Morphological Studies of the Mandible of the Indonesian Native Pigs and Seven Types of Asian Wild Boars

Yoshihiro HAYASHI, Takao NISHIDA¹⁾, Tsutomu HASHIGUCHI²⁾, and Koshi MOCHIZUKI¹⁾

Department of Parasitology, Institute of Medical Science, University of Tokyo, Minato, Tokyo 108,

¹⁾Laboratory of Veterinary Anatomy, Faculty of Agriculture, University of Tokyo,

Bunkyo, Tokyo 113, and ²⁾Laboratory of Animal Breeding, Faculty of Agriculture,

Kagoshima University, Kagoshima 890, Japan

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In order to clarify the relationship between three types of Indonesian native pigs (Bali, Batak of North Sumatra, and Toraja of South Sulawesi) and seven populations of Asian wild boars (Honshu, Kyushu, and Amami of Japan, Taiwan, Sumatra and Sulawesi of Indonesia, and Thai), the multivariate craniometric comparisons using 10 mandibular measurements were carried out in the present study. The results are summarized as follows: (1) Seven populations of Asian wild boars were separated into three groups by sizes: small, medium, and large, based on the discrimination by the first principal component acceptable as a size vector. The second principal component, acceptable as a shape vector, also contributed some towards the discrimination of the small-sized group from the other groups. (2) There is a complete overlapping of the principal component chart between the Batak native pigs and Toraja native pigs, both of which are short-eared. These two pigs occupy the intermediate situation between the small-sized wild boar and the medium-sized one, when they are projected into the axis of the first component. On the other hand, when they are projected into the axis of the second component, these two pigs fell in the medium-sized group of the wild boar. The Bali native pig, which is a Hainun type of the native pig, is probably to be separated both from the wild boars and from other native pigs. (3) The proportion of the ramus of the mandible to the body of the mandible seems to be an important discriminator in its shape, since the eigenvectors of measurements belonging to the ramus of the mandible show negative values, whereas those belonging to the body of the mandible show positive ones, in the second component.—*Key words:* Wild boar, Native pig, Multivariate craniometrics.

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Although most of the Indonesian people are Moslems who never breed pigs, two types of native pigs are found in the limited areas where Christians or Hindus live: One is the short-eared type bred by the Batak people in North Sumatra and the Toraja people in South Sulawesi; the other is the Hainun-like type bred by the Balinese people in Bali Island. On the other hand, it is reported that two species (*Sus scrofa* and *S. verrucosus*) and three subspecies (*S. s. vittatus*, *S. s. milleri*, and *S. s. floresianus*) of wild boars are distributed in Indonesia [4].

Most kinds of domestic animals are believed to have been domesticated in some limited areas and have been introduced into various

countries. In the case of the pig, however, it seems impossible to take the monophyletic domestication theory, since the wild boar which has been considered to be an ancestor of the pig, is distributed widely in the world and is an animal to be captured and kept with little difficulty. Therefore, it is no wonder that the domestication of the pig has occurred in various areas.

This assumption may be supported by the fact that the C band of serum transferrin, not detected both in the European wild boars and in European pigs, has been found with high frequencies, both in the Japanese wild boars and in the Asian native pigs [9]. From the morphological point of view, however, there

are few evidences for this assumption on the phylogeny of the native pigs in Asia. In order to clarify the relationship between the three types of Indonesian native pigs and the seven populations of Asian wild boars, the craniometric comparisons using multivariate analysis were carried out in the present study.

MATERIALS AND METHODS

The localities and numbers of the samples are shown in Fig. 1. The scientific names of 7 populations of the wild boars are as follows: Honshu and Kyushu Islands of Japan (*Sus scrofa leucomystax*), Amami Island of Japan (*S. s. riukiuanus*), Taiwan (*S. s. taiwanus*), and Sulawesi (*S. verrucosus*).

Except for the native pigs of Bali, all the samples are males of more than 4 years old, so that the following analyses might be free both from the sexual difference and from the growth variation. According to the age determination by the status of eruption and wearing of the molar teeth [5], all the samples of Bali native pigs were estimated to be males of

2 years old.

The 10 mandibular measurements used in this study are defined by Duerst [3] and Driesch [2]. Fig. 2 shows these measurements with the important measuring points. All the measurements were taken with the sliding or spreading calipers and recorded to the nearest 0.1 millimeter.

RESULTS

Table 1 shows the means and standard deviations of 10 mandibular measurements for 7 populations of Asian wild boars. Since there were only two in the samples of both Taiwan wild boars and Thai wild boars, the standard deviations for them were not calculated. The mandibular measurements of Thai wild boars were remarkably larger than those of other wild boars in most measurements. On the other hand, most of the measurements of Amami wild boars and Sulawesi wild boars were remarkably smaller than those of the

Fig. 1. Origin of the samples.

Numbers without D in parentheses represent the sample size of wild boar and numbers with D represent that of domestic pig.

Fig. 2. Measurements of the mandible of *Sus scrofa*. (1) Length from the angle: Goc—Id, (2) Length from the condyle, (3) Aboral height of the vertical ramus, (4) Middle height of the vertical ramus, (5) Height of the mandible behind M₃, (6) Length of the median section of the body of mandible, (7) Length: Goc—aboral border of the alveolus of M₃, (8) Length of the horizontal ramus, (9) Length of the cheektooth row P₂-M₃, (10) Width of the mandible: Gol—Gol

Table 1. Means and standard deviations of 10 variables for mandibles of seven populations of wild boar in Eastern Asia. (mm)

Item	Honshu (10)		Kyushu (8)		Amami (5)		Taiwan (2)	Sulawesi (7)		Sumatora (5)		Thai (2)
1	241.4	5.6	237.0	7.4	209.0	7.9	230.0	202.1	9.9	250.0	7.2	277.0
2	249.8	8.4	243.6	9.4	215.8	8.8	236.0	200.6	9.5	254.2	6.3	288.0
3	111.8	6.7	110.0	4.4	91.2	7.5	113.0	88.3	2.9	105.2	9.1	132.5
4	100.7	3.7	98.5	5.0	81.6	7.6	100.0	81.0	3.7	98.0	8.2	116.5
5	47.1	1.2	44.3	2.1	38.2	3.6	48.0	42.6	2.2	51.6	4.0	56.0
6	69.8	7.2	74.3	6.4	62.2	6.2	75.0	67.3	8.3	78.2	6.2	85.5
7	77.0	5.6	73.8	6.8	68.0	5.6	67.0	63.0	5.6	82.8	2.9	82.0
8	166.0	3.2	164.0	4.4	142.4	6.1	164.0	141.1	6.3	172.8	8.2	200.0
9	65.5	1.4	62.4	1.2	52.6	3.7	69.0	55.7	2.8	62.4	5.2	78.5
10	119.9	7.5	116.8	7.2	95.8	6.0	116.0	105.0	9.5	113.8	9.4	139.5

Fig. 3. Principal component chart of the first two transformed variables for seven populations of the wild boar. (○ Amami, ● Sulawesi, ▼ Taiwan, □ Kyushu, ■ Honshu, ★ Sumatra, ▽ Thai).

other wild boars. Thus, the 7 populations of wild boars may be divided into three groups, *i. e.*, the small-sized, the medium-sized, and the large-sized.

Fig.3 shows the principal component chart constructed by the first two transformed variables, *i. e.*, the first and second principal components extracted from the correlation matrix of 10 mandibular measurements. The first component accounts for 71.80% of all the variations and the second one for 12.65%, respectively.

In morphometric application of the principal component analysis, the first component is acceptable as a “size” vector, and the second one as a “shape” vector [1]. The 7 populations of wild boars of Table 1 were separated into three groups in the chart of Fig. 3, almost entirely based on the discrimination afforded by the first component (size vector). The second component, acceptable as a shape vector, also contributed some towards the discrimination of the small-sized group from the others.

Table 2. shows the means and standard deviations of three types of Indonesian native pigs. The measurements of Batak native pigs are similar to those of Toraja native pigs in most measurements. The measurements of Bali native pigs are smaller than those of the other two, and is assumed to be caused mainly by the premature age of the samples.

Fig. 4 shows the principal component chart of the first and the second components both for the wild boars and for three types of

Table 2. Means and standard deviations of 10 variables for mandibles of three types of Indonesian native pigs.(mm)

Item	Bali (10)		Batak (4)		Toraja (7)	
1	185.2	8.2	222.8	4.7	219.9	3.4
2	191.6	8.1	230.8	3.3	218.1	2.9
3	91.9	4.4	102.8	4.0	95.7	4.4
4	79.8	5.5	93.8	3.6	89.0	3.4
5	37.8	3.9	45.5	3.7	44.9	1.9
6	56.9	4.1	66.8	2.9	74.1	4.6
7	69.2	4.1	68.5	3.1	72.4	2.5
8	120.9	10.7	157.8	3.3	149.0	3.4
9	26.9	7.4	55.0	4.8	54.9	2.9
10	110.2	7.9	107.0	6.6	116.9	5.0

Indonesian native pigs. There is a complete overlapping between the Batak native pigs and the Toraja native pigs as shown in Table 2. These two types of native pigs occupy the intermediate situation between the small-sized wild boars and the medium-sized ones, when they are projected into the axis of the first component. On the other hand, when they are projected into the axis of the second component, they fall in the medium-sized group of the wild boars. The Bali native pigs, which is a Hainun type of native pig, is separated completely from the other native pigs and wild boars as shown in Fig. 4, based on the discrimination both by the first component and the second one.

Table 3 shows the eigenvectors of 10 mandibular measurements classified by the first and the second components. In the first component, all the eigenvectors show positive uniform values, indicating that this component may be acceptable as a size vector. In the second component, however, 4 of 10 eigenvectors belonging to the measurements of the ramus of mandible (item nos. 3, 4, 7,

Fig. 4. Principal component chart of the first two transformed variables for three native pigs and wild boars. (●Bali, ▲Batak, ★Toraja, ○ Small-sized wild boar, □ medium-sized wild boar).

Table 3. Eigenvectors of the first (PC1) and second (PC2) principal components

Item	PC1 (71.80%) ^{a)}	PC2 (12.65%)
1: B+R	0.3671	0.0387
2: B+R	0.3632	-0.0427
3: R	0.3272	-0.2895
4: R	0.3455	-0.1944
5: B	0.2797	0.4825
6: B	0.2841	0.2159
7: R	0.2502	-0.4723
8: B	0.3583	0.1687
9: B	0.3169	0.3995
10: R	0.2376	-0.4296

R: Ramus of mandible, B: Body of mandible.

a) Numbers in parentheses represent the percentage of the variation explained by the component.

10), show negative values, whereas 4 eigenvectors belonging to the measurements of the body of mandible (nos. 5, 6, 8, 9) show positive values, indicating that the proportion of the ramus of mandible to its body is an important discriminator in the second component. The remaining two eigenvectors (nos. 1 and 2), which belong to the combined measurements of the ramus and the body of mandible, do not contribute much to the variational pattern as shown in Figures 3 and 4, since the absolute values of them are relatively small.

DISCUSSION

For clarification of the process of domestication, the wild boar is an important animal, since the gene-flowing between the wild boar and its domesticated form seems to exist even now [8]. As mentioned in the introduction, the genetical investigations are useful in clarifying the relationship between the wild boar and the native pig. Except for the studies of the Japanese wild boars [7] and three subspecies of Eurasian wild boars [10], there are few genetical studies because of the difficulties in collecting blood samples from the wild boar. The present study, which utilizes the craniometric method, offers a new line of information on the relationship between the

Indonesian native pig and the Asian wild boar.

Of the two types of Indonesian native pigs, the short-eared type called the Batak native pig or Toraja native pig in this study, resembles the wild boar in coat-color and form as compared with the Hainun type, *i. e.*, the Bali native pig. As shown in Fig. 4, the relation between the wild boars and the native pigs mentioned above, corresponds to the characteristics given by the external characters of these animals. For example, it is not possible to discriminate the Batak native pig and Toraja native pig from the medium-sized boar by the second principal component (shape vector). Also in the first principal component (size vector), there is an overlapping between these native pigs and the medium-sized boars. However, it would be premature to assume that both the Batak and the Toraja native pigs are the domesticated forms of the medium-sized wild boars in Asia, since it is possible that the 10 mandibular measurements used in this study may lack the important characters which contribute towards the discrimination of these native pigs from the wild boars.

The small-sized group of wild boars, consisting of the Sulawesi wild boars and Amami wild boars, is to be separated from the other groups based on the discrimination afforded not only by the size vector but also by the shape vector, as shown in Fig. 3. Since the Sulawesi wild boar is reported to belong to a species different from others (*Sus verrucosus*), it is not surprising that this boar should be separated from others both by the size and by the shape. It is difficult, however, to explain why the Amami wild boar belonging to the species, *Sus scrofa*, is to be separated from the other boars, which belong to the same species.

There are two possibilities: (1) the Amami wild boar is not a subspecies of *Sus scrofa*, but a different species, *e. g.*, *Sus riukiuanus* [6]; (2) the Sulawesi wild boar is not an independent species but a subspecies of *Sus*

scrofa. Since one of these notions can be presently substantiated, further detailed studies will be required before the relationships among the Asian wild boars can be clarified.

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要 約

インドネシア在来豚およびアジアイノシシ7集団の下顎骨の形態学的研究: 林 良博・西田隆雄¹⁾・橋口 勉²⁾・望月公子¹⁾ (東京大学医科学研究所寄生虫研究部, ¹⁾東京大学農学部家畜解剖学教室, ²⁾鹿児島大学農学部家畜育種学教室)——インドネシア在来豚3系統(バリ豚, バタック豚, トラジャ豚)アジアとのイノシシ7集団(日本の本州・九州・奄美, 台湾, インドネシアのスマトラとスラウェシ, タイ)の下顎骨10部位を計測し, 主成分分析法によって比較検討した。その結果, 以下の形態学的特性が明らかになった。(1) アジアイノシシ7集団は, 下顎骨の大きさによって大, 中, 小の3群に大別された。またその形によって, 小形イノシシは中・大型イノシシと区別された。(2) 小耳種型のバタック豚とトラジャ豚は, 主成分図上で同一の位置にあり, しかも小型と中型のイノシシの中間の位置を占めた。一方, 海南島種型のバリ豚は, 他の2系統の在来豚およびイノシシと全く異なった主成分図上の位置を占めた。(3) これらの在来豚およびイノシシの下顎骨の形の差違をきめるのは, 下顎体と下顎枝の比率であり, 家畜化の程度によってその比率が異なると考えられた。