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Multivariate Analysis of Morphological Traits of Local Goats in Central Java, Indonesia

Research Article

E. Kurnianto[1*], S. Sutopo[1], E. Purbowati[1], E.T. Setiatin[1], D. Samsudewa[1] and T. Permatasari[1]

[1] Laboratory of Animal Genetics, Breeding and Reproduction, Faculty of Animal Science and Agriculture, Diponegoro University, Tembalang Campus, Semarang, 50275, Indonesia

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*Correspondence E-mail: kurniantoedy17@gmail.com

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ABSTRACT

The objective of this research was to discriminate four local breeds of goat in Central Java-Indonesia using multivariate analysis. Data from eight morphological traits of four goat breeds, namely Kejobong goat (JG), Etawa Grade goat (EGG), Kacang goat (KG) and Jawarandu goat (RG) originated from Purbalingga, Purworejo, Grobogan and Pemalang regencies, respectively, were used. One hundred and sixty six animals were used as materials, in which they were classified into two groups, namely young group (<1 year old) and mature group (≥1 years old). The number of goats designated as male-young, male-mature, female-young and female-mature were 54, 32, 38 and 42 heads, respectively. GLM, CANDIS, PRINCOMP and DISCRIM procedures of SAS were used to compute all data observed. UPGMA of MEGA 5 was used to illustrate the distance among breeds. Results showed that body weight as reflection of body measurements in the mature group was higher in males than those in females. Males tended to be heavier than the females. The chest circumference (CC) was the most influential single variable in determining breed. KG, JG and EGG were categorized into a similar group, while KG showed farther distance in relation to the other three breeds.

KEY WORDS Central Java-Indonesia, local goat, morphological traits, multivariate analysis.

INTRODUCTION

Goats and sheep as small ruminants are the potential animals which have been raised in area in which incomes of farmers are low. In Indonesia, goats are raised in different geographic areas and management systems. Once goats have short reproduction cycle and produce quality meat, they are raised as an extra investment without major labor input by the marginal farmers (Sodiq and Sumaryadi, 2002). It was reported by Budisatria *et al.* (2010) that economic benefits from goats in Indonesia were about 25% higher than those from the sheep flock. The expert panel's recommendation of FAO (1987) on principles for genetic improvement of indigenous animals in the tropics indicated that the government should actively promote the conservation of local animals. It should include information on assessing the potential economic value of loss-known breeds. All stakeholders' participation is highly desirable on that activity.

The population of goats in Indonesia in 2010 was estimated in 16, 619 and 599 heads. Goat population in Central Java contributes 22.21% to national population. There are many local goat breeds in Indonesia as the national genetic resources.

Indonesia Research Institute for Animal Production has characterized seven local breeds of goat according to their

phenotypic characteristics: Marica, Samosir, Muara, Kosta, Gembrong, Ettawah Grade and Kacang.

In Central Java province, there are four local breeds of goat, namely Etawa Grade, Jawarandu, Kejobong and Kacang, which exist to meet the economic needs of farmer family. Phenotypic performance of body measurements of the first three breeds tended to be similar, but the last one is very different. A distinctive aspect is that the Kejobong goats are only raised by smallholder in Kejobong district, Purbalingga regency. Up to now, this goat has not yet been known nationally.

Some studies have been performed to evaluate the effect of feeding and management on productivity of goat. Study on breeding, especially elucidating analysis of relationships among local goats based on practical body measurements is lacked. Multivariate analysis was used to study the breed characterization of sheep in Indonesia (Suparyanto *et al.* 1999), swamp buffalo in Indonesia (Johari *et al*. 2009), goat in Nigeria (Okpeku *et al.* 2011; Yakubu, 2011a; Birteeb *et al.* 2012), cattle in Mexico (Alfonso *et al*. 2011) and rabbit (Setiaji *et al.* 2012). There is limited information on multivariate analysis of characterization of goat breed in Central Java, Indonesia. Accordingly, this study was undertaken to evaluate the body performance relating to the grouping of breed and genetic distance between four local breeds of goat in Central Java.

MATERIALS AND METHODS

Data collection

This study was carried out at four regencies in Central Java of Indonesia, namely Purbalingga, Purworejo, Grobogan and Pemalang where the Kejobong, Ettawah Grade, Kacang and Jawarandu goats, respectively, were observed. Purposive sampling method was applied to determine the location based on population density of the goat breeds.

A total of 166 heads of goats comprising 37 Kejobong (20 males and 17 females), 51 Etawa Grade (23 males and 28 females), 41 Kacang (22 males and 19 females) and 37 Jawarandu (21 males and 16 females) were used in this study. These goats were reared by farmers under the traditional system. The animals were divided into two groups, namely young group (<1 year old) and mature group (≥1 years old). The number of goats designated as male-young, male-mature, female-young and female-mature were 54, 32, 38 and 42 heads, respectively.

The following traits were recorded in all the animals: Body weight (BW) was obtained by a hanging scale; Chest circumference (CC) was taken from the chest just behind the fore legs and withers; Chest width (CW) was the distance between the outer edges of right and left side of the sternum; Chest depth (CD) was the distance from the backbone at the shoulder to the sternum between the fore legs; Body length (BL) was the distance from the occipital protuberance to the base of the tail; Wither height (WH) was the distance from the surface of a platform on which the animal stand to the withers; Hip height (HH) was the distance from the surface of a platform to the hip; and Hip width (HW) was the distance between the outer edges of the major hip bone on the right and left side. The CC was determined by a tape-scale and other body measurements were obtained by a measuring stick.

Statistical analysis

Cronbach's alpha (SAS, 2004) was used to measure reliability of samples. It measures how well a set of variables was taken; the higher values of alpha are more desirable. Data of each breed was analyzed as separated groups.

The traits were analyzed by General Linear Model (GLM) procedure of SAS (2004) to test the effects of breed, sex, age and their interaction. Mean comparison for sex and age were performed in each breed using Duncan's Multiple Range Test after examining the significance effect of breed on variables observed.

CANDISC procedure (SAS, 2004) was used to perform a canonical discriminant analysis and to compute squared Mahalanobis distance. Based on the squared Mahalanobis distance, phenogram illustrating distance among goat breeds was constructed by UPGMA (Unweighted Pair-Group Method with Arithmetic Mean) of MEGA 5 (Tamura *et al.* 2011). The between-breed squared Mahalanobis distance matrix was computed as: Mahalanobis distance that is written as:

$$D_{ij}^2 = (\overline{X}_i - \overline{X}_j)' \, Cov^{-1} \, (\overline{X}_i - \overline{X}_j)$$

Where:

D_{ij}^2: distance between i^{th} breed and j^{th} breed.

Cov^{-1}: the inverse of the covariance matrix of measured variable X.

X_i and X_j: are the means of variable X in i^{th} breed and j^{th} breed, respectively.

PRINCOMP procedure (SAS, 2004) was used to perform principal component analysis (PCA). PCA is a data reduction technique to examine the modes of variation of a multivariate random variable in high dimension. DISCRIM procedure of SAS (2004) was performed to determine percentage assignment of individuals into their own population. Discriminant function attempts to establish whether a set of variables can be used to distinguish among groups. The number of misclassification individuals indicates the degree of intermingling among the four goat breeds.

RESULTS AND DISCUSSION

Cronbach's alpha was used as a measure of the internal consistency and is known as a coefficient of reliability. In this study, standardized Cronbach's coefficient alpha was > 0.70 for all breeds (Table 1) that mean that the sample was satisfactory.

Table 1 Standardized Cronbach's Alpha coefficient of data from four local breeds of goats of Indonesia

Breed	Alpha
Kejobong	0.9611
Ettawa grade	0.9814
Kacang	0.9074
Jawarandu	0.9292

The analysis of variance obtained by GLM indicated that effects of breed were highly significant for all studied traits (Table 2). Based on this result, the age and sex effects on quantitative traits were analyzed separately by breeds. Table 3 and Table 4 present the mean and standard deviation of morphological traits in Kejobong, Ettwa Grade, Kacang and Jawarandu goats. It was stated by Falconer and Mackay (1996) that performance of animal was affected by genetic and non genetic factors. Within species, various performances are due to a difference in breed, age and sex.

Body measurement reflects the body weight of animal (Cam *et al.* 2010). It was evident from Table 3 and Table 4 that most of the body dimensions of mature goat (MG) were higher (P<0.05) than those of young goat (YG) paralleling with growth and development of linear body measurement. The consequence is that body weight in MG was higher in males than those in females. Expectedly, males tended to have higher mean values of body measurement compared to females in four all breeds (Table 3 and Table 4). This condition resulted in heavier body weight in males (P>0.05). The influence of sex on the body weight and morphological traits in the present study are likely connected with usual between the differences of the sex-hormonal actions which lead to differential growth rates. It was stated by Carneiro *et al.* (2010) that the differential obtained in morphological traits of the sexes could be attributed to sexual dimorphism. The finding of present study in Kacang goat was in agreement with the report of Sodiq *et al.* (2010) wherein, the average birth weight, weaning weight and pre weaning growth of males were higher than females. Principal component analysis (PCAs) is often applied to discriminate population. Eigenvalue of PCAs explained by CC was about 91.5% and 81.0% of the total variation for males and females, respectively (Table 5).

Table 2 Mean squares in general linear model for morphological traits in four breeds of goats of Indonesia

Source of variation	Mean squares and significance								
	DF	CC	CW	CD	BL	WH	HH	HW	BW
Breed	3	853.4	43.8	160.7	388.9	2559.4	2921.2	12.8	1399.9
Sex	1	809.73	1.6^{ns}	102.1	33.3	1202.1	742.9	4.6*	1152.1
Age	1	5669.8	234.9	1006.1	2562.6	4182.4	4131.4	201.5	7448.3
Breed × sex	3	200.3	30.2	104.9	79.6	139.5	105.7	22.3	649.8
Breed × age	3	600.8	9.4	49.9	187.1	185.6	164.3	12.3	361.8
Sex × age	1	25.3^{ns}	18.2	44.9	0.3^{ns}	2.6^{ns}	35.7	4.7*	27.9
Breed × sex × age	3	512.6	36.4	115.3	243.5	355.2	192.2	24.8	973.4
Error	150	44.9	4.2	12.69	39.0	39.8	39.2	5.8	59.9

* (P<0.05) and NS: non significant.
CC: chest circumference; CW: chest width; CD: chest depth; BL: body length; WH: wither height; HH: hip height; HW: hip width and BW: body weight.

Table 3 Mean and standard deviation of morphological traits in Kejobong and Etawa Grade goats of Indonesia

Traits	Kejobong				Etawa grade			
	Male		Female		Male		Female	
	YG (10)	MG (10)	YG (10)	MG (7)	YG (11)	MG (12)	YG (11)	MG (17)
CC	68.9±6.6^{b,K}	77.5±5.2^{a}	59.9±6.8^{b,L}	76.7±5.3^{a}	68.4±13.3^{b}	96.3±4.2^{a,P}	66.4±9.5^{b}	75.6±4.2^{a}
CW	14.6±2.5^{K}	16.1±1.5	12.5±1.5^{b,L}	17.1±3.3^{a}	14.1±2.8^{b}	19.7±2.2^{a,P}	13.8±2.3^{b}	15.5±1.4^{a,Q}
CD	24.9±2.9^{K}	28.4±4.5	21.8±3.2^{b,L}	29.9±1.8^{a}	24.8±5.5^{b}	37.2±3.6^{a,P}	24.4±4.1^{b}	28.1±3.5^{a,Q}
BL	48.4±6.9^{b}	56.1±6.2^{a}	43.1±7.2^{b}	55.4±2.8^{a}	49.5±11.3^{b}	70.0±4.2^{a,P}	49.4±7.8^{b}	56.4±3.5^{a,Q}
WH	63.1±5.0^{b,K}	72.6±6.3^{a}	56.5±7.8^{b,L}	69.1±4.9^{a}	66.0±12.8^{b}	90.9±4.9^{a,P}	63.6±9.4^{b}	71.8±2.8^{a,Q}
HH	65.4±6.9^{b}	75.1±5.4^{a}	59.5±8.2^{b}	71.9±3.2^{a}	69.2±13.4^{b}	92.2±4.6^{a,P}	67.3±8.9^{b}	76.5±3.6^{a,Q}
HW	11.7±1.2	12.9±1.8^{Q}	11.6±2.2^{b}	15.5±2.3^{a,P}	11.7± 2.9^{b}	17.3±2.9^{a,P}	11.8±1.9^{b}	13.7±1.1^{a,Q}
BW	28.2±5.6^{b,K}	39.9±6.1^{a}	18.8±7.8^{b,L}	36.9±5.6^{a}	30.0±12.8^{b}	64.7±8.8^{a,P}	26.1±6.1^{b}	35.5±6.6^{a,Q}

CC: chest circumference; CW: chest width; CD: chest depth; BL: body length; WH: wither height; HH: hip height; HW: hip width and BW: body weight.
YG: young goat (< 1 year old) and MG: mature goat (≥ 1 years old).
Number in parenthesis represents the number of sample.
Unit for BW is kg and units for body measurements are cm.
$^{a, b}$: the means with at least common letter within sex-between young and mature goats are not significantly different (P<0.05).
$^{K, L}$: the means with at least common letter within breed-between male and female in young goat are not significantly different (P<0.05).
$^{P, Q}$: the means with at least common letter within breed-between male and female in mature goat are not significantly different (P<0.05).

This means that CC was the most influential single variable. Badi *et al.* (2002) recommended the use of the heart girth (chest circumference) as the most reliable variable to predict BW under field conditions. The importance of chest circumstance in weight estimation could be a result from the fact that muscle and some fat along with bone structure contribute towards its formation.

Table 6 shows eigenvectors of PC1 and PC2 for male and female from four breeds of goat. In morphometric application of PCAs, PC1 was acceptable as a "size" vector and PC2 as a "shape" vector as reported in cattle (Carpenter *et al.* 1978; Hayashi *et al.* 1981; Hayashi *et al.* 1988), pig (Hayashi *et al.* 1984), yak (Hayashi *et al.* 1989), rabbit (Fukuta *at al.* 1996), and sheep (Yakubu *et al.* 2011b).

Table 4 Mean and standard deviation of morphological traits in Kacang and Jawarandu goats of Indonesia

Traits	Kacang				Jawarandu			
	Male		Female		Male		Female	
	YG (16)	MG (6)	YG (9)	MG (10)	YG (17)	MG (4)	YG (8)	MG (8)
CC	63.6±5.3^{b}	70.1±4.0^{a}	58.8±7.8^{b}	70.5±6.3^{a}	70.7±6.2^{K}	74.5±6.7	64.4±6.1^{b,L}	79.9±4.5^{a}
CW	13.2±1.5	13.9±1.1	12.0±1.1^{b}	14.5±2.4^{a}	14.5±2.2	14.1±2.4^{P}	14.4±1.9^{b}	18.6±2.1^{a,Q}
CD	22.6±3.3^{b}	26.8±1.5^{a}	21.5±3.4	24.8±3.8	26.7±3.7	27.2±2.4	24.1±2.7^{b}	30.6±2.9^{a}
BL	47.7±3.3^{b}	53.5±1.8^{a}	45.5±5.2^{b}	51.7±3.8^{a}	54.2±5.4	53.6±3.2	49.4±5.9	57.8±12.5
WH	52.5±4.6^{b}	60.8±3.6^{a,P}	47.3±8.6^{b}	55.1±2.9^{a,Q}	64.9±4.7^{K}	66.3±2.9	57.3±7.3^{b,L}	70.6±5.0^{a}
HH	53.6±4.7^{b}	62.2±4.2^{a,P}	51.0±6.1^{b}	56.8±3.7^{a,Q}	67.2±5.5	72.6±4.1	63.4±5.2^{b}	74.8±1.8^{a}
HW	13.3±3.1	14.1±2.3	13.8±2.3	15.7±3.5	13.6±2.7	13.9±1.5	13.1±1.8^{b}	16.1±2.6^{a}
BW	22.8±4.9^{b}	29.0±4.9^{a}	19.2±8.2^{b}	29.7±8.1^{a}	31.8±10.2^{K}	33.0±11.5^{P}	22.7±5.6^{b,L}	45.5±6.5^{a,Q}

CC: chest circumference; CW: chest width; CD: chest depth; BL: body length; WH: wither height; HH: hip height; HW: hip width and BW: body weight.
YG: young goat (< 1 year old) and MG: mature goat (≥ 1 years old).
Number in parenthesis represents the number of sample.
Unit for BW is kg and units for body measurements are cm.
$^{a, b}$: the means with at least common letter within sex-between young and mature goats are not significantly different (P<0.05).
$^{K, L}$: the means with at least common letter within breed-between male and female in young goat are not significantly different (P<0.05).
$^{P, Q}$: the means with at least common letter within breed-between male and female in mature goat are not significantly different (P<0.05).

Table 5 Eigenvalues of the covariance matrix of principal component analysis in male and female goats of Indonesia

Traits	Eigenvalue		Proportion		Cumulative	
	Male	Female	Male	Female	Male	Female
CC	767.973	401.409	0.915	0.810	0.915	0.810
CW	27.137	45.594	0.032	0.092	0.947	0.902
CD	18.137	24.324	0.022	0.049	0.969	0.951
BL	7.633	9.474	0.009	0.019	0.978	0.971
WH	6.036	8.914	0.007	0.010	0.985	0.981
HH	5.048	4.485	0.006	0.009	0.991	0.989
HW	4.294	3.092	0.005	0.006	0.996	0.996
BW	3.157	1.966	0.004	0.004	1.000	1.00

CC: chest circumference; CW: chest width; CD: chest depth; BL: body length; WH: wither height; HH: hip height; HW: hip width and BW: body weight.
Unit for BW is kg and units for body measurements are cm.

Table 6 Eigenvector of body weight and body measurements in male and female goats of Indonesia

Traits	Eigenvector			
	Male		Female	
	PC1	PC2	PC1	PC2
CC	0.421	0.173	0.438	0.369
CW	0.083	0.073	0.100	0.114
CD	0.184	0.031	0.193	0.039
BL	0.300	0.143	0.327	-0.002
WH	0.450	-0.431	0.463	-0.459
HH	0.455	-0.586	0.453	-0.535
HW	0.058	0.219	0.073	0.198
BW	0.528	0.605	0.478	0.584

CC: chest circumference; CW: chest width; CD: chest depth; BL: body length; WH: wither height; HH: hip height; HW: hip width and BW: body weight.
Unit for BW is kg and units for body measurements are cm.

In the present study, the variation in size difference could be explained by CC, WH, HH and BW. Figure 1 presents plotting membership of breed based on body measurements and body weight. Etawa Grade tended to show the largest size and shape proved by positive value of PC1 and PC2, followed by Jawarandu breed.

Kejobong breed showed the smaller size compared to Etawa Grade and Jawarandu, but it was larger than Kacang breed.

Table 7 shows the squared Mahalanobis distance aggregated (pooled) by sex between the four breed of local goats. The greatest morphological divergence was shown between

Etawa Grade and Kacang, and the smallest one was between Kejobong and Jawarandu breeds.

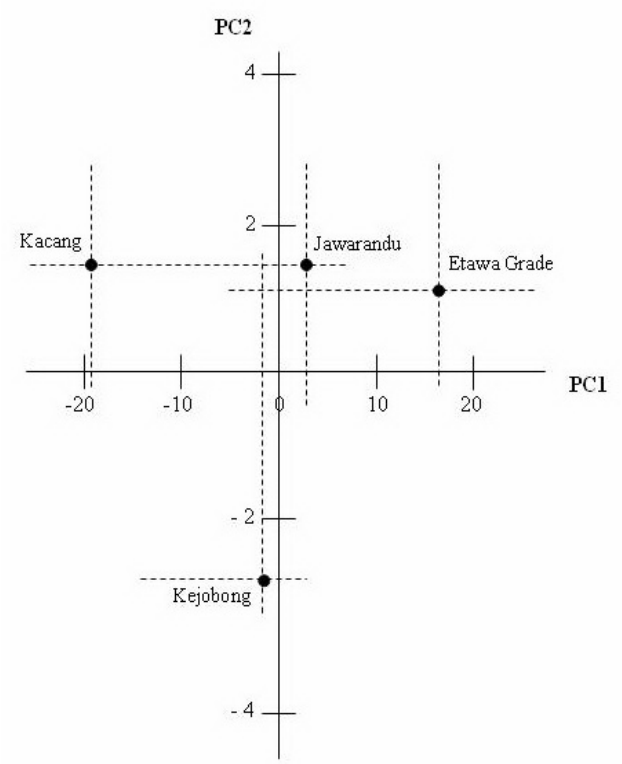

Figure 1 Plot of membership for pooled sex goat based on average body measurements and body weight of local goat breeds of Indonesia

A dendrogram among breeds constructed by squared Mahalanobis distance is presented in Figure 2.

Figure 2 shows that the four local goat breeds were categorized into two major groups, the first group consisted of Kejobong, Jawarandu and Etawa Grade breeds, and the second group with Kacang breed.

Historically, Kacang goat is the indigenous breed of Indonesia, included in Central Java. Meanwhile, Etawa Grade goat is a breed originating from the grading up of goat breeds introduced from India (Etawa or Benggala) and local breed from hundreds years ago. Kejobong goat is a new breed that is the result of crossbreeding between Etawa and Kacang breeds and that was initially only found in Purbalingga Regency, Central Java, especially in Kejobong District.

The starting time of crossbreeding of those two breeds is unknown. Clearly, Kejobong goats have well-adapted to the local environment. Jawarandu goat is crossbred of Etawa and Kacang breeds that can be found in many regions of Indonesia, being the common native breed well-adapted to the local environment.

Discriminant function analysis to determine the percentage of individuals correctly grouped into their own breeds is presented in Table 8. Kejobong, Etawa Grade, Kacang and Jawarandu were correctly grouped into their own breeds for about 16.22%, 70.59%, 92.68% and 51.35%, respectively. On average, 34.18% of individuals were missing grouped into other breeds. The lowest misclassification error of Kacang breed may be an indication of more uniformity as a result of more homogeneity of this breed. Kacang goat is small in body size, so most of them could not be wrongly categorized to larger breed, such as Etawa Grade, Jawarandu and Kejobong.

Table 7 Mahalanobis distance for pooled sex between the four local goat breeds of Indonesia

Goat Breed	Kejobong	Etawa grade	Kacang	Jawarandu
Kejobong	-	1.42266	8.71860	1.12447
Ettawa grade	0.0006	-	14.64042	2.47551
Kacang	< 0.0001	< 0.0001	-	5.96046
Jawarandu	0.0144	< 0.0001	< 0.001	-

Values on above of diagonal represent Mahalanobis distance.
Value on below of diagonal represents significance probability of Mahalanobis distance.

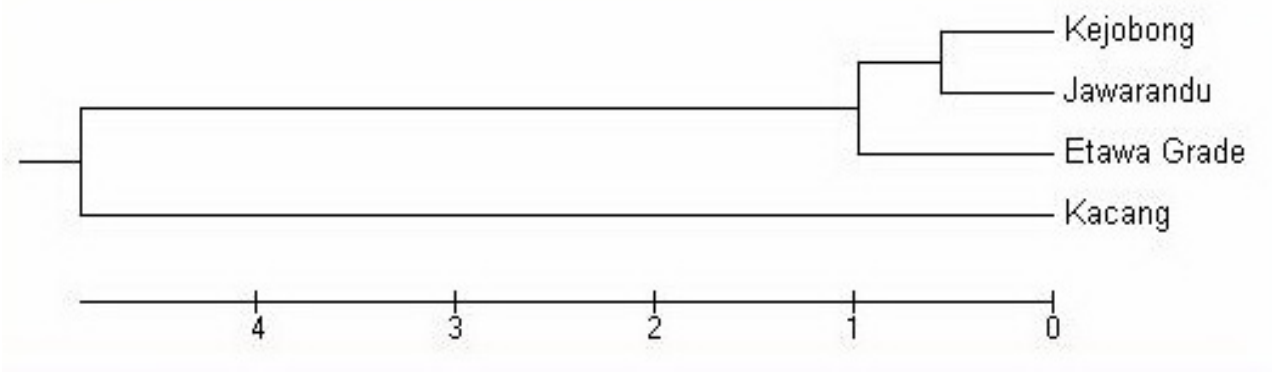

Figure 2 Dendrogram constructed based on Mahalanobis distance of the four local goat breeds

Table 8 Number of observation, percent classification (in parenthesis) into goat breed and error count estimates for local goat breeds of Indonesia

Breed	Kejobong	Etawa grade	Kacang	Jawarandu	Total	Error count estimate
Kejobong	6 (16.22)	11 (29.73)	2 (5.41)	6 (16.22)	37 (100.00)	0.5135
Etawa grade	13 (25.49)	36 (70.59)	0 (0.00)	2 (3.92)	51 (100.00)	0.2941
Kacang	0 (0.00)	0 (0.00)	38 (92.68)	3 (7.32)	41 (100.00)	0.0732
Jawarandu	8 (21.62)	4 (10.81)	6 (16.22)	19 (51.35)	37 (100.00)	0.4865
Total	39 (23.49)	51 (30.72)	46 (27.71)	30 (18.07)	166 (100.00)	-

In implication, a clear distinction between breeds is very necessary for the farmer and researcher in preserving the indigenous breeds of goats.

CONCLUSION

Four local breeds of goats in Central Java-Indonesia could be categorized into two major groups, where the first group included goats of Kejobong, Jawarandu and Etawa Grade breeds, and the second group includes Kacang breed.

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REFERENCES

Alfonso R.E., Herrera H.J., Lemus F.C., Ortega C.M.E., Cortez R.C. and Perez P.J. (2011). Morphometric characterization of American Brown Swiss cows in a tropical region of Chiapas, Mexico. *J. Anim. Vet. Adv*. **10,** 454-459.

Badi A.M.I., Fissehaye N. and Rattan P.J.S. (2002). Estimation of live body weight in Eritrean goat from hearth girth and height at withers. *Indian J. Anim. Sci*. **72,** 893-895.

Birteeb P.T., Peters S.O., Yakubu A., Adeleke M.A. and Ozoje M.O. (2012). Multivariate characterization of the phenotypic traits of Djallonke and Sahel sheep in Northern Ghana. *Trop. Anim. Health. Prod.* **12,** 23-27

Budisatria I.G.S., Udo H.M.J., Udo Eilers C.H.A.M., Baliarti E. and Van Der Zijpp A.J. (2010). Preferences for sheep or goats in Indonesia. *Small Rum. Res.* **88,** 16-22.

Cam M.A., Olfaz M. and Soydan E. (2010). Body measurements reflect body weights and carcass yields in Karayaka sheep. *Asian J. Anim.Vet. Adv*. **5,** 120-127.

Carneiro H., Lovandini H., Paira S.R., Macedo F., Mernies B. and McManus C. (2010). Morphological characterization of sheep breeds in Brazil, Uruguay and Colombia. *Small Rum. Res.* **94,** 58-64.

Carpenter Jr J.A., Fitzhugh H.A., Cartwright T.C., Thomas R.C. and Melton A.A. (1978). Principal components for cow size and shape. *J. Anim. Sci*. **46,** 370-375.

FAO. (1987). Animal genetic resources: Strategies for improved use and conservation. FAO Animal Production and Health Paper No. 66.

Falconer D.S. and Mackay T.F.C. (1996). Introduction to Quantitative Genetics. 4th Edition, Longman. England.

Fukuta K., Nagura Y., Harada M. and Goto N. (1996). Analysis of mandible of new developing strain of Japanese White rabbit (Nlb:JWNS). *Exp. Anim*. **45,** 361-368.

Hayashi Y., Nishida T., Mochizuki K. and Otsuka J. (1981). Measurements of the skull of native cattle and Banteng in Indonesia. *Jpn. J. Vet. Sci*. **43,** 901-907.

Hayashi Y., Nishida T., Hashiguchi T. and Mochizuki K. (1984). Morphological studies of the mandible of the Indonesian native pigs and seven type of Asian wild boars. *Jpn. J. Vet. Sci.* **46,** 99-104.

Hayashi Y., Otsuka J. and Nishida T. (1988). Multivariate craniometrics of wild banteng, *Bos banteng*, and five types of native cattle in eastern Asia. *Jpn. J. Zootech. Sci*. **59,** 660-672.

Hayashi Y. Nishida T., Shotake T. and Kawamoto Y. (1989). Multivariate craniometrics of Yak in Nepal. *Jpn. J. Vet. Sci*. **51,** 1037-1039.

Johari S., Kurnianto E., Sutopo V. and Harmayanti W.A. (2009). Multivariate analysis on phenotypic traits of body measurement in swamp buffalo (*Bubalus bubalis*). *J. Indonesian Trop. Anim. Agric*. **34,** 289-294.

Okpeku M., Yakubu A., Peters S.O., Ozoje M.O., Ikeobi C.O.N., Adebambo O.A. and Imumorin I.G. (2011). Application of multivariate principal component analysis to morphological characterization of indigenous goats I Southern Nigeria. *Act. Agric. Slovenica*. **98,** 101-109.

SAS Institute. (2004). SAS®/STAT Software, Release 9.11. SAS Institute, Inc., Cary, NC.

Setiaji A., Sutopo V. and Kurnianto E. (2012). Morphometric characterization and genetic distance among four breeds of rabbit (*Oryctolagus cuniculus*). *J. Anim. Prod*. **14,** 92-98.

Sodiq A. and Sumaryadi M.Y. (2002). Productive performance of Kacang and Peranakan Etawah goat in Indonesia. *Anim. Prod*. **4,** 52-59.

Sodiq A., Priyono A. and Tawfik E.S. (2010). Assessment of the kid production traits of Kcang goat under smallholder production system. *Anim. Prod.* **12,** 111-117.

Suparyanto A., Purwadaria T. and Subandriyo. (1999). Pendugaan jarak genetic dan factor peubah pembeda bangsa dan kelompok domba di Indonesia melalui pendekatan analisis morfologi. *J. Ilmu. Tern. Vet*. **4,** 80-87.

Tamura K., Peterson D., Peterson N., Stecher G., Nei M. and Kumar S. (2011). MEGA 5: Molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum Parsimony methods. *Mol. Biol. Evol*. **28,** 2731-

2739.

Yakubu A., Salako A.E. and Imumorin I.G. (2011a). Comparative multivariate analysis of biometric traits of West African Dwarf and Red Sokoto goats. *Trop. Anim. Health. Prod.* **43,** 561-566.

Yakubu A., Salako A.E. and Abdullah A.R. (2011b). Varimaz rotated principal component analysis of the zoometrical traits of Uda sheep. *Arch. Zootech*. **60,** 813-816.