Nigerian J. Anim. Sci. 2023, 25 (2): 1-11

Morphological Traits and Body Indices for West African Dwarf and Yankasa Sheep

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***Target Audience:** Researchers, Animal breeders, Geneticist and farmers*

Abstract

Linear measurements are relevant for within-herd use but may be influenced by management systems. Objective assessment of body conformation may be easier with the introduction of indices from body measurements. The aim of this study was to evaluate the morphological structure and body indices of West African dwarf and Yankasa sheep. Body weight (BW) and morphological traits of West African and Yankasa sheep were measured. The morphological parameters were used to calculate body indices, traits measured were rump height, chest width, wither height, heart girth, rump width, body length, body depth, neck width, ear length, shoulder width, tail length, head length and face length. Yankasa sheep were heavier and larger in morphological structure than the West African dwarf. The calculated indices indicated both breeds of sheep slightly slope backward. The correlation coefficients amongst the morphological traits in the West African dwarf sheep were all positive and significant ($P<0.05-0.01$) except the correlation of rump width with Neck Width ($r =-0.476$) and Ear Length (:r $=-0.164$). However, the correlation coefficient between all the morphological traits and BW in Yankasa sheep were generally weak. The principal component analysis (PCA) of the morphometric traits extracted one component with total variance of 60.198% in the West African Dwarf and two components with total variance of 58.699% in the Yankasa sheep. It was concluded that there were prospects for the WAD sheep to be improved through cross breeding with the Yankasa sheep because of the variations in body weight and morphometric traits between the two breeds.

***Keywords:** Morphometric traits, Body Indices, Correlation, Principal components, Sheep*

Description of Problem

Small ruminants are important livestock species in developing countries like Nigeria. They contribute significantly to the national and household economy in the country and they are about 76 million and 43.4 million head of goats and sheep in Nigeria respectively (1). Small ruminants, contribute substantial amounts to income, food (meat and milk), and non-food products like manure, skins and wool (2). They also serve as means of risk mitigation during crop failures, property security, monetary saving and investment in addition to many other socioeconomic and cultural functions (3). The Yankasa sheep is one of the breeds of sheep found in Nigeria. It is commonly found with the agro- pastoralist within the northern subhumid and semi-arid zones of the country (4). The West African Dwarf (WAD) sheep is the most numerous in the humid southern part of Nigeria, a large proportion of which is mostlty managed extensively. The breed is mainly kept for meat production (5). Despite the benefits derived from sheep, the genetic resources of these animals are still not fully utilized, these genetic resources can be exploited to increase the productivity of these species of ruminant. The first step involve in any animal genetic improvement programme is to describe the important morphometric traits (6). Morphometric characteristics are essential to breed identification and classification (7).

Weight measurement has been accepted as an objective measurement of growth, however due to the cost in procuring the weighing equipment especially in rural areas and in large animals, attempts have been made to develop method for estimating weight with the use of linear body measurements. The use of body measurements in the estimation of weights and the accuracies of body weights in the estimation of size among livestock species has been widely reported (5, 8, 9,10, 11, 12, 13,14).

Most times desirable body conformation from the meat and milk production view point is such a complex character that little progress has been made in reducing it to a single corporal measurement which can be taken on the live animal (11).

It has been reported (8) that the value of weight itself is limited without some qualification and probably quantification of associated type and conformation. Single linear measurements have been reported to be more relevant for on-farm within-herd use (15). Reports have shown that management system significantly affect some body measurement (8). However, with the introduction of indices from body measurements, objective assessment of body conformation may be easier. Body indices are relationship among body measurements that are used to describe the proportion and general size of the body parts of animals (11). Body indices are considered a good option for weight assessment because they incorporate measures of desirable conformation such as length and balance (15). They are often used to draw some conclusions concerning proportionality and maturity of the animals, especially when taken with some other traits such as live weight.

A lot of researches have been carried out in beef cattle using the combination of linear body measurements to estimate weight (16,17,18). The ratios body weight/ wither height and round measurement wither height has been proposed as an index of beef type and this was found to be highly correlated with grade in Hereford cattle (15). A model involving girth height and body length to describe weight was develop by, (19). (20) also used body indices to asses Bunaji and Friesian-Bunaji crosses and concluded that Bunaji cattle are medium size animals, although they are used for both meat and milk production (multipurpose) that their morphology showed some resemblance to milk type animal. (8) also used body indices in the Assessment of Type and Function in Sheep (West African Dwarf and Yankasa) in South West Nigeria. The author concluded that tested indices showed that both sheep breeds are typical meat animals.

Principal component analysis is a multivariate method which transforms the variables in a multivariate data set into new variables, which are uncorrelated with each other and accounted for decreasing proportions of the total variance of the original variables (21). PCA can be an intermediary analysis for other analysis like cluster analysis variables. A good number of studies have been carried out using principal component analysis to extract factors contributing towards variation amongst individual animals based on body measurements (20, 22, 23). There are limited information on the use of principal component analysis to extract factors contributing to variations among the local sheep populations in the south - south part of Nigeria There is also paucity of information on the use of morphological structure and body indices in assessing type and function of sheep in South - south Nigeria. Therefore, the objective of this study was to provide information on the morphological structure and body indices of West African Dwarf and Yankasa Sheep as well as application of Principal component analysis.

Materials and methods

Experimental Site

Linear body measurements were taken on 40 West African Dwarf and 25 Yakassa sheep at Small ruminant unit of the Department of Animal Science, Akwa Ibom State University, Obio Akpa Campus. Obio Akpa is situated between latitude $5^{o}17^{1}$N and $5^{o}27^{1}$N and longitude $7^{o2}1^{1}$E and $7^{o}58^{1}$E with an annual rainfall ranging from 3500-5000 mm, monthly temperature range of 24-26^{o}C and relative humidity between 60-90% (24). The animals measured comprised of both rams and ewes and were managed under semi intensive system of management; whereby they were grazed during the day around the unit and return into pens later in the day where pasture and concentrate were served.

Ethical clearance

Since the study did not involve any invasive or painful procedure to the animals, ethical approval was not sought, however the guidelines and procedures for the use of animals in the University (Akwa Ibom State University) where the research was conducted was strictly followed.

Data collection

Morphological traits measured were Rump Height (RH), Chest Width (CW), Wither Height (WH), Heart Girth (HG), Rump Width (RW), Body Length (BL), Body Depth (BD), neck width (NW), ear length (EL), shoulder width (SW), tail length (TL), head length (TL), face length(FL) and Body Weight (BW). The morphological traits were measured in centimeter (cm) using calibrated measuring pole and flexible metric tape, while the body weight was measured using Measuretec^{R} hanging scale. Pregnant animals were not included in the study because of the effect of pregnancy on weight and shape of the animal, also only matured sheep of between 3-4 years were used for the study. All the morphological measurements were taken with the animals standing on a flat surface in a tight stall with the head held up. To reduce the errors, measurements were taken two or three times in each animal. Some morphological variables measured were used to calculate ten body indices. The details of the measurements and definition of the traits has earlier been described by (8).

Statistical analysis

The data were analyzed using descriptive statistics and Analysis of Variance of fixed effect of breed on the morphological characteristics was done using Univariate Analysis of General Linear Model procedure of (25).

The following indices were calculated from the mean values of body measurements for each breed, according to the method of (15):

Height slope: Wither height – rump height
Length index: Body length/wither height
Width slope: Hip width/chest width
Depth index: Chest depth/ wither height
Foreleg length: Wither height - chest depth
Body index: (Body length/heart girth) x 100
Height index: Withers height/body length
Weight index: Body weight x withers height
Balance:(RHXRW)/(HGXCW)
Body: Body length x 100/Heart girt; when IB > 0.90 the animal is longiline; between

0.86 and 0.88 is medigline, and less than 0.85 is brevigline (26)

Correlation between body weight and morphological traits as well as among the morphological traits computed for each breed.

Results and Discussion

The summary statistics showing the means and standard error (SE), standard deviation (SD) and coefficient of variability (CV)of each morphometric trait as well as the significance of breed difference between WAD and Yankasa sheep are presented in Table I.

Body weight was the most variable body measurement as indicated by the CV of 38.80(%)and 29.91(%) for WAD and Yankasa respectively. The other morphological traits also show moderate variability (CV ranges from 1.74% to 27.91%) in Yankasa sheep. The Yankasa sheep had higher morphometric values than the WAD sheep except the shoulder width (12.54±0.2cm and 6.54±0.24cm respectively)

The large difference between most of these morphometric traits in the two breeds indicated that Yankasa sheep is generally bigger than the WAD sheep as clearly indicated in the test of significance between the two breeds. The variability of the body weight and linear body measurements in this study implies that the weight and these morphometric traits have adequate variation to allow selection response. In both breeds, the wither heights were higher than the rump height, indicating that both breeds slopes backwards from the posterior, the result is in agreement with the report of 8 and 27. Wither height (54.22±0.18 and 74.42±0.27 for WAD and Yankasa respectively) and rump height (52.75±1.22 and 69.38±1.11 for WAD and Yankasa respectively). When body length and wither height were considered, it was observed that the two traits were closer in WAD (54.00cm±0.16 and 54.22±0.18 for WAD and Yankasa) than in Yankasa (67.45±0.20 and 74.42±0.27cm) sheep.

The results also indicated that the Yankasa were also broader than the west African dwarf as seen, the value of chest width (12.01±0.21) and hearth girth (83.91±0.28) as compared to WAD which recorded 9.01±0.24 for chest width and 70.24±0.303 for hearth girth.

Yankasa sheep was heavier (33.63±2.052cm) than the WAD sheep (20.082±0.161cm). The measurement of morphometric traits in the two breeds studied were comparable to previous records reported by (28). (29) had earlier reported that WAD sheep are relatively small but they are not achondroplasia. Morphometric trait measurements have been recommended as good indicators of body weight and size especially in traditional systems where breeding practices are not documented and in a less complicated and expensive way (30,31).

Body indices of WAD and Yankasa sheep is presented in Table 2. The results indicated that the Yankasa sheep had bigger body than the WAD sheep in height index, width slope, Depth index, balance and body. The WAD sheep had a higher length index compared to the Yankasa sheep and this indicated that the WAD sheep were longer than the Yankasa sheep while the Yankasa sheep were taller than the WAD. This result is in consonance with the reports of (8 28). (32) had earlier opined that WAD and Yankasa sheep are both taller than the western meat livestock who are better meat animals. Thus, this study suggests that the WAD goats which is longer in size contain more meat than the Yankasa.

Table 1: Descriptive Statistics of Morphological Traits in WAD Goats and Yankasa Sheep

	West African Dwarf Goats			Yankasa Sheep			Breed
TRAITS(unit)	Means ± SE	SD	CV(%)	Means ±SE	SD	CV (%)	difference
BW (kg)	20.082±0.16	7.79	38.80	33.63±2.053	10.06	29.91	13.55**
RH (cm)	52.75±1.22	5.99	10.94	69.38±1.11	5.45	7.32	16.63**
CW (cm)	09.01±0.24	1.19	13.20	12.01±0.21	1.04	8.65	3.00**
WH (cm)	54.22±0.18	0,91	1.74	74.42±0.27	1.36	1.95	20.20**
HG (cm)	70.24±0.30	1.48	7.31	83.91±0.28	1.40	2.37	38.67**
RW (cm)	11.71±0.24	1.19	10.16	24.52±0.25	1.26	5.13	12.81**
BL (cm)	54.00±0.16	0.79	1.46	67.45±0.20	0.99	1.46	13.45**
BD (cm)	23.42±0.48	2.38	10.16	48.22±1.08	5.32	11.03	24.80**
NW (cm)	9.14±0.50	2.48	27.13	14.59±0.27	1.34	9.18	5.45**
EL (cm)	8.12±0.31	1.56	19.21	16.66±4.20	3.57	21.48	8.54NS
SW (cm)	12.54±0.21	1.04	8.29	6.54±0.24	1.19	18.19	-6.00**
TL (cm)	24.11±0.21	1.04	4.31	13.57±0,26	1.27	9.35	-10.54**
HL (cm)	27.17±0.16	0.82	3.01	33.43±0.31	1.53	4.57	6.26**
FL (cm)	15.25±017	0.84	5.50	30.45±0.32	1.59	5.22	15.20**

BW = Body weight, RH = Rump height, CW = Chest width, WH = Wither height, HG = Heart girth, RW = Rump width, BL= Body length, BD = Body depth, NW= Neck width, EL = Ear length, SW = Shoulder width, TL= Tail length, HL = Head length, FL = Face length, SE=Standard error, SD= Standard deviation, CV = Coefficient of variation

Foreleg length was 28.80cm in WAD and 21.20cm in Yankasa. This type of body structure is considered to be an adaptive feature of the WAD sheep to effectively dissipate heat.

(28) had earlier reported that WAD sheep is long bodied with short stature while the Yankasa sheep appear tall with a compact body size. This WAD stature is directly related to adaptation to humid tropic environment where the WAD sheep are predominantly found. The study reveals that WAD and Yankasa sheep are not mesomorphic as their body length was slightly lower than their wither height. The body index which is used to determine the animals proportion was 76.87 in WAD and 80.38 in Yankasa. There should be a balance between height, body length and hearth girth of the animal. This is because imbalance in center of gravity may affect its ability to balance on the ground (11).

Table 2: Morphological indices of west African Dwarf and Yankasa sheep

Body Indices	West African Dwarf	Yankasa
Height Slope (cm)	1.47	5.04
Width Slope(cm)	1.29	2.04
Length Index	1.03	0.91
Depth Index	0.43	0.64
Foreleg Length(cm)	30.80	26.20
Body Index	76.87	80.38
Height Index	1.04	1.10
Weight Index	1088.84	2488.62
Balance	0.976	0.83
Body	76.87	80.38

The correlation coefficient between body weight and amongst the morphological traits in WAD (lower matrix) and Yankasa (upper matrix) sheep is presented in Table 3. The results indicated that the body weight had a very highly positive and significant ($P<0.05 -0.001$) correlation with all the morphometric traits measured. The correlation coefficient (r) range between 0.275 −0.937. The highest r value seen in the relationship between body weight and facial length (FL). All other morphometric traits had positive correlation amongst themselves except the correlation between RW with NW and EL, which were negative in the WAD sheep. A unity correlation (r=1.000) was observed in the relationship between BD with RW in WAD.

When the Yankasa sheep was considered, it was observed that body weight had a low but positive relationship with all the morphometric traits measured. The relationship amongst other morphometric traits were positive and highly ($P<0.001$) significant, except the relationship between RH and all other morphometric traits which were all negative. However, a unity correlation was also observed between CW and SW in Yankasa sheep. These positive and significant correlation between body weight and morphometric traits as well as amongst the morphometric traits in both breeds of sheep indicate a high level of dependency amongst the morphometric traits. Therefore, incorporating all these morphometric traits in the development of selection index aimed at improving the performance of these two breeds of sheep may not be necessary. This is because selection for improvement in one trait will result in the correlated response in the other traits (11, 9, 33). Specifically, in WAD sheep, a very strong positive relationship was recorded for BW with CW (0.808), WH (0.931), BL (0.974), this indicate that these morphometrical traits (CW, WH, BL) in WAD sheep can be very effective in predicting BW and their selection in breeding programmes would results in remarkable body weight improvement. Conformation traits have high heritability (2) and can be recorded in a single assessment which makes them cheaper and more practicable to measure in the field than BW. This would justify their inclusion in a selection index for BW improvement.

Table 4 indicated the summary of principal component analysis (PCA) and the loading pattern of the morphological measurements on the principal components (PCs) after the varimax rotation. The loading pattern showed the relative contribution of each measurement to a particular PC, whilst the percentage of the total variance is used as an index to determine how well the total components extracted account for what the measurement together represents. PCA determines the variability of individual traits and how these contribute towards the total morphological and structural variance of the animal (20, 34).

In the WAD sheep, all the variable was grouped into one PC with eigen value of 4.816 accounted for a total variance of 60.198. All variables measured had high positive loading on a single PC. This indicated that the morphological variables measured in WAD sheep can be reduced into one composite variable without losing much of the information. In the Yankasa sheep two PCs were extracted and accounted for 58.69 of the total variance. The first PC explained 56.60 of the total variance and was characterized by relative high positive loadings for BW, CW, WH, HG, RW, and BL. The second PC had high loading for CW, WH, HG, RW and BL explaining 58.699 of the total variance. The proportion of common variance present in the variables (that is communality estimates) for all the morphological measurements ranged from 0.465 (RH) to 0.999 (RW, BD) in WAD sheep and 0.349 (RH) to 0.933 (WH) in the Yankasa sheep. The percentage of variance explained by PCA in WAD sheep (60.198) and Yankasa sheep (58.699) were lower than those reported by 35 (73.03) in Yankasa sheep and 8 in immature uda sheep.

Table 4: Correlation coefficients amongst morphometric traits of Yankasa (upper matrix) and WAD (lower Matrix)

	BW	RH	CW	WH	HG	RW	BL	BD	NW	EL	SW	TL	HL	FL
BW	1	0.120	0.165	0.124	0.023	0.166	0.044	0.198	0.149	0.306	0.165	0.134	0.161	0.207
RH	0.481*	1	-0.075	-0.159	-0207	0.002	-0.108	-0.191	0.013	-0.126	-0.075	0.017	-0.002	-0.066
CW	0.808**	0.602**	1	0.796**	0.736**	0.840**	0.598**	0.556**	0.811**	0.143	1.00**	0.829**	0.783**	0.808
WH	0.931**	0.528**	0.857**	1	0.910**	0.938**	0.805**	0.593**	0.945**	0.194	0.796**	0.956	0.870**	0.903**
HG	0.658**	0.633**	0.558**	0.649**	1	0.846**	0.887**	0.540**	0.868**	0.284	0.736**	0.846	0.818	0.859
RW	0.275	0.242	0.256	0.193	0.183	1	0.767**	0.673**	0.986**	0.151	0.840**	0.985	0.867	0.920**
BL	0.974**	0.465**	0.842**	0.938**	0.642**	0.278	1	0.311	0.795**	0.178	0.598**	0.776**	0.745**	0.810**
BD	0.275	0.242	0.257	0.194	0.183	1.000**	0.277	1	0.663**	0.115	0.556**	0.603**	0.565**	0.576**
NW	0.310	0.290	0.152	0.333	0.296	-0.476*	0.278	-0.477*	1	0.139	0.811**	0.977**	0.887**	0.933**
EL	0.492*	0.341	0.446*	0.497*	0.240	-0.164	0.487*	-0.163	0.151	1	0.143	0.144	0.149	0.145
SW	0.808**	0.602**	1.000**	0.857**	0.558**	0.256	0.842**	0.257	0.152	0.446*	1	0.829**	0.783**	0.808**
TL	0.861**	0.619**	0.769**	0.860**	0.590**	0.256	0.870**	0.256	0.265	0.478**	0.769**	1	0.869**	0.912**
HL	0.931**	0.59**7	0.828**	0.919**	0.68**	0.234	0.908**	0.234	0.360	0.432**	0.828**	0.890**	1	0.948*
FL	0.937**	0.527**	0.838**	0.909**	0.699**	0.207	0.922**	0.207	0.291	0.495*	0.838	0.874**	0.932**	1

BW = Body weight, RH = Rump height, CW = Chest width, WH = Wither height, HG = Heart girth, RW = Rump width, BL= Body length, BD = Body depth, NW= Neck width

This is an indication that more morphological variations were left unexplained in the present study probably because of the difference in ages of the animal used. The remaining unexplained variance could be attributed to measurement error and environmental factors, mostly on the measurements that are not so close to the bone structure of the animals (26,34, 36). The morphological structures associated with bone structure and body size of the animals (BD, HW and BL) loaded heavily on first and second PC in the Yankasa, these morphological traits are good descriptors of body shape and could be significantly influenced by nutritional and other environmental factors (36). It has been noted by 34 that muscle fat together with bone structure contributes to their formation.

Table 4: Eigen values, share of total variance along with factor loadings after varimax rotation and communalities of the morphological measurements of West African Dwarf and their Yankasa Sheep

Traits	West African Dwarf		Yankasa		
	CP1	Communality	CP1	CP2	Communality
BW	0.936	0.894	0.795	0.809	0.655
RH	0.933	0.465	0.564	0.583	0.349
CW	0.925	0.811	0.861	0.843	0.742
WH	0.889	0.914	0.965	0.956	0.933
HG	0.761	0.606	0.940	0.947	0.899
RW	0.681	0.999	0.960	0.953	0.925
BL	0.436	0.989	0.835	0.875	0.785
BD	0.899	0.999	0.684	0.612	0.574
Eigen value	4.816		4.528	4.696	
%Variance	60.198		56.604	58.699	
Cummulative Variance	60.198		56.604	58.699	

BW = Body weight, RH = Rump height, CW = Chest width, WH = Wither height, HG = Heart girth, RW = Rump width, BL= Body length, BD = Body depth

Conclusion and Application

1. The study revealed that the Yankasa breeds of sheep were heavier than the WAD, although the West African Dwarf were longer than the Yankasa who were taller(higher values of height at wither).
2. The correlation coefficients reveled that BW had high positive relationship with all the morphometric traits of WAD sheep but very week relationship with the same traits in Yankasa. The correlation coefficient among the two breeds were very high indicating a very high level of interdependency among the morphometric traits. Thus, selection for one traits will lead to improvement in other traits.
3. The body indices indicated that both breeds slopes slightly back though very balanced. The indices also revealed that Yankasa breed are mesomorphic in stature as their body length was higher than wither height.
4. The study also revealed that PCA

could be used in a sheep to predict body weight. Principal component (PC) analysis after varimax rotation produced one PC which showed 60.198% total variance in WAD sheep, whereas 2 PCS were produced in Yankasa sheep with total variance of 56.604%. These can be used to increase the accuracy of body weigh prediction.

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