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ORIGINAL ARTICLE

Morphometric characterization of Kacang goats raised in lowland and highland areas of Jambi Province, Indonesia

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ABSTRACT

Objective: The objective of this study was to characterize Kacang goats (aged 1–2 years) in the highland (group 1) and lowland (group 2) areas of Jambi Province based on their body measurements and body indices.
Materials and Methods: A total of 320 goats were collected from lowland (*n* = 160), and highland (*n* = 160) areas with sex proportions of 80 bucks and 80 does for each area. Eight body measurements and 12 body indices were used to characterize the Kacang goats from different areas.
Results: The research showed that each animal group had one principal component (PC) for body measurements and four PCs for body indices. Thus, the body measurement of rump height (RH) and the body indices of area index, weight index, and thoracic development were suggested as the variables to distinguish the Kacang goats from different areas. However, the canonical correlation (r_c) value in the study was approximately 0.30 (low). Therefore, about 59.4% (lowland) and 60.6% (highland) of Kacang goats were characterized by the body measurements, and the body indices were indicated approximately 48.8% (lowland) and 61.2% (highland) of Kacang goats. A cluster analysis of the four Kacang populations revealed that Kacang goats in this study were grouped into a first cluster (Kerinci) and a second cluster (Muaro Jambi, Batanghari, and Sungai Penuh).
Conclusion: It is concluded that body measurements and body indices cannot characterize the Kacang goats from lowland and highland areas.

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Introduction

Kacang goats, the native Indonesian goats, are kept by smallholders for meat production. The average slaughter weight, carcass weight, carcass percentage, and non-carcass percentage in Kacang bucks fed a soybean meal diet were 25.56 kg, 11.94 kg, 46.80%, and 53.20%, respectively [1]. The average litter size and kidding interval in Kacang goats are 2.95 kids/doe/year and 217–271 days, respectively [2]. One of the breeding tracts for Kacang goats in Indonesia is located in Jambi Province. The total number of goats in this province in 2017 reached 483,990 heads, or 2.63% of the total goat population (18,410,379 heads) in Indonesia [3].

In Jambi Province, the breeding tract for Kacang goats covers lowland and highland areas. No studies on the morphometric characteristics of Kacang goats in Jambi Province have been published recently. Breed characterization in goats and sheep can be carried out based on body measurements and body indices [4–7]. Hence, morphometric characteristics can characterize goats and sheep from different populations [8–13]. The morphometric characterization of livestock is essential for planning improvement, sustainable utilization, conservation strategies, and breeding programs for a breed [14]. Morphometric characterization can be carried out using three statistical analyses, namely principal component analysis (PCA), canonical discriminant analysis (CDA), and hierarchical cluster analysis (HCA). These are widely used to characterize goats and sheep breeds from different populations [15–19]. Therefore, this study aimed to characterize the Kacang goats in lowland and highland areas. This

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study's results can be used as early information to develop a breeding program for Kacang goats in Jambi Province in the future.

Materials and Methods

Research site and animals

A total of 320 goats were collected from lowland (160 goats) and highland (160 goats) areas with sex proportions of 80 bucks and 80 does for each area. The Batanghari and Muaro Jambi Regencies represent the lowland area (100–500 m above sea level). Meanwhile, the highland area (≥1,500 m above sea level) is characterized by Kerinci Regency and Sungai Penuh city (Fig. 1). Jambi Province is located at latitude 0°45′–2°45′ S and longitude 101°10′–104°55′ E. The air temperature is approximately 22°C–27°C with an air humidity of roughly 97% and rainfall intensity of approximately 3,030 mm/years.

Data collection

The body measurements were taken from animals in a standing position with a raised head. The body measurements were carried out using a measuring stick and flexible measuring tape, as per the method described by the Food and Agriculture Organization [14]. Thus, a weighing scale was used to obtain the body weight (BW) of the animals. Eight body measurements, i.e., body length (BL), withers height (WH), chest girth (CG), chest depth (CD), shoulder width (SW), rump height (RH), rump width (RW), and cannon circumference (CC) were carried out. BL was measured from the point of the shoulder to the pin bone. WH was measured from the surface of the platform on which the animal stood to the withers of the animal. CG was measured as the body circumference just behind the forelegs. CD was measured from the most dorsal point of the withers to the ventral surface of the sternum. SW was measured as the distance from the left to right shoulder blade. RH was measured from the surface of a platform to the rump. RW was measured as the distance between two *tuber coxae.* The scheme for body measurements in Kacang goats is shown in Figure 2.

Moreover, body indices were calculated in this study according to Birteeb et al. [20], Khargharia et al. [21], and Boujenane et al. [22] as follows: Length index (LI) = [BL/

Figure 1. The Kacang goat population in Jambi Province, Indonesia, in the lowland areas (Batanghari and Muaro Jambi regions) and the highland areas (Kerinci and Sungai Penuh regions).

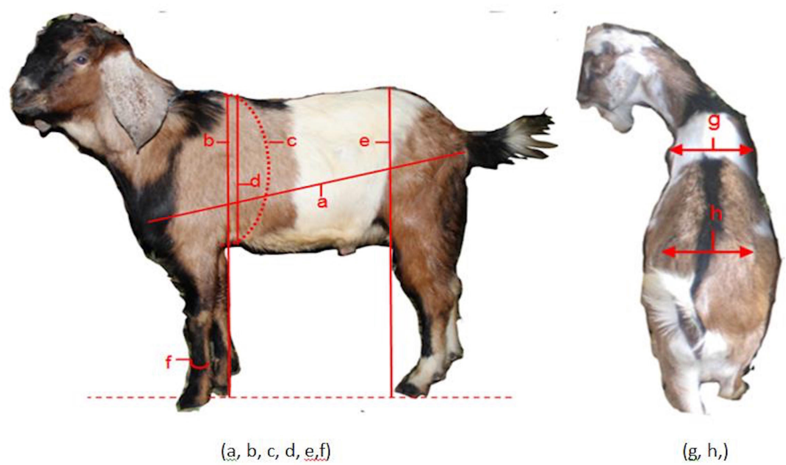

Figure 2. The body measurement scheme for Kacang goats consisting of BL (a), WH (b), CG (c), CD (d), RH (e), CC (f), chest width (g) and RW (h).

WH]×100; Thoracic index (TI) = [SW/CD] × 100; Depth index (DI) = [CD/WH] × 100; Height index (HI) = [WH/RH] × 100; Thoracic development (TD) = [CG/WH] × 100; Dactyl thorax index (DTI) = [CC/CG] × 100; Conformation index (CI) = CG^2/WH; Relative cannon index (RCI) = [CC/WH] × 100; Index of body weight (IBW) = [BW/WH] × 100; Body index (BI) = [BL/CG] × 100; Proportionality (Pr) = [WH/BL] × 100; and Area index (AI) = WH×BL.

According to the BI value, the body of goats can be described using three categories: short or brevigline animals (BI < 85), medigline animals (86 < BI < 88) and longline animals (BI > 88). Hence, according to their DTI values, the bodies of goats can be classified into four categories: light animals (DTI < 10.5), intermediary animals (10.6 < DTI < 10.8), light meat-type animals (10.9 < DTI < 11.0), and massive meat-type animals (DTI > 11.0) [4,23].

Statistical analysis

Descriptive statistics for the body measurements and body indices were carried out using Microsoft Office Excel 2007 to describe the mean and standard deviation. Meanwhile, Pearson's coefficient of correlation (*r*) value between BW and somebody measurements was carried out using Statistical Package for the Social Sciences 16.0 software. Therefore, morpho-structural characterization of goats was conducted using three statistical analyses: PCA, canonical discriminant analysis (CDA), and HCA using the same software. In the PCA, Kaiser–Meyer–Olkin (KMO) measures sampling adequacy, and Bartlett's test of sphericity and communality was computed to obtain the principal component (PC) factor. The PC factor with a KMO greater than 0.50 was the main factor explaining the animal morpho-structure. The orthogonal rotation method's varimax criterion was employed in the rotation of the factor matrix to enhance the factor analysis's interpretability. In the CDA, Mahalanobis distance (D^2), tolerance (T), Wilk's lambda (λ) values, and the linear discriminant function were computed to obtain the discriminating variable for the Kacang goats in the two different areas. Here, the CDA was applied with the backward-stepping automatic elimination method for the variables, with *F*-value entry = 3.84 and *F*-value removal = 2.71. The *T*-value (0–1) was computed to detect the correlation among the discriminant function variables. Suppose a variable is positively correlated with one or more of the others. In that case, the - value is minimal, and the resulting estimates of the discriminant function coefficients may be unstable. HCA was used to cluster the Kacang goats from different populations. In this study, the HCA was conducted using combination data (BW, body measurements, and body indices) with the nearest-neighbor method, the Euclidean distance measure, and the Z score's transformed value.

Results

Animal performance

The average BW, body measurements, and body indices of the Kacang goats are presented in Table 1. The average BW in Kacang goats in the highland area was higher than that in the lowland area, and the difference was significant ($p < 0.05$). Thus, the average BI and DTI values in the studied goats were approximately 89.33 (longline animals) and 10.67 (intermediary animals), respectively (lowland area) and 89.68 (longline animals) and 12.03 (massive

Table 1. The average morphostuctural characteristics of Kacang goats in two different areas.

Parameter	Lowland			Highland		
	Buck (80)	Doe (80)	Total (160)	Buck (80)	Doe (80)	Total (160)
BW (kg)	18.05 ± 2.82	16.35 ± 2.59	17.20 ± 2.83[a]	19.95 ± 2.90	17.34 ± 3.63	18.64 ± 3.53[b]
Body measurements (cm)						
BL	51.93 ± 3.29	50.23 ± 2.54	51.08 ± 3.05	53.03 ± 3.01	51.31 ± 2.11	52.17 ± 2.73
WH	50.58 ± 2.52	48.45 ± 2.17	49.52 ± 2.58	52.07 ± 2.79	49.63 ± 2.22	50.85 ± 2.79
CG	58.09 ± 2.51	56.28 ± 2.46	57.18 ± 2.64	59.08 ± 2.48	57.28 ± 2.58	58.18 ± 2.68
CD	23.42 ± 2.79	20.63 ± 3.06	22.02 ± 3.24	24.42 ± 2.56	22.25 ± 2.99	23.34 ± 2.99
SW	12.14 ± 2.29	10.12 ± 2.71	11.13 ± 2.70	13.58 ± 2.26	11.27 ± 2.42	12.42 ± 2.60
RH	52.61 ± 2.12	50.12 ± 2.61	51.36 ± 2.68	53.92 ± 2.26	52.06 ± 2.94	52.99 ± 2.78
RW	11.73 ± 1.73	10.48 ± 2.54	11.10 ± 2.26	12.83 ± 2.21	11.27 ± 2.33	12.05 ± 2.40
CC	6.80 ± 1.96	5.52 ± 2.44	6.15 ± 2.30	7.90 ± 1.73	6.19 ± 2.51	7.05 ± 2.31
Body indices						
LI	102.65 ± 3.76	103.77 ± 4.90	103.21 ± 4.48	101.89 ± 4.09	103.49 ± 4.48	102.59 ± 4.34
TI	51.55 ± 4.93	49.51 ± 12.33	50.53 ± 9.46	55.37 ± 5.13	51.08 ± 10.99	53.22 ± 8.77
DI	46.20 ± 4.02	42.51 ± 5.53	44.36 ± 5.14	46.85 ± 3.61	44.80 ± 5.54	45.83 ± 4.75
HI	96.14 ± 2.39	96.77 ± 3.55	96.45 ± 3.07	96.58 ± 3.18	95.46 ± 3.86	96.02 ± 3.56
TD	114.92 ± 3.01	116.29 ± 5.08	115.60 ± 4.26	113.57 ± 3.88	115.46 ± 3.44	114.52 ± 3.77
DTI	11.62 ± 2.61	9.71 ± 3.94	10.67 ± 3.55	13.31 ± 2.46	10.75 ± 4.15	12.03 ± 3.63
CI	66.76 ± 3.62	65.50 ± 4.96	66.13 ± 4.35	67.10 ± 3.84	66.17 ± 4.10	66.63 ± 3.97
RCI	13.34 ± 2.97	11.32 ± 4.80	12.33 ± 4.17	15.10 ± 2.67	12.42 ± 4.85	13.76 ± 4.11
IBW	35.52 ± 4.09	33.66 ± 4.57	34.59 ± 4.44	38.17 ± 4.23	34.76 ± 6.22	36.47 ± 5.56
BI	89.34 ± 2.76	89.32 ± 4.30	89.33 ± 3.63	89.72 ± 2.58	89.63 ± 2.89	89.68 ± 2.72
Pr	97.55 ± 3.65	96.59 ± 4.68	97.07 ± 4.30	98.32 ± 4.36	96.81 ± 4.22	97.56 ± 4.33
AI	2,633.54 ± 273.16	2,436.09 ± 197.11	2,534.81 ± 260.13	2,767.12 ± 275.20	2,548.77 ± 189.85	2,657.94 ± 259.58

Different letters (a, b) in the same rows indicate significant differences ($p < 0.05$).

meat-type animals), respectively (highland area). The r-value between BW and each body measurement in this study ranged from 0.60 to 0.93, as presented in Table 2. Meanwhile, a high r-value ($0.60 < r < 0.80$) was shown between BW and DTI (0.72), RCI (0.70), and AI (0.84) for Kacang goats in the lowland area. BW had a high r-value with CI (0.72), AI (0.86), and IBW (0.97) for Kacang goats in the highland area (Table 3).

Principal component analysis

The PCA of the body measurements of Kacang goats revealed one principal component (PC1), as presented in Table 4. Hence, all body measurements included the first component explaining Kacang goat morphometrics in lowland and highland areas. PC1 in this study explained approximately 73% of the total variance in Kacang goat morphometry in lowland and highland areas.

Five body indices, DI, DTI, RCI, IBW, and Pr, were included in PC1 for the Kacang goats in the lowland area. Meanwhile, HI and TD were included in PC1 for the Kacang goats in the highland area. The component plots for the body indices of Kacang goats in lowland and highland regions are shown in Figure 3.

Canonical discriminant analysis

The CDA for body measurements and body indices of Kacang goats in this study are presented in Table 6. This study's goat characterization revealed a low r_c value, i.e., 0.29 (body measurements) and 0.30 (body indices). RH was selected as the describing variable for Kacang goats, with $D^2 = 0.36$ and Wilk's $\lambda = 0.92$. Hence, three body indices, AI, IBW, and TD, were selected as the describing variables in Kacang goats, with $D^2 = 0.28$ and Wilk's $\lambda = 0.93$. Moreover, approximately 59.40% of Kacang goats in the lowland area and 60.60% of Kacang goats in the highland area can be characterized based on body measurements (Table 7). Meanwhile, approximately 48.80% of Kacang goats in the lowland area and 61.20% of Kacang goats in the highland area can be characterized by body indices.

Table 2. Pearson's correlations between BW and body measurements of Kacang goats in lowland (above diagonal) and highland (below diagonal) areas.

Body measurements	BW	BL	WH	CG	CD	SW	RH	RW	CC
BW	–	0.76	0.79	0.81	0.75	0.77	0.76	0.68	0.76
BL	0.78	–	0.70	0.75	0.71	0.62	0.66	0.57	0.53
WH	0.79	0.67	–	0.72	0.71	0.66	0.81	0.65	0.57
CG	0.93	0.82	0.79	–	0.81	0.73	0.73	0.67	0.68
CD	0.76	0.63	0.63	0.72	–	0.66	0.71	0.71	0.62
SW	0.74	0.66	0.71	0.76	0.67	–	0.71	0.67	0.76
RH (HH)	0.84	0.75	0.76	0.91	0.66	0.75	–	0.61	0.57
RW	0.70	0.62	0.66	0.74	0.69	0.68	0.68	–	0.67
CC	0.56	0.53	0.58	0.61	0.51	0.64	0.59	0.61	–

Table 3. Pearson's correlations between BW and body indices of Kacang goats in lowland (above diagonal) and highland (below diagonal) areas.

Body indices	BW	LI	TI	DI	HI	TD	DTI	CI	RCI	IBW	BI	Pr	AI
BW	–	0.11	0.37	0.58	0.05	−0.11	0.72*	0.51	0.70*	0.97	0.20	−0.10	0.84*
LI	−0.04	–	−0.03	0.26	−0.26	0.49	0.03	0.39	0.09	0.23	0.62	−0.99	0.20
TI	0.35	−0.07	–	−0.13	−0.09	−0.03	0.43	0.17	0.43	0.37	−0.01	0.05	0.25
DI	0.51	0.20	−0.20	–	−0.15	0.21	0.46	0.60	0.49	0.56	0.08	−0.27	0.57
HI	−0.03	−0.58	−0.06	−0.25	–	−0.45	0.01	−0.27	−0.05	−0.06	0.13	0.27	0.20
TD	−0.01	0.70	−0.07	0.27	−0.81	–	0.01	0.73	0.13	0.07	−0.37	−0.50	−0.29
DTI	0.46	−0.09	0.39	0.28	0.03	−0.13	–	0.43	0.99	0.69	0.03	−0.03	0.56
CI	0.72*	0.39	0.30	0.51	−0.54	0.63	0.32	–	0.52	0.57	−0.23	−0.41	0.40
RCI	0.45	−0.01	0.39	0.30	−0.07	−0.01	0.99	0.39	–	0.70	−0.01	−0.10	0.52
IBW	0.97*	0.11	0.29	0.55	−0.18	0.19	0.37	0.78	0.39	–	0.10	−0.23	0.71
BI	−0.04	0.65	−0.01	−0.01	0.06	−0.09	0.02	−0.12	−0.01	−0.04	–	−0.61	0.47
Pr	0.04	−0.99	0.06	−0.20	0.58	−0.69	0.08	−0.38	0.01	−0.11	−0.65	–	−0.20
AI													

AI = Area.
*indicates significant difference.

The canonical plots of the body measurements and body indices of Kacang goats are shown in Figure 4.

The differences in genetics (breed), location (geographical area), agro-climatic conditions, and animal management systems explain the different results for this breed characterization compared to those in previous studies.

Hierarchical cluster analysis

The HCA based on BW, body measurements and body indices revealed two population clusters. Kerinci Regency was clustered into the first cluster, and Sungai Penuh, Muaro Jambi, and Batanghari regencies were clustered into the second cluster (Fig. 5). The shortest Euclidean distance was found between the Muaro Jambi and Batanghari regencies (2.81) because both regencies are located in a similar geographic area (lowland).

Discussion

Putra and Ilham [6] reported that the average BI and DTI of Kacang does in the Bone Bolango Regency of Indonesia were approximately 86.95 (medigline animals) and 10.24 (light-meat animals), respectively, which were lower than those in this study. Chacon et al. [23] reported that the body indices of Cuban Creole does were approximately 85.29 (BI), 93.19 (Pr), 47.66 (DI), 9.58 (DTI), and 97.01 (CI). Meanwhile, the body indices of Anglo-Nubian goats were approximately 81.96 (BI), 95.90 (Pr), 47.13 (DI), 9.15 (DTI), and 105.37 (CI). Khargharia et al. [21] reported that the body indices of Assam Hill does were approximately 1.14 length index (LI), 0,51 depth index (DI), 86.87 body index (BI), 88.52 proportionality (IPr), 50.88 relative depth of thorax (IPRT)), 9.82 Dactyl thorax index (DTI), 1,32 thoracic development (TD), 3355.13 area Index (AI), and 12.95 relative cannon thickness index (RCTI). The body indices BI and Pr of Kacang does in this study were higher than those of Cuban Creole, Anglo-Nubian, and Assam Hill does. However, the *r*-value between the BW and each body measurement in this study ranged from 0.60 to 0.93, as shown in Table 2. Meanwhile, a high *r*-value ($0.60 < r < 0.80$) was shown between BW and DTI (0.72), RCI (0.70), and AI (0.84) for Kacang goats in the lowland area (Table 3). BW had a high *r*-value with CI (0.72) and AI (0.86) for Kacang goats in the highland area. However, a high *r*-value in BW–CI (0.69) and BW–AI (0.64) was reported in Kacang does in the Bone Bolango Regency [6].

Table 4. Eigenvalues, total variance, cumulative, commonalities, KMO measure of sampling adequacy and Bartlett's test of sphericity in the body measurements of Kacang goats in two different areas.

Body measurements	Lowland		Highland	
	PC1	Com.	PC1	Com.
BW	0.92	0.85	0.93	0.86
BL	0.82	0.67	0.84	0.71
WH	0.86	0.74	0.86	0.73
CG	0.89	0.81	0.95	0.90
CD	0.87	0.76	0.81	0.66
SW	0.85	0.73	0.86	0.74
RH	0.86	0.73	0.91	0.82
RW	0.81	0.65	0.83	0.68
CC	0.80	0.64	0.72	0.52
Eigenvalues	6.57	–	6.61	–
Variance (%)	73.0	–	73.5	–
Cumulative (%)	73.0	–	73.5	–
KMO	0.93		0.94	
Bartlett's test	**		**	

Com.: communality.
**indicates very significant difference.

The PCA of the body measurements of Kacang goats revealed PC1, as presented in Table 4. Hence, all body measurements included the first component to explain Kacang goat morphometrics in the lowland and highland areas. PC1 in this study explained approximately 73% of the total variance in Kacang goat morphometrics in the lowland and the highland regions. Pares-Casanova [24] obtained a PC1 that explained about 75% of goat morphometrics' total variance, close to this study's result. Okpeku et al. [25] obtained a PC1 that explained approximately 92.46% (male) and 87.00% (female) of the total variance in West African Dwarf goat morphometrics. Besides, PC1 explained 86.38% (male) and 79.89% (female) of the total variance in morphometric analysis of Red Sokoto goats [25]. Yakubu [26] obtained a PC1 that explained 73.03% of Yankasa sheep morphometrics' total variance at 15.5 months old and was close to that in this study. The PCA of the body indices of the Kacang goats in each area revealed

Table 5. Eigenvalues, total variance, cumulative, commonalities, KMO measure of sampling adequacy and Bartlett's test of sphericity in the body indices of Kacang goats in two different areas.

Body indices	Lowland					Highland				
	PC1	PC2	PC3	PC4	Com.	PC1	PC2	PC3	PC4	Com.
LI	0.10	0.91[a]	0.37	−0.06	0.98	0.62	−0.06	0.08	0.77[a]	0.99
TI	0.32	−0.03	0.05	0.87[a]	0.86	0.06	0.79[a]	−0.11	−0.05	0.65
DI	0.73[a]	0.13	0.18	−0.50	0.83	0.17	−0.09	0.84[a]	0.03	0.75
HI	0.05	−0.12	−0.67[a]	−0.17	0.49	−0.91[a]	−0.04	−0.08	−0.06	0.84
TD	0.04	0.11	0.95[a]	−0.12	0.94	0.96[a]	−0.11	0.12	0.09	0.96
DTI	0.87[a]	−0.07	0.01	0.30	0.86	−0.09	0.84[a]	0.28	−0.01	0.80
CI	0.63	0.08	0.67[a]	−0.15	0.88	0.59	0.33	0.67[a]	−0.02	0.90
RCI	0.87[a]	−0.05	0.13	0.28	0.86	0.02	0.84[a]	0.30	0.001	0.79
IBW	0.86[a]	0.17	0.04	0.12	0.78	0.13	0.32	0.84[a]	−0.02	0.82
BI	0.07	0.87[a]	−0.47	0.05	0.98	−0.16	0.03	−0.02	0.98[a]	0.99
Pr	0.80[a]	0.31	−0.36	−0.05	0.86	−0.33	0.52	0.68[a]	0.19	0.87
AI	−0.10	−0.91[a]	−0.38	0.07	0.98	−0.62	0.06	−0.08	−0.78[a]	0.99
Eigenvalues	4.43	2.62	2.11	1.14	–	4.12	3.31	1.70	1.21	–
Variance (%)	36.93	21.83	17.57	9.49	–	34.32	27.61	14.19	10.07	–
Cumulative (%)	36.93	58.76	76.33	85.82	–	34.32	61.93	76.12	86.19	–
KMO		0.55					0.51			
Bartlett's test		**					**			

Com. = communality.
[a]Main component.

Table 6. Factors selected by stepwise discriminant analysis to characterize Kacang goats in two different areas.

Factor/Step	Variables entered	Tolerance	F_{remove}	D^2	Wilk's λ
Body measurements (r_c = 0.29)					
Step 1	RH	1.00	28.76	0.36	0.92
Body indices (r_c = 0.30)					
Step 1	AI	0.91	13.14	0.22	0.95
Step 2	IBW	0.61	11.41	0.24	0.94
Step 3	TD	0.57	8.91	0.28	0.93

D^2 = Mahalanobis distance; r_c = canonical correlation.

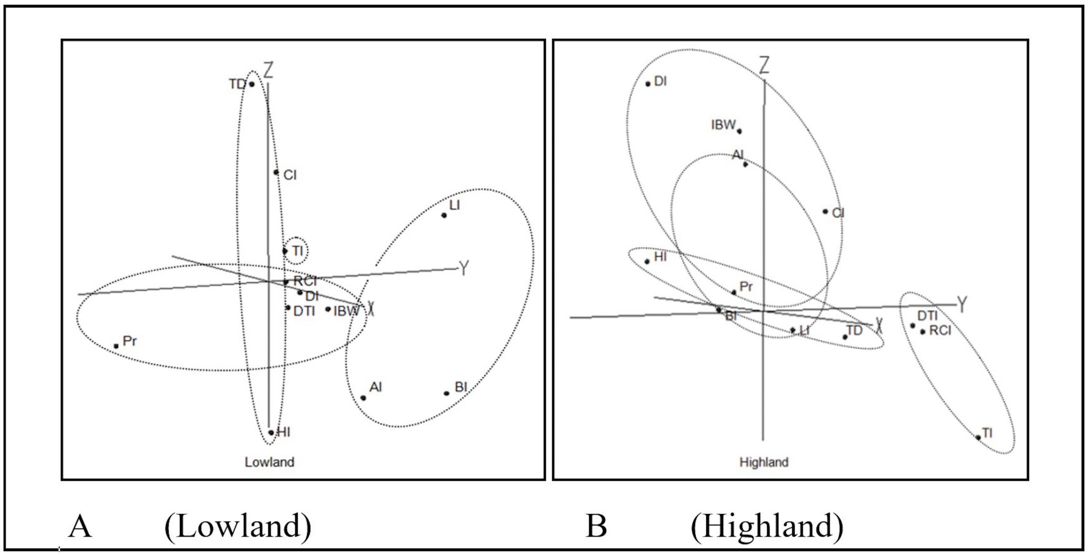

Figure 3. The component plot of body indices in Kacang goats based on a rotated component matrix.

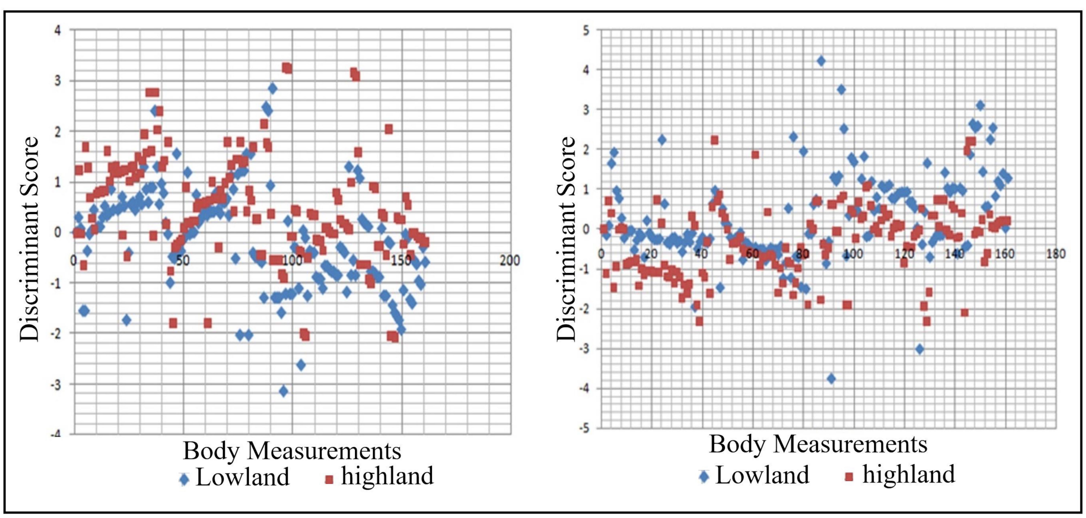

Figure 4. The canonical discriminant plot of the body measurements and body indices characterizing Kacang goats in two different area.

Table 7. Percentage (%) of individual classification per breed based on discriminant analysis.

Factors	Area	Predicted group membership (*N*)		Total (*N*)
		Lowland	Highland	
Morphometric	Lowland	59.4 (95)	40.6 (65)	100.0 (160)
	Highland	39.4 (63)	60.6 (97)	100.0 (160)
Body indices	Lowland	48.8 (78)	51.2 (82)	100.0 (160)
	Highland	38.8 (62)	61.2 (98)	100.0 (160)

N: number of animals

Table 8. Genetic distance (Centimorgan cM) between Kacang goats from different populations based on BW, body measurements, and body indices.

Population	Kerinci	Sungai Penuh	Muaro Jambi	Batanghari
Kerinci	0.00	7.46	8.21	8.94
Sungai Penuh	–	0.00	4.79	4.27
Muaro Jambi	–	–	0.00	2.81
Batanghari	–	–	–	0.00

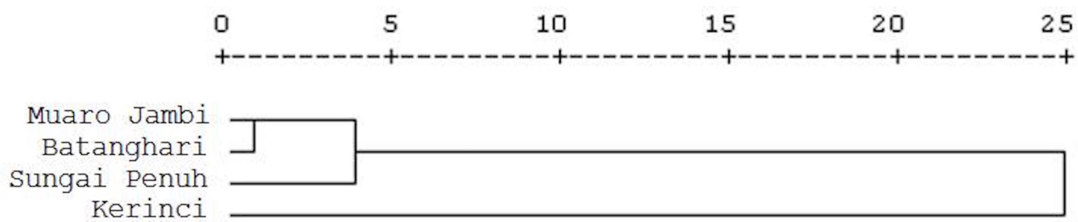

Figure 5. Dendrogram based on distances among Kacang populations based on BW, body measurements and body indices.

four PCs, as presented in Table 5. Hence, four PCs explain approximately 86% of Kacang goat morphometrics' total variance in the lowland and highland areas. Putra and Ilham [6] obtained four PCs based on body indices that explained approximately 86.84% of Kacang doe morphometrics' total variance in Bone Bolango Regency. However, PC1 for Kacang does in this regency consisted of CI and TD [6]. Five body indices, DI, DTI, RCI, IBW, and Pr, were included in PC1 for the Kacang goats in the lowland area. Meanwhile, HI and TD were included in PC1 for the Kacang goats in the highland area. The component plots of the body indices of Kacang goats in the lowland and highland regions are shown in Figure 3.

A breed characterization based on morphometric traits was not accurate for characterizing Arabian goats in the northern ecotype (40.30%) of Algeria [5], Burkina Faso goats in the Sudan area (6.00%) [9], and Algerian sheep in the southern (10.00%) and central (14.75%) areas of Algeria [11]. However, the D^2 value between Kacang goats in the lowland and the highland regions based on body measurements was 0.36 (Table 6). It was similar to the D^2 value observed between Arbi goats in the Jerid and Nefzawa populations (0.33) of Tunisia [10]. Arandas et al. [27] found that 66.67% of Caninde does in a Pernambuco herd could be characterized by morphometric traits, similar to the Kacang goats highland area. The differences in genetics (breed), location (geographical area), agro-climatic conditions, and animal management systems can explain the different results of this breed characterization compared to those in previous studies.

The value of the genetic distance matrix between goats from different populations based on body weight and body size is presented in Table 8. The value of this genetic distance matrix is used to construct a phenogram tree as shown in Figure 5. The phenogram tree describes the genetic distance of the goat population in Muaro Jambi, Batanghari, Sungai Penuh, and Kerinci. Accortding to Figure 5, Kacang goats at Muaro Jambi and Batanghari were classified in the similar cluster with a Euclidean distance value of 2.81 (Table 8). Both regencies are located in the similar geographic area (lowlands) with similar environmental factors that affecting to the morphometric traits of goats rose at both regencies. Meanwhile, Kacang goats at Kerinci regency alone were classified in different cluster. It can be suggested that Kacang goats at this location have the different of morphometric traits rather than the other regencies.. Previous studies obtained a Euclidean distance of 1.87–8.87 among Pramenka sheep from six different populations in Slovenia [7] and of 2.34–7.77 among Black Creole goats from seven diverse communities in Mexico [13]. The differences in animal management, selection, geographical area, agro-climatic conditions, and natural resources can be affected by phenotypic variation among breeds from different populations. Moreover, the low r_c value between Kacang goats raised in lowland and highland areas can be caused by no environmental effects on goat's morphometrics. Hence, both areas' ecological impact might be affected by animals' vital signs and reproductive traits. On the contrary, Utomo [28] reported that the reproductive traits of Ettawa does raise in lowland and highland areas were not different significantly. In the future, studying to investigate the environmental effect in lowland and the highland regions on vital signs and reproductive traits of Kacang is essential for improving the management systems.

Conclusion

Eight body measurements, BL, WH, CG, CD, SW, RH, RW, and CC, in this study were included in the first component explaining Kacang goat morphometric traits in lowland and highland areas. Moreover, these body measurements had a high *r*-value with the BW trait (0.68–0.81). Unfortunately, this study's r_c value was low (± 0.30), suggesting that the breed characterization based on body measurements and body indices was not accurate for the studied goats in the lowland and highland areas. However, the HCA with combination data revealed that Kacang goats were separated into different clusters. Hence, a genetic study (DNA analysis) of Kacang goats, mainly those in Kerinci Regency, is essential for developing these goats into a Kerinci goat breed in the future.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Authors' contributions

DD and WPBP contributed to the experiment and sample collection and wrote the article. GG and YA contributed to the statistical analysis and data interpretation. HS carried out the analysis and wrote the article.

References

[1] Adiwinarti R, Kustantinah, Budisatria IGS. Improving the performance of local Kacang goats using ruminally undegradable protein feeds. Asian J Anim Sci 2016; 10:262–7; https://doi.org/10.3923/ajas.2016.262.267

[2] Sodiq A, Soedito A, Ezzat ST. Reproduction rate of Kacang and Peranakan Etawah goats under village production systems in Indonesia. Int Res Food Sec 2003; https://ei-ado.aciar.gov.au/sites/default/files/SodiqEtAl(2003)ReproductionRateGoatsUnderVillageProductionSystemsIndo.pdf (Accessed on July 01, 2020)

[3] Kementan RI. Livestock and animal health statistics. Jakarta, Indonesia: Directorate General of Livestock and Animal Health, 2017.

[4] Esquivelzeta C, Fina M, Bach R, Madruga C, Caja G, Casellas J, et al. Morphological analysis and subpopulation characterization of Ripollesa sheep breed. Anim Genet Resour 2011; 49:9–17; https://doi.org/10.1017/S2078633611000063

[5] Ouchene-Khelifi NA, Ouchene N, Silva AD, Lafri M. Multivariate characterization of phenotypic traits of Arabia, the main Algerian goat breed. Livest Res Rural Dev 2018; 30(7); http://www.lrrd.org/lrrd30/7/nakh30116.html (Accessed on July 01, 2020)

[6] Putra WPB, Ilham F. Principal component analysis of body measurements and body indices and their correlation with body weight in Katjang does of Indonesia. J Dairy Vet Anim Res 2019; 8(3):124–34; https://doi.org/10.15406/jdvar.2019.08.00254

[7] Markovic B, Dove P, Markovic M, Radonjic D, Adakalic M, Simčič M, et al. 2019. Differentiation of some Pramenka sheep breeds based on morphometric characteristics. Arch Anim Breed 2019; 62:393–402; https://doi.org/10.5194/aab-62-393-2019

[8] Zaitoun IS, Tabbaa MJ, Bdour S. Differentiation of native goat breeds of Jordan on the basis of morphostructural characteristics. Small Rumin Res 2005; 56:173–82; https://doi.org/10.1016/j.smallrumres.2004.06.011

[9] Traore A, Tamboura HH, Kabore A, Royo LJ, Fernandez I, Alvarez I, et al. Multivariate analyses on morphological traits of goats in Burkina Faso. Arch Tierzuecht Dummerstorf 2008; 6:588–600; https://doi.org/10.5194/aab-51-588-2008

[10] Nafti M, Khaldi Z, Haddad B. Multivariate characterization of morphological traits in local Tunisian oases goats. Anim Genet Resour 2014; 55:29–38. https://doi.org/10.1017/S2078633614000265

[11] Dekhili M. A morphometric study of sheep reared in North-East Algerian. Arch Zootec 2014; 63(244):623–31; https://doi.org/10.4321/S0004-05922014000400006

[12] Gatew H, Hassen H, Kebede K, Haile A, Lobo RNB, Yitayew A, et al. Characterization of indigenous goat populations in selected areas of Ethiopia. Am Eurasian J Sci Res 2015; 10(5):287-298.

[13] Jarquin JCS, Ponce SIR, Aguilar MD, Avila HRV, Sandoval VHC et al. Morphostructural characterization of the Black Creole goat raised in Central Mexico, a currently threatened zoogenetic resource. Animals 2019; 9:459; https://doi.org/10.3390/ani9070459

[14] FAO. Phenotypic characterisation of animal genetic resources. FAO Animal Production and Health Guidelines No. 11. Commission on Genetic Resources for Food and Agriculture, Rome, Italy, p 31, 2012; http://www.fao.org/3/a-i2686e.pdf (Accessed 1 June 2020)

[15] Birteeb PT, Sunday OP, Yakubu A, Adeleke MA, Ozoje MO. Multivariate characterisation of the phenotyphic traits of Djallonke and Sahel sheep in Northern Ghana. Trop Anim Health Prod 2012; 45(1):267–74; https://doi.org/10.1007/s11250-012-0211-4

[16] Aziz MMA, Al-Hur FS. Differentiation between three Saudi goat types using size-free canonical discriminant analysis. Emirates J Food Agric 2013; 25(9):723–35; https://doi.org/10.9755/ejfa.v25i9.15827

[17] Boujenane I, Derqaoui L, Nouamane G. Morphological differentiation between two Maroccan goat breeds. J Livest Sci Technol 2016; 4(2):31–8.

[18] Dauda A, Abbaya HY, Ebegbulem VN. Application of multifactorial discriminant analysis of morphostructural differentiation of sheep. J Genet Genet Eng 2018; 2(2):11–16
[19] Edouard NGK, Severin KG, Cyrille KN, Etienne LN, Yves EJ, et al. Primary morphological characterization of West African dwarf (Djallonke) ewes from Cote d'Ivoire based on qualitative and quantitative traits. Int J Genet Mol Biol 2019; 11(2):16–28. https://doi.org/10.5897/IJGMB2019.0170
[20] Birteeb PT, Sunday OP, Michael OO. Analysis of the body structure of Djallonke sheep using multideterminant approach. Anim Genet Resour 2014; 54:65–72; https://doi.org/10.1017/S2078633614000125
[21] Khargharia G, Kadirvel G, Kumar S. Principal component analysis of morphological traits of Assam hill goat in Eastern Himalayan India. J Anim Plant Sci 2015; 25(5):1251–8.
[22] Boujenane I. Multivariate characterisation of Oulmes-Zaer and Tidili cattle using the morphological traits. Iran J Appl Anim Sci 2015; 5(2):293–9.
[23] Chacon E, Macedo F, Velazquez F, Paiva SR, Pineda E et al. Morphological measurements andbody indices for Cuban Creole goats and their crossbreds. Rev Bras Zootec 2011; 40(8):1671–9; https://doi.org/10.1590/S1516-35982011000800007
[24] Pares-Casanova PM. Body weight is an important trait for comparisons of goat breeds. Iran J Appl Anim Sci 2015; 5(2):463–6.
[25] Okpeku M, Yakubu A, Peters SO, Ozoje MO, Ikeobi CON, Adebambo OA, et al. Application of multivariate principal component analysis to morphological characterization of indigenous goats in Southern Nigeria. Acta Agric Slov 2011; 98(2):101–9; https://doi.org/10.2478/v10014-011-0026-4
[26] Yakubu A. Principal component analysis of the conformation traits of Yankasa sheep. Biotechnol Anim Husbandry 2013; 29(1):65–74; https://doi.org/10.2298/BAH1301065Y
[27] Arandas JKG, Silva NMV, Nascimento RB, Filho ECP, Brasil LHA, Ribeiro MN. Multivariate analysis as a tool for phenotyphic characterization of an endangered breed. J Appl Anim Res 2017; 45(1):152–8; https://doi.org/10.1080/09712119.2015.1125353
[28] Utomo, S. Effect of altitude differences on results artificial insemination in Ettawa cross-breed goats. Sains Peternakan 2013; 11(1):34–42. Available via https://jurnal.uns.ac.id/Sains-Peternakan/issue/view/576 (Accessed 01 July 2020)