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Identification and Some Morphological Characters of *Clethrionomys rufocanus* and *Eothenomys regulus* from USSR, Northeast China, and Korea in Comparison with *C. rufocanus* from Finland

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Abstract. Museum specimens of 210 red-backed voles from USSR, northeast China (Manchuria), and Korea were compared with 70 specimens of *Clethrionomys rufocanus* from Finland. Condylobasal length (CBL) correlated positively with ages determined by developmental stages of molar roots in the samples from Finland throughout the year. All skulls measuring CBL = 26 mm or more had roots in the samples collected from Finland in the first half of the year. In the Asiatic specimens collected in the first half of a year and from 41°N latitude and north (northern voles), all skulls with 26 mm CBL or more lacked alveolar capsules, indicating the development of roots. On the other hand, in museum specimens collected in the first half of the year and from 41°N latitude and south (southern voles), all skulls, even in skulls with 26 mm CBL or more, had strongly bulged alveolar capsules, indicating rootless molars. The occlusal patterns of M3 change with increase in CBL were the same between *C. rufocanus* from Finland and northern voles: simplex form was common in larger individuals, whereas the complex form was rare. On the other hand, the complex form was abundant in all CBL classes in southern voles. Northern voles were slightly narrower in interorbital width and slightly shorter in tail length than southern ones. I identified the northern vole as *C. rufocanus*, and the southern vole as *Eothenomys regulus*. I suggest that the true geographical demarcation line between the two species lies on the western and southern boundary of the Kaima Plateau, North Korea.

Key words: *Clethrionomys rufocanus*; *Eothenomys regulus*; Identification; Distribution; Eastern Asia.

Introduction

With the exception of *Clethrionomys rutilus*, the classification of red-backed voles (*Clethrionomys* and *Eothenomys*) from northeast China (Manchuria) and Korea has been very confused. The red-backed vole of Korea was first described by Thomas (1907) under the name of *Craseomys regulus*. Allen & Andrews (1913) and Sowerby (1923) identified the vole from Korea and northeast China as *Craseomys regulus*. In 1926, Hinton revised the classification of red-backed voles from eastern Asia and recognized only one species of vole in this region, namely *Evotomys* (=*Clethrionomys*) *rufocanus*. Since that time, many taxonomists have followed his classification at the species level (Howell, 1929; Goodwin, 1933; Kuroda, 1934, 1938, 1939, 1940; Allen, 1940; Tokuda, 1941; Ellerman, 1941; Mori, 1942; Ellerman & Morrison-Scott, 1951; Ognev, 1950; Jones & Johnson, 1956, 1965; Shou, 1962; Won, 1961, 1965; Gromov *et al.*, 1963; Zimmermann, 1964; Gromov & Polyakov, 1977; Aimi, 1980; Gromov & Baranova, 1981).

Corbet (1978), however, proposed a new classification of Oriental voles of this region. He allocated the vole from Korea and the Provinces of Shansi and Hopei, China, to *Eothenomys*, but also recognized *C. rufocanus* in northeast China and Korea. Honacki *et al.* (1982) followed the classification of Corbet (1978) as did Nadachowski (1984). However, the descrimination of *C. rufocanus* and *E. regulus* remains unsettled, because Corbet (1978) only provided some simple keys for these groups and a crude distribution map.

In the present paper, I compare cranial and molar characters of red-backed voles from USSR, northeast China, and Korea with those of *C. rufocanus* from Finland. By these comparisons and examination of age variation, I present more practical criteria for identifying *Clethrionomys rufocanus* in this region separating it from *Eothenomys regulus*.

Materials and Methods

A total of 280 specimens was examined: 70 specimens of *C. rufocanus* collected from Kilpisjarvi (69°03′N, 20°49′E), Finland from February to September, 1983, by A. Kaikusalo; and 210 specimens of *Clethrionomys* and *Eothenomys* from USSR, northeast China, and Korea housed in the following institutions: British Museum (Natural History) (BM), UK; Museum of Comparative Zoology, Harvard University (MCZ), American Museum of Natural History (AMNH), United States National Museum of Natural History (USNM), and Field Museum of Natural History (FMNH), USA; and Yamashina Institute for Ornithology (YIO), Chiba, Japan.

The locality and its reference number in Fig. 9, latitude, longitude, date collected, museum, and registration number of all specimens examined are listed in the Appendix. Latitude and longitude of the localities were determined from the gazetteers in John & Johnson (1965), Zhuang (1983) and Su (1984). Some of these specimens were previously described and identified by Thomas (1907), Allen & Andrews (1913), Sowerby (1923), Hinton (1926), Howell (1929), Goodwin (1933), Kuroda (1934, 1939), Allen (1940), Jones & Johnson (1956, 1965), Corbet (1978), and Aimi (1980).

Tail length (TL) was recorded from the skin label. Condylobasal length (CBL) and interorbital width (IOW) were measured on undamaged skulls to the nearest 0.1 mm with a dial caliper by the author. The CBL is the distance between the occipital condyle and the anterior part of premaxillae. The IOW is the least distance of the frontal bones between orbits.

The disappearance of the $\underline{M2}$ alveolar capsule was recorded for the skulls of *C. rufocanus* from Finland and all museum specimens (Prychodko, 1951;

Koshkina, 1955). Three stages were recognized: a strong arched alveolar capsule; an intermediate stage, in which the capsule is slightly swollen; a capsule flattened and reduced to a straight line.

Skulls of *C. rufocanus* from Finland were aged according to the developmental stages of their molar roots following the criteria of Abe (1976). Eight age classes were determined: I+II, III+IV, V, less than 33% of root ratio (VI), from 33 to 60% of root ratio (VII), and 61% or more of root ratio (VIII).

Patterns of crown wear of $M\underline{3}$ were drawn for *C. rufocanus* from Finland by the stereo microscope (SMZ—10) produced by Nippon Kogaku with an accessory apparatus at 15x magnification. For museum specimens, figures were drawn from close-up pictures of the molar rows (1.75x magnification) using the stereo microscope at 6.6x magnification after the pictures were taken in the museum with an accessory close-up lens attached to an Olympus camera. Dental patterns of $M\underline{3}$ were classified into four types (Abe, 1982): type 4+5 is complex form with three reentrant angles on the buccal side; type 6 has three salient angles on the buccal side, a short posterior loop, and a confluent dental isthmus between triangles; type 9 has three salient angles, in which the internal posterior enamel lamella are straight to convex; type 7+8 has three salient angles on the buccal side with slightly concave internal posterior lamella except for type 9. Furthermore, the fourth outer salient angle was checked on the left side of $M\underline{3}$.

Results

1. Variation of Clethrionomys rufocanus *from Finland*

In the large sample of *C. rufocanus* from Finland, CBL correlates positively with six age classes defined on root development ($r = 0.790$, $df = 67$, $p<0.001$) and may be used as an approximate indicator of age (Fig. 1). Two skulls having an intermediate stage of the alveolar capsule, or without the capsule, are found among 15 specimens (13%) in the 22—24 mm CBL range (Fig. 1). Ten of 18 specimens (56%) with 25 mm CBL lack a capsule. All skulls measuring CBL = 26 mm or more exhibit root development and the alveolar capsule has disappeared (VI, VII and VIII age classes).

The disappearance of the alveolar capsule in relation to CBL was compared among the samples collected in different months (Fig. 2). In *C. glareolus*, the development of molar roots is known to be retarded in the autumn-born cohort compared with spring- or summer-born cohorts (Lowe, 1971; Zejda, 1971). Among specimens collected in February, March, and May, the capsule disappeared in animals as small as CBL = 24 mm; whereas, among those taken in July and September, the capsule was absent only in individuals with 26 mm CBL or more (Fig. 2). Specimens collected in the later months with CBL less than 26 mm possess an alveolar capsule, which suggests a retardation of molar formation. In the following comparison of capsule development, museum specimens were divided into two periods according to the collecting date: the first half of the year (January to June), and the second half of the year

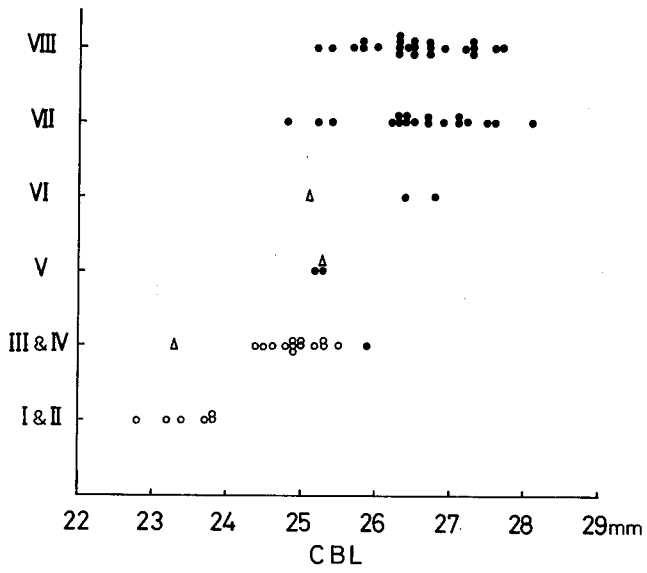

Fig. 1. Relationship between condylobasal length (CBL), age classes (I-VIII) and development of alveolar capsule in *C. rufocanus* from Finland. Symbols: capsule present = open circle; capsule absent = closed circle; and intermediate stage = open triangle.

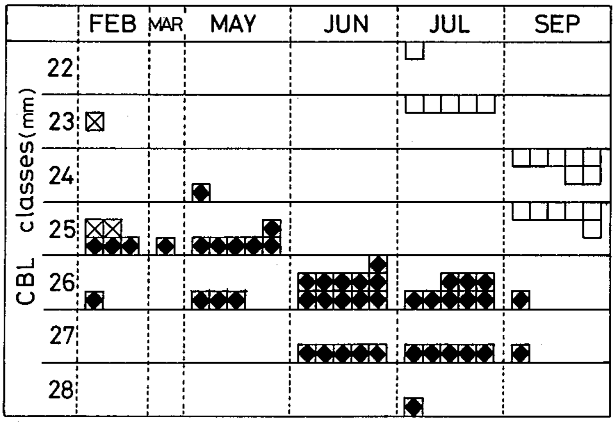

Fig. 2. Monthly variation of frequency distributions of condylobasal length (CBL) with development of alveolar capsule in *C. rufocanus* from Finland. One square indicates one specimen. Symbols: capsule present = open rectangle; capsule absent = small closed rhombus within a square; and intermediate stage = X-letter within a square.

Table 1. Frequencies of dental patterns of M3 on both sides in *Clethrionomys rufocanus* from Finland.

	Left side				
	Type 6	Type 4+5	Type 7+8	Type 9	Total
Right side					
Type 6	6	0	0	0	6
Type 4+5	0	6	3	0	9
Type 7+8	0	5	27	3	35
Type 9	0	0	9	11	20
Total	6	11	39	14	70

Table 2. Frequencies of dental patterns of the left M3 in *Clethrionomys rufocanus* from Finland observed in seven CBL classes.

CBL classes (mm)	Type 6	Type 4+5	Type 7+8	Type 9	Total
22.0—22.9	1	0	0	0	1
23.0—23.9	5	0	1	0	6
24.0—24.9	0	0	8	0	8
25.0—25.9	0	2	10	6	18
26.0—26.9	0	6	12	6	24
27.0—27.9	0	2	7	2	11
28.0—28.9	0	0	1	0	1
Total	6	10	39	14	69

(July to December).

The correspondence of the occlusal patterns between the left and right M3s was tested (Table 1). The *G*-test with Williams adjustment (Sokal & Rohlf, 1973) indicated that bilateral patterns were strongly associated (G_{adj} = 56.3616, $df = 9$, $p < 0.005$). Only the left side pattern was examined in the following study.

The dental pattern of M3 changes with increase in CBL (Table 2). Type 6 was the most frequent in the CBL classes under 24 mm. The simplex form (type 7+8) varied greatly from 17 to 100% in 23—27 mm CBL classes. Another simplex form (type 9) occurred at 0—33% level in 23—27 mm CBL classes. The complex form (type 4+5) was observed at 11—25% level in 25—27 mm CBL classes. Thus, the two simplex forms (type 7+8 and type 9) were found in large numbers (75—100%) in 24 mm CBL class or more.

A fourth outer salient angle of the grinding surface in M3 was observed in only one skull among the 70 specimens of *C. rufocanus* from Finland.

The IOW and TL of *C. rufocanus* from Finland varied seasonally (Fig. 3): IOW or TL are slightly narrower or shorter in February than in other months and are slightly wider or longer in June than in other months. The IOW ranged from 3.4 to 4.5 mm and TL from 20 to 39 mm.

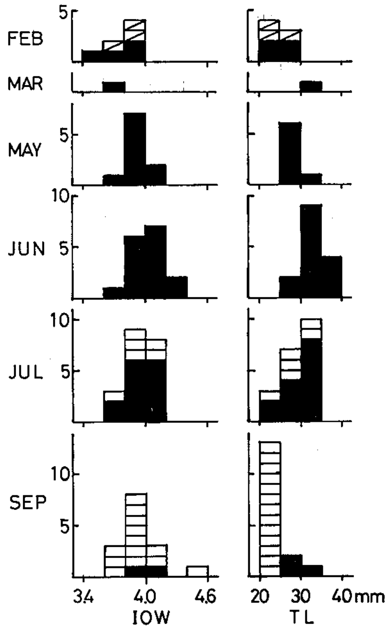

Fig. 3. Monthly variation of frequency distributions of interorbital width (IOW) and tail length (TL) in relation to development of alveolar capsule in *C. rufocanus* from Finland. One rectangle shows one specimen. Symbols: capsule present = open rectangle; capsule absent = closed rectangle; and intermediate stage = X-letter within a rectangle.

2. Variation of specimens collected from USSR, northeast China, and Korea

Plots of CBL and the occurrence of the alveolar capsule were arranged from north to south and divided into two periods (from January to June, and from July to December) for the museum specimens examined (Fig. 4). In the first half of the year, the alveolar capsule is absent in all skulls measuring CBL = 26 mm or more (and in some skulls only 24 and 25 mm) from 41°N latitude and north; whereas, from 41°N latitude and south, the capsule is uniformly present even in skulls with 26 mm CBL or more. Alternatively, in the samples of the second half of the year, the capsule is absent in two skulls (locality 9) measuring CBL = 25−26 mm from 41°N latitude and north, and the capsule is present even in skulls with 26 mm CBL or more from 41°N latitude and south.

The frequency of M$\underline{3}$ dental patterns (Fig. 5) indicates that simplex forms (type 7+8 and type 9) (Fig. 6) are most common (91/109 = 83.5%), and the complex form (type 4+5) (6/109 = 5.5%) and the fourth outer salient angle (4/109 = 3.5%) are uncommon among northern voles. In contrast, the simplex form is uncommon among southern voles (23/97 = 23.7%), the complex form is the most dominant (69/97 = 71.1%), and the fourth angle (Fig. 6) occurred frequently (59/97 = 60.8%). However, geographical clinal variation is not evident.

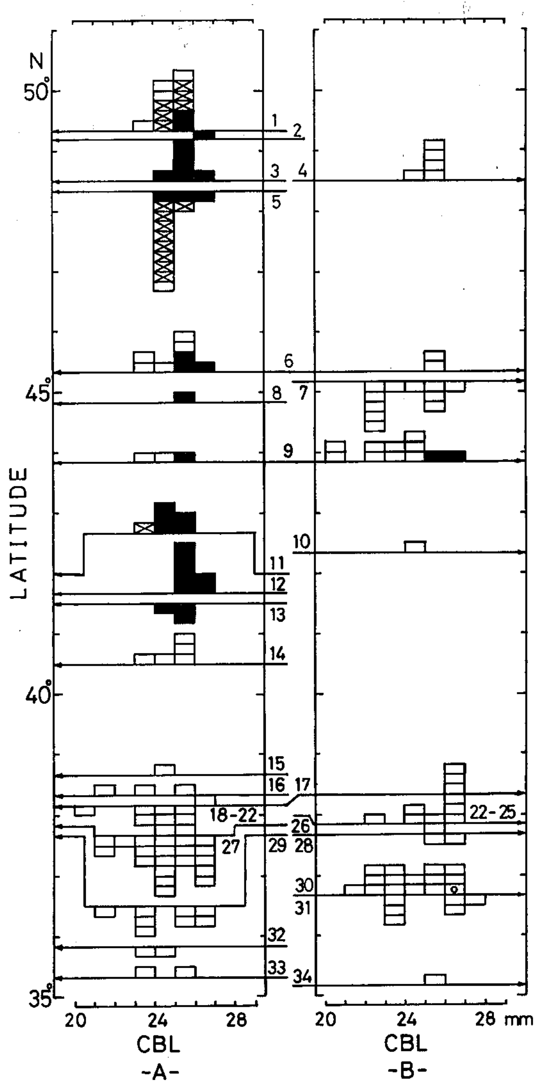

Fig. 4. Latitudinal variation of frequency distributions of condylobasal length (CBL) with development of alveolar capsule in samples of red-backed voles from USSR, northeast China, and Korea. The numbers (1—34) show the localities which are explained in the Appendix. The left column (A) contains samples collected from January to June and the right column (B) samples collected from July to December. Further explanation is given in Fig. 3.

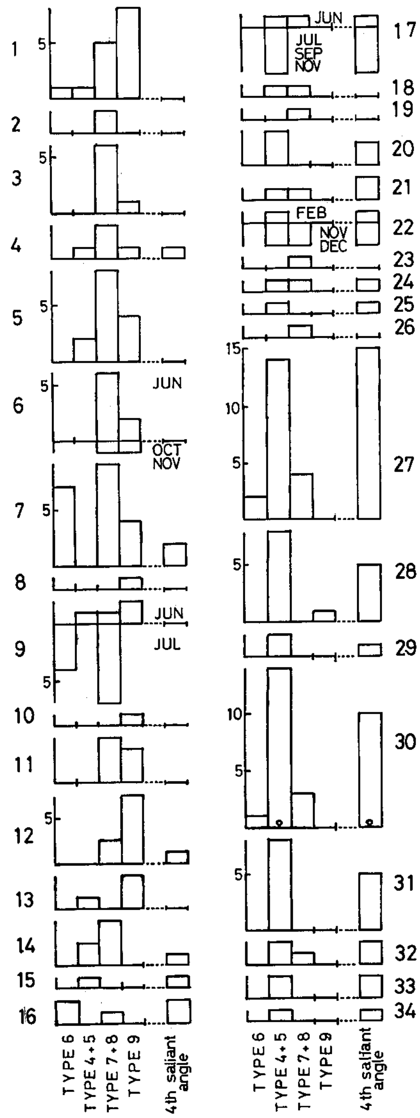

Fig. 5. Frequency distributions of dental patterns (type 6, type 4+5, type 7+8, and type 9) and the occurrence of the fourth outer small salient angle in the upper left side M3 in samples of red-backed voles from USSR, northeast China, and Korea. The numbers (1—34) show the localities which are explained in the Appendix.

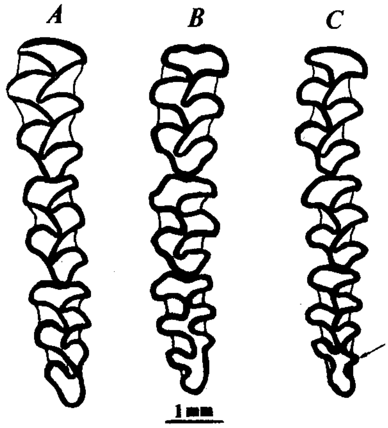

Fig. 6. Common dental pattern of M3. A, the simplex form of northern vole (AMNH 34038 collected from locality 11, condylobasal length = 25.4 mm with roots); B, the complex form of southern vole (USNM 199665 collected from locality 14, condylobasal length = 25.3 mm without roots); C, the complex form with the fourth outer small salient angle (arrow) of southern vole (USNM 294646 collected from locality 20, condylobasal length = 25.2 mm without roots). The locality numbers are shown in the Appendix.

The frequency of the M3 dental patterns in relation to CBL is shown for the samples from localities 1, 5, 7 and 9 (Table 3), and 27 and 30 (Table 4). Other samples are too small in number to tabulate. In localities 1, 5, 7 and 9, the simplex forms (type 7+8 and type 9) occur principally in animals with large CBL, the complex form (type 4+5) is infrequent, and type 6 was observed in animals with a small CBL except for locality 5, where small-sized individuals are absent. In contrast, most skulls from localities 27 and 30 possess the complex form at almost all CBL sizes, and the simplex forms are uncommon.

In the museum specimens, the IOW ranged from 3.2 to 4.1 mm for specimens collected north of 41°N latitude; whereas the width varied from 3.9 to 4.7 mm for specimens from south of 41°N latitude (Fig. 7). TL ranged from 20 to 49 mm in northern voles, and from 30 to 54 mm in southern ones (Fig. 8). Thus, northern voles are slightly narrower in interorbital width and shorter in tail than southern individuals.

3. *Taxonomic conclusion*

There was a sharp contrast in molar root occurrence between northern and southern voles among the specimens collected in the first half of a year (Fig. 4). The northern vole has rooted molars, which begin to develop from CBL = 24 to 25 mm. Furthermore, among northern voles, the simplex form of the dental pattern is the more common, the complex form is uncommon, the fourth outer salient angle occurred in a small number (Fig. 5), and type 6 with confluent dental isthmus appeared in the small-sized CBL (Table 3). These characteristics are the same as described for *C. rufocanus* from Finland (Fig. 1 and Table 2). Consequently, I identify the voles collected from 41°N and north as *Clethrionomys rufocanus*.

The voles collected from 41°N and south are allocated to *Eothenomys regulus*. This species has the same palatal shelf in the skull as in *Clethrionomys* but lacks roots even in old age, and the molar reentrant folds are narrower than in *Alticola*, which has little cement in the folds. This combina-

Table 3. Frequencies of dental patterns of the left M3 in red-backed voles from USSR and northeast China found in CBL classes.

CBL classes (mm)	Type 6	Type 4+5	Type 7+8	Type 9	Total
Locality 1					
23.0—23.9	1	0	0	0	1
24.0—24.9	0	1	2	2	5
25.0—25.9	0	0	2	4	6
Total	1	1	4	6	12
Locality 5					
24.0—24.9	0	0	5	3	8
25.0—25.9	0	1	1	0	2
26.0—26.9	0	0	1	0	1
Total	0	1	7	3	11
Locality 7					
22.0—22.9	3	0	2	0	5
23.0—23.9	0	0	1	0	1
24.0—24.9	0	0	1	0	1
25.0—25.9	0	0	3	0	3
26.0—26.9	0	0	0	1	1
Total	3	0	7	1	11
Locality 9					
20.0—20.9	2	0	0	0	2
21.0—21.9	0	0	0	0	0
22.0—22.9	1	0	1	0	2
23.0—23.9	0	1	2	0	3
24.0—24.9	0	0	3	1	4
25.0—25.9	0	0	1	1	2
26.0—26.9	0	0	1	0	1
Total	3	1	8	2	14

tion of traits forms the generic diagnostic of *Eothenomys* (Hinton, 1926 ; Ellerman, 1940 ; Corbet, 1978). Because the holotype of *Craseomys regulus* Thomas, 1907 (BM 6.12.6.89) is from locality 30 (Figs. 4, 5, 7, and 8, and Table 4), the southern vole can be recognized as *E. regulus*. *Eothenomys regulus* averages slightly wider in IOW and longer in TL than *C. rufocanus* from the USSR, northeast China, and North Korea ; however, IOW and TL show slight seasonal variation in *C. rufocanus* from Finland (Fig. 3), and the ranges of IOW and TL overlap between the two species (Figs. 7 and 8). The distribution of *C. rufocanus* and *E. regulus* is shown by the localities examined in this study (Fig. 9).

Discussion

Few studies have been made on the development of molar roots or on M3 occlusal pattern change with CBL growth in the nominate subspecies of *C. rufocanus*. Hinton (1926) demonstrated that CBL reaches about 24.5 mm when

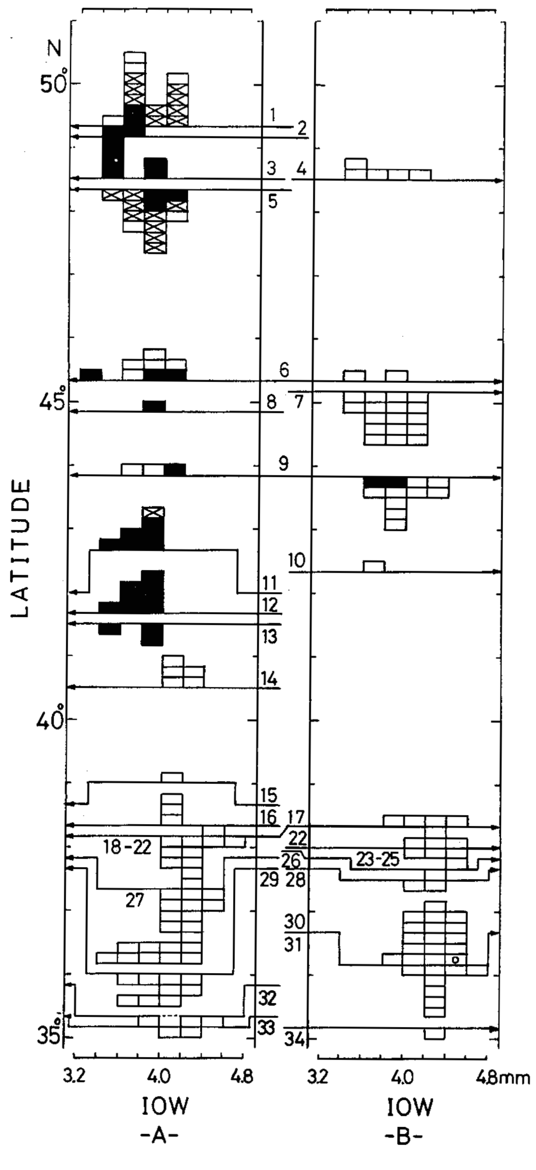

Fig. 7. Latitudinal variation of frequency distributions of interorbital width (IOW) with development of alveolar capsule in samples of red-backed voles from USSR, northeast China, and Korea. Further explanation is given in Figs. 3 and 4.

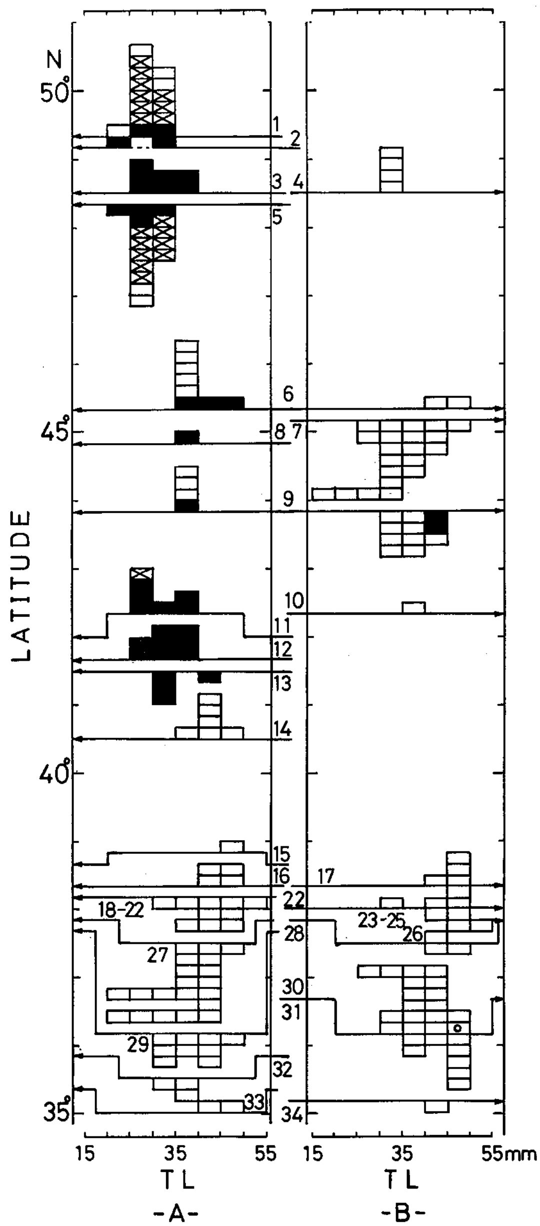

Fig. 8. Latitudinal variation of frequency distributions of tail length (TL) with development of alveolar capsule in samples of red-backed voles from USSR, northeast China, and Korea. Further explanation is given in Figs. 3 and 4.

Table 4. Frequencies of dental patterns of the left M3 in red-backed voles from Korea found in CBL classes.

CBL classes (mm)	Type 6	Type 4+5	Type 7+8	Type 9	Total
Locality 27					
21.0—21.9	1	1	0	0	2
22.0—22.9	1	0	0	0	1
23.0—23.9	0	3	0	0	3
24.0—24.9	0	4	2	0	6
25.0—25.9	0	3	0	0	3
26.0—26.9	0	3	2	0	5
Total	2	14	4	0	20
Locality 30					
21.0—21.9	0	1	0	0	1
22.0—22.9	0	3	0	0	3
23.0—23.9	0	2	1	0	3
24.0—24.9	0	2	0	0	2
25.0—25.9	1	2	0	0	3
26.0—26.9	0	3(Type)*	0	0	3
Total	1	13	1	0	15

* The holotype of *Craseomys regulus* Thomas, 1907 (BM 6.12.6.89) is classified in this category.

the cement spaces of molars are closing at apical portions of roots, the growth stage of which corresponds with my finding that skulls with 24–25 mm CBL exhibit the initial stage of root-closing (age group III & IV) (Fig. 1). Furthermore, he illustrated molars with roots for specimens with CBL = 26.1 mm or more. Thus, his fragmentary description does not contradict my results.

Miller (1912) and Crowcroft & Godfrey (1959) studied the occurrence of a complex M3 in *C. rufocanus* from Scandinavia, but they did not present age variation and their localities examined. In the island population of *C. rufocanus* on Hokkaido, Japan, Abe (1982) demonstrated that the type 6 was dominant in young animals and then decreased, that the complex form occurred less than 10% till age group V, and that the simplex forms (type7+8 and type 9) increased in number with age. Thus, his findings accord with my study of *C. rufocanus* from Finland. Dental patterns may vary geographically, because the proportion of the complex form is 6.2% (1/16) in Scandinavia (Miller, 1912), 14.5% (10/69) in Finland (Table 2), 9% in Hokkaido (Abe, 1982), and 0—9.1% in localities 1, 5, 7, and 9, northeast China (Table 3).

Skulls and dental characters of *C. rufocanus* from northeast China and Korea have not been studied in detail. Hinton (1926) examined specimens from Lake Baikal, Irkutsk, USSR, and Korea, but did not examine specimens from northeast China. He studied four specimens with roots from Irkutsk, three specimens with roots from Potaidon and Pochong, North Korea, and 12 specimens without roots from South Korea. Based on these examinations, he allocated the voles from northeast China and Korea to *Evotomys* (= *Clethrionomys*) *rufocanus regulus*, because he considered the root development to be

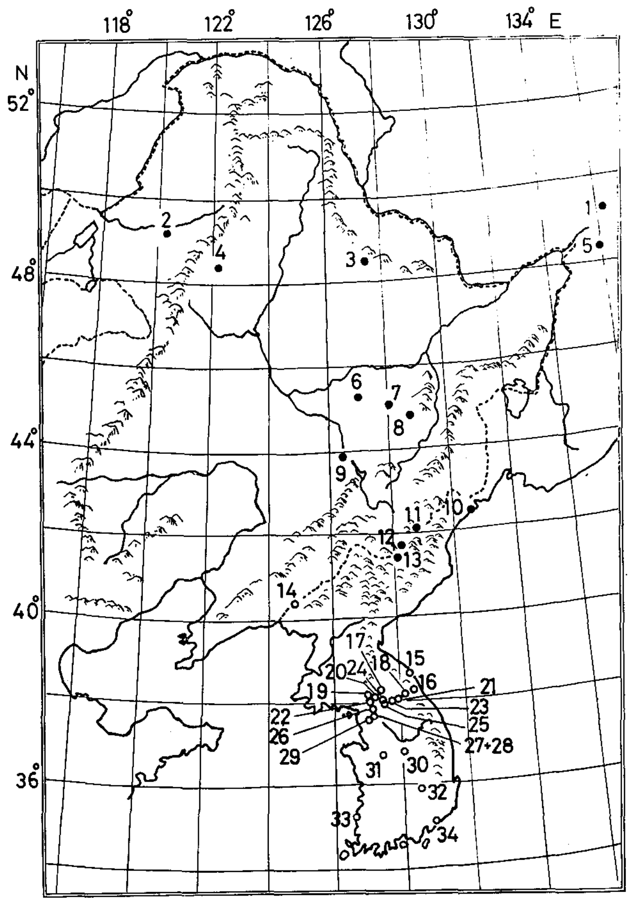

Fig. 9. Localities of *C. rufocanus* (a closed circle) and *E. regulus* (an open circle) identified in the present study. The numbers (1—34) indicate the localities which are explained in the Appendix.

retarded in parallel among the northeast China and Korean vole (*C. rufocanus regulus*), the Chinese vole (*C. rufocanus shanseius*) and the Japanese vole (*C. rufocanus smithii*). However, my study shows that, as found in *C. rufocanus* from Finland, skulls with 26 mm CBL or more have roots in all museum specimens collected at or north of 41°N and in the first half of a year. Consequently, the development of roots does not abate in *C. rufocanus* from eastern Asia as stated by Hinton (1926); only the samples collected in the second half of the year from Finland and eastern Asia show retardation of root development (Figs. 2 and 4). On the other hand, voles living south of 41°N lack roots, even in those with 26 mm CBL or more. With regard to rooted or rootless molars, a sharp contrast exists north and south of 41°N. The present findings, therefore, cannot support the classification of Hinton (1926).

Howell (1926) (the Yalu River, North Korea), Kuroda (1934) (South Korea), Jones & Johnson (1965) (the Yalu River and South Korea), Won (1961, 1965) (South Korea) and Aimi (1980) (South Korea), too, did not pay attention to molar root condition in the classification of voles. I examined all their specimens (except Won, 1961, 1965), and found rootless molars among these specimens (Fig. 4). Tokuda (1941) examined red-backed voles from northeast China and North and South Korea, but did not distinguish skulls with or without roots. Thus, his data on the dental pattern frequency is not comparable with the present study.

Corbet (1978) distinguished *C. rufocanus* and *E. regulus* in this region by the character of rooted or rootless molars, which accords with the present taxonomic conclusion. However, his key is not always complete for practical identification because he did not analyse the size range of skulls that have roots and those that do not. Although Nadachowski (1984) distinguished two species from North Korea following Corbet (1978), he did not specify the skull sizes with and without roots. From this study, these two voles can be identified by the absence or presence of roots at least in 26 mm CBL or more, when voles were collected during January to June. Furthermore, the interorbital width is also a key character to discriminate the two species in this region: when it exceeds 4.4 mm, it is *E. regulus.*

Hinton (1926) mentioned that the $M\underline{3}$ of young *Evotomys rufocanus regulus* (= *Eothenomys regulus*) tends to be more complex. However, his observation is not supported because the complex form (type 4+5) was found in all CBL classes (Table 4). The fourth outer salient angle is a common character (Figs. 5 and 6) as described in Hinton (1926) and Nadachowski (1984).

Jones & Johnson (1965) distinguished *C. rufocanus regulus* (= *E. regulus*) from *C. rufocanus arsenjevi* (= *C. rufocanus*) from North Korea by a wider interorbital width, longer tail length and others, though they misidentified one specimen (AMNH 34011) of *C. rutilus* as *C. rufocanus arsenjevi*. The former two characters were confirmed in this study.

Some authors noted habitat for red-backed voles collected in this region. However, because identification is sometimes uncertain, I refer to the description of the voles that I examined in this study. Allen & Andrews (1913) reported that the habitat is thinly or heavily forested in the Tumen River valley (locality 10) and the edge of primeval forests in Nonsatong (locality 11). Sowerby (1923) collected a large number of red-backed voles in forested areas (Imien-po, locality 7) and in the open valley of the lower Sungari (locality 9); these specimens are identified now as *C. rufocanus.*

Thomas (1907) described the habitat of the holotype of *Craseomys regulus* as "mossy talus overgrown with bushes" and "from burrow in barley field on dry hill side" from the field note of M. P. Anderson. His original field notes further mentioned: "The vole 653 etc. (now registered as BM 6.12.6.98) is common in this neighborhood. It chiefly affects the rocks but is also found in grassy embankments, where it burrows near the surface. I have sometimes found their mouths filled with millet seeds. Also eats seeds of some bushes".

"At Mingyong (=locality 30) is one of the King's reserved forests. It consists of scattered pines of fair size, and on some of the higher slopes, firs. The mountains are rocky and unfertile and the soil seems to retain moisture poorly". On the skin labels, the habitat is described as follows: "Mossy stones among bushes; Burrow in stone-walled embankment; By rock among bushes and grass; Stone wall on grassy flat; Under decaying log on hill side". Therefore, these habitat descriptions suggest that *E. regulus* prefers principally rocky areas, whereas *C. rufocanus* lives mainly in wooded areas.

In comparison with the map of Corbet (1978), the distribution of *C. rufocanus* extends farther to the west in northeast China and less to south in North Korea (Fig. 9). Nadachowski (1984) reported *C. rufocanus* from Samjiyon (41°29′N, 128°12′E), Hyesan (41°14′N, 128°07′E) and Pektu-san (42°00′N, 128°03′E), and *E. regulus* was collected from Sokvang-sa (38°35′N, 127°13′E) and Kumgang-san (38°40′N, 128°08′E). Therefore, I suggest that the southern distributional limit of *C. rufocanus* is the western and southern boundary of the Kaima Plateau, North Korea, a highland that Kishida & Mori (1931) and Jones & Johnson (1965) noted is mostly covered with coniferous forests resembling the flora of northeast China. However, the northeast boundary of *E. regulus* needs to be clarified. Li (1983) collected *C. rufocanus* from the Liaodong Peninsula, China, near the Yalu River, but his method of identification for *C. rufocanus* was not given.

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Appendix

Specimens Examined

Locality numbers used this study (see Fig. 9), locality, latitude and longitude, month and year collected, museum, and registration number of all specimens examined are listed below from north to south. Locality numbers 1—13 are here referred to *Clethrionomys rufocanus* and numbers 14—34 to *Eothenomys regulus*.

1. Monoma River, Amur land, USSR ; 49°15′N, 136°19′E ; January 1930, AMNH 85424—29, 85436—37, 85448—50, 85452, 85454—55, 85458.
2. Jaramtai, Inner Mongolia, China ; 49°12′N, 120°24′E, May 1935, YIO 873—874.
3. Xia-hinggan-liang, Heilung-kiang Prov., China ; approximately 48°30′N, 127°30′E ; June 1935, YIO 875—881.
4. Yalu St., Great Khingan Mts., Inner Mongolia, China ; 48°30′N, 122°12′E ; November 1934, FMNH 46034 ; July 1935, FMNH 44353 ; September 1939, FMNH 49906 ; October 1939, USNM 27055 ; FMNH49905.
5. Nelta River, Amur land, USSR ; 48°19′N, 135°05′E ; February 1930, AMNH 85471, 85474-76, 85480, 85483—84, 85490, 85492—94, 85499, 85503—05.
6. Hsialing, Kirin Prov., China ; 45°18′N, 127°18′E ; June 1938, MCZ 41144 ; June 1937, YIO 1086—1092 ; October 1937, MCZ 41145 ; September 1939, FMNH 49904.

7. Imien-po, Heilung-kiang Prov., China ; 45°06′N, 128°06′E ; September 1914, USNM 199643, FMNH 43416 ; October 1914, USNM 199644—47, 199649—51, 199653, FMNH 43415 ; September 1915, USNM 201255, 201258—66.
8. Kaolingtsu St., Kirin Prov., China ; 44°48′N, 128°48′E ; June 1940, USNM 270556.
9. Sungari River, 60 miles SW of Kirin, China ; 43°54′N, 126°30′E ; June 1913, USNM 197820—24 ; July 1913, USNM 197825—28, 197831—35, FMNH 43413—14.
10. Tumen River, North Korea ; approximately 42°20′N, 130°40′E ; October 1935, BM 1938.8.8.16.
11. Nongsa-dong, North Korea ; 42°02′N, 128°49′E ; May 1912, AMNH 34023, 34029—30, 34035, 34038—40.
12. Potai-dong, North Korea ; approximately 41°43′N, 128°22′E ; May 1912, BM 13.5.27.53—54, MCZ 15292, USNM 197976—77, AMNH 34007, 34009, 34015.
13. Pochong, North Korea ; approximately 41°31′N, 128°18′E ; June 1912, BM 13.5.27.56, AMNH 34016—18.
14. Yalu River, 150 miles up the Yalu River, North Korea ; approximately 40°25′N, 124°50′E ; May 1914, USNM 199638—41, 199642 ; June 1914, 199665.
15. Changjon, North Korea ; 38°44′N, 128°11′E ; June 1929, YIO 73.
16. 1 mile N of Oho-ri, South Korea ; 38°20′N, 128°32′E ; April 1954, USNM 298952—53 ; June 1954, USNM 298956.
17. Kumhwa, South Korea ; 38°17′N, 127°28′E ; June 1952, USNM 294648—49 ; November 1906, BM 7.6.3.61 ; July 1952, USNM 294650, 298063 ; September 1952, USNM 298064.
18. 1 mile W of Tangjonggok, South Korea ; 38°11′N, 128°9′E ; April 1954, USNM 298954—55.
19. Taegwang-ni, South Korea ; 38°11′N, 127°06′E ; March 1954, USNM 298949.
20. Chip'o-ri, South Korea ; 38°08′N, 127°19′E ; June 1952, USNM 294644—47.
21. 3 miles SW of Yanggu, South Korea ; 38°06′N, 128°00′E ; April 1954, USNM 298950—51.
22. Chang Ami-ri, Idong Myon, South Korea ; 38°03′N, 127°12′E ; February 1974, BM 75.806 ; November 1973, BM 75.802 ; December 1973, BM 75.803—805.
23. Ori-dong, South Korea ; 38°03′N, 126°58′E ; September 1952, USNM 298067.
24. Ch'ongsong-ni, South Korea ; 38°02′N, 127′09′E ; September 1952, USNM 298065 ; October 1952, USNM 298066.
25. 3 miles SSE Sumil-ri, South Korea ; 38°02′N, 127°30′E ; September 1954, USNM 29905.
26. Samsimgok-ri, Shinbook Myon, Pochon Gun, Kyonggi Do, South Korea ; approximately 37°50′N, 127°10′E ; November 1973, BM 75.817.
27. Kwangnung National Forest, South Korea ; BM 37°45′N, 127°11′E ; February 1974, BM 75. 782—785 ; March 1974, BM 75.786—788, 75.793—796 ; April 1974, BM 75.789—792 ; June 1974, BM 75.797—801.
28. Near Pup'yong-ni, Central National Forest, South Korea ; 37°44′N, 127°12′

E; August 1952, USNM 298068; November 1954, USNM 300646.

29. Ilyung-ri, Changhon Myon, Yangju Gun, Kyongyi Do, South Korea; approximately 37°40′N, 127°00′E; February 1974, BM 75.807; April 1974, BM 75.808—811, 75.813—814; May 1974, BM 75.815—816.
30. Mun'gyong, 110 miles SE of Seoul, South Korea; 36°44′N, 128°07′E; November 1905, BM 6.12.6.89 (the holotype of *Craseomys regulus* Thomas, 1907), 6.12.6.98—100; December 1905, BM 6.12.6.90—97, 6.1.6.101—106.
31. Near Ch'ongju, Chung Chong Prov., South Korea; 36°38′N, 127°29′E; December 1906, BM 7.6.3.53—60.
32. 10 miles N of Taegu, South Korea; 35°52′N, 128°35′E; December 1905, BM 6.12.6.107; January 1906, BM 6.12.6.108, 6.12.6.110.
33. Yonggwang, South Korea; 35°16′N, 126°31′E; May 1930, YIO 75—76.
34. 30 miles N of Pusan, South Korea; 35°08′N, 129°04′E; August 1952, USNM 298069.