Morphometric variation of house mice (*Mus musculus*) on the Izu Islands

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Abstract. We conducted univariate and multivariate statistical analyses of the morphometry of five island populations of the house mouse *Mus musculus*, from the Izu Islands (Oshima, Nijima, Kozushima, Miyakejima, Hachijojima), and compared them with three populations from the Japanese mainland of Honshu (from Kamogawa, Yokosuka, and Kawazu). Analyses were based on bodies, mandibles and molars. According to the analyses based on the mandible and molar measurements, the island samples differed from each other, and many of them also differed from the Honshu samples, although there was no evidence of positive directional variation, such as gigantism, in the insular samples. Cluster analyses of morphological distance, based on mandible and molar measurements, indicated that the island populations, with the exception of that on Oshima, were closely related to those on Honshu, while the Oshima population was slightly more distantly related. These results indicate that the divergence of the island populations is mainly attributable to the genetic variation of the initial founders and to subsequent isolation. The differentiation of the island populations may have taken place as recently as within the past 1,200 years.

Key words: Izu Islands, mandible, molar, morphometric variation, *Mus musculus*.

Islands are physically isolated, and changes amongst island populations can be expected to be conserved and to progress rapidly. Information concerning morphological and genetic changes in island populations is important, therefore, in contributing to an understanding of speciation. Island populations of rodents have proven to differ morphologically and genetically from both mainland populations and from each other (see for example Hiraiwa et al. 1958; Miyao et al. 1968; Berry 1969; Berry and Rose 1975; Berry and Peters 1977; Berry et al. 1978; Sakai and Miyao 1979). That these genetic differences can accumulate rapidly, has been shown by Berry and Jakobson's (1975) classic example of a mouse population on Skokholm Island, UK, which showed genetic changes over just 30 years.

The house mouse *Mus musculus* (or *Mus molossinus* according to Marshall and Sage (1981)), occurs on many of the small Japanese islands (Imaizumi 1960; Abe et al. 1994). So far, genetic studies using biochemical markers have concentrated on the geographical variation amongst house mice throughout Japan (Minezawa et al. 1979, 1980), but they have not

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found clear-cut divergences among insular populations, presumably due to the small number of specimens examined from each locality and because of the limited number of markers. Several studies have also revealed morphological variations amongst some insular house mice populations (Suzuki 1980; Takada et al. 1994), however, populations within an archipelago have not, so far, been studied.

The Izu Islands lie 90 km (Oshima) to 350 km (Aogashima) south of Tokyo Bay (Fig. 1). They range in size from Oshima, which at 91 km² is the largest, to Toshima and Shikinejima, which at just 4 km² are the smallest. These islands are mostly inhabited, but have just five species of rodents and insectivores. These are the house mouse, two species of rats *Rattus norvegicus* and *R. rattus*, the Japanese field mouse *Apodemus speciosus*, and the white-toothed shrew *Crocidura dsinezumi* (Nishikata 1986; Takada et al. 1999). Both the field mouse and the house mouse occur together on Oshima, Nijima, Kozushima (Kozu) and Miyakejima (Miyake). In addition, field mice alone are found on Shikinejima, and house mice are found alone on Hachijojima (Hachijo). White-toothed shrews occur on Toshima, Nijima and Shikinejima.

In this paper, we describe the morphological differentiation of house mice in the Izu archipelago, having analyzed morphological variation amongst five insular populations from Oshima, Nijima, Kozu, Miyake and Hachijo. Furthermore, we compare these five island

Fig. 1. A map showing sampling localities.

populations with three mainland populations from Kamogawa (Boso Peninsula), Yokosuka (Miura Peninsula) and Kawazu (Izu Peninsula) areas of Honshu, the Japanese mainland.

Materials and methods

House mice were collected from December to March 1994 to 1997, using snap and live traps set in grassland around cultivated fields. Each island and peninsula was visited once for four to five days, with the exception of Kozu, which was visited three times in 1995 and 1996. The following data were recorded: sex, body weight (BW; for pregnant females, excluding embryos and uterus), head and body length (HBL; from rostrum to anus), tail length (TL; from anus to tail tip) and hindfoot length (HFL).

The age of the mice specimens collected was predicted using a linear regression equation of eye lens weight against age (after Takada 1985). Only data from adults (two months old and more) were analyzed for bodily dimensions.

Mouse heads were skinned and boiled for several minutes in water then soaked with a trypsin solution in order to produce clean skeletons (following Takada et al.'s (1994) technique).

The right mandibles and right molars were measured to the nearest 1/100 mm and 1/1000 mm, respectively, using a Nikon Measurescope. For mandible measurements, only specimens aged two to eight months old were used in order to reduce age-related variation (Lovell et al. 1984). The X-axis was fixed as the inferior edge of the mandible and the Y-axis as the anterior edge. Ten dimensions were measured; five (M1–M5) consisted of heights and the other five (M6–M10) of lengths (Fig. 2).

The buccolingual crown diameter was measured for upper (UM1 to UM3) and lower molars (LM1 to LM3). The occlusal surface was kept horizontal and the widest part of the crown was measured at right angles to the longitudinal axis of each molar; the axis being a line connecting the central cusps for upper molars, and the central groove for lower ones. For molar measurements, specimens with slightly worn cusps (dental wear categories 3 and 4 in Lidicker's (1966) criteria) were used, and an average of two measurements for each molar was used for the following analyses. Measurement errors were negligible; for the Oshima sample ($n=27$), σ_{errors} was $2.1 \cdot 10^{-3}$ to $3.1 \cdot 10^{-3}$ mm for each molar, where σ_{errors}^2 was the sum of the squared difference of the two measurements divided by $2n$ (after Murai 1975).

Because no significant sexual differences ($P>0.05$) were found (either for body (HBL,

Fig. 2. Diagram of right mandible showing the 10 measurements.

HFL, tail ratios=TL/HBL), or mandible or molar measurements; tested by *t*-statistics and Mann-Whitney's *U*- one TTEST and UTEST respectively (see Aoki 1995) for body, and using Wilks' Λ - one (WILKS, Aoki 1995) for mandible and molar measurements), data from both sexes were pooled for the following analyses.

Morphometric differences between samples were analyzed using univariate and multivariate statistics. Significant differences between sample pairs were tested using the Scheffé's method of multiple comparisons after Kruskal-Wallis test for the tail ratio, and using Ryan's method of multiple comparisons for the other variables (KWTEST and MCOMP respectively, Aoki 1995). To evaluate the divergence of the island samples, the relative deviation from the Yokosuka sample, one of the mainland samples with a relatively large number of specimens, was calculated using $(\text{mean}_1 - \text{mean}_2)/SD_2$, where, mean_1 was a sample mean, and mean_2 and SD_2 were the mean and *SD* of the Yokosuka sample. For multivariate statistics, principal component analysis (PCA, Tanaka et al. 1984), using a correlation matrix of pooled samples, was employed. Mahalanobis' generalized distance (D^2) was calculated as an indication of morphological divergence between samples (MAHPCV, Tanaka et al. 1984). Cluster analysis (CLUST, Tanaka et al. 1984) was also carried out using the group average method based on D^2 .

Results

Body sizes

Significant differences between sample pairs were tested for HBL, HFL and tail ratios, but no positive directional change was found among insular and mainland samples. For sample means and *SDs* of adult mice see Table 1, and for a list of variables indicating significant differences between samples see the Appendix.

Table 1. Measurements for body size. For each measurement, sample means, *SD*, and number of specimens are given from the top.

	Oshima	Nijima	Kozu	Miyake	Hachijo	Kawazu	Kamogawa	Yokosuka
BW (g)	11.18	10.96	12.15	11.68	12.30	12.47	15.82	10.42
	2.67	1.53	2.94	1.91	1.94	2.02	2.28	2.37
	16	29	22	15	26	25	21	27
HBL (mm)	68.16	68.90	68.59	69.11	71.48	71.30	75.59	65.27
	5.86	4.82	6.21	4.82	5.29	5.40	4.42	5.36
	17	30	22	15	26	26	21	26
TL (mm)	55.89	57.66	56.00	59.51	62.02	60.71	59.42	55.14
	4.01	4.62	4.63	3.06	2.80	4.32	3.08	2.42
	15	30	22	15	26	25	22	27
HFL (mm)	15.35	15.63	15.28	15.23	15.67	15.74	15.74	15.46
	0.46	0.38	0.38	0.43	0.32	0.56	0.40	0.27
	17	30	22	15	26	26	22	27
TL/HBL (%)	82.15	83.85	81.81	86.29	87.03	85.09	78.43	85.00
	4.24	6.19	4.52	4.25	4.49	5.02	3.74	5.34
	15	30	22	15	26	25	21	26

BW: body weight; HBL: head and body length; TL: tail length; HFL: hindfoot length.

Mandible and molar measurements

Significant differences were found in variables between all pairs of sample means (see Table 2 for mandibles and Table 3 for molars).

Principal component analysis

The first component, expressing the overall size of the mandibles, arranges the samples from the largest, Kamogawa, to the smallest, Yokosuka and Miyake (see Table 4, Fig. 3). The second component, expressing the shape, particularly the height (M1, M2, M4; positive vector) to the length (M6, M7, M8; negative vector), arranges the samples from the highest, Oshima, to the lowest, Hachijo, Miyake and Kawazu. The third component, expressing relative height of the posterior (M3, M4, M5; positive vector) to anterior part (M1, M2;

Table 2. Measurements for mandible ($\times 100$, in mm). For each measurement, sample means, *SD*, and relative deviation from Yokosuka sample are given from the top. *n*, number of specimens.

	Oshima	Nijima	Kozu	Miyake	Hachijo	Kawazu	Kamogawa	Yokosuka
<i>n</i>	14	28	18	16	16	24	18	25
Age	mean	78	116	90	86	113	106	78
in days	<i>SD</i>	16	45	30	27	53	52	19
M1	164.3	165.4	155.4	156.6	155.4	154.9	165.7	152.6
	5.6	5.4	6.1	5.2	6.0	5.6	5.5	5.0
	2.32	2.54	0.56	0.79	0.56	0.45	2.60	0.00
M2	224.6	214.7	207.0	209.6	206.4	209.1	223.2	205.9
	7.8	9.3	9.4	8.8	9.5	9.4	8.8	7.6
	2.46	1.16	0.14	0.48	0.07	0.42	2.27	0.00
M3	434.4	452.3	457.3	428.9	446.8	442.9	455.2	433.9
	15.1	13.3	17.7	11.6	23.4	16.9	15.6	13.3
	0.04	1.38	1.76	-0.38	0.97	0.68	1.60	0.00
M4	476.3	476.6	481.0	441.3	475.9	468.3	489.0	465.1
	16.8	16.5	20.0	12.9	26.9	17.3	17.7	16.2
	0.69	0.71	0.98	-1.47	0.67	0.20	1.48	0.00
M5	541.2	546.5	556.2	520.8	544.9	550.9	559.5	530.1
	15.7	16.0	25.3	17.3	30.5	20.2	20.3	16.6
	0.67	0.99	1.57	-0.56	0.90	1.26	1.78	0.00
M6	722.5	742.6	741.2	755.4	757.5	762.9	767.6	729.8
	19.8	24.5	25.7	15.1	34.9	35.4	20.7	21.4
	-0.34	0.60	0.53	1.19	1.29	1.54	1.76	0.00
M7	781.8	795.5	793.9	797.4	798.9	829.6	818.2	773.8
	24.2	27.5	33.9	21.7	43.8	43.3	31.9	26.6
	0.30	0.82	0.76	0.89	0.94	2.10	1.67	0.00
M8	894.9	907.0	897.1	907.2	941.3	929.5	939.4	893.7
	25.6	28.8	33.8	20.4	41.0	32.9	23.6	24.4
	0.05	0.55	0.14	0.55	1.95	1.47	1.87	0.00
M9	1012.1	1004.8	991.9	1011.8	1047.1	1025.2	1054.1	987.7
	30.0	34.2	40.9	23.9	49.8	34.1	30.9	32.1
	0.76	0.53	0.13	0.75	1.85	1.17	2.07	0.00
M10	1047.5	1069.5	1068.2	1051.8	1086.9	1078.1	1103.3	1049.3
	33.9	36.1	47.4	23.3	44.1	43.9	31.6	33.5
	-0.05	0.60	0.57	0.07	1.12	0.86	1.61	0.00

Table 3. Measurements for molar ($\times 100$, in mm). For each measurement, sample means, *SD* and relative deviation from Yokosuka sample are given from the top. *n*, number of specimens.

	Oshima	Nijima	Kozu	Miyake	Hachijo	Kawazu	Kamogawa	Yokosuka
<i>n</i>	27	46	46	27	72	49	60	44
UM1	108.79	109.43	106.55	106.05	102.86	105.29	104.83	104.99
	1.81	1.99	1.49	2.25	2.04	2.30	2.22	2.11
	1.81	2.11	0.74	0.51	-1.01	0.14	-0.08	0.00
UM2	91.97	94.38	89.34	90.93	88.81	89.11	89.62	89.37
	1.95	2.18	2.24	1.97	1.90	1.80	2.47	2.19
	1.19	2.29	-0.01	0.71	-0.26	-0.12	0.11	0.00
UM3	61.15	64.99	63.02	63.62	64.60	60.61	62.50	61.83
	1.45	2.20	2.80	1.78	1.55	2.06	2.40	2.67
	-0.25	1.18	0.44	0.67	1.03	-0.46	0.25	0.00
LM1	87.59	87.37	85.18	82.98	81.44	83.89	83.84	82.40
	1.38	2.03	1.33	1.70	1.64	2.28	1.86	1.84
	2.82	2.70	1.51	0.31	-0.52	0.81	0.78	0.00
LM2	86.34	86.38	85.18	84.49	82.59	84.60	83.62	83.38
	1.40	1.60	1.01	1.89	1.73	1.75	2.20	1.77
	1.67	1.69	1.01	0.63	-0.45	0.68	0.13	0.00
LM3	54.86	57.84	59.98	58.92	57.64	56.13	56.85	56.68
	1.44	1.36	1.34	1.36	1.46	1.95	1.98	1.78
	-1.03	0.65	1.85	1.26	0.54	-0.31	0.09	0.00

negative vector), arranges the samples from the highest, Kozu, to the lowest, Miyake and Oshima.

The first component, expressing the overall size of the molars, arranges the samples from the largest, Nijima, to the smallest, Hachijo. The second component, expressing the relative size of the third molars (UM3, LM3; positive vector) to the first molars (UM1, LM1; negative vector), arranges the samples from the largest, Hachijo, to the smallest, Oshima. The third

Table 4. Principal component analysis of 10 mandible measurements based on pooled samples.

Variable	Component		
	1	2	3
M1	0.258	0.517	-0.380
M2	0.257	0.420	-0.533
M3	0.316	0.204	0.443
M4	0.299	0.316	0.450
M5	0.338	0.139	0.331
M6	0.327	-0.375	-0.141
M7	0.316	-0.332	-0.164
M8	0.340	-0.288	-0.075
M9	0.343	-0.164	-0.108
M10	0.351	-0.187	0.026
Eigenvalue	7.195	1.206	0.904
Proportion (%)	71.95	12.06	9.04

Fig. 3. Plots of sample means of the first three principal components, based on mandible measurements.
g: Kamogawa; h: Hachijo; k: Kozu; m: Miyake; n: Nijima; o: Oshima; w: Kawazu; and y: Yokosuka.

component, expressing the relative size of the lower molars (LM2, LM3; positive vector) to the upper molars (UM2, UM3; negative vector), arranges the samples from the largest, Kozu, to the smallest, Oshima and Nijima (see Table 5 and Fig. 4).

Morphological differentiation

Morphological differentiation between samples was estimated from the Mahalanobis' distance (D^2) based on the mandible and molar measurements to be found in Table 6. The two sets of values are slightly different, but significantly correlated ($r=0.63$, $df=26$, $P<0.001$). The distance based on each character, i.e. mandibles and molars, indicates that many of the island samples differ from the mainland ones, whereas the mainland samples are

Table 5. Principal component analysis of 6 molar measurements based on pooled samples.

Variable	Component		
	1	2	3
UM1	0.478	-0.247	0.009
UM2	0.458	0.008	-0.511
UM3	0.266	0.659	-0.471
LM1	0.445	-0.333	0.126
LM2	0.473	-0.153	0.268
LM3	0.262	0.609	0.655
Eigenvalue	3.569	1.300	0.576
Proportion (%)	59.48	21.67	9.60

Fig. 4. Plots of sample means of the first three principal components, based on molar measurements. g: Kamogawa; h: Hachijo; k: Kozu; m: Miyake; n: Nijima; o: Oshima; w: Kawazu; and y: Yokosuka.

similar to each other. In contrast, the insular samples were found to differ greatly from each other (see Fig. 5).

The results of cluster analyses based on the two sets of the values are different (see Fig. 6). On the basis of their mandibles, three groups are identified, namely a) Oshima; b) Nijima, Yokosuka, Kamogawa, Kozu; and c) Miyake, Hachijo, and Kawazu. In contrast, on the basis of their molars, just two groups are identified, namely a) Oshima, Nijima; and

Table 6. Mahalanobis' distances (D^2) between samples using 10 mandible and 6 molar measurements. For each pair-samples, the values from mandible and molar are given in the upper and lower lines respectively.

	Oshima	Nijima	Kozu	Miyake	Hachijo	Kawazu	Kamogawa
Nijima	24.05 7.20						
Kozu	39.51 26.36	17.53 14.95					
Miyake	50.49 24.99	25.58 11.44	37.65 4.47				
Hachijo	41.53 33.74	24.32 19.21	29.92 9.89	13.54 4.86			
Kawazu	38.46 9.38	24.19 9.16	15.13 8.54	18.56 6.71	11.67 11.15		
Kamogawa	12.26 14.21	9.07 7.33	21.97 5.95	20.76 3.72	13.85 4.93	17.17 2.36	
Yokosuka	21.70 17.37	13.78 10.27	9.00 7.03	22.80 2.05	13.24 5.13	9.16 2.59	8.51 1.49

All the values are significantly different from zero ($P < 0.002$).

Fig. 5. Mahalanobis' distances (D^2) between samples, based on molar measurements.

b) all of the others.

Discussion

It is necessary to examine factors affecting size, such as sex, growth and so on, before comparing variations among populations on the basis of morphometrics (Thorpe 1981). In this study, only characteristics that did not differ significantly between the sexes were analyzed. Many bodily dimensions increase after reaching sexual maturity, whereas hind-foot length and tail ratio increase only slightly (Hamajima 1963). Similarly, the shape of the mandible is nearly constant after seven weeks of age, although the overall size increases slightly (Lovell et al. 1984). In addition, the enamel of the molar crowns does not change in size and shape after reaching full size, without there being severe wear to the cusps (Sakai 1989). For this analysis, only external body and mandible measurements from adult mice were used. Molar size is a very useful characteristic for use in morphometric comparisons because the size of the crown changes very little, and because its heritability is relatively high (Leamy 1974; Murai 1975).

Differences were found in both mandible and molar measurements between mice from the various islands in the Izu archipelago, however difference in bodily dimensions were not so conspicuous. The variations were not, however, directional, and there was no evidence of

Fig. 6. Cluster analyses based on molar (upper) and mandible measurements (lower).

the gigantism amongst insular mice and insectivores as reported, for example, by Foster (1964) and Miyao (1970). Bodily dimensions (HBL, HFL, TL/HBL) of the insular samples ranged within those of the mainland samples (Table 1 and Appendix). Similarly, the overall mandible size of the insular samples, judging from the first component of PCA, ranged within that of the mainland samples (Fig. 3). Some insular samples (Oshima, Nijima) had larger molars, whereas specimens from Hachijo had the smallest molars, judging from the first component (Fig. 4).

Morphological differentiation was greater among most of the island populations than among the mainland ones, as indicated by the Mahalanobis' distance (Table 6 and Fig. 5). Most of the distances between the island samples exceeded those between the mainland ones (islands: 13.54–50.49 for mandibles, 4.47–33.74 for molars; mainland: 8.51–17.17 for mandibles, 1.49–2.59 for molars). It seems that differentiation among the island populations were unrelated to the geographical distance separating them. For example, although the islands of Nijima and Kozu are only 15 km apart, their mice populations are well differentiated from each other. Furthermore, many of the island populations have also diverged from

the mainland populations, although this was more conspicuous when examining molars than mandibles (Table 6 and Fig. 6). The Oshima population (on the basis of its mandibles and molars) and the Nijima population (on the basis of its molars) were particularly well differentiated from the mainland populations, according to cluster analyses based on the Mahalanobis' distance. In contrast to these cases, some island populations were closely related to some of the mainland populations on the basis of their mandibles or molar measurements. In the case of mandible measurements, the Kozu population was similar to the Yokosuka population, Nijima to Kamogawa, Hachijo to Kawazu. In the case of molar measurements, the Miyake population was similar to the Yokosuka population.

In general, insular mice and insectivores diverged both morphologically and genetically. Japanese field mice, *Apodemus speciosus*, *A. argenteus*, and shrew-moles, *Urotrichus talpoides*, on the Oki Islands differ from island to island (Dogo, Dozen), in body, skull and molar sizes (Hiraiwa et al. 1958; Miyao et al. 1968; Sakai and Miyao 1979; Uematsu 1993; Sakai et al. 1997a, b). Similarly, voles and mice in the British Isles differ both morphologically and genetically among adjacent islands, i.e. Orkney voles, *Microtus arvaris* on the Orkney Islands (Berry and Rose 1975), house mice, *Mus domesticus* on the Faeroe Islands (Berry and Peters 1977; Berry et al. 1978; Davis 1983), and wood mice, *A. sylvaticus* on the Hebridean and Shetland Islands (Berry 1969).

The degree of the divergence found in the house mice on the Izu Islands matches that found in the field mice and shrew-moles on the Oki Islands, judging from an index of the relative deviation from a mainland sample. The maximum value of the index for molar sizes (buccolingual crown diameters) ranged from 1.03 to 2.82 in the present results (Table 3). The relevant figures are 2.32 and 3.50 for *A. speciosus* (Sakai and Miyao 1979), 0.89 and 1.95 for *A. argenteus* (Sakai et al. 1997b) and 0.5, 2.5 and 3.0 for shrew-moles (Sakai et al. 1997a).

It seems that insular populations are likely to differentiate from each other over rather short periods of time. Examples among rodents have been reported from the Orkney and Guernsey voles, three subspecies of *M. arvalis* (Berry and Rose 1975), and in 15 subspecies or races of wood mice, *A. sylvaticus*, on the Hebridean and Shetland Islands (Berry 1969). Berry and Rose (1975) suggested that the Orkney vole was brought to the islands by man about 4,000 years ago, and Berry (1969) considered that the Hebridean and Shetland groups of mice were introduced by the Vikings or their descendants. Another example comes from among the populations of house mice in the Faeroe Islands, some of them were probably founded less than 200 years ago, yet nevertheless, these newer populations are as distinct as the older ones (Berry et al. 1978). Berry (1981) considered these to be examples of instant sub-speciation.

On the basis of the geological evidence, and from data relating to sea-level changes, it seems that the Izu Islands have never been connected to the Japanese mainland by land (Taira 1990; Shimizu 1996). House mice are presumed to have been inadvertently transported to the islands in ships carrying cargo. If so, it is likely that the island populations were founded by small numbers of mice from the mainland, with perhaps some later re-colonization.

The divergence of the mouse populations on the Izu Islands might have arisen either from natural selection after colonization and isolation, or from the genetic variants among the founders. Any change due to the latter is stochastic, and is known as the founder prin-

ciple (Williamson 1981). As no directional change was found among these insular populations, it seems most likely that they have diverged as a result of the founder principle. The subsequent divergence may be ascribed to natural selection working on the original genetic traits of the founders. Repeated colonization of the islands by mice from the mainland or other islands may have occurred in accordance with recent increases in traffic. Colonization, however, may not always have been successful (Berry et al. 1982). Re-colonization by large numbers of mice may accelerate both hybridization with an initial population and genetic and morphological differentiation, that processes were analyzed experimentally by Berry et al. (1991) and Scriven and Bauchau (1992).

The combination of isolation and history are very important contributory factors to the divergence of island populations. A good example can be found among the house mice on Chichijima, in the Ogasawara Islands. Their existence on the island is probably associated with the human colonization that took place from Hachijo and Hawaii during the 19th century (Takada et al. 1994). On the basis of their genetic traits, the mice on Chichijima seem to be hybrids between *Mus musculus molossinus* and *M. m. domesticus* (Moriwaki et al. 1984; Miyashita et al. 1985; Yonekawa et al. 1988), and they appear unique both in their overall morphology and specifically in their mandibles (Tateishi and Takada 1994; Takada et al. 1994). Isolation on the island probably accelerated the hybridization. Furthermore, isolation combined with colonization by a small number of mice has probably been the cause of very low genetic variation within individual insular populations of mice (Berry and Peters 1977; Berry 1981).

The earliest human traces on the Izu Islands date back to the Paleolithic Period (up to about 20,000 B. P.), although confirmed evidence of human settlement in the islands dates to the Jomon (up to about 10,000 B. P.) and Yayoi periods. Many of the remains have been recorded since the 8th century (the Nara Age), indicating regular traffic between the islands and the nearby mainland, especially the Izu Peninsula (Hashiguchi 1988; Nijimamura 1996). In more modern times (the Edo Age), commerce prospered and many ships from various parts of Japan were wrecked on the islands (Hachijocho-Kyoiku-Linkai 1973; Nijimamura 1996). Unfortunately, there is no reliable information on the timing of the colonization of the islands by the house mouse, though it may have been during the 8th century when there was frequent freight traffic to and from the mainland, or during the 17th and 18th centuries when agriculture prospered (Hachijocho-Kyoiku-Linkai 1973; Danki 1976).

The house mice populations currently living on the Izu Islands are clearly related to those of the Japanese mainland. Some island populations, such as that on Oshima, differ slightly from the others, indicating that they may have a different genetic background. In order to understand the nature of the differentiation between the populations, and to ascertain the origins of the island mice populations, it is necessary to know their genetic traits and to synthesize these with their morphological variation.

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Appendix. Statistical table for body size-variables indicating significant differences between pairs of samples (tested by Ryan's method of multiple comparisons for H, F and Kruskal-Wallis test for T; $P=0.05$).

	Oshima	Nijima	Kozu	Miyake	Hachijo	Kawazu	Yokosuka
Nijima							
Kozu		F					
Miyake		F					
Hachijo			F	F			
Kawazu			F	F			
Yokosuka					H	H	
Kamogawa	H	H	H,F	H,F,T	T	T	H,T

H, HBL; F, HFL; T, TL/HBL.