Multivariate Craniometrics of Yak in Nepal

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The domesticated yak, *Bos mutus* (domestic), is found in the plateaus and mountains of Tibetan and adjacent areas [9]. In order to clarify the morphological relationship between the yak and the native bovinæ in Asia, the principal component analysis was conducted using 15 cranial measurements taken from the following 8 different cattle, *i. e.*, wild banteng (*B. javanicus*), yak, cattle native to Bali, Madura and Aceh in Indonesia, Leyte in Philippines, Korea, and Nepal.

Males were excluded from the present data because of the shortage of specimens. Young females, of which skulls might not have reached final proportions, were also excluded from the data so that the analysis would not be complicated by variations due to growth. Finally, a total of 66 females including five domesticated yaks, which were estimated to be more than four years old by the status of eruption and wear of the incisor teeth, was used in the present study.

The following 15 cranial measurements used in this study were those defined by Driesch [2]: 1) profile length, 2) median frontal length, 3) length of the nasals, 4) Rhinion—Prosthion, 5) basal length, 6) Basion—Staphylion 7) median palatal length, 8) least breadth between the bases of the horncores, 9) least frontal breadth, 10) greatest breadth of the skull, 11) least breadth between the orbits, 12) least breadth between the supraorbital foramina, 13) breadth between the infraorbital foramina, 14) height of the occipital region, and 15) height of the nasal region. All measurements were taken with sliding or spreading calipers and were recorded to the nearest 0.1 millimeter. The principal components were extracted from a covariance matrix of mean values of 15 measurements.

First, the analysis was conducted using 7 populations without the yak. The first principal component (PC1) and the second principal com-

ponent (PC2) accounted for 79.5% and 10.1% of all the variation and the sum of both components reached about 90%. As shown in Fig. 1, the Bali cattle are located on the chart nearest to the banteng. This resemblance is not based on the PC1 scores but on the PC2 scores. In the morphometric applications of the principal component analysis, PC1 is acceptable as a "size" vector, and PC2 as a "shape" vector [1]. The results suggest a close phylogenetic relationship between the banteng and the Bali cattle, since the phylogeny is thought to be reflected more clearly on the skull-shape than on the skull-size [4]. This assumption is in agreement with those of the previous studies [3, 5, 6, 7, 8].

The subsequent analysis was carried out to examine the relationship between the yak and the above-mentioned 7 populations (Fig. 2). There is no essential difference between Figs 1 and 2 with respect to the locations of Nepalese and Korean cattle. In fact, the greatest PC1 score is given to the Korean cattle and the smallest one is to the Nepalese cattle in both figures.

However, a remarkable alteration occurred in the locations of banteng and Bali cattle, *i. e.*, the two cattle are clearly separated from others in Fig. 1, mainly based on the discriminatory power of PC2, whereas they are buried in others in Fig. 2. This alteration, caused by the entry of domesticated yak into Fig. 2, is interpreted as follows; the difference between the banteng-Bali cattle group and the other cattle group is negligible as compared to the great difference between the yak and the remaining cattle, in other words, the yak (*B. mutus*) is a cattle isolated from the banteng (*B. javanicus*) and common domestic cattle (*B. primigenius*) from craniometric points of view.

The results also suggest the necessity of careful applications of the principal component analysis to phylogenetic studies. Looking again at two figures, it is clear that the entry of domesticated yak into the analysis disordered the arrangement of Asian native cattle, probably due to the cancel

Fig. 1. The principal component chart of the first two transformed variables derived from the covariance matrix of 15 cranial measurements of 7 populations without domesticated yak.

Fig. 2. The principal component chart drawn by the same procedure in Fig. 1. The domesticated yak is included in this analysis.

Fig. 3. Male (left) and female (right) yak.

of significant variations within the native cattle by the entry of large variations. The results indicate that the heterogeneous populations should be excluded from the analysis to clarify the exact relationship between the closely related populations.

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要 約

ネパール産家畜ヤク頭蓋の多変量解析(短報): 林 良博・西田隆雄・庄武孝義¹⁾・川本 芳²⁾(東京大学農学部獣医解剖学教室, ¹⁾京都大学霊長類研究所変異部門, ²⁾名古屋大学農学部家畜育種学教室)——ネパールにおいてヤク5頭の頭蓋計測をおこない, アジア在来牛6集団および野生バンテンと多変量解析法を用いて比較した。その結果, ヤクはアジアの野生および在来牛と著しく異なる形態の頭蓋を有することが示された。