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Taxonomic status of the *Apodemus agrarius chejuensis* population of Cheju Island, Korea, From the standpoint of external and cranial characters

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Abstract

In order to re-examine status of the Korean striped field mice, *Apodemus agrarius chejuensis* from the Cheju Island, external values and skull characters were compared with A. a. coreae from the Korean Peninsula, *A. specious, A. argenteus,* and *A. semotus.* Skull characters of *A. a. chejuensis*(Cheju population) and *A. a. coreae*(mainland population) were fitted onto two different clines. The regression lines of the body weight of *A. a. chejuensis* and *A. a. coreae* were virtually parallel and there were significant differences between sections. Significant differences were furthermore detected between *A. a. chejuensis* and *A. a. coreae* in 8 parts(condylobasal length, nasal length, frontal length, interorbital breadth, auditory bulla length, breath of occipital foramen, height of mandible and length of the lower molar series). Moreover, distances between the posterior end of incisive foramina and anterior end of the first upper molar in the Cheju Island and mainland populations were different. These data support the specific division of "*Apodemus chejuensis*" occurring in the Cheju Island from *A. agrarius* in the mainland, as proposed by Oh and Mori(1998).

Key words : Taxonomy, *Apodemus chejuensis,* external and cranial characters, Cheju Island

Introduction

Research into specific characters(growth and variation patterns) of the external values and skull as well as age assessment have been conducted for various species of the genus *Apodemus* including *A. agrarius*(Haitlinger, 1962; Adamczewska- Andrzejewska, 1971, 1973; Sikorski, 1982) and *A. sylvaticus* (Delany and Davis, 1961; Haitlinger, 1969; Delany, 1970; Gurnell and Knee, 1984) in Europe as well as *A. a. coreae*(Koh, 1983, 1986, 1991) in Korea, *A. speciosus*(Imaizumi, 1962; Miyao *et al.*, 1968; Yoshida, 1983) and *A. argenteus*(Miyao and Mori, 1968; Yoshida, 1984) in Japan, *A. semotus*(Lin et al., 1992) in Taiwan. However, all of these researches were conducted based on field collected samples with unknown age. Comparing with these *Apodemus* spp., data for *A. agrarius* were constructed, especially for *A. agrarius chejuensis*. Thus, it seems to be important to show detailed morphological data of *A. agrarius* in order to clarify the taxonomic problem of *A. agrarius chejuensis* population.

The purpose of this study is to give some evidences to clarify the classification of the Cheju Island population of the striped field mouse, by showing intra-specific and inter-specific variations in body and cranial characters. Originally, the population of *A. agrarius* in the Cheju Island had been classified to a subspecies because of their large body size compared to other *A. agrarius*. In this study, we focus on the proportional differences in morphology between *A. agrarius chejuensis* and *A. agrarius coreae*. We also compared these data with those of three other Asian species, *A. speciosus* and *A. argenteus* in Japan and *A. semotus* in Taiwan to demonstrate the inter-specific variation of *Asian Apodemus* spp. and to evaluate the differences between *A. agrarius chejuensis* and *A. agrarius coreae*.

Materials and Methods

To show inter-specific morphological variations Asian *Apodemus*, 40 samples consisted of 20 males and 20 females were collected in the field for each of *A. agrarius chejuensis* was captured at Mt. Halla of Cheju Island in Korea, from March to August, 1994. *A. agrarius coreae* was captured at Mt. Whangreung in Pusan in Korea from August to September, 1994. *A. speciosus* and *A. argenteus* were captured at Mt. Abura at Fukuoka in Japan in November and December, 1994, respectively. A. semotus was captured at the Alisan Alpine Forest Park in Taiwan in April, 1986. These samples of A. semotus were measured their body size and conserved in 70% alcohol. Adult were determined by the degree of wear of the upper 1st, 2nd and 3rd molars based on Hikida and Murakami(1980). To show external morphological characteristics, five variables were measured for each specimen: weight, head and body length, tail length(from the anus to the end of the tail), hind foot length(without claws) and ear length. After external morphometry, we prepared cranial specimens and measured 19 parts of skull with digital Vernier calipers to the nearest 0.01mm. The 19 parts, greatest length(GL), basilar length(BL), palatilar length(PL), nasal length(NL), frontal length(FL), parietal length(Prl), interparietal length(IL), length of incisive foramen(LIF), auditory bulla length(ABL), zygomatic breadth(ZB), interorbital breadth(IB), breadth of rostrum(BR), breadth of occipital foramen (BOF), length of upper molar series(LUM), length of upper diastema(LUD), length of mandible(LM), height of mandible(HM) and length of lower molar series(LLM). In addition, sexual dimorphism in size is also considered as a specific characteristics. Results are expressed as mean± 1SD. The differences of averages in body and cranial measurements were tested by ANOVA. To show the proportional difference, partial lengths of body were regressed on total length(head and body length) and those of skull were regressed on the greatest length of the skull. I estimated the slopes and Y-intercepts of regression lines for each species/subspecies. The slopes of these lines were compared by t-test between all dyad combinations of examined five species/subspecies. When there was no significant differences, we tested the Y-intercepts(Zar, 1984). Differences between each part of the body and skull size of males and females were compared by unpaired t-tests.

Results

1. Body size comparison between species and subspecies

Using head and body length as an index of body size, we found that there are clearly defined differences in the head and body length between species and subspecies (ANOVA, $F=102.9$, $d.f.=4, 195$, $p<0.0001$). *A. speciosus*(111.94± 8.21mm) was the largest, followed by *A. a. chejuensis*(103.07± 7.38mm), *A. semotus*(101.59± 3.99mm), *A. a. coreae*(88.47± 12.00mm) while *A. argenteus*(80.45± 4.83 mm) was the smallest, in that order. In post-hoc tests, there were significant differences between all with the exception of *A. a. chejuensis* and *A. semotus*(p+0.40); the head and body length of *A. a. chejuensis* was greater than that of *A. a. coreae.*

In a comparison of body weight, tail length, hind foot length and ear length to head and body length between species and subspecies, significant differences were found in the linear regression coefficients and between sections(Table 1). The species and subspecies each regressed on different lines(Fig. 1).

Table 1. Statistical differences(t -test, Zar, 1984) among regression lines of three body measurements and the greatest length of the skull against the head and body length in five species and two subspecies of *Apodemus*. Differences of the regression coefficients (R) and the Y-intercepts(I) are shown for dyad with $p<0.05$. Y-intercepts were tested for dyad with equal regression coefficients.

Dyad			Body weight (g)	Tail length (mm)	Hind foot length (mm)	Ear length (mm)	Greatest length of skull (mm)
A. a. chejuensis	:	*A. a. coreae*	I	I	I	I	I
A. a. chejuensis	:	*A. speciosus*	R	I	I	I	ns
A. a. chejuensis	:	*A. argenteus*	I	I	I	I	R
A. a. chejuensis	:	*A. semotus*	I	I	I	I	R
A. a. coreae	:	*A. speciosus*	R	R	I	R	R
A. a. coreae	:	*A. argenteus*	I	I	I	I	I
A. a. coreae	:	*A. semotus*	I	I	I	I	R
A. speciosus	:	*A. argenteus*	R	I	I	I	R
A. speciosus	:	*A. semotus*	I	I	ns	I	R
A. argenteus	:	*A. semotus*	R	ns	I	ns	R

The regression lines of the body weight of *A. a. chejuensis* and *A. a. coreae* were virtually parallel and there were significant differences between sections. In addition, the degree of variance in body weight was greatest in *A. speciosus*($SD=7.84$) and least in *A. argenteus*($SD=1.93$). Significant differences were detected in the length of three parts, tail length, hind foot length and ear length, between virtually all of the species and subspecies and there were differences between sections in essentially all cases, in contrast to differences in regression coefficients between *A. a. coreae* and *A. speciosus* (Fig. 1b, c and d).

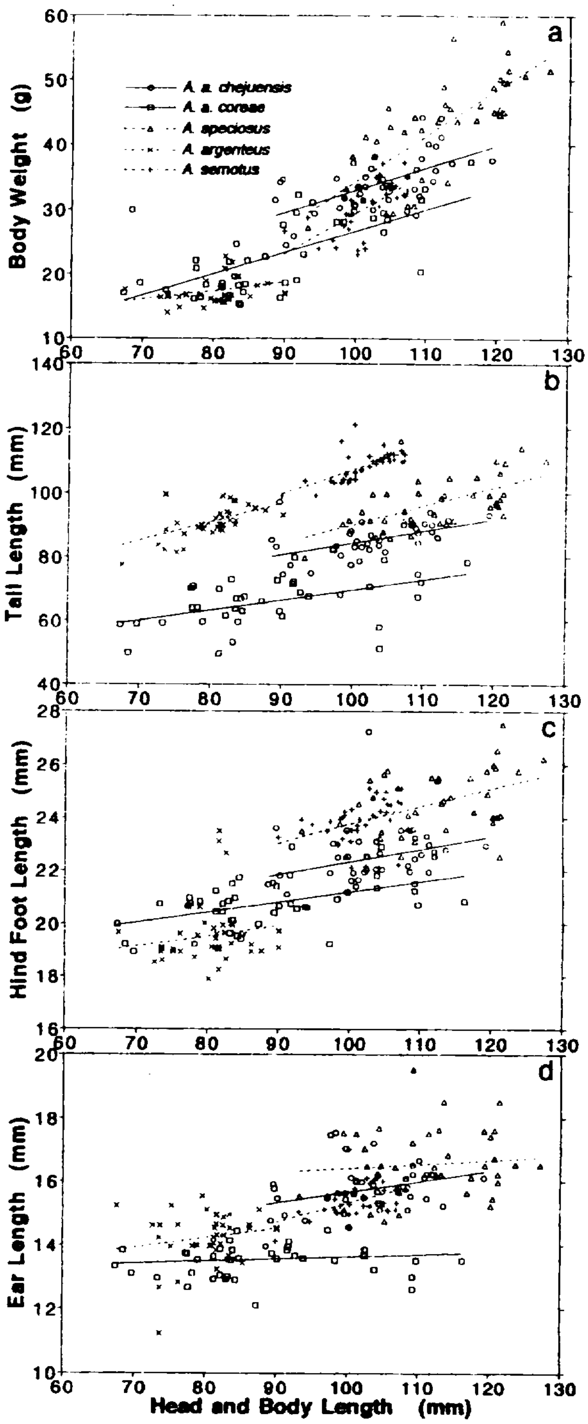

Fig. 1. The relationships of the difference between a) body weight; b) tail length; c) hind foot length; d) ear length against head and body length of the external morphological traits in *Apodemus.*

In regard to body size, the *A. semotus* indicated the greatest sexual dimorphism with males significantly larger than females in all measurement values while *A. speciosus* indicated low sexual dimorphism(Table 2). In regard to body weight, most of the specimens were characterized by male-dominant sexual dimorphism; however, *A. argenteus* alone indicated female-dominant sexual dimorphism. In terms of head and body length, all of the mice with the exception of *A. argenteus* indicated male-dominant sexual dimorphism. In tail length, *A. a. chejuensis* and *A. semotus* indicated male dominant sexual dimorphism, although *A. a. coreae* did not show a significant difference. *A. semotus* indicated male-dominant sexual dimorphism in hind foot length while *A. semotus* hand male-dominant sexual dimorphism and *A. argenteus* had female-dominant sexual dimorphism in ear length.

Table 2. Sexual dimorphism in five measurements of body size in four species and two subspecies of *Apodemus*. Larger sexes are shown with the significant levels(t-test, $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$).

	Body weight(g)			Head and body length(mm)		
	male	female	larger sex	male	female	larger sex
A. a. chejuensis	36.80 ± 3.63	31.42 ± 3.19	male***	105.53 ± 7.91	100.61 ± 6.04	male*
A. a. coreae	27.68 ± 4.66	18.15 ± 2.12	male***	93.89 ± 12.45	83.05 ± 8.87	male**
A. speciosus	45.58 ±7.91	40.26 ± 6.97	male*	115.14 ± 6.94	108.74 ± 8.28	male*
A. argenteus	16.64 ± 1.33	18.38 ± 2.07	female**	79.03 ± 4.08	81.87 ± 5.19	
A. wemotus	32.98 ± 2.81	28.11 ± 3.22	male***	103.34 ± 4.60	99.84 ± 2.26	male***

	Tail length(mm)			Hind foot length(mm)		
	male	female	larger sex	male	female	larger sex
A. a. chejuensis	87.85 ± 3.85	83.49 ± 5.56	male**	22.60 ± 0.68	22.37 ± 1.41	
A. a. coreae	67.85 ± 9.44	64.12 ± 5.72		21.01 ± 1.09	20.51 ± 0.72	
A. speciosus	98.95 ± 7.32	95.34 ± 8.54		24.58 ± 1.26	24.55 ± 1.22	
A. argenteus	90.53 ± 4.89	92.23 ± 5.54		19.22 ± 0.41	19.91 ± 1.53	
A. wemotus	110.64 ± 4.36	106.61 ± 3.74	male**	24.32 ± 0.75	23.48 ± 0.68	male***

	Ear length(mm)		
	male	female	larger sex
A. a. chejuensis	15.78 ± 0.76	15.74 ± 0.89	
A. a. coreae	13.72 ± 0.78	13.41 ± 0.53	
A. speciosus	16.75 ± 0.96	16.38 ± 1.15	
A. argenteus	13.85 ± 0.85	14.66 ± 0.51	female**
A. wemotus	15.60 ± 0.61	15.22 ± 0.31	male*

2. Relative growth in the cranial measurements of *A. a. chejuensis*

The logistic method applies well to growth of the overall length of the overall length of the skull and the correlation coefficient was 0.98, the inflection point was 0.8 days old, the asymptotic value was 29.23mm and the growth rate coefficient was 0.069 (Fig. 2).

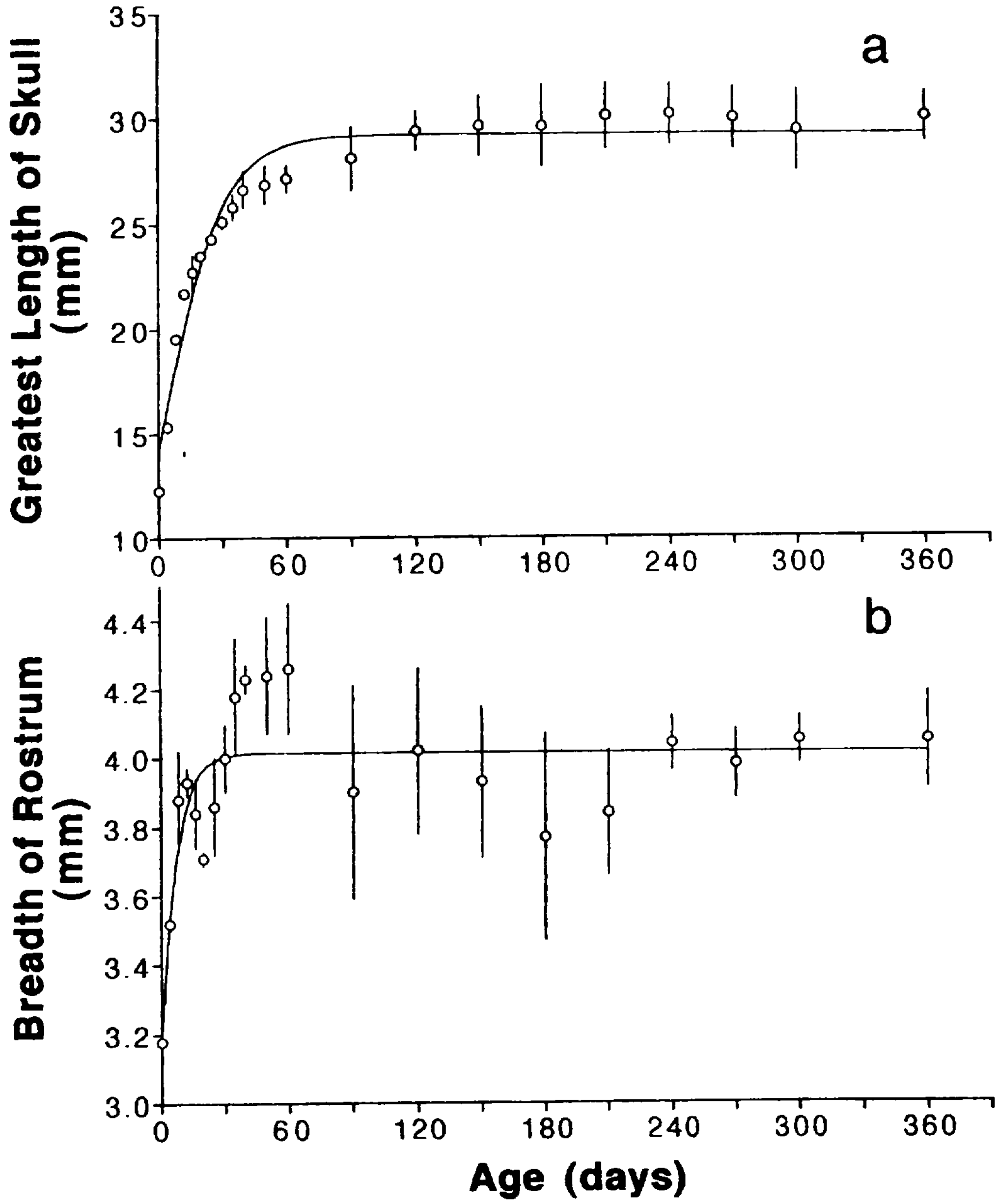

Fig. 2. Growth curves of the greatest length of length of the skull (a) and breadth of the rostrum (b) in *Apodemus agrarius chejuensis.*

In regard to the growth of other measured parts of the skull, we carried out absolute growth analyses by logistic method and rela tive growth analyses of each part against the overall length of the skull(Fig. 3). The α value of the basilar length indicated equal gro-

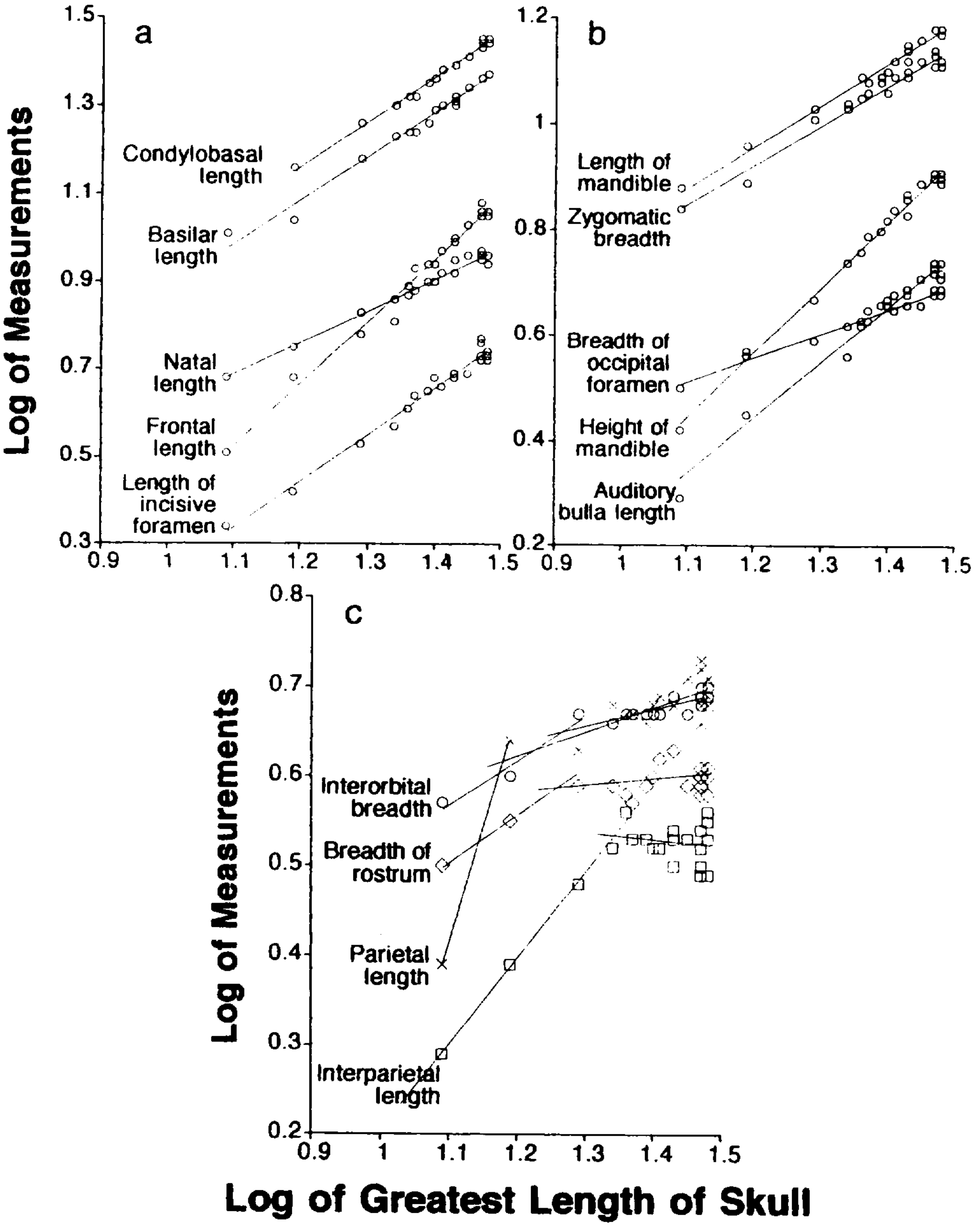

Fig. 3. Relative growth of the 14 skull measurements against the greatest length of the skull in *Apodemus arrarius chejuensis*.

wth against the greatest length of the skull, the frontal length, length of the incisive foramen, zygomatic breadth and length of the mandible indicated somewhat inferior growth and the breadth of the occipital foramen indicated inferior growth. In addition, the condylobasal length, length of the incisive foramen and auditory bulla length indicated equal growth and the nasal length and height of mandible indicated superior growth(p <0.01). The values for the interparietal length, parietal length, breadth of rostrum and interorbital breadth, in which the α value varies, against cranial length were between 1.18 and 1.34, that is, the greatest cranial length was 15.14mm~21.88mm, and, in regard to age, there were intersecting points between 4 days old and 12 days old and they were all parts with small correlation coefficients by the logistic method(p=0.80~0.94; others were 0.96~0.98). The zygomatic breadth showed linear growth; however, growth ceased in the interorbital breadth and breadth of rostrum while the greatest length of the cranium continued to grow and, in addition, the growth of the frontal bone, which comprises the braincase, was linear; however, there was a tendency for growth to stop short in the parietal bone and interparietal bone, that is, we observed growth of the distal portion due to growth of the latter half.

3. Interspecific comparison of cranial size

In order to carry out interspecific compa-

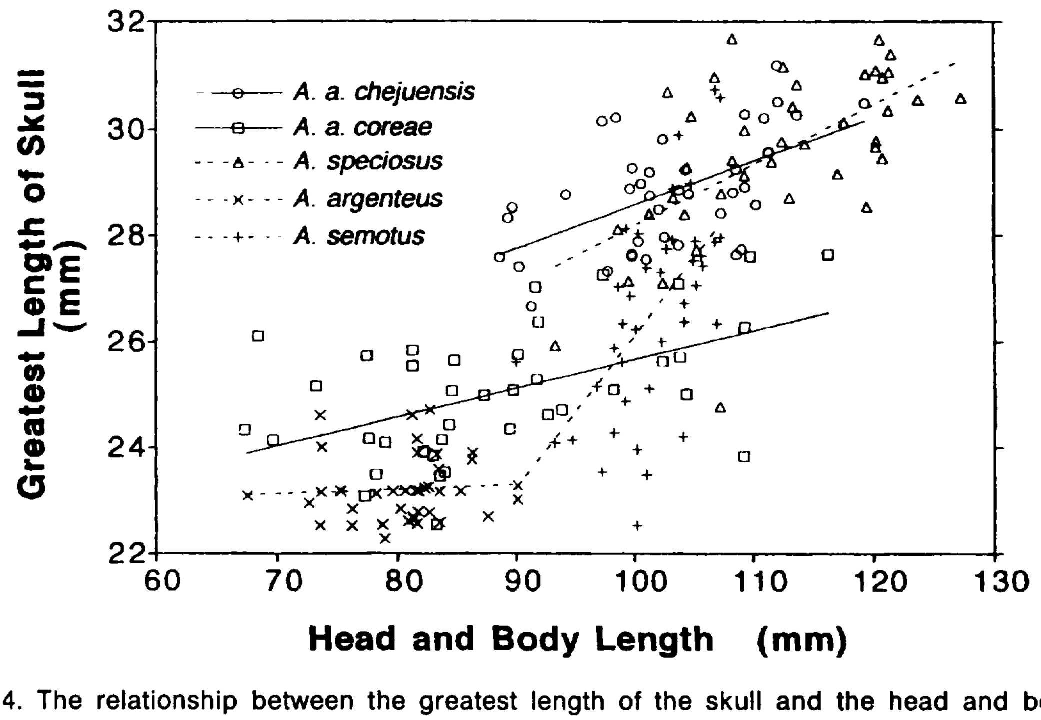

Fig. 4. The relationship between the greatest length of the skull and the head and body length in *Aodemus.*

risons of cranial size in relation to body size, we determined the regression of the greatest length against head and body length. *A. a. chejuensis* and *A. speciosus* are distributed in virtually the same position, forming a group with relatively large skull(Fig. 4), and there was no significant difference in their lineal regression(Table 2). There were no significant differences in the linear regression between other species and subspecies with the regression coefficient greatest in the case of *A. semotus*(0.29), while that of *A. agrarius coreae* was less than *A. a. chejuensis* and *A. argenteus* was the smallest. More pronounced sexual dimorphism was furthermore observed in the greatest cranial length in the male specimens than in female specimens of *A. a. coreae* and *A. semotus*(Table 3)

Table 3. Sexual dimorphism (t -test) in 19 measurements of skull in two subspecies of *Apodemus agrarius* and other three *Apodemus* species. Values indicate the remainders which subtracted female average values form male ones.

Measurements	*A. a. chejuensis*	*A. a. coreae*	*A. speciosus*	*A. argenteus*	*A. semotus*
GLS: greatest length of skull	0.74ns	1.31***	0.28ns	-0.02ns	1.95***
CL: condylobasal length	0.75*	0.97**	0.34ns	-0.19ns	1.66**
BL: basilar length	0.58ns	1.28***	-0.07ns	0.18ns	1.48*
PL: palatilar length	0.27ns	0.54***	0.15ns	-0.08ns	1.05**
NL: nasal length	0.42*	0.48***	-0.09ns	0.26ns	1.33**
FL: frontal length	0.00ns	0.56**	-0.21ns	0.12ns	0.12ns
PrL: pariental length	0.10ns	-0.06ns	-0.05ns	0.06ns	0.31ns
IL: interpariental length	0.14ns	0.15ns	0.14ns	0.04ns	0.03ns
LIF: length of incisive foramen	0.23ns	0.09ns	0.13ns	-0.04ns	0.41**
ABL: auditory bulla length	-0.03ns	0.02ns	0.07ns	-0.04ns	0.30*
ZB: zygomatic breadth	0.21ns	0.55***	-0.02ns	-0.20*	0.63*
IB: interorbital breadth	0.08ns	0.03ns	0.06ns	0.05ns	0.21*
BR: breadth of rostrum	0.06ns	0.05ns	0.08ns	0.03ns	0.26*
BOF: breadth of occipital foramen	-0.06ns	-0.19*	0.30ns	-0.02ns	-0.02ns
LUM: length of upper molar series	-0.05ns	0.05ns	0.11ns	0.04ns	0.24*
LUD: length of upper diastema	0.22ns	0.44**	0.34ns	-0.02ns	0.68**
LM: length of mandible	0.36ns	0.81***	0.15ns	0.12ns	0.99**
HM: height of mandible	0.21ns	0.68***	-0.06ns	-0.01ns	0.51*
LLM: length of lower molar series	-0.11ns	-0.03ns	0.08ns	0.11*	0.25*

$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$, ns: statistically non-significant($p>0.05$)

Table 4. Measurements (mm, mean±SD) of the skull in two subspecies of *Apodemus agrarius* and three other *Apodemus* species.

Measurements	*A. a. chejuensis*	*A. a. coreae*	*A. speciosus*	*A. argenteus*	*A. semotus*
GLS: greatest length of skull	28.82 ± 1.07	25.04 ± 1.26	29.54 ± 1.54	23.22 ± 0.61	26.58 ± 1.96
CL: condylobasal length	26.65 ± 1.16	23.32 ± 1.21	27.33 ± 1.38	21.71 ± 0.57	24.52 ± 1.88
Ratio to GLS	92.47%	93.12%	92.50%	93.52%	92.24%
BL: basilar length	22.34 ± 1.03	19.39 ± 1.16	23.31 ± 1.20	17.73 ± 0.60	20.07 ± 1.90
Ratio to GLS	77.50%	77.43%	78.90%	76.37%	75.48%
PL: palatilar length	12.52 ± 0.58	10.94 ± 0.53	13.15 ± 0.72	9.80 ± 0.32	11.27 ± 1.18
Ratio to GLS	43.43%	43.69%	44.50%	42.23%	42.40%
NL: nasal length	11.07 ± 0.62	9.35 ± 0.47	11.42 ± 0.88	7.97 ± 0.51	10.46 ± 1.53
Ratio to GLS	38.39%	37.33%	38.66%	34.32%	39.34%
FL: frontal length	8.93 ± 0.51	8.33 ± 0.60	9.19 ± 0.46	7.76 ± 0.35	7.98 ± 0.67
Ratio to GLS	30.98%	33.26%	31.10%	33.42%	30.01%
PrL: parietal length	5.06 ± 0.31	4.65 ± 0.29	5.40 ± 0.33	5.00 ± 0.31	4.82 ± 0.58
Ratio to GLS	17.55%	18.56%	18.26%	21.55%	18.14%
IL: interparietal length	3.34 ± 0.33	3.18 ± 0.34	3.70 ± 0.37	3.26 ± 0.25	3.36 ± 0.33
Ratio to GLS	11.60%	12.68%	12.52%	14.05%	12.65%
LIF: length of incisive foramen	5.31 ± 0.38	4.64 ± 0.33	5.61 ± 0.35	4.38 ± 0.21	5.02 ± 0.50
Ratio to GLS	18.44%	18.54%	18.99%	18.87%	18.88%
ABL: auditory bulla length	5.39 ± 0.24	4.97 ± 0.24	5.83 ± 0.29	4.70 ± 0.44	4.78 + 0.44
Ratio to GLS	18.71%	19.86%	19.73%	20.26%	17.99%
ZB: zygomatic breadth	13.31 ± 0.54	12.08 ± 0.50	14.62 ± 0.65	11.57 ± 0.31	12.57 ± 0.91
Ratio to GLS	46.18%	48.23%	49.50%	49.84%	47.28%
IB: interorbital breadth	4.92 ± 0.21	4.46 ± 0.21	4.98 ± 0.20	4.19 ± 0.23	4.60 + 0.29
Ratio to GLS	17.07%	17.80%	16.85%	18.03%	17.29%
BR: breadth of rostrum	4.48 ± 0.26	4.17 ± 0.22	4.54 ± 0.33	3.57 ± 0.15	4.17 + 0.39
Ratio to GLS	15.55%	16.67%	15.35%	15.38%	15.70%
BOF: breadth of occipital foramen	4.82 ± 0.21	4.48 ± 0.28	5.27 ± 0.48	4.97 ± 0.52	4.66 + 0.28
Ratio to GLS	16.71%	17.88%	17.84%	21.39%	17.53%
LUM: length of upper molar series	4.17 ± 0.18	3.99 ± 0.15	4.41 ± 0.22	3.69 ± 0.15	3.96 ± 0.38
Ratio to GLSs	14.46%	15.95	14.93	15.88	14.91%
LUD: length of upper diastema	8.15 ± 0.41	6.82 ± 0.49	8.04 ± 0.61	6.14 ± 0.33	6.89 ± 0.77
Ratio to GLS	28.29	27.22	27.21%	26.47%	25.93%
LM: length of mandible	14.47 ± 0.64	12.64 ± 0.72	15.98 ± 0.86	12.12 ± 0.44	13.90 ± 1.21
Ratio to GLS	50.22%	50.50%	54.11%	52.19%	52.29%
HM: height of mandible	7.68 ± 0.36	6.43 ± 0.46	7.69 ± 0.60	6.20 ± 0.32	6.93 + 0.66
Ratio to GLS	26.65%	25.70%	26.02%	26.72%	26.06%
LLM: length of lower molar series	4.19 ± 0.24	3.93 ± 0.17	4.50 ± 0.23	3.64 ± 0.14	4.04 ± 0.36
Ratio to GLS(%)	14.54%	15.70%	15.23%	15.69%	15.20%

and, in addtion, when comparing the external appearance of the skull, the skull of *A. a. chejuensis* was characterized by a larger size, long and narrow rostrum and, especially, the long length of the upper diastema. The skull of *A. agrarius coreae* was *smaller* than that of *A. a. chejuensis.* The skull of *A. speciosus* is also large similar to that of *A. a. chejuensis* and the rostrum is long and wedge-shaped constricted at the center and the back of the skull was narrow with a clearly-defined lateral processus.

A. argenteus was small with a long rostrum and with a braincase that was flatter than in the other specimens and no lateral processus. *A. semotous* in intermediate in form and nasal length was longer in relation to the greatest length of the skull than in the other species. In addition, comparing the ratios of the various parts of the skull in relations to the greatest length of the skull in *A. a. chejuensis* and *A. a. corea,* the nasal length, length of the upper diastema and height of the mandible were larger in *A. a. chejuensis,* though the other parts were larger in *A. a. coreae.*(Table 4).

A. a. coreae and *A. semotus* are a group that indicates sexual dimorphism in cranial size while clearly marked sexual dimorphism was not observed in *A. a. chejuensis, A. speciosus* or *A. argenteus.* In particular, though it seemed at a glance that the skull of the male was larger than the female in A. speciosus, the range of cranial size overlaps in the males and females and no significant differences were detected in the overall measurement values.

We carried out a comparison between species and subspecies using linear regression of the various parts of the skull against the greatest cranial length. Overall, *A. speciosus* had many characters demonstrating a significant difference compared to other species and subspecies with differences in 14 parts of *A. a. chejuensis,* 14 parts of *A. a. coreae,* 14 parts of *A. argenteus* and 16 parts of *A. semotus*(Table 5), while, in contrast, *A. a. chejueniss,* showed few characters indicating significant differences compared to other species and subspecies with the exception of A. speciosus and, among the species of the genus *Apodemus* that we examined, indicated average characters. Significant differences were observed between *A. a. chejuensis* and *A. argenteus* in 6 parts, the condylobasal length, nasal length, parietal length, breadth of rostrum, length of the upper molar series and length of the lower molar series, and between *A. a. chejuensis* and *A. semotus* in 7 parts, nasal length, frontal length, auditory bulla length, breadth of rostrum, length of upper diastema, length of mandible and length of lower molar series. Significant differences were furthermore detected between *A. a. chejuensis* and *A. a. coreae* in 8 parts (condylobasal length, nasal length, frontal length, interorbital breadth, auditory bulla length, breath of occipital foramen, height of mandible and length of the lower molar series).

Table 5. Statistical differences(t-test) among regression lines of two subspecies of *Apodemus agrarius* and other three *Apodemus* species for each of 18 skull characters against the greatest length of the skull(GLS). CH=*A. a. chejuensis*, CO=*A. a. coreae*, SP=*A. speciosus*, AR=*A. argenteus*, SE=*A. semotus*. Differences of the regression coefficients(R) and the Y-intercepts(I) are shown for dyad with $p<0.05$, Y-intercepts were tested for dyad with equal regression coefficients. Cite Table 3 for the abbreviations of skull characters.

Dyad	CL	BL	PL	NL	FL	PrL	IL	LIF	ABL	ZB	IB	BR	HOF	LUM	LUD	LM	HM	LLM
CH : CO	R			R	I				R		I		I				I	I
CH : SP	R	R	I			I	I	I	I	I			I	I	I	I	I	I
CH : AR	R			I		I						I		I				I
CH : SE				I	I				R			R			I	I		R
CO : SP		I	I	I	R	I	R	I	R	I	I		I	I		I		I
CO : AR			I	I		I					I	I	I	I		I	I	I
CO : SE		I	R	R	I		I		R		R	R		I	I	I		R
SP : AR	I	I	I	I			I	I		I	I	I	I	I		I	I	I
SP : SE	I	I	I	R	I	I	I		R	I	R	R	R	R	R	I		R
AR : SE	R	I	I		I	I			R	I			I		I		I	

4. Form of the upper and lower molars in the genus *Apodemus*

The upper and lower molars of the genus *Apodemus* are generally obtuse type with a number of cusps with 3 processus on which a number of cusps are concentrated are arrayed on each molar. The anterocone of the upper 2nd and 3rd molars is small and the anterolingual conule, consisting of 3 constrictions, is continuous, forming the shape of a mountain, and the basic form was the same as the upper 1st molar. In addition, the distance between a line connecting the left and right rear extremities of the incisive foramen and a line connecting the left and right front extremities of the upper 1st molar differs between *A. a. chejuensis* and *A. a. coreae*, being obviously longer in the former(*A. argenteus* 0.88± 0.18; *A. a. chejuensis* 1.11± 0.21; *A. a. coreae* 0.21± 0.11; *A. semotus* 0.79± 0.12; *A. speciosus* 1.16± 0.19). There was significance in this distance in all of the species ($F=189.4$, $d.f.=195$, $p<0.001$). The ratio of the distance between a line connecting the left and right rear extremities of the incisive foramen and a line connecting the left and right front extremities of the upper 1st molar against the greatest cranial length was significantly smaller in *A. a. coreae* and *A. semotus* than in the other species(post hoc-test, $p<0.001$) and, in particular, it was conspicuously small in *A. a. coreae*. There were no significant differences between *A. argenteus*, *A. a. chejuensis* and *A. speciosus*.

Discussion

The degree of sexual dimorphism in the genus *Apodemus* differs between the subspecies and species different results were obtained for *A. agrarius*, a Eurasian species which is reported to have little morphological variation(Haitlinger, 1962) and *A. a. coreae*, native to the Korean mainland, reported to have no sexual dimorphism(Koh, 1983). In other words, the significant differences that were observed between *A. a. chejuensis* and *A. a. coreae* in head and body length, body weight, tail length, hind foot length and ear length as well as the fact that each showed regression on different lines are good indications of the differences between the two subspecies. In addition, it can also be said that, while tail length is a sexual dimorphic character of *A. a. chejuensis*, the fact that the *A. a. coreae* did not indicate a significant difference in sexual dimorphism and the fact that the *A. a. coreae* has a lower tail ratio than *A. a. chejuensis* reflect differences in the living environments of these two subspecies and are interesting characters. *A. a. chejuensis* which inhabits Cheju Island, is large both in body and cranial size compared to the subspecies *A. a. coreae* and coincides well with corresponds well with the Island rule. *A. a. coreae* also differed in size, though basically it was expected to be much the same as *A. a. chejuensis*. As inferred from research (Yoon et al., submitted for publication) relating to biogeography, group genetic structure and speciation relating to *A. agrarius* native to Korea, *A. agrarius* in Korea is thought to originate in *A. a. chejuensis*. The two subspecies are therefore thought to have been subjected to th influence of different environmental and natural enemy factors as well as genetic relationships, causing each to evolve in different directions. In addition, dimorphism is clear in the case of the forest-dwelling *A. semotus* in terms of body size, while little was found in the case of *A. argenteus*, which is thought to reflect the different way of life of the various species, resulting in differences in morphological expression.

Comparing the results of the Formosan wood mouse, *A. semotus*(Lin and Shiraishi, 1992), which has close affinity to the relative growth of the skull in *A. a. chejuensis*, there were general similarities in the growth rate coefficient and the initial growth index of each part; however, the growth rate coefficient of the breadth of the rostrum and interorbital breadth was greater in the former, while that of zygomatics breadth and breadth of occipital foramen was smaller. In addition, it has been reported in research involving *A. speciosus*(Hiraiwa *et al.*, 1958), *A. agrarius*(Tanaka, 1942) and *A. semotus*(Lin and Shiraishi, 1992) that the growth of the interorbital breadth and interparietal length is slower than that of the other parts; however, the growth rate coefficient of the breadth of rostrum and interorbital breadth is large in the case of *A. a. chejuensis* and the fact that, even when an adult, they continue to grow for a longer time than in other *Apodemus* species is thought to be a characters of this species.

Interspecific differences in rodent crania are observed in those parts directly related to the molars and masticatory muscle, which take a form that enables adaption to the unique feeding habits of the animal species. The species of genus *Apodemus* have various feeding habits, such as *A. flavicollis* and *A. sylvaticus* of Europe(Hansson, 1971), *A. speciosus, A. a. chejuensis, A. a. coreae and A. semotus*, which feed on seeds and insects, and *A. argenteus*, which is insectivorous. Based on the results of a comparison of the parts of the skull between species, significant differences were found in the relationship that greater between the two subspecies, significant differences were found in the relationship that are greater between the two subspecies *A. a. chejuensis* and *A. a. coreae* than *A. argenteus* and *A. semotus*. Furthermore, it is thought that the distance between a line connecting the left and right rear extremities of the incisive foramen and a line connecting the left and right front extremities of the upper first molars, which is different between *A. a. coreae* and *A. a. chejuensis*, originates in the fact that the upper diastema is longer in *A. a. chejuensis* than in other species. Thus, in the taxonomic relationship between *A. a. coreae* and *A. a. chejuensis*, judging from the fact that there are various differences in the cranial characters, the distance between the rear extremities of the incisive foramen and front extremities of the upper first molars and the various characters of the external morphology, we have concluded that there are significant morphological differences between these two subspecies and that they have an extremely distant taxonomic relationship.

Reference

Adamczewska-Andrzejewska, K. (1971) Methods of age determination on *Apodemus agrarius*. *Ann. Zool. Fenniici*, 8: 68-71.

Adamczewska-Andrzejewska, K. (1973) Growth, variation and criteria in *Apodemus agrarius*. *Acta Theriol.*, 18/19: 353-394.

Delany, M. J. (1970) Variation and ecology of island populations of the long-tailed field mouse *Apodemus sylvaticus*. *Proc. zool. Soc. Lond.*, 26: 283-295.

Delany, M. J. and P. E. Davis (1961) Observations on the ecology and life history of the Fair Isle field mouse, *Apodemus sylvaticus fridariensis* (Kinnear). *Symp. Zool. Soc. Lond.*, 136: 439-452.

Gurnell, J. and C. I. Knee (1984) Determining the age of wood mice *Apodemus sylvaticus*. *Folia Zool.*, 33: 339-348.

Haitlinger, R. (1962) Morphological variability in *Apodemus agrarius* (Pallas 1771). *Acta Theriol.*, 6: 239-256.

Haitlinger, R. (1969) Morphological variability of the Wroclaw population of *Apodemus sylvaticus* (Linnaeus, 1758). *Acta Theriol.*, 14: 285-302.

Hansson, L. (1971) Small rodent food, feeding and population dynamics, a comparison between granivorous and herbivorus species in Scandinavia. *Oikos*, 22: 183-198.

Hikida, T. and O. Murakami (1980) Age determination of the Japanese wood mouse, *Apodemus speciosus*. *Jap. J. Ecol.*, 30: 109-116 (in Japanese with English synopsis).

Hiraiwa, Y. K., M. Tokuda, T. Uchida and H. Sugiyama (1958) Some small mammals from the Islands of Oki, with especial reference to detail examination of their subspecific characteristics. *Sci. Bull. Fac.*

Agri. Kyushu., 16: 547-574 (in Japanese with English synopsis).

Imaizumi, Y. (1962) On the species formation of the *Apodemus speciosus* group, with special reference to the importance of relative values in classification. *Bull. Nat. Sci. Mus.*, 5: 163-259 (in Japanese with English resume).

Koh, H. S. (1983) A Study of age variation and secondary sexual dimorphism in morphometric characters of Korean rodents: I. An analysis on striped field mice, *Apodemus agrarius coreae from Chongju. Kor. J. Zool.*, 26: 125-134.

Koh, H. S. (1986) Geographic variation of morphometric characters among three subspecies of striped field mice, *Apodemus agrarius* Palla (Muridae, Rodentia), from Korea. *Kor. J. Zool.*, 29: 272-282.

Koh, H. S. (1991) Morphometric analyses with eight subspecies of striped field mice, *Apodemus agrarius* Pallas (Rodentia, Mammalia), in Asia: The taxonomic status of subspecies *chejuensis* at Cheju island, Korea. *Kor. J. Syst. Zool.*, 7: 179-188.

Koh, H. S. and B. S. Yoo (1992) Variation of mitochondrial DNA in two subspecies of striped field mice, *Apodemus agrarius coreae* and *Aopdemus agrarius chejuensis*, from *Korea. Kor. J. Zool.*, 35: 332-338.

Lin, L. K. and S. Shiraishi. (1992) Skull growth and variation in the Formosan Wood Mouse, *Apodemus semotus. J. Fac. Agr. Kyushu Univ.*, 37: 51-69.

Miyao, T. and T. Mori. (1968) Studies on the geographical variation of the small mammals in japanese Islands. III. Geographical variation of body sizes in *Apodemus argenteus. J. Growth.*, 7: 1-8 (in Japanese with English summary).

Oh, H. S. and T. Mori (1998) Taxonomic reexamination of the striped field mouse, *Apodemus agrarius coreae* and *A. a. chejuensis:* Evidence from crossbreeding experiments (Mammalia: Rodentia). *J. Fac. Agr., Kyushu Univ.*, 43: 143-151.

Sikorski, M. D. (1982) Craniometric variation of *Apodemus agrarius* (Pallas, 1771) in urban green areas. *Acta Theriol.*, 27: 71-81.

Tanaka, R. (1942) A biostatistical analysis of *Apodemus agrarius* from Formosa with special reference to its systematic characters. *Mem. Fac. Sci. Agr. Taihoku Imp. Univ. Formosa, Japan*, 23: 212-282.

Yoon, M. H., I. Kim, H. S. Oh and C. J. Phillips. Biography, genetic structure and speciation in the striped field mouse, *Apodemus agrarius* in southern Korea (submitted for publication).

Yoshida, H. (1983) A note on the morphology of Aopdemus *speciosus* collected in the mountain districts in Kyushu. *Biologia Fukuokana,* 23: 19-24 (in Japanese).

Yoshida, H. (1984) A note on the morphology of *Apodemus argenteus* collected in the mountain districts in Kyushu. *Biologia Fukuokana,* 24: 22-27 (in Japanese).

Zar, J. H. (1984) Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 718 pp.

외부형태와 두골의 특징으로 본 제주도산 등줄쥐 개체군의 분류학적 위치

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초 록

제주도산 등줄쥐의 분류학적 위치를 재검토하기 위하여 두골의 특징과 외부형태를 한국 본토산 등줄쥐 *Apodemus agraius coreae*와 근연종인 일본산 *A. specious, A. argenteus* 및 타이완산 *A. semotus*와 비교하였다. 외부형태 및 두골의 특징으로부터 제주도산 등줄쥐와 한국 본토산 등줄쥐 사이에는 2개의 계열에 속해 있었다. 체중의 회귀직선은 거의 평행으로 절편간에 유의차가 있었으며, 두골 각 부위의 두골전장에 대한 회귀직선의 비교에서도 8개의 부위에서 유의차가 있었다. 또한 절치공후단과 상악제일구치의 전단 사이의 거리도 서로 달라 제주도산 등줄쥐와 한국 본토산 등줄쥐는 형태학적으로 서로 다르다고 판단되어 제주도산 등줄쥐를 "*Apodemus chejuensis*"라고 제안한 Oh와 Mori(1998)의 의견을 지지한다.