

**Morphometric Analyses of the Three Subspecies
of Striped Field Mouse, *Apodemus agrarius*
Pallas (Mammalia: Rodentia) from Far Eastern Asia:
Taxonomic Status of North Korean Striped Field Mice**

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ABSTRACT

Four external and 27 cranial characters of three subspecies of striped field mice (*Apodemus agrarius*) from 15 regions in far eastern Asia (South Korea, North Korea, northeastern China, and far eastern Russia) were analyzed by multivariate methods in order to determine taxonomic status of striped field mice from North Korea. Three subgroups were recognized: a large-size form from two localities in South Korea (Cheju Island, Wando Island); a medium-size form from eight localities in South Korea and North Korea (Jindo Island, Kunsan, Mt. Chirisan, Cheongju, Mt. Weolaksan, Mt. Taebaksan; Haeju, Sineuiju); a small-size form from five localities in North Korea, northeastern China, and far eastern Russia (Mt. Kumkangsan, Mt. Myohyangsan; Jirin, Yichun; Vladivostok). It is confirmed that the large-size form, the medium-size form, and the small-size form are subspecies *chejuensis*, *coreae*, and *manchuricus*, respectively, as noted by Koh *et al.* (1997). It is revealed that striped field mice (the medium-size form) from western region of North Korea (Haeju, Sineuiju) is classified into *A. agrarius coreae*, as noted by Thomas (1908), but striped field mice (the small-size form) from eastern region of North Korea (Mt. Kumkangsan, Mt. Myohyangsan) is *A. agrarius manchuricus*.

Key words: Taxonomy, Morphometry, *Apodemus agrarius*, North Korea

INTRODUCTION

Striped field mouse, *Apodemus agrarius* Pallas, inhabits from western Germany to the Korean peninsula, and most of subspecies were designated on the basis of slight differences in pelage colour and/or body size (Corbet, 1978). He summarized 24 nominal subspecies into three subspecies (*agrarius*, a western subspecies including 12 named subspecies; *ningpoensis*, an eastern subspecies including *manchuricus*, *pallidior*, *insulaemus* in China, *coreae* and *chejuensis* in South Korea, and other three named subspecies; *chevrieri*, a southern Chinese subspecies including one named subspecies). Wang (1985) concluded that subspecies *chevrieri* is a distinct species, and Kobayashi (1985) noted that subspecies classification of *A. agrarius* is still in confusion.

In China, *Apodemus agrarius manchuricus* inhabits northeastern China and eastern Inner Mongolia (Xia, 1984). In South Korea, four subspecies of *A. agrarius* are recognized (Jones and Johnson, 1965): *A. a. manchuricus* in the extreme northern part, *A. a. coreae* throughout the major portion of the peninsula, *A. a. pallescens* in the coastal lowlands of southern and southwestern Korea; and *A. a. chejuensis* on Cheju island. They, however, stated that they have seen no specimens from the vast area of North Korea between the Yalu River on the north and the Kumhwa-Chorwon area on the south.

The methods of numerical taxonomy based on equal weighting and overall similarity seemed to have potential for the resolution of taxonomic problems at the infraspecific level (Flake and Turner, 1968). In morphometric analyses with samples of three subspecies of *A. agrarius* from ten localities of South Korea, it was revealed that *A. a. pallescens* is a synonym of *A. a. coreae* (small-size form) and that *A. a. chejuensis* is distinctly large (Koh, 1986). In the analysis with morphometric characters of six subspecies of striped field mice from China and South Korea (Koh *et al.*, 1997), three subgroups were revealed: 1) *chejuensis*, 2) *coreae*, 3) other four subspecies including *manchuricus*, *pallidior*, *ningpoensis*, and *insulaemus*.

In this paper, morphometric characters of samples of North Korean striped field mice were analyzed together with the samples of three subspecies of *A. agrarius* (subspecies *coreae*, *chejuensis*, and *manchuricus*) from South Korea, northeastern China, and far eastern Russia in order to clarify the taxonomic status of North Korean striped field mice.

MATERIALS AND METHODS

Sexual variation was not significant, but age variation was evident in *Apodemus agrarius* (Koh, 1983). Juveniles, subadults, and old adults were not used, and 474 samples of young and middle-aged adults from 15 localities in South Korea, North Korea, northeastern China, and far eastern Russia, representing three subspecies (*coreae*, *chejuensis*, and *manchuricus*), were analyzed (see Table 1 and Fig. 1). All of these specimens are in the collection of four Institutions (Department of Biology, Chungbuk University, Cheongju, South Korea; Zoological Department, Hungarian Natural History Museum, Budapest, Hungary; Institute of Biology & Pedology, Russian Academy of

Table 1. Specimens of striped field mice, *Apodemus agrarius* from 15 localities from far eastern Asia (South Korea, North Korea, northeastern China, and far eastern Russia).

Subspecies	Locality	No. of Samples	OTU
<i>chejuensis</i>	Mt. Hanlasan, South Korea	47	1
"	Wando Island, South Korea	25	2
<i>coreae</i>	Jindo Island, South Korea	20	3
"	Kunsan, South Korea	28	4
"	Mt. Chirisan, South Korea	21	5
"	Cheongju, South Korea	85	6
"	Mt. Weolaksan, South Korea	35	7
"	Mt. Taebaeksan, South Korea	14	8
"	Haeju, North Korea	19	9
"	Mt. Kumkangsansan, North Korea	25	10
"	Sineuiju, North Korea	21	11
"	Mt. Myohyangsan, North Korea	27	12
<i>manchuricus</i>	Vladivostok, Russia	44	13
"	Jirin, China	46	14
"	Yichun, China	17	15
Total		474	

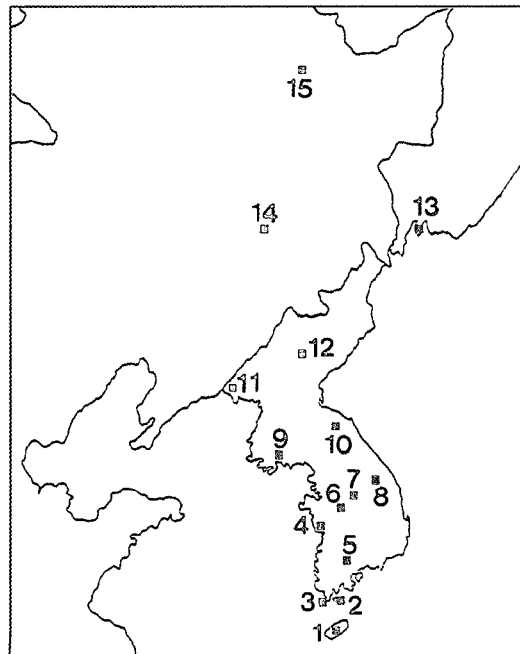


Fig. 1. A map showing 15 OTUs representing three subspecies of *Apodemus agrarius* from far eastern Asia. The subspecies name and number of samples in each OTU are given in Table 1.

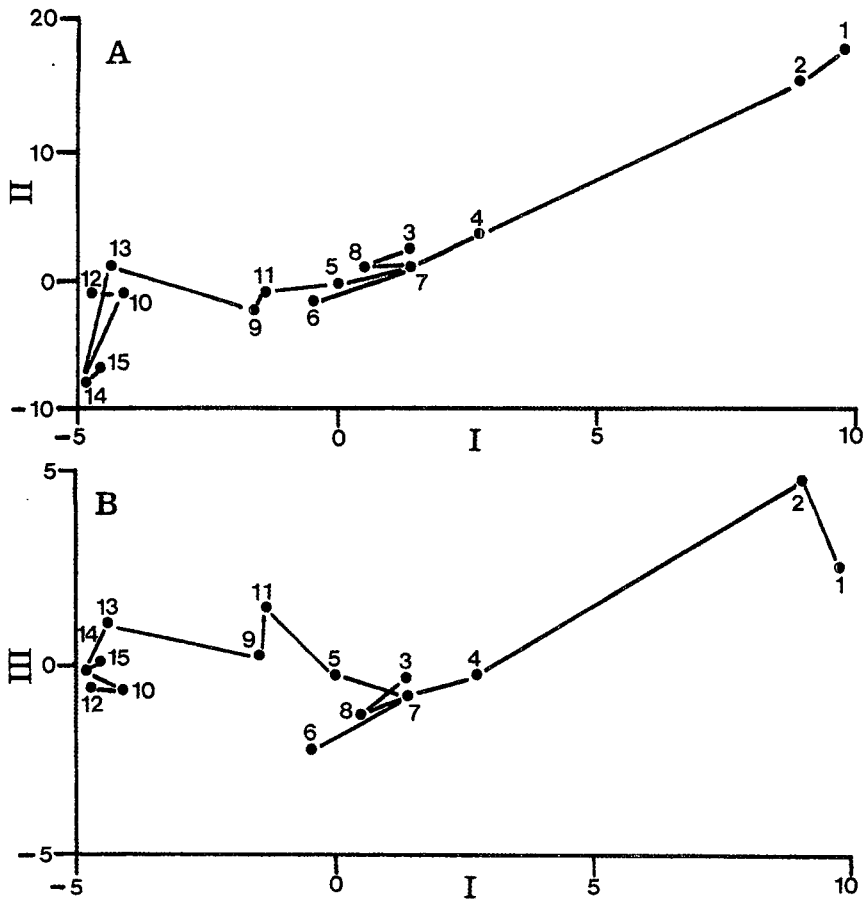


Fig. 2. Plottings of 15 OTUs in three subspecies of *Apodemus agrarius* from far eastern Asia by discriminant analysis. Numerals indicate the centroid of OTUs and minimum spanning tree is superimposed on the plots. A, OTUs ordinated with functions I vs. function II. B, OTUs ordinated with function I vs. function III. The subspecies name and locality of each OTU are given in Table 1.

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Four external and 27 cranial characters were measured (for details see Koh, 1983). Sample statistics such as mean were calculated by subprogram DESCRIPTIVE of SPSS/pc+ program: discriminant analysis was also performed by subprogram DISCRIMINANT. Principal component analysis and cluster analysis were carried out using subprogram EIGEN and SAHN of NTSYS/pc program, respectively: minimum spanning tree was also produced by subprogram MST.

RESULTS

Two dimensional plottings from discriminant analysis with 15 OTUs of *Apodemus agrarius* are

shown in Fig. 2 (numerals indicate centroids of OTUs and minimum spanning tree is superimposed on the plots). Functions I, II, and III represented 55.4, 18.9, and 6.1 percents of the variance, respectively (80.4 percents in total). Three subgroups were revealed: a large-size form (OTUs 1 and 2), a medium-size form (OTUs 3, 4, 5, 6, 7, 8, 9, and 11), and a small-size form (OTUs 10, 12, 13, 14, and 15).

Two dimensional configurations with 15 OTUs of *A. agrarius* by principal component analysis are shown in Fig. 3 (minimum spanning tree is superimposed on the plots). Factors I, II, and III represented 73.6, 11.5, and 4.9 percents of the variance, respectively (90.0 percents in total). Three subgroups were recognized, as revealed by discriminant analysis. Fifteen OTUs were also grouped by cluster analysis of average linkage with taxonomic distances, as shown in Fig. 4. Three subgroups mentioned above were revealed.

In summary, three subgroups were recognized: a large-size form from two localities in South

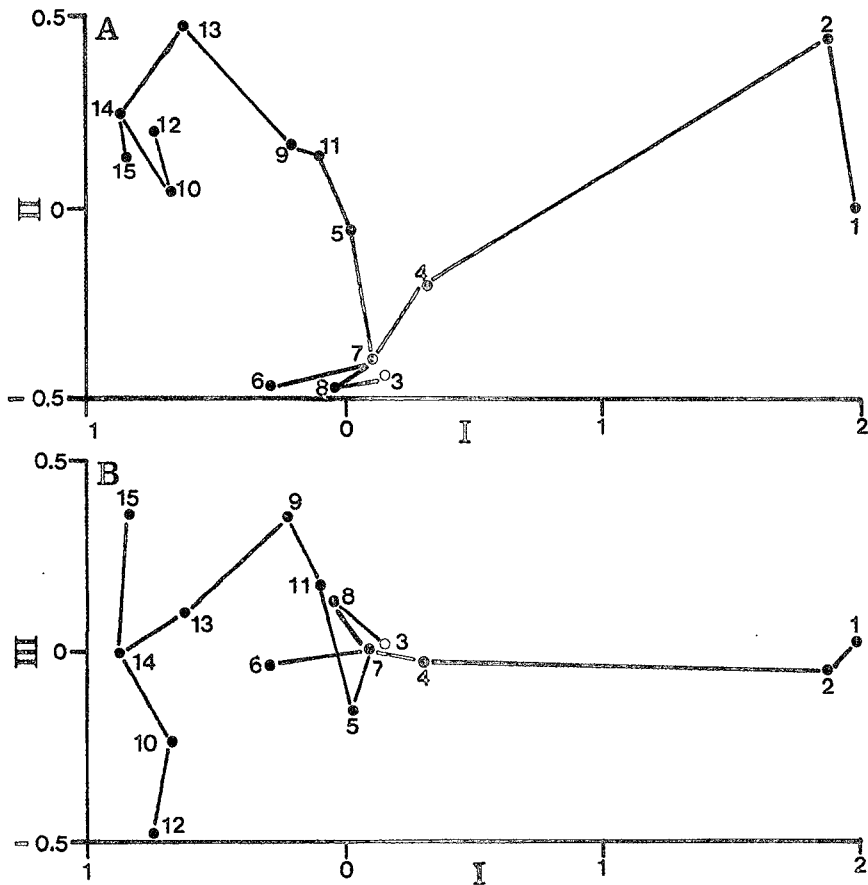


Fig. 3. Projections of 15 OTUs in three subspecies of *Apodemus agrarius* from far eastern Asia by principal component analysis. Numerals indicate OTUs and minimum spanning tree is superimposed on the plots. A, OTUs ordinated with factor I vs. factor II. B, OTUs ordinated with factor I vs. factor III. The subspecies name and locality of each OTU are given in Table 1.

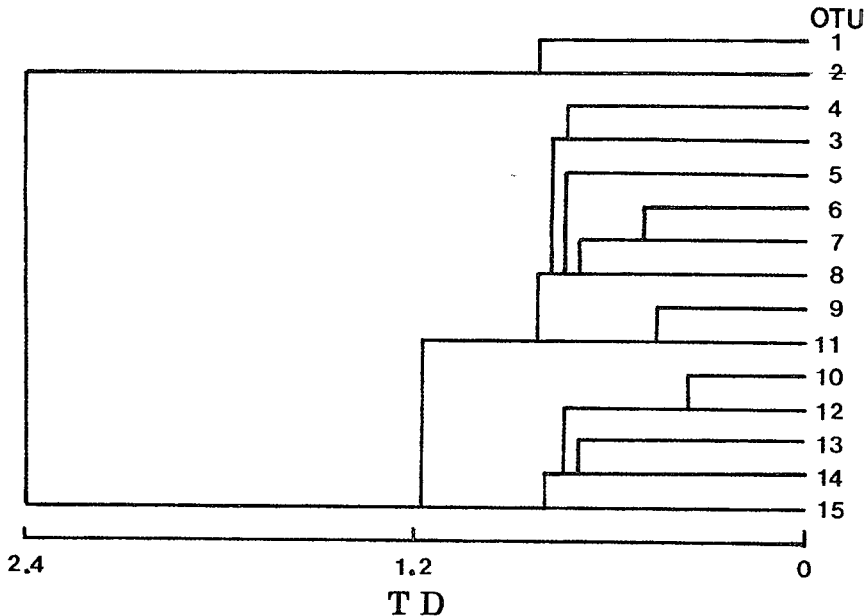


Fig. 4. Grouping of 15 OTUs in three subspecies of *Apodemus agrarius* from far eastern Asia by cluster analysis of average linkage with taxonomic distances (TD). The subspecies name and locality of each OTU are given in Table 1.

Korea (Cheju Island, Wando Island); a medium-size form from eight localities in South Korea and North Korea (Jindo Island, Kunsan, Mt. Chirisan, Cheongju, Mt. Weolaksan, Mt. Taebaksan; Haeju, Sineuiju); a small-size form from five localities in North Korea, northeastern China, and far eastern Russia (Mt. Kumkangsan, Mt. Myohyangsan; Jirin, Yichun; Vladivostok).

DISCUSSION

Sneath and Sokal (1973) stated that there are no satisfactory methods for telling whether clustering or ordination is appropriate. In this paper based on discriminant analysis (Fig. 2), principal component analysis (Fig. 3), and average linkage cluster analysis (Fig. 4) with morphometric characters, three subgroups were recognized: a large-size form (OTUs 1 and 2), medium-size form (OTUs 3, 4, 5, 6, 7, 8, 9 and 11), and a small-size form (OTUs 10, 12, 13, 14, and 15).

Koh (1986) performed morphometric analysis with samples of *A. agrarius* from ten localities in South Korea, including eight samples from Kunsan and four samples from Mokpo [subspecies *pallescens* by Jones and Johnson (1965)], and concluded that subspecies *pallescens* is the synonym of subspecies *coreae*. In the morphometric analyses with seven subspecies of *A. agrarius* from Asia (Koh, 1991) and with six subspecies of *A. agrarius* from China and South Korea (Koh *et al.*, 1997), three subgroups were revealed: small-size form (*agrarius*, *manchuricus*, *pallidior*,

ningpoensis, and *insulaemus*) from China, medium-size form (*coreae*) from South Korea, large-size form (*chejuensis*) from Cheju Island, South Korea. In this paper with morphometric analyses of striped field mice from Far Eastern Asia (see Table 1 and Figs. 2, 3, and 4), three subgroups were recognized: a large-size form (OTUs 1 and 2), medium-size form (OTUs 3, 4, 5, 6, 7, 8, 9, and 11), small-size form (OTUs 10, 12, 13, 14, and 15), and it is confirmed that the large-size form, the medium-size form, and the small-size form are *A. agrarius chejuensis*, *A. agrarius coreae*, and *A. agrarius manchuricus*, respectively.

Jones and Johnson (1965) reported four subspecies of *Apodemus agrarius*: *manchuricus* in the extreme northern part, *pallescens* in the coastal lowlands of southern and southwestern Korea, *coreae* throughout the major portion of the Korean peninsula, and *chejuensis* in Chejudo. They also noted that when specimens are available from northern part of Korean peninsula they would expect to find *manchuricus* in the high mountains of extreme northern Korean peninsula and *coreae* in the north-central parts. In this paper, it is concluded that striped field mice (the medium-size form) from western region of North Korea (Haeju, Sineuiju) is subspecies *coreae*, as noted by Thomas (1908), and that striped field mice (the small-size form) from eastern region of North Korea (Mt. Kumkangsan, Mt. Myohyangsan) is not *coreae*, but *manchuricus*.

In future, it is necessary to perform further researches with more samples from North Korea and by molecular methods in order to confirm these results.

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극동아시아에 서식하고 있는 등줄쥐 *Apodemus agrarius* Pallas
(포유 강: 설치 목) 3아종의 형태 형질의 분석:
북한산 등줄쥐의 분류학적 위치

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요 약

북한산 등줄쥐의 분류학적 위치를 결정하기 위해, 극동아시아 (한국, 북한, 북동 중국, 극동 러시아)의 15개 지역에서 채집한 등줄쥐 (*Apodemus agrarius*) 3아종의 31개 형태 형질들을 다변량방법으로 분석하였다. 분석 결과 세 군으로 나누어졌는데, 한국의 2개 지역 (제주도, 완도)의 큰형, 한국과 북한의 8개 지역 (진도, 군산, 지리산, 청주, 월악산, 태백산; 해주, 신의주)의 중간형과 북한, 중국, 러시아의 5개 지역 (금강산, 묘향산; 길림, 이춘; 블라디보스톡)의 작은형이었다. 큰형, 중간형, 그리고 작은형은 고 등 (1991, 1997)이 밝힌 대로 각각 *A. a. chejuensis*, *A. a. coreae*, *A. a. manchuricus*임이 확인되었다. 북한의 서부 지역 (해주, 신의주)의 등줄쥐 (중간형)는 Thomas (1908)가 언급한 대로 *A. a. coreae*로 분류된다고 밝혀졌지만, 북한의 동부지역 (금강산, 묘향산)의 등줄쥐 (작은형)는 *A. a. manchuricus*이었다.