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Research Article

Morphometric Characterization and Principal Component Analysis of Different Goats Breeds

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Abstract

Goats play a very vital role in the livestock industry and are the only livestock not forbidden by any religion. Morphometric characterization is very important for the improvement of goat breeds and the proper classification of these animals. A linear measurement was carried out on sixty goats consisting of 20 each Red Sokoto (RS), West African Long logged (WLL), and West African Dwarf WAD) goat. Parameters measures were Withers height (WH), Rump height (RH), Body length (BL), Sternum height (SH), Body depth (BD), Bicostal diameter (BC), Ear length (EL), Rump width (RW), Head width (HW), Rump length (RL), Head length (HL) Heart girth (HG), Cannon bone Circumference (CB), Muzzle diameter (MD). The data collected was subjected to statistical analysis using R. version 4.0.2. It was observed that WH, RH, BL, SH, BD, BC, EL, RW, HW, RL, HL, HG, CB, and MD, exhibit variations across different age groups. For example, WH increases from 36.89 cm (at 1.00 years) to 63.98 cm (at 4.00 years), indicating a growth in wither height as goats increase in age. A significant difference ($p<0.05$) in the morphometric parameters across different age groups was observed. The lowest mean weight (11.50 ±1.1) was recorded in WAD while the highest (24.40 ±1.24) was recorded in WLL). These variations in weight were significant ($p<0.05$) across the breeds. Principal Component Analysis shows that four components contributed to 74% of the variation in the goat. The estimation classified the goats as heavy meat type while the Dactyl thorax index classified the WAD and RS as brevigline and the WLL as medigline. This study therefore contributes to a better understanding of goat morphology which has practical implications for livestock breeding and management programs. Informed decisions can also be made about breeding strategies, selecting animals specifically, and improving the overall goat population using the information provided in this study.

Keywords

Morphometric Characterization, Body Index Score, PCA, Correlation, Goat Breeds

1. Introduction

Goat is one of the easiest animals to raise and thus the reason it is being domesticated by many rural farmers and women. The meat from the goat has little or no cultural or religious barrier compared to other animals. Different body linear measurements can be used in the differentiation of one goat from another [6]. Body morphometric can also be used in the description or characterization of different goat breeds. [7, 10]. Using body index score, goats can be characterized into four categories light animals, intermediary animals, light meat-type animals, and massive meat-type animals depending on their dept indices [6].

The morphometric characteristics of different local goat breeds in Burkina Faso show a variation in body morphometrics and

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weight among the breeds [2]. It was also observed through principal component analysis shows structures between the breeds any strict separation. It had also been reported from a PCA investigation on goat morphometrics that a significant correlation of -0.76 to 0.88 [12]. Body weight and ear length were reported to have a low correlation. It had been noted that height at withers was an accurate and repeatable measurement for frame size. However, the superiority of heart girth over other linear body measurements has been reported [11]. The higher association of body weight with chest girth could be attributed to a relatively larger contribution in body weight by chest girth which consists of bones, muscles, and visceral organs. The aim of this research is there for to carry out the morphometric characterization of goats and to also use body index values to classify the goats.

2. Methodology

2.1. Location

This was also carried out at the University of Benin's Teaching and Research Farm in Edo State, Nigeria. The University of Benin is located in the Humid Rain Forest Zone of Southern Nigeria, at latitude 6.02 ℕ and longitude 5.06 ℇ, with an annual temperature range of 24.5 to 32.7 ℃, with a mean of 28.6 ℃. The average annual rainfall is 2430 mm, with a range of 1498 to 3574 mm. The relative humidity and daily sunshine hours range between 63.3 and 81.7% and 5.85 and 7.5 hours, respectively, with means of 73.5% and 6.68 hours.

2.2. Experimental Animal

About sixty (60) goats, twenty (20) West African Dwarf (WAD), twenty (20) Red Sokoto or Maradi, twenty (20) West African Long Legged (WALL) breeds of Goats of different ages were used in this experiment. This researched was conducted between June 2023 to August 2023.

2.3. Data Collection

Data were collected on the weight of the animals using a hanging scale (10kg to 200kg), the age of the animal were recorded with the animal's dentition observed, and the following morphometric parameters were measured using a measuring tape and recorded;

Withers height (WH), Rump height (RH), Body length (BL), Sternum height (SH), Body depth (BD), Bicostal diameter (BC), Ear length (EL), Rump width (RW), Head width (HW), Rump length (RL), Head length (HL) Heart girth (HG), Cannon bone Circumference (CB), Muzzle diameter (MD).

2.4. Statistical Analysis

The collected data were analyzed using R version 4.0.2 to carry out summary statistics, Principal Component Analysis and Correlation. In order to further classify the goats, there body indices were calculated as follows: Length Index (LI) = BL/WH x 100, Thoraxic Index (TI) = SW/CD x 100, Depth index (DI) = CD/WH x 100, Height index (HI) = WH/RH x 100, Thoracic development (TD) = CG/WH x 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. [4, 5].

Table 1. *Summary statistics for the goat morphometrics based on their age.*

AGE	WEIGHT	WH	RH	BL	SH	BD	BC
1.00	8.02 ±1.2 ^{a}	36.89 ±2.02^{a}	38.11 ±1.59^{a}	46.78 ±2.66^{a}	26.22 ±1.70 ^{a}	45.22 ±2.49^{a}	26.22 ±1.96^{a}
2.00	17.69 ±1.80^{b}	55.10 ±3.65^{b}	58.60 ±3.35^{b}	57.80 ±1.95^{b}	38.00 ±2.90^{b}	62.00 ±2.46^{b}	35.20 ±1.58^{b}
3.00	18.67 ±1.23^{b}	56.70 ±3.00^{b}	58.77 ±2.86^{b}	60.07 ±1.85^{bc}	37.87 ±2.26^{b}	64.43 ±1.92^{bc}	37.83 ±1.2^{bc}
4.00	23.92 ±1.05^{c}	63.98 ±1.28^{c}	65.96 ±1.15^{c}	63.77 ±0.69^{c}	43.69 ±1.04^{b}	68.62 ±0.58^{c}	40.65 ±0.68^{c}

EL	RW	HW	RL	HL	HG	CB	MD
9.22 ±0.49^{a}	9.44 ±0.65^{a}	11.11 ±0.39^{a}	10.00 ±0.47^{a}	15.33 ±0.85^{a}	55.78 ±4.00^{a}	9.33 ±0.29^{a}	8.22 ±0.28^{a}
13.00 ±0.80^{b}	13.70 ±0.70^{b}	14.00 ±0.63^{b}	13.50 ±0.69^{b}	18.20 ±0.57^{b}	70.70 ±1.87^{b}	12.90 ±0.64^{bc}	10.10 ±0.28 ^{b}
13.67 ±0.92^{b}	14.07 ±0.44^{bc}	14.77 ±0.60^{b}	14.47 ±0.61^{b}	19.5 ±0.46^{bc}	72.17 ±1.32^{b}	12.57 ±0.41^{b}	10.5^{c} ±0.27^{bc}
14.92 ±0.62 ^{b}	15.38 ±0.32^{c}	15.69 ±0.42^{b}	16.9 ±0.47^{c}	20.65 ±0.34^{c}	74.85 ±0.90^{b}	14.00 ±0.28^{c}	11.23 ±0.18^{c}

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

Table 2. *Summary statistics for the goat morphometrics based on their breeds.*

BREED	WEIGHT	WH	RH	BL	SW	CD	BC
WAD	11.50 ±1.1 [a]	40.45 ±1.26[a]	42.95 ±1.33[a]	51.35 ±1.72[a]	27.65 ±0.94[a]	51.40 ±1.87[a]	30.35 ±1.49[a]
RS	21.65 ±0.72[b]	62.45 ±0.77[b]	64.53 ±0.91[b]	60.30 ±0.70[b]	42.30 ±0.80[b]	68.08 ±0.85[b]	39.83 ±0.86[b]
WLL	24.40 ±1.24[b]	66.95 ±1.16[c]	68.80 ±0.86[c]	66.25 ±0.87[c]	46.05 ±1.09[c]	69.40 ±0.42[b]	40.45 ±0.60[b]

EL	RW	HW	RL	HL	HG	CB	MD
9.85 ±0.30[a]	10.85 ±0.42[a]	12.10 ±0.35[a]	10.95 ±0.33[a]	16.60 ±0.52[a]	64.05 ±2.75[a]	10.15 ±0.28[a]	9.25 ±0.29[a]
13.25 ±0.28[b]	15.25 ±0.28[b]	15.75 ±0.54[b]	15.80 ±0.44[b]	19.63 ±0.29[b]	74.48 ±1.17[b]	14.03 ±0.21[b]	10.70 ±0.25[b]
17.20 ±0.55[c]	15.55 ±0.34[b]	15.63 ±0.36[b]	16.40 ±0.44[b]	21.30 ±0.34[c]	73.35 ±0.60[b]	14.10 ±0.25[b]	11.28 ±1.17[b]

Table 3. *Body Index scores.*

BI Breed	LI	TI	DI	HI	TD	DTI	CI	RCI	IBW	BI	Pr	AI
WAD	1.27	0.54	1.27	0.94	1.58	0.16	101.41	0.25	0.28	0.84	0.79	2077
RS	0.96	0.62	1.09	0.97	1.19	0.19	88.83	0.22	0.35	0.81	1.04	3766
WLL	0.99	0.66	1.04	0.97	1.10	0.19	80.36	0.22	0.39	0.90	1.01	4375

Length Index (LI), Thoracic Index (TI), Depth index (DI), Height index (HI), Thoracic development (TD), Dactyl thorax index (DTI), Conformation index (CI), Relative cannon index (RCI), Index of body weight (IBW), Body index (BI), Proportionality (Pr), and Area index (AI)

Table 3 shows that the DTIs are greater than 10 and thus the goats studied can be classified as heavy meat-type animals as also shown by some author [7] who classified goats as 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). WAD and RS in the above table can be said to be short or brevigline animals while WLL can be grouped into longline animals. None of the goats studied in this research falls into medigline animals. This is also in line with the classification by some authors [7] who grouped goat in short or brevigline animals (BI < 85), medigline animals (86 < BI < 88), and longline animals (BI > 88).

Table 4. *Principal Component Analysis (PCA) Of Morphometric Parameters.*

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.834	41.669	41.669	5.834	41.669	41.669
2	1.687	12.048	53.717	1.687	12.048	53.717
3	1.663	11.880	65.597	1.663	11.880	65.597
4	1.226	8.759	74.356	1.226	8.759	74.356
5	.910	6.501	80.857			

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
6	.761	5.437	86.294			
7	.581	4.148	90.443			
8	.522	3.730	94.173			
9	.268	1.913	96.086			
10	.205	1.463	97.549			
11	.173	1.239	98.787			
12	.073	.521	99.309			
13	.063	.452	99.761			
14	.033	.239	100.000			

Table 5. *Correlations of the different morphometric parameters.*

	WH	RH	BL	SH	BD	BC	EL	RW	HW	RL	HL	HG	CB	MD
WH	1													
RH	.90**	1												
BL	.53**	.58**	1											
SH	.88**	.77**	.34	1										
BD	.57**	.53**	.14	.49*	1									
BC	.24	.32	.08	.26	.54**	1								
EL	.78**	.78**	.70**	.74**	.41*	.27	1							
RW	.63**	.67**	.20	.62**	.27	.26	.46*	1						
HW	.30	.20	-.06	.30	.18	-.11	.09	.17	1					
RL	.44*	.48*	.10	.50**	.44*	.12	.40*	.55**	.14	1				
HL	.40*	.42*	.39*	.52**	.32	.07	.60**	.12	.20	.33	1			
HG	-.37	-.38	-.10	-.50**	.28	.13	-.24	-.61**	-.15	-.26	-.09	1		
CB	.61**	.49*	.14	.62**	.53**	.24	.30	.35	.33	.24	.16	-.11	1	
MD	.05	.23	.06	-.01	-.07	.08	.20	.07	-.29	-.02	.13	.04	-.19	1

*Significant at 0.05 **Significant at 0.01

The effect of age on the weight and morphometric parameters of goats as seen in table 1, shows a significant ($p<0.05$) increase of weight with age and that most parameters, such as WH, RH, BL, SH, BD, BC, EL, RW, HW, RL, HL, HG, CB, and MD, exhibit variations across different age groups. For example, WH increases from 36.89 cm (at 1.00 years) to 63.98 cm (at 4.00 years), indicating a growth in wither height as the goat grows older similar to the findings of mean body index of goats of age 1–2 years (93.86 ± 0.35; 92.05 ±0.00) and age 3–4 years (94.7 ±0.34; 94.13 ±0.30) in Aroresa and Lokabaya districts, respectively [8].

From table 2 it can be observed that there was a significant ($p<0.05$) variation of the body morphometric across the different breed investigated. West African Dwarf (WAD) goat had the lowest morphometrics measurement with an average weight of 11.40kg followed by Red Sokoto (RS). West African

Long Legged (WLL) has the highest mean weight (24.50) and it also has the highest value of the morphometric parameters measured. These values were significant ($p<0.05$) for both the weight and the body linear measurement. This is in line with an investigation that shows different breeds of goats (Kalahari and Sokoto reds, Sahel and WAD) native to Africa in which had a significant variation in goat morphometry. [6]

The correlation between the various morphometric parameters shown in table 5, shows that body length and body depth have a positive correlation coefficient that is highly significant ($p<0.01$). This implies that a selection of these traits will positively influence each other. Another highly significant correlation (0.88 at $p<0.01$) was observed between wither height and sternum height. The least non-significant correlation (-0.02) was between head length and muzzle diameter. [1] in Red Sokoto and Sahel goats in Maigatari Local Government Area of Jigawa State reported similar findings. [11] Our range of correlation in this study is 0.02 to 0.90. -0.76 to 0.88 had been reported [9]. The morphological correlations did not consider the influence between the traits or how much each trait contributed to the variation in body weight. [3] Hence, the Principal Component Analysis (PCA) was used to evaluate related morphological traits and their contribution to body weight. The PCA obtained three significant components with a % of variance of 41.669%, 12.048%, and 11.880% respectively which is not very similar to the work where PCA extracted two significant components for male Kalahari Red goats with a variance of 87.31%, while female Kalahari Red goats also extracted two significant components which accounted for 62.32% of the variance [3].

3. Conclusion

For an effective breeding program, there is a need for morphometric characterization of the animal of interest. It was observed from this study that there was variation in body morphometrics amongst all the breeds and across ages. RS and WAD were classified as brevigline while WLL was classified as medigline. All the goats studied falls into heavy meat-type animals and the correlations amongst these goats ranged from 0.02 to 0.90. The PCA showed that four components contributed to the 74% variation observed.

Abbreviations

WH	Withers Height
RH	Rump Height
BL	Body Length
SH	Sternum Height
BD	Body Depth
BC	Bicostal Diameter
EL	Ear Length
RW	Rump Width
HW	Head Width
RL	Rump Length
HL	Head Length
CB	Cannon Bone Circumference
MD	Muzzle Diameter
LI	Length Index
TI	Thoracic Index
DI	Depth Index
HI	Height Index
TD	Thoracic Development
DTI	Dactyl Thorax Index
CI	Conformation Index
RCI	Relative Cannon Index
IBW	Index of Body Weight
BI	Body Index
Pr	Proportionality
AI	Area Index

Conflicts of Interest

The authors declare no conflicts of interest.

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