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Quantifying of morphological character for Kacang goat using principal component factor analysis

D. A. Lestari[1], S. Sutopo[1], E. Kurnianto[1], M. I. A. Dagong[2], S. R. A. Bugiwati[2], K. Mamat-Hamidi[3], A. Yakubu[4], N. S. Pandupuspitasari[1], I. Agusetyaningsih[1], F. T. Kamila[1], and A. Setiaji[1*]

[1]Department of Animal Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Tembalang Campus, Semarang, 50275 Central Java, Indonesia.
[2]Faculty of Animal Science, Hasanudin University, Tamalanrea Campus, South Sulawesi, Makasar, Indonesia
[3]Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia, UPM Serdang, Selangor, 43400, Malaysia
[4]Department of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia Campus, P.M.B. 135, Lafia, 950101, Nigeria
**Corresponding email: asepsetiaji93@gmail.com*

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ABSTRACT

The study's objective was to estimate the association among various linear body measurements and body weights of adult Kacang goats. The data was obtained from 209 heads of adult Kacang Goat, compressed 78 bucks and 131 ewes. The morphological evaluation was performed by measuring body weight (BW), body length (BL), chest depth (CD), chest girth (CG), chest width (CW), and withers height (WH). Factor PROCEDURE was performed to estimate the principal component. The result of factor analysis was used to determine the independent variable for linear regression analysis. BW has a favorable correlation with CG, BL, CD, CW, and WH for bucks and ewes. PC 1 accounts for 55.62% of the variation in bucks, while PC 2 accounts for an additional 18.34%. PC 1 accounts for just 0.45% of the overall variation in ewes, whereas PC 2 accounts for 0.24%. The R-squared (R^2) values for bucks and ewes in the regression equation with CG as the independent variable are 0.32 and 0.41, respectively. For both bucks and ewes, the regression equation with CW as the independent variable had a higher R^2 of 0.52 and 0.20, respectively. For bucks and ewes, the regression equation's R^2 values are 0.54 and 0.44, respectively, with combined CG and CW acting as independent variables. This integrated approach to analyzing body measurements in Kacang Goats provides a robust foundation for making informed decisions in goat farming.

Keywords: Eigen values, Linear regression, Pearson correlation, R-squared, Total variance.

INTRODUCTION

Kacang goat is a kind of native livestock in Indonesia raised by traditional farmers for meat production. This goat has a tiny body, a flat snout, small erect ears, short fur, and a broad range of colors. Kacang goat has been proven to be adaptable to the tropical environment, has a robust tolerance to heat stress and capable of productivity with limited resources (Syafiqa *et al.,* 2023; Elieser *et al*., 2012). Understanding the morphological characteristics of Kacang goats is essential for enhancing the breed, initiating breeding projects, and maintaining sustainable management. The morphological traits are important for breed identification and selection since they also show how well an animal has adapted to a certain tropical condition (Kebede *et al*., 2012; Sejian *et al*., 2018).

A strong statistical method for reducing multidimensional data to a more comprehensible format is principal component factor analysis. This analysis allows researchers to find the underlying structure of the multivariate variables in the data sets (Everitt *et al.,* 2001; McGarigal *et al*., 2013). Furthermore, principal component factor analysis also can reduce the dimensionality of a dataset while retaining as much variance as possible, uncover underlying structures (factors) that explain the variability in the data, helps in identifying the underlying structure in the data and improves interpretability through rotation (Jolliffe, 2002; Johnson and Wichern, 2007; Hair *et al.,* 1998; Tabachnick and Fidell 2013). The principal component factor analysis has been applied to analysis of morphological traits in several breeds of goats, among them: West African Dwarf and Red Sokoto (Okpeku *et al*., 2011), Assam Hill goat in Eastern Himalayan India (Khargharia *et al*., 2015), Canindé goats (Arandas *et al*., 2017), Malahari goats of India (Valsalan *et al*., 2020), Arabia goat in Algeria (Laouadi *et al*., 2021).

The objective of this study was to estimate the association among various linear body measurements and body weights of adult Kacang goats and then categorize the morphological indices of Kacang goats. The results of this study are expected to shed light on the essential factors that contribute to the diversity and adaptability of the Kacang goat. By quantifying and analyzing these morphological indices, we aim to provide valuable insights for better-informed decision-making in the breeding, conservation, and sustainable management of native goats.

MATERIAL AND METHODS

The data was obtained from 209 heads of adult Kacang Goat, comprising 78 bucks and 131 ewes. The criteria of goat chosen was more than twelve months old and the ewe was not pregnant. The morphological evaluation was performed by measuring body weight (BW), body length (BL), chest depth (CD), chest girth (CG), chest width (CW), and withers height (WH). The descriptive statistic of body weight, and linear body measurements data is presented in Table 1.

Statistical Analysis

The data was analyzed using the Statistical Analysis System (SAS) On Demand for Academic (SAS, 2021). The Correlations PROCEDURE was used to estimate the coefficient correlation among traits. Factor PROCEDURE was performed to estimate the principal component. The result of factor analysis was used to determine the independent variable for linear regression analysis. The linear regression PROCEDURE was used to construct a regression equation with body weight as the dependent variable and selected body measurements. The general equation of factor analysis for reducing the total variance component of multivariate variables is as follows:

$$y_1 = a_{11}x_1 + a_{12}x_2 + \cdots + a_{1p}x_p$$

$$y_2 = a_{21}x_1 + a_{22}x_2 + \cdots + a_{2p}x_p$$

$$y_p = a_{p1}x_1 + a_{p2}x_2 + \cdots + a_{pp}x_p$$

Where Y_1, Y_2,…………..Y_p decrease in fractions for the overall variance component of body measurements for Kacang goat X_1, X_2, ……….., X_p.

Using the stepwise variable selection multiple regression technique, the following models were developed to predict body parts and identify principle components:

$$\mathrm{BW} = \mathrm{a} + \mathrm{B_i x_i} + \cdots + \mathrm{B_k x_k}$$

$$\mathrm{BW} = \mathrm{a} + \mathrm{B_i PC_i} + \cdots + \mathrm{B_k PC_k}$$

where: BW stands for body weight, a for regression intercept, B_i is the i-th partial regression coefficient of the main component or linear body measurement.

RESULTS AND DISCUSSION

Table 1 lists descriptive data for the linear body measures and weights of Kacang goats according to sexes (Ewe for females and Buck for males). The mean BW of bucks (23.11 kg) is slightly lower than that of ewes (24.48 kg). Bucks have a longer BL on average (62.29 cm) compared to ewes (60.63 cm). Bucks have a slightly higher CD (26.71 cm) compared to ewes (27.96 cm). The CV for CD is moderate for both bucks (12.43%) and ewes (12.55%). Ewes have a higher CG on average (66.23 cm) compared to bucks (64.25 cm). The mean CW is quite similar between bucks (15.15 cm) and ewes (15.78 cm). The CV for CW is high for both bucks (28.58%) and ewes (23.19%), indicating a notable degree of variability. Bucks have a higher WH on average (58.89 cm) compared to ewes (56.76 cm). The CV for CG and WH are relatively low for both bucks (8.17%) and ewes (9.02%), suggesting less variability in both traits compared to the others traits.

Table 2 displays the correlation coefficients between bodyweight and other linear body measures for both ewes (below diagonal) and bucks (above diagonal). BW has a favorable correlation with CG (0.56), BL (0.46), CD (0.65), CW (0.72), and WH (0.36) for bucks. Similar favorable relationships between BW and BL (0.32), CD (0.43), CG (0.63), and CW (0.45) are shown for ewes. Different qualities and BL have different correlations. BL has a stronger positive link with CG (0.54) and CD (0.28) than it does with CW and WH. BL has a positive correlation with CG (0.11), CW (0.43), and CD (0.39) for ewes.

The findings of a principal component for the linear body measures and body weight of

Table 1. Descriptive statistics of bodyweight and linear body measurements of Kacang Goat

Traits	Buck				Ewe			
	N	SD	Mean	CV	N	SD	Mean	CV
BW	78	4.86	23.11	21.03	131	5.24	24.48	21.41
BL	78	6.37	62.29	10.23	131	5.89	60.63	9.71
CD	78	3.32	26.71	12.43	131	3.51	27.96	12.55
CG	78	5.28	64.25	8.22	131	5.87	66.23	8.86
CW	78	4.33	15.15	28.58	131	3.66	15.78	23.19
WH	78	4.81	58.89	8.17	131	5.12	56.76	9.02

BW: body weight; BL: body length; CD: chest depth; CG: chest girth; CW: chest width; WH: withers height; [2]N: number of goats; [3]SD: standard deviation; [4]CV: coefficients of variance.

Table 2. Coefficients of correlation among bodyweight and linear body measurements for buck (above diagonal) and ewe (below diagonal).

Trait[1]	BW	BL	CD	CG	CW	WH
BW	-	0.46**	0.65**	0.56**	0.72**	0.36**
BL	0.32**	-	0.28*	0.54**	0.49**	0.21
CD	0.43**	0.39**	-	0.48**	0.71**	0.42**
CG	0.63**	0.11	0.19*	-	0.60**	0.48**
CW	0.45**	0.43**	0.29**	0.45**	-	0.14
WH	0.44**	0.11	0.24**	0.60**	0.25**	-

BW: body weight; BL: body length; CD: chest depth; CG: chest girth; CW: chest width; WH: withers height;

Table 3. Principal component for bodyweight and linear body measurements of Kacang goat

Traits	Buck			Ewe		
	PC 1	PC 2	Communality	PC 1	PC 2	Communality
BL	0.67	-0.32	0.56	0.57	0.65	0.75
CD	0.79	0.05	0.63	0.61	0.41	0.53
CG	0.84	0.07	0.72	0.74	-0.52	0.82
CW	0.82	-0.39	0.84	0.74	0.18	0.59
WH	0.56	0.81	0.95	0.67	-0.54	0.75
Eigenvalues	2.78	0.92		2.24	1.19	
% total variances	55.62	18.34		0.45	0.24	

BW: body weight; BL: body length; CD: chest depth; CG: chest girth; CW: chest width; WH: withers height.

Kacang goats, broken down by sexes are shown in Table 3 and depicted in Figure 1. PC 1 has high loadings for all qualities, especially CG, CW, and WH, in dollars. PC 2 features robust CD and BL loadings. For ewes, BL and CD have a greater effect on PC 2, whereas CG, CW, and WH have the most influence on PC 1. The commonality values are rather high in both bucks and ewes, indicating that a significant portion of the variation in the original variables is captured by the chosen main components. Eigenvalues show how much of each primary component's variation is explained. The eigenvalue of PC 1 is significantly higher in bucks and ewes than that of PC 2, suggesting that PC 1 accounts for a greater share of the overall variation. The percentage of total variances is the share of total variation that each primary component accounts for. PC 1 accounts for 55.62% of the variation in bucks, while PC 2 accounts for an additional 18.34%. PC 1 accounts for just 0.45% of the overall variation in ewes, whereas PC 2 accounts for 0.24%.

The results of various regression models predicting BW based on CG and CW are shown in Table 4. The R-squared (R^2) values for bucks and ewes in the regression equation with CG as the independent variable are 0.32 and 0.41, respectively. For both bucks and ewes, the regression equation with CW as the independent variable had a higher R^2 of 0.52 and 0.20, respectively. For bucks and ewes, the regression equation's R^2 values are 0.54 and 0.44, respectively, with combined CG and CW acting as independent variables.

A variety of characteristics, including BW, BL, CG, and WH, are different between bucks and ewes. The relative variability of each attribute is shown by the coefficients of variance. Greater variability is indicated by higher CV values, whilst greater consistency within the sample is shown by lower values. These parameters are important to determine the normal size and diversity among the population, which is crucial for goat farming and breeding operations (Tsegaye *et al*., 2013). Using this knowledge, choices about diet, breeding programs, and general herd management may be made with confidence.

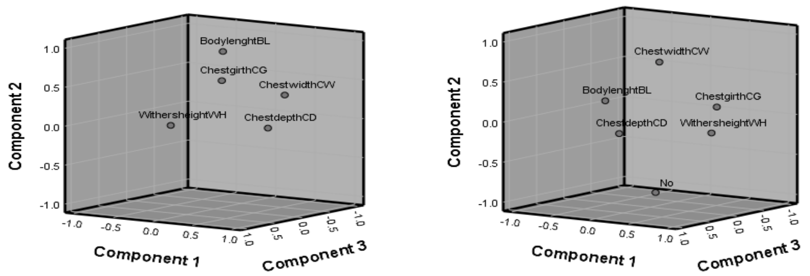
The correlations provide light on the connections between the various body measures of Kacang goats. Positive correlations show that a trait tends to rise in tandem with an increase in one another. Robust associations exist between body weight and other linear parameters, particularly chest breadth in bucks, indicating that these characteristics are correlated and may be utilized to predict or estimate one another. Certain attributes may not have a strong linear relationship with one another, as seen by the lesser correlations in some circumstances. When choosing breeding pairings for particular qualities or objectives, these correlation coefficients can help researchers and goat breeders understand the underlying patterns in the correlations between various body parameters (Okpeku *et al*., 2011; Abd-El Rahman *et al*., 2019)

The primary component analysis reduces the original body measurements to a more manageable collection of uncorrelated variables, or main

Table 4. Multiple regression of body weight on the original body measurements and on their principal components.

Traits	Model	R^2	SE
Buck			
CW	BW=10.91+0.81CW	0.52	3.39
CW and WH	BW=-4.29+0.76CW+0.27WH	0.59	3.16
PC1	BW=23.11+3.08PC1	0.41	3.78
PC1 and PC2	BW=23.11+3.07PC1+1.82PC2	0.54	3.33
PC1, PC2, and PC3	BW=23.11+3.07PC1+1.82PC2+1.09PC3	0.59	3.16
Ewe			
CG	BW=-13.03+0.57CG	0.41	4.06
CG and CD	BW=-22.58+0.51CG+0.47CD	0.49	3.74
CG, CD and BL	BW=-28.28+0.51CG+0.38CD+0.14BL	0.52	3.67
PC1	BW=24.49+2.80PC1	0.28	4.44
PC1 and PC3	BW=24.49+2.80PC1+1.71PC3	0.39	4.11
PC1, PC2 and PC3	BW=24.49+2.80PC1+1.66PC2+1.71PC3	0.49	3.77

BW: body weight; BL: body length; CD: chest depth; CG: chest girth; CW: chest width; WH: withers height; R^2: coefficie of determination; SE: standard error.



Buck **Ewe**

Figure 1. Projection Principal Component Analysis of Kacang Goat

components, that account for the majority of the data's variability (Yakubu *et al*., 2009). The WH, CG and CW all have a significant impact on PC 1, which appears to indicate total body size. Additional heterogeneity about CD and BL was captured by PC 2. PC 1 for ewes is dominated by CG, CW, and WH, indicating that these characteristics are important in determining the total body size of female goats. The principle components account for a significant portion of the variability in bucks, according to the eigenvalues and the percentage of total variances, whereas the selected main components account for a comparatively small portion of the variability in ewes. These findings may help with selection criteria for breeding programs that focus on particular body features and streamline. It is important to acknowledge that interpretation must take into account the breeding program. The commonality values show how much of the variance in each variable can be explained by its major components. Greater communality values show that the major components adequately capture the variable (Bandalos and Finney, 2018).

The equations for estimating BW based on CW and WH for bucks and CW and CD for ewes independently are provided by these regression models. The CW and CG separately explain some of the variation in BW in both bucks and ewes, respectively with the influence of CW being greater in bucks. The higher R^2 values compared to individual models show that combining CW and WH in a multiple regression model enhances the prediction accuracy of body weight in both bucks and ewes. The accuracy of the regression coefficients can be gauged from the standard errors of the estimations. More accurate estimations are shown by lower standard errors (Harding *et al*., 2014). In order to help with management and breeding decisions, goat farmers and breeders might find these regression equations useful for calculating the BW of their animals based on selected body measurements (Mebratie *et al*., 2022). It is notable that, in the lack of validation, the models in question may not generalize to other breeds and are specific to the Kacang Goat population.

The models provided for predicting BW using principal components demonstrate varying levels of accuracy and precision for both bucks and ewes. For bucks, including more PC progressively increases the model's R^2 value from 0.41 to 0.59 and decreases the standard error (SE) from 3.78 to 3.16, indicating better prediction accuracy and precision. Similarly, for ewes, adding PC improves R^2 from 0.28 to 0.49 and reduces SE from 4.44 to 3.77. However, the improvement is more pronounced for bucks compared to ewes, suggesting that additional factors might influence ewe body weight predictions. Overall, models incorporating more PCs are more effective in capturing the variance in BW.

CONCLUSION

The comprehensive analysis of body measurements in Kacang Goats, provides valuable insights for goat farming and breeding operations. Understanding the correlations between these body measures allows for informed choices in selecting breeding pairs for specific traits or objectives. This integrated approach to analyzing body measurements in Kacang Goats provides a robust foundation for making informed decisions in goat farming, breeding programs, and herd management.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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