Principal component analysis of morphometric traits in Indonesian male Sakub sheep

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Abstract. Principal component analysis (PCA) was utilized to explore the morphological features of livestock, a statistical method that had not previously been applied to Indonesian Sakub sheep. Consequently, this study focused on analyzing PCA in male Sakub sheep. Morphometric traits examined included head length (HL), heart girth (HG), ear width (EW), chest width (CW), body length (BL), rump length (RL), wither height (WH), rump height (RH), head width (HW), ear length (EL), chest depth (CD), and rump width (RW)., Data analysis encompassed descriptive statistics, correlation analysis, and PCA conducted using SPSS 25.0 software. The average measurements for these morphometric traits were 23.63±2.27 cm, 94.47±9.44 cm, 6.95±0.97 cm, 21.08±4.61cm, 79.71±6.86 cm, 24.95±3.36 cm, 76.24±5.52 cm, 74.55±5.19 cm, 14.17±1.60 cm, 14.42±2.37 cm, 36.27±4.75 cm, and 18.17±3.21 cm, respectively. The sphericity test using Bartlett's ($p < 0.001$) and the sampling adequacy determined using Kaiser-Meyer-Olkin (KMO) exceeded 0.883. Two principal components were identified: PC1 (comprising HG, BL, WH, HL, RH, CD, and RW) and PC2 (including EL, CW, EW, RL, and HW), accounting for approximately 61.429% of the total variance. These findings provide insights that can be utilized in the management, selection, and breeding programs for male Sakub sheep.

1 Introduction

Sakub sheep is a unique breed and original type traditionally raised in Brebes Regency, Central Java, Indonesia. This breed was designated as a new local Indonesian sheep breed through a Decree of the Indonesian Ministry of Agriculture (No.882/KPTS/PK.010/M/12/2022). As a local breed, Sakub sheep is particularly valued for its adaptability to the local environment and productivity. Sakub sheep have also been an integral part of the local agricultural landscape for generations, and the breed has considerable socio-economic and cultural importance for the people of the Brebes Regency [1, 2]. More specific research and scientific exploration of the Sakub sheep is needed. This knowledge gap provides a significant opportunity to contribute to our understanding of this breed, its characteristics, and its potential for local and regional development. The analysis

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of morphometric features significantly contributes to a better understanding of populations that are not well-known and helps in identifying and classifying [3-5]. Methods like principal component analysis within multivariate statistics have provided a more dependable evaluation of morphometric relationships among livestock breeds.

The statistical technique known as Principal Component Analysis (PCA) is utilized to characterize livestock based on their morphometric traits. This method has been applied in various studies to understand the morphological structure and variability within different livestock species [6-11]. In South African Kalahari Red goats, PCA was utilized to determine the morphological structure using morphometric traits and body indices. [5]. Similarly, in Campolina horses, PCA was used to assess genetic diversity and the relationships between morphometric traits, contributing to the creation of selection indices [9]. Furthermore, in Thalli sheep, PCA was conducted to explain the morphological structure based on morphometric traits, providing insights into the breed's characteristics [10].

The morphological traits of livestock are analyzed using PCA in Indonesian livestock, including Bali cattle [12, 13], Katjang goat [14], swamp buffalo [15], Wonosobo sheep, and Batur sheep [16]. Still, Indonesian Sakub sheep have not yet been subjected to this statistical method. This method not only aids in characterizing livestock breeds but also plays a crucial role in breeding programs, conservation efforts, and selection strategies to enhance desirable traits within populations. Therefore, this research aimed to examine the PCA of morphometric characteristics in male Sakub sheep from Indonesia.

2 Materials and methods

2.1 Ethical approved

The Ethics Commission of the Faculty of Veterinary Medicine at Universitas Gadjah Mada, Indonesia, authorised this experiment under reference number 036/EC-FKH/Eks/2022.

2.2 Location and measurements

This study took place in Paguyangan and Sirampog districts, located in Brebes Regency, Central Java, Indonesia. 66 male Sakub sheep with 2-3-year-old (having 1-4 pairs of permanent incisors) were used in this study. Morphometric traits were determined with a measuring stick and tape (Figure 1). Measurements were performed based on the FAO procedure [17], which first positioned the sheep upright parallel to the pen floor.

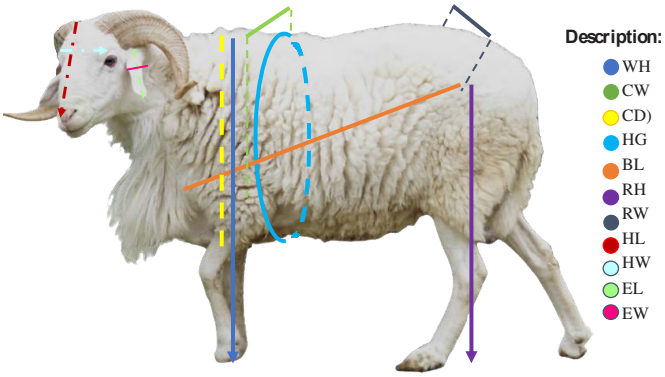

Fig. 1. Morphometric traits of male Sakub sheep

2.3 Data analysis

SPSS (25 version) software was utilized to perform PCA with varimax rotation. Before conducting this analysis, the initial examination of morphometric traits data included descriptive and correlation analyses. Ms. Excel was employed to visualize Pearson's correlation coefficients among morphometric traits in the form of a heatmap graphic.

3 Result

Descriptive data of the male Sakub sheep's body measures and weight in this study are presented in Table 1. According to the study, BL, WH, HG, HL, and RH exhibited minimal variation (CV < 10%) in their morphometric traits. Other morphometric traits have moderate (CD, HW, EL, EW, RL, and RW) and high (CW) CV values.

Table 1. Descriptive statistics of morphometric traits

Traits	Mean	Standard deviation	CV (%)
Body Length	79.712	6.852	8.596
Wither Height	76.242	5.525	7.247
Heart Girth	94.474	9.440	9.992
Chest Depth	36.265	4.750	13.098
Chest Width	21.080	4.606	21.851
Head Length	23.629	2.266	9.589
Head Width	14.171	1.601	11.299
Ear Length	14.424	2.373	16.454
Ear Width	6.947	0.973	14.009
Rump Height	74.545	5.189	6.960
Rump Length	24.947	3.358	13.462
Rump Width	18.174	3.206	17.642

In this study, Pearson's coefficients of correlation (r) among various morphological traits of male Sakub sheep are visualized in Figure 2. All morphometric variables investigated in this study demonstrated significant positive correlations, except for the association between HG and EL. The Bartlett's test of sphericity ($p < 0.001$) and a Kaiser-Meyer-Olkin (KMO) score of sampling adequacy exceeding 0.883 were revealed by the PCA analysis of these morphometric traits. The accuracy of PCA results is characterized by KMO is more than 0.5 with a significant Bartletts test value ($p<0.01$) [18].

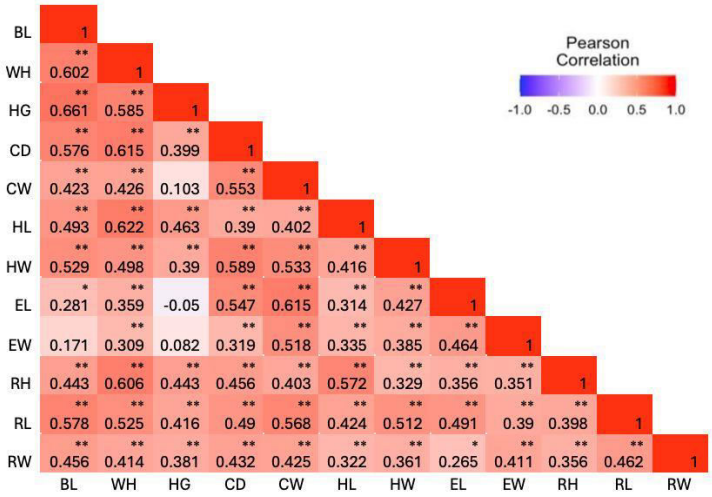

Fig. 2. Significant correlation coefficients were observed for morphological traits at the 0.01 level ($p < 0.01$) and approached significance at the 0.05 level ($p < 0.05$), according to Pearson's correlation analysis.

In this investigation, two significant components (Eigenvalue>1), which collectively account for 61.429% of the overall variability, were identified through PCA conducted on morphometric traits of male Sakub sheep, as shown in Figure 3 and Table 2. A previous study on morphometric traits in Ripollesa sheep similarly demonstrated a PCA revealing approximately 59.00% total variance across two principal components [19]; 61.53% (4 PCs) in Rampur-Bushair [7]; 96.65% (3 PCs) in Pramenka [20]; 76.58% (3 PCs) in Wonosobo and 73.51% (3 PCs) in Batur [16] sheep

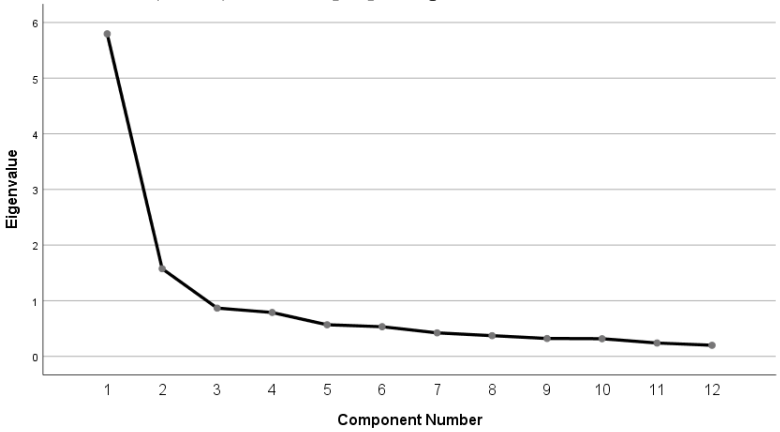

Fig. 3. The scree plot depicts the relationship between component numbers and their corresponding eigenvalues.

Table 2. Explained variance totals were obtained through the examination of rotated component matrices, communalities extracted (EC), and sums of squared loadings after rotation

Traits	PC1	PC2	EC
Heart Girth	0.897*	-0.163	0.831
Body Length	0.816*	0.202	0.707
Wither Height	0.786*	0.304	0.709
Head Length	0.663*	0.285	0.521
Rump Height	0.622*	0.324	0.492
Chest Depth	0.560*	0.541	0.606
Rump Width	0.488*	0.395	0.394
Ear Length	0.090	0.846*	0.724
Chest Width	0.260	0.817*	0.735
Ear Width	0.113	0.728*	0.543
Rump Length	0.537	0.540*	0.580
Head Width	0.509	0.520*	0.530
Eigenvalues	4.101	3.270	-
Variance (%)	34.176	27.253	-
Cumulative (%)	34.176	61.429	-

Note: *Main component; EC: extraction communalities

The projection on PCA of the factors and the association among morphometric traits in male Sakub sheep is illustrated in Figure 4. The high loadings on these traits suggest that PC1 primarily indicates the sheep's general body size and bulk [21]. Meanwhile, PC2 consists of EL, CW, EW, RL, and HW. The traits loading heavily on PC2 highlight

variations in body structure that are not directly related to overall size but to the shape and form of the animals [7].

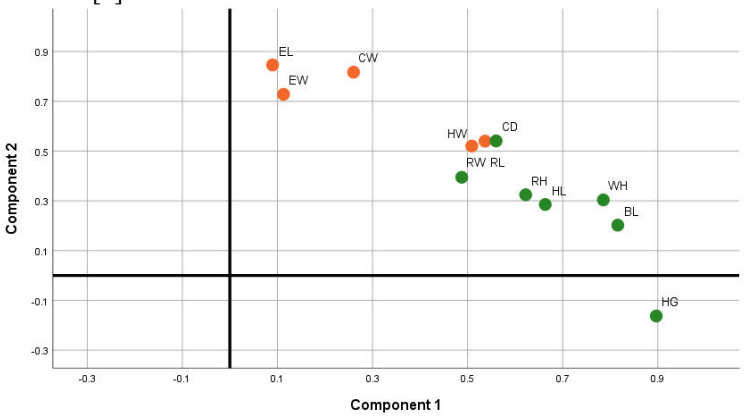

Fig. 4. The plot component in the rotated space of PC1 and PC2.

4 Discussion

The Coefficient of variation (CV) in this study was low and moderate according to the CV level by Hozein-Zadeh and Gahremani [22] namely high (CV > 20%), moderate (10% < CV < 20%), and low (CV < 10%). In male Yankasa sheep, CV values in BL, CG, WH, EL, EW, and RW are categorized as moderate values [23]. In male Thalli sheep, the CV values in WH, BL, HG, HL, HW, EW, and RL are moderate CV values, while EL and RW are low and high CV values, respectively [10]. Two significant components were identified through PCA conducted on morphometric traits of male Sakub sheep was 61.429% of the overall variability. Identifying these two principal components provides valuable insights into the phenotypic structure of the male Sakub sheep population. As previously reported, principal components are standard morphometric trait measures used for selection criteria in sheep. Comparing these findings with PCA studies conducted on other sheep breeds closely related to Sakub sheep, such as Wonosobo and Batur sheep, reveals exciting parallels and differences. A study on Wonosobo sheep identified 3 PCs, with PC1 predominantly loaded with general body size traits including BL, WH, RH, RW, and CD, similar to Sakub sheep but differing from HG and RL. In contrast to the Sakub sheep, HG in the Wonosobo sheep loaded into PC2, while RL loaded into PC1. In Batur sheep, a similar finding of 3 PCs was noted, with PC1 encompassing BL, WH, RH, RW, and CD, PC2 including EL and EW, but differing with HL, which fell into PC3 with a negative correlation [16].

The PCA could help design management, selection, and breeding programs for male Sakub sheep. The differences in PCA results of morphometric traits in livestock can be influenced by a combination of genetic markers [24], inbreeding levels [25], welfare considerations [26], genetic and environmental interactions [27], epigenetic factors [28], and other variables that collectively shape the phenotypic diversity observed in livestock populations

5 Conslusion

In conclusion, PCA analysis of morphometric traits in male Indonesian Sakub sheep revealed two significant components: PC1 (including BL, HG, HL, WH, CD, RH, and RW)

and PC2 (comprising EL, CW, EW, RL, and HW), jointly accounting for approximately 61.429% of the total variance. These findings may inform the development of management, selection, and breeding strategies for male Sakub sheep.

6 Acknowlegment

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