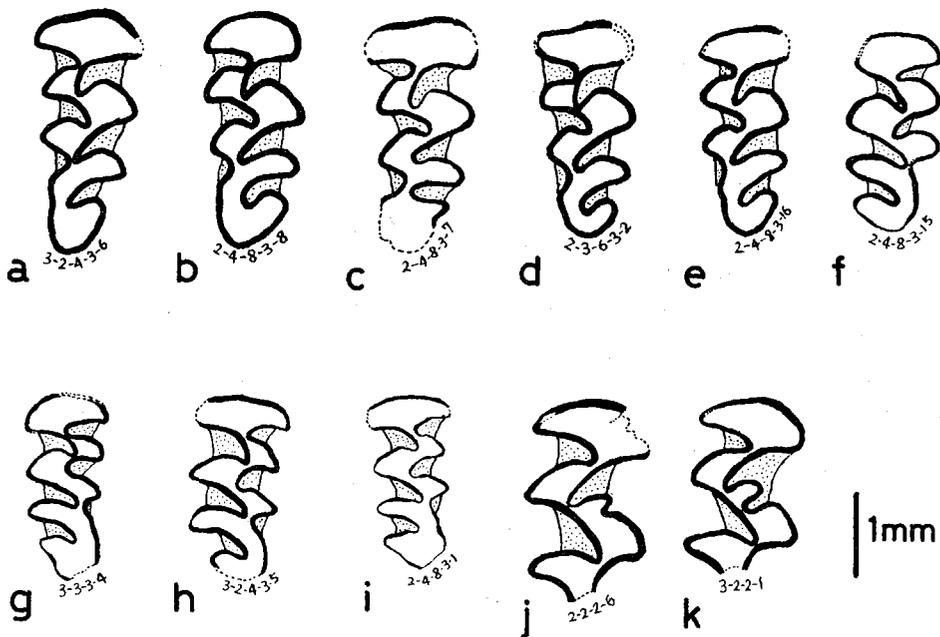


Fig. 4. The third upper molars (a-i) of not identified nine specimens and the second upper molars (j-k) of *M. oeconomus*. a, OPM 3.2.4.3.6; b, OPM 2.4.8.3.8; c, OPM 2.4.8.3.7; d, OPM 2.3.6.3.2; e, OPM 2.4.8.3.16; f, OPM 2.4.8.3.15; g, OPM 3.3.3.4; h, OPM 3.2.4.3.5; i, OPM 2.4.8.3.1; j, OPM 2.2.2.6; k, OPM 3.2.2.1.

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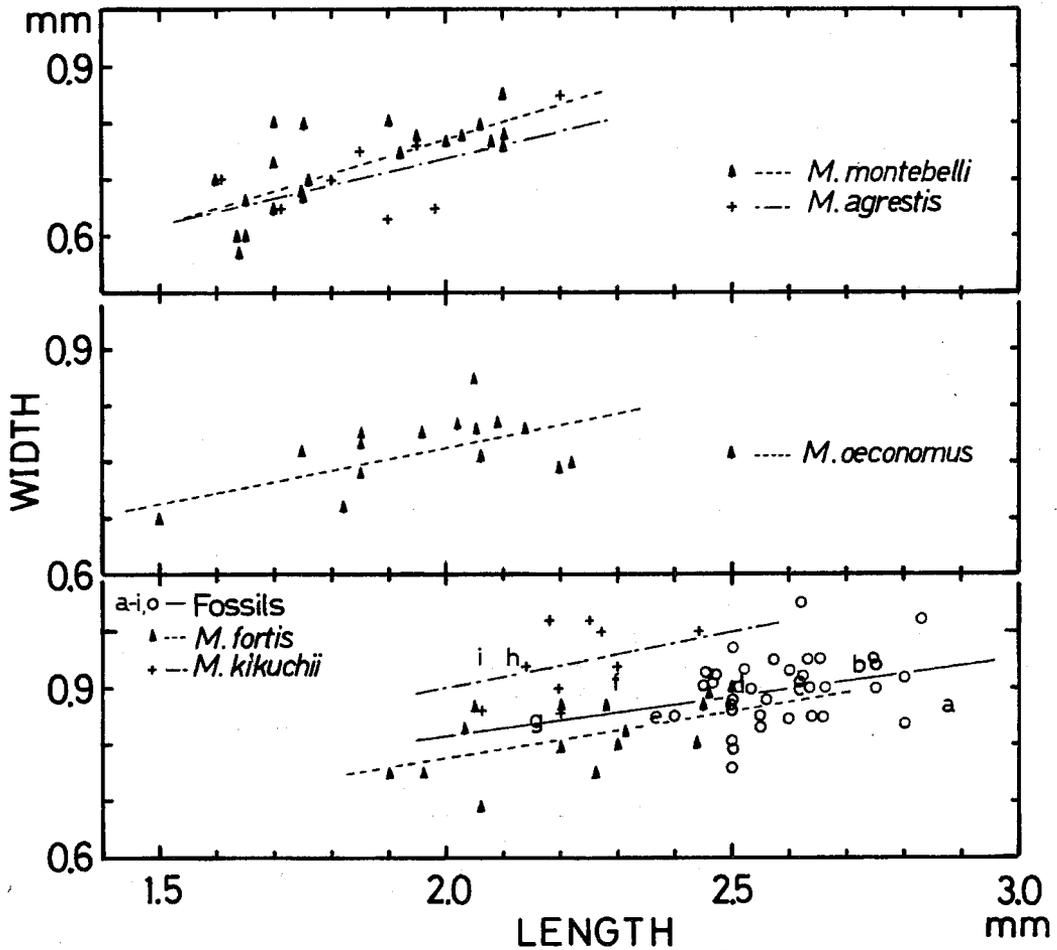


Fig. 5. Scatter diagrams of the length and width of the third upper molar. The registration number for the specimens (a-i) is shown in Fig. 4.

*M. fortis* examined in this study. The measurements of the molar (Table 1) are larger than those of the two specimens described by Tokuda (1939).

A character of the anterior loop of the lower first molar in *M. fortis* agrees with the figures given by Young (1934), Pei (1936, 1940), Teilhard de Chardin and Pei (1941), Chi (1974), Kowalski and Hasegawa (1976), and Kawamura and Kajiura (1980). These authors, however, reported their fossils as *M. brandtioides* (Young, 1934; Teilhard de Chardin and Pei, 1941; Chi, 1974), *M. epiratticeps* (Young, 1934;

Pei, 1940; Kowalski and Hasegawa, 1976; Kawamura and Kajiura, 1980), or *M. complicidens* (Pei, 1936). The diagnostic character mentioned by Pei (1936) is not correct (cf. Corbet, 1978) because he only took the number of absolutely closed triangles on the first lower molar into consideration, instead of the enamel pattern of the anterior loop. Two fossils (NSM 9939-4 and NSM 10028) in the National Science Museum of Japan (NSM), which have been described as *M. epiratticeps* by Kowalski and Hasegawa (1976) were identified as *M. fortis* by one of the present authors

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Table 4. Measurements of the length and width of the third upper molars and regression equations in fossil (F) and living (L) species of *Microtus*. Mean±standard deviation and range in parentheses.

Species name	N	Molar length(X)	Molar width(Y)	Regression equation
<i>Microtus</i> spp. (F)	40	2.59±0.12 (2.37-2.88)	0.90±0.06 (0.76-1.05)	Y=0.53+0.14X
<i>M. fortis</i> (L)	15	2.23±0.19 (1.90-2.50)	0.82±0.06 (0.69-0.90)	Y=0.40+0.19X
<i>M. oeconomus</i> (L)	15	1.96±0.19 (1.50-2.22)	0.72±0.07 (0.58-0.85)	Y=0.34+0.19X
<i>M. kikuchii</i> (L)	9	2.23±0.11 (2.06-2.44)	0.95±0.06 (0.86-1.02)	Y=0.22+0.33X
<i>M. montebelli</i> (L)	22	1.84±0.18 (1.60-2.10)	0.73±0.08 (0.57-0.85)	Y=0.15+0.31X
<i>M. agrestis</i> (L)	8	1.87±0.18 (1.61-2.20)	0.71±0.07 (0.63-0.85)	Y=0.27+0.23X

Table 5. Measurements of the length and width of the second upper molars and regression equations in fossil (F) and living (L) species of *Microtus*. Mean±standard deviation and range in parentheses.

Species name	N	Molar length(X)	Molar width(Y)	Regression equation
<i>M. fortis</i> (L)	15	1.89±0.12 (1.74-2.10)	1.20±0.08 (1.05-1.29)	Y=0.50+0.37X
<i>M. oeconomus</i> (L)	15	1.73±0.10 (1.58-1.86)	1.07±0.08 (0.88-1.20)	Y=-0.05+0.65X
<i>M. kikuchii</i> (L)	9	1.84±0.06 (1.75-1.90)	1.26±0.05 (1.19-1.35)	Y=1.20+0.03X
<i>M. montebelli</i> (L)	22	1.72±0.10 (1.52-1.93)	1.12±0.09 (0.96-1.27)	Y=0.05+0.62X
<i>M. agrestis</i> (L)	8	1.67±0.10 (1.53-1.85)	1.05±0.10 (0.95-1.20)	Y=-0.22+0.76X

(Kaneko).

As well as fossil *M. fortis* identified by Tokuda (1939), these fossils which I could identify as *M. fortis* mentioned in the previous paragraph have been aged as either of the late or middle Pleistocene: Research Group of Higher Vertebrates at the Institution of Paleovertebrates (1959) estimated the excavation site reported by Tokuda (1939) as of the late Pleistocene; Pei (1940), Chi (1974), Kowalski and Hasegawa (1976; NSM 10028), and Kawamura and Kajiura (1980) are the late Pleistocene; Young

(1934), Pei (1936), Teilhard de Chardin and Pei (1941), and Kowalski and Hasegawa (1976; NSM 9939-4) are the middle. From these information, it is apparent that fossil *M. fortis* was distributed throughout the areas of Miyako Island, the Ryukyu Islands, Honshu, Japan, Manchuria, Beijing, and Shensi Province, China in the late Pleistocene. On the other hand, the living *M. fortis* is found in the highlands of Fukien (von Lehmann, 1955; Hong, 1982), Chekiang (Zhuge, 1982), and from the lower Yangtze Valley through Manchuria and Korea

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northward to the Amur Valley, westward to the Lake Baikal (Corbet, 1978). Thus, the occurrence of fossil *M. fortis* from the Miyako Island (about 24° 45' N) means to extend the southern limit of the distribution range and it is very close to that of the living *M. fortis* in Fukien, where the southern boundary lies at 27° N.

The total molar lengths of recent *M. fortis* are slightly longer from Fukien, China (von Lehman, 1955; Hong, 1981) and South Korea (Jones and

Johnson, 1955) than from Heilongjiang (=Manchuria), China (Ma, 1986) and southern Siberia (Meyer, 1978). Thus, the fossil *M. fortis* from the Miyako Island may belong to one of the southern forms of *M. fortis*. However, it is difficult to estimate the route through which the fossil *M. fortis* moved to colonize the Miyako Island: that is from Taiwan or Kyushu.

Arvicolid rodents which include *M. fortis* and *M.*

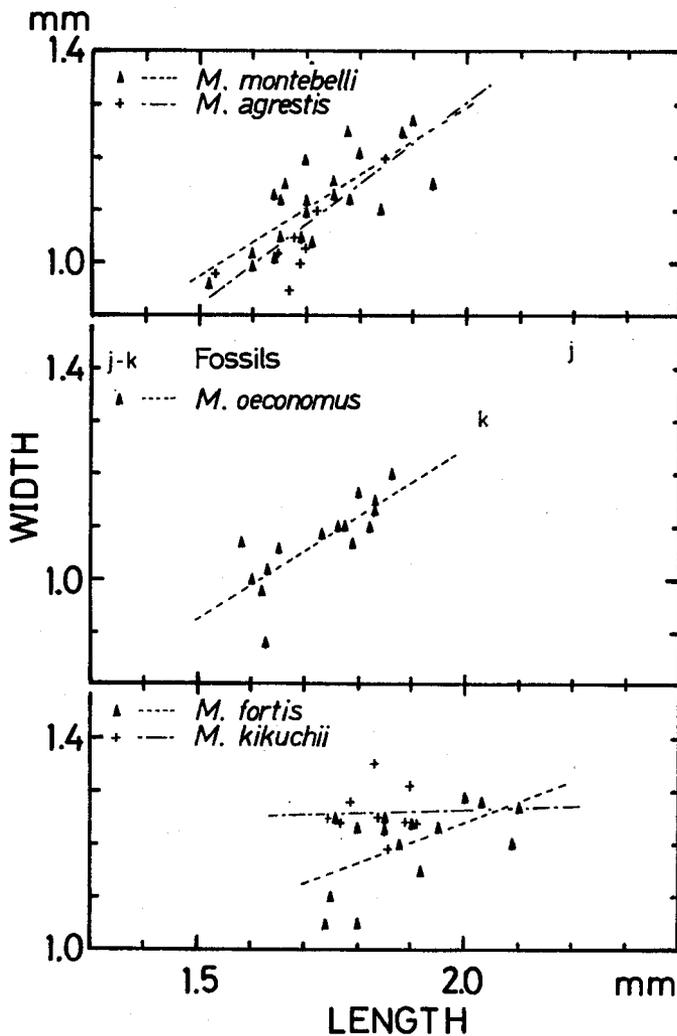


Fig. 6. Scatter diagrams of the length and width of the second upper molar. The registration number for the specimens is shown in Fig. 4.

*oeconomus* are Holarctic mammals and are distributed mainly throughout Northern Hemisphere from about 23.5° N (Carleton and Musser, 1984). Many recent Palaearctic mammals including *M. fortis* are distributed to the northern part of 19°C isotherms in Fukien, China (Hong, 1982). Studies on recent mammals have indicated that the Watase line on Nansei Islands, Japan, and the River Yangtze in China demarcates the Palaearctic Region from Oriental one (Kuroda, 1939; Hwang *et al.*, 1966, 1978; Imaizumi, 1970). Therefore, it is possible that after *M. fortis* and *M. oeconomus* had colonized on the Miyako Island from the continent, the Island was isolated from it and would become a small area in the ocean. And, because the climate has become warming up (now average temperature in a year is 23.1°C by the Japan Meteorological Agency, 1981) and changing the flora and fauna since that time, it would cause the extinction of *M. fortis* and *M. oeconomus*.

Finally we consider the discoveries of the fossil *M. fortis* and *M. oeconomus* on the Miyako Island in relation with the information of paleobotany and paleogeography. The flora of the Miyako Island in the late Pleistocene has been estimated as evergreen broad-leaved forests (Kamei and Research Group for biogeography from Würm Glacial, 1981). The habitats of the two living voles, however, are grassy and wet areas near water. For example, the living *M. fortis* inhabits banks of rivers, more or less swampy grounds (Thomas, 1902; Sowerby, 1923; Hong, 1981), abandoned paddies (Jones and Johnson, 1965), and meadows (Nadachowski, 1984), as well as the living *M. oeconomus* prefers wet, grassy and marshy habitats (Corbet, 1966). If the two fossil voles preferred the same habitats as the two living ones do, the northern and grassy flora might have been existed on the Miyako Island in the late Pleistocene. Therefore, there is a discrepancy between the preferred habitats of the voles and the findings in paleobotany.

Two living endemic species of rats, i.e. the Ryukyu spiny rat (*Tokudaia osimensis*) and the Ryukyu long-

haired rat (*Diplothrix legata*), originated from the Oriental Region are distributed on the islands of Amami-ooshima, Tokunoshima, and Okinawa, the Ryukyu Islands (Tokuda, 1941; Kaneko, 1994). Misonne (1969) explained that both species have colonized by an oceanic drift (=Kuro Shio), which running from the eastern coast of Luzon, Philippines, because the two species have no relatives on Chinese mainland nor on Taiwan. However, this explanation could be denied by the discoveries of *Diplothrix legata* and *Tokudaia osimensis* from the Ryukyu Islands in the late Pleistocene (Hasegawa *et al.*, 1973; Kawamura, 1989). Because the two species of rats live in evergreen forests dominated by *Castanopsis sieboldii* (Mitsui and Ikehara, 1979), the Miyako Island might be covered by evergreen forests in the late Pleistocene, if the two species required the same habitats at the time. This suggestion, however, is not consistent with the discoveries of fossil *Microtus fortis* and *M. oeconomus* from the Miyako Island in the late Pleistocene which prefer grassy habitats, but agrees well with the flora at the time estimated by (Kamei and Research Group for Biogeography from Würm Glacial, 1981).

From the viewpoint of paleogeography, Kizaki and Oshiro (1977) and Oshima (1979) supposed that the Ryukyu Islands have been isolated from Taiwan and the northern part of Nansei Islands in the middle Pleistocene after connecting with Taiwan and the continent of eastern Asia in the early Pleistocene. On the other hand, Hasegawa *et al.* (1973) and Hasegawa (1980) suggested from the discoveries of *Rattus* (= *Diplothrix*) cf. *legata*, *Sus*, and *Tetsudo emys?* (Reptilia: Chelonia) from the Miyako Island that the Ryukyu Islands would be connected with the continent even in the late Pleistocene. The difference between the two opinions means whether the two species of *Microtus* living in grasses and the two species of rats living in forests can inhabit together on the Miyako Island or not, even in a small area. We, therefore, take into consideration of the recent small voles' and mice's fauna on small islands in Japan (Ota,

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1984). Two species of voles (*Clethrionomys rufocanus* and *C. rex*) and one species of field mice (*Apodemus speciosus*) occur on the Rishiri Island (area=183 km<sup>2</sup>), and the two species of voles occur on the Rebun Island (area=77 km<sup>2</sup>). On both islands *Sasa* grasses and coniferous trees are dominant. On the other hand, one species of vole (*Microtus montebelli*) and two species of mice (*A. speciosus* and *A. argenteus*) occur on the Sado Island (area= 857 km<sup>2</sup>) where *Sasa* grasses and deciduous trees are dominant, and one species of vole (*Eothenomys smithii*) and the two species of mice occur on the Dogo Island (area=243 km<sup>2</sup>), the Oki Islands, where there are grasses and evergreen forests. When Miyako Island (area=159 km<sup>2</sup>) isolated from the continent and became into a small island in the Pleistocene as supposed by Kizaki and Oshiro (1977) and Oshima (1979), two species of *Microtus* and two species of rats (*Diplothrix legata* and *Tokudaia osimensis*) would not be able to live together due to such a small area. Therefore, as suggested by Hasegawa *et al.* (1973) and Hasegawa (1980), we are inclined to agree with their opinions that the Miyako Island isolated from the continent in the late Pleistocene.

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## 琉球列島宮古島ピンザアブ洞穴における化石ハタネズミ科臼歯について

金子之史・長谷川善和

琉球列島の宮古島のピンザアブ洞穴で、後期更新世(25,800±900y.B.P.と26,800±1,300y.B.P.)と判定された、680個の遊離臼歯と臼歯のついた3個の下顎骨が1982-83年に発掘された。化石臼歯はプリズム型のエナメル質をもち無根歯であった。82個の下顎第一臼歯のうち、70個は*Microtus fortis*、5個は*M. oeconomus*と同定され、ほかに7個の特徴を記載した。74個の上顎第三臼歯には、下側に4個の凸角をもち前環うしろの第一と第二のエナメル三角形の象牙質が連合していたが、属の同定には至らなかった。2個の上顎第二臼歯には第二番目の閉鎖三角形の頰側に凹角がみられたので、*M. oeconomus*と同定された。宮古島での後期更新世の*M. fortis*と*M. oeconomus*の化石臼歯の発見は、今まで報告されていた古地理学や古植物学の見地とはことなっていた。

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