FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 4 No. 1, March, 2020, pp 333 – 339

MULTIVARIATE PRINCIPAL COMPONENT ANALYSIS OF MORPHOLOGICAL TRAITS IN WEST AFRICAN DWARF GOATS

***[1]Rotimi, E. A., [2]Momoh, O. M., [2]Egahi, J.O. and [2]Dim, N. I.**

[1]Department of Animal Science, Federal University Dutsin-Ma. Katsina state.
[2]Department of Animal Breeding and Physiology, Federal University of Agriculture, Makurdi, Benue State.

*Corresponding author's email: earotimi@gmail.com, +2347037968698

ABSTRACT
Multivariate analysis are important tools when considering all variables simultaneously. Principal component analysis using morphological variables of the West African Dwarf goats of Nigeria were carried out based on age and sex. A total of 250 goats, comprising of 143 does and 107 bucks, were used for this study. Data were collected from 10 morphological traits, including; body weight (BWT), body length (BL), height at wither (HW), rump height (RH), paunch girth (PG), heart girth (HG), ear length (EL), tail length (TL), horn length (HoL) and neck circumference (NC). Data collected were subjected to analysis procedures of SPSS (2011) statistical programme. Majority of the goats sampled were female indicating goat keepers' preference for female than male for herd multiplication. Results of the ANOVA obtained revealed that sex had significant ($P<0.05$) effects on body weight, height at withers, rump height, body length, paunch girth, heart girth, ear length, horn length and neck length where female goats were significantly ($P<0.05$) higher than males (16.94±0.39 kg and 11.94±0.36 kg, 47.92±0.40 cm and 45.58±0.42 cm, 52.59±0.50 cm and 49.10±0.46 cm, 55.71±0.54 cm and 50.54±0.51 cm, 68.96±0.77 cm and 61.39±0.62 cm, 62.35±0.56 cm and 55.24±0.59 cm, 12.10±0.12 cm and 11.39±0.13 cm, 7.56±0.28 cm and 5.68±0.32 cm, 28.69±0.32 cm and 27.02±0.34 cm respectively) while sex had no significant ($P>0.05$) effect on tail length. PC1 and PC2 were extracted for all the ages of the goats, totaling to 68.798 %, 53.833 %, 47.302 % and 51.880 % respectively, of the total variances explained. Principal component analysis results indicated higher loadings for PG and HG in the PC1 for 1, 2 and 4 years (0.841 and 0.793, 0.761 and 0.704, 0.826 and 0.743 respectively) but highest in the PC2 for 3 years (0.791 and 0.743 respectively). Two principal components were extracted for female and male goats amounting to 67.305 % and 66.999 % respectively of the total variances.

Keywords: Age, goats, morphometric traits, principal components, sex.

INTRODUCTION

Domestic goats (*Capra hircus*) are the most numerous of all domesticated ruminants in Nigeria with an estimated population of 79.38 million, representing about 6.56% of the world's goat population (FAOSTAT, 2018). Goats play very significant role in the socio-cultural and socio-economic livelihoods of rural communities (Kosgey and Okeyo, 2007). Goats is an important source of milk, meat, hide and source of income for the rural dwellers (Adebambo *et al*., 2011).

Indigenous goats in Nigerian have been classified into three separate breeds according to phenotypic traits, origin, function, body size, length or height, these are; Sahel, Red Sokoto and West African Dwarf goats (Ngere *et al.*, 1984). The West African Dwarf (WAD) goat is widely distributed across the rainforest region in Nigeria (Ojo, 2014). The coat colour is predominantly black, although brown, gray and white or combinations, can be found (Mourad *et al*., 2000). They are short-legged and small-bodied breed (Mourad *et al.*, 2000). The breed is well adapted to humid environment and are more trypano-tolerant than other breeds of domestic goat (Chiejina *et al*., 2015). Phenotypic characters have been used to characterize genetic resources (Aziz and Al Hur 2013; Jimcy *et al*. 2011; Revidatti *et al*. 2007). Many tools are available that can help determine the discriminatory power that variables have in describing breed patterns. Analysis of variance is widely used to examine phenotypic relationships among traits in a breeding program.

Principal component analysis is a multivariate technique which could be successfully used when there is multicolinearity and correlation among morphological variables. Principal components are linear combinations of the correlated variables whereby the first principal component explain the largest percentage of the total phenotypic variation (Truxillo, 2003). The resulting principal components help to eliminate data redundancy and removes multicollinearity which may lead to wrong conclusions.

Many authors have used the multivariate technique of principal component factor analysis to estimate body weight (Yakubu and Ayoade, 2009), functional traits (Karacaoren and Kardamideen, 2008), and as a selection criterion for the improvement of body size (Pinto *et al*., 2006) in the prediction of genomic breeding values (Macciotta and Gaspa, 2009). Therefore, the aim of this study was to evaluate the effects of age and sex on morphological traits in West African Dwarf goats using Principal Components Analysis (PCA) procedures.

MATERIALS AND METHODS

Experimental Animals and Management

The study was conducted in Benue state, Nigeria. Two hundred and fifty (250) West African Dwarf goats comprising of both sexes and ages 1 – 4 years (Table 1). Goats were randomly sampled across Makurdi and its surrounding. Makurdi is located within the latitude 7° 44' N and longitude 8° 32' E (Distancesto.com, 2019). The ages of the animals were determined using their dentitions (Solomon and Kassahun, 2009; FAO, 2012 and Dereje *et al*., 2013). The goats were reared under the traditional extensive system of management.

Data collection

Data were collected on 11 morphological variables include; body weight (BWT), height at withers (HW), rump height (RH), body length (BL), paunch girth (PG), heart girth (HG), ear length (EL), tail length (TL), horn length (HoL), neck length (NL) and neck circumference (NC). Body weight (kg) of was measured using electronic balance in the morning by the same person to avoid human error. Length and girth measurements were taken using simple tailor's measuring tape (cm) while height measurements were taken using meter ruler (cm).

All the linear, girth and height measurements were taken to the nearest 0.5 cm. The reference points and procedure for the body measurements were in accordance with the method described by FAO (2012) and Akpa *et al*. (2014).

The morphological traits measured were;

1. Body weight (BWT): The live body weight was obtained by using a weighing scale.
2. Height at Wither (HW): The vertical distance from the top of the shoulder to the ground.
3. Body Length (BL): This was taken as the horizontal length from the point of shoulder to the pin bone.
4. Paunch girth (PG): This is the body circumference taken around the umbilicus.
5. Heart girth (HG): The circumference of the chest posterior to the forelegs at right angles to the body axis. This is also called Chest Girth.
6. Ear Length (EL): This is the length of the external ear from its root to the tip.
7. Tail Length (TL): This was measured from the point of attachment to the tip;
8. Horn Length (HoL): This is measured from the base of the horn at the skull along the dorsal surface to the tip of the horn.
9. Neck circumference (NC): This is taking as the circumference at base of neck

Statistical analysis

Data obtained from the morphological traits were subjected to analysis of variance to determine age and sex effects. Data collected were analysed using the programme of SPSS (2011) statistical procedures. The PC analysis was verified for validity using Kaiser-Meyer-Olkin test and sphericity using Bartlett's test. The appropriateness of the factor analysis was further tested using communalities and ratio of cases to variables. The varimax criterion of the orthogonal rotation method was employed in the rotation of the factor matrix to enhance the interpretability of the principal components.

RESULTS AND DISCUSSIONS

Table 1 shows the distributions of the goats sampled for this study. Frequency of the goats sampled increased with the age. Majority of the goats are at 1 year, meaning they are growers while the least are 4 years and above. Percentage distribution for female animal was higher than that of males (57.20% and 42.80% respectively). The trend of the results obtained in this study is similar with the reports of Katangole *et al*. (1996) and Rotimi *et al*. (2015, 2018) who obtained female to male sex ratios of; 69% and 31%, 75.23% and 24.77%, 60.19% and 39.26% respectively. This is as a result of goat keepers' preference to keep more female goats than males for purpose of multiplication in the herd. There is need to keep more reproductive females longer in their flock than males (Rotimi *et al*., 2018). Again, most of the males were sold for income, given as gifts and used during rituals or sacrifices and more importantly slaughtered for food more often. This was buttressed by Apori *et al*. (2011) and Rotimi *et al*. (2018) who reported that keeping small ruminants, such as goats, plays very important role in the livelihood of the small holders, which enables households to get quick income to settle urgent financial needs such as buying food items and farm inputs, paying family hospital bills, school fees for their children, expenses for funeral, marriage and naming ceremonies and other needs.

Table 2 shows the variations in the body weight (kg) and linear body measurements (cm) based on age and sex. There were significant ($P<0.05$) effects of age on body weight (kg). Goats in ages 3 years were significantly ($P<0.05$) heavier than goats in ages 1 and 2 years (10.66 ± 0.40kg, 16.05 ± 0.42kg and 18.67 ± 0.46kg respectively) while goats in ages 3 and 4 were not significantly ($P>0.05$) different in body weight (kg). The overall body weight (kg) recorded was 14.80 ± 0.31kg. The overall mean value is obtained in this study is quite lower than the values obtained on Moxoto goat breeds in Brazil (Ribeiro *et al*., 2004), goat breeds in Mexico (Montaldo *et al*., 1995), Assam Hill goats (Khagharia *et al*., 2015), Sannen goats (Pesmen and Yardimci, 2008) and goats of Pakistan (Khan *et al.*, 2006).

Sex had significant ($P<0.05$) effects on body weight (kg) and linear body measurements (cm) where female goats had significantly ($P<0.05$) higher values in all the traits measured than male goats. The results showed clear manifestations of sexual dimorphism in the goats studied with female having significantly ($P<0.05$) higher values in body weight, height at withers, rump height, body length, paunch girth, heart girth, ear length, horn length and neck length (16.94 ± 0.39 kg and 11.94 ± 0.36 kg, 47.92 ± 0.40 cm and 45.58 ± 0.42 cm, 52.59 ± 0.50 cm and 49.10 ± 0.46 cm, 55.71 ± 0.54 cm and 50.54 ± 0.51 cm, 68.96 ± 0.77 cm and 61.39 ± 0.62 cm, 62.35 ± 0.56 cm and 55.24 ± 0.59 cm, 12.10 ± 0.12 cm and 11.39 ± 0.13 cm, 7.56 ± 0.28 cm and 5.68 ± 0.32 cm, 28.69 ± 0.32 cm and 27.02 ± 0.34 cm respectively). However, there was no significant difference in tail length. The results revealed that sex is an important source of variation for body weight (kg)

and body linear measurements (cm) in West African Dwarf goats.

This report is similar with the findings of Fajemilehin and Salako (2008), who also reported sexual differences in morphological variables in West African Dwarf in southwestern Nigeria. This is also in consonance with the works of Akpa *et al*. (1998) and Devendra and Burns, (1983) who reported that both sex and strains significantly influenced body weight and linear body measurements. This sex-influenced differences in body weight and linear measurements might be partly due to hormonal effect (Frandson and Elmer, 1981). However, Olutogun *et al*. (2003) reported that sex had no significant effect on body weight and linear measurements except heart girth in White Fulani and Gudali cattle breeds in Nigeria.

Table 1: Age and sex distribution of experimental animals

Parameters	Levels	Frequency	Percentage (%)
Age (years)	1	92	36.80
	2	78	31.20
	3	57	22.80
	4	23	9.20
	Total	250	100.00
Sex	Female	143	57.20
	Male	107	42.80
	Total	250	100.00

Table 2: Mean (±SE) for body weight (kg) and different linear body measurements (cm) of West African Dwarf goat based on age and sex

Traits	Age (years)					Sex		
	1	2	3	4	Overall	Female	Male	Overall
BW	10.66±0.40^{c}	16.05±0.42^{b}	18.67±0.46^{a}	17.52±0.80^{ab}	14.80±0.31	16.94±0.39^{a}	11.94±0.36^{b}	14.80±0.31
HW	43.78±0.53^{b}	48.15±0.40^{a}	49.67±0.41^{a}	48.48±0.63^{a}	46.92±0.30	47.92±0.40^{a}	45.58±0.42^{b}	46.92±0.30
RH	46.83±0.58^{b}	53.31±0.53^{a}	53.75±0.48^{a}	54.13±0.84^{a}	51.10±0.36	52.59±0.50^{a}	49.10±0.46^{b}	51.10±0.36
BL	48.12±0.60^{c}	55.26±0.49^{b}	58.30±0.54^{a}	57.13±1.03^{ab}	53.50±0.41	55.71±0.54^{a}	50.54±0.51^{b}	53.50±0.41
PG	59.07±0.74^{b}	68.40±0.70^{a}	70.97±1.17^{a}	70.26±1.51^{a}	65.72±0.56	68.96±0.77^{a}	61.39±0.62^{b}	65.72±0.56
HG	52.96±0.62^{c}	61.55±0.59^{b}	64.47±0.64^{a}	64.30±1.10^{a}	59.31±0.46	62.35±0.56^{a}	55.24±0.59^{b}	59.31±0.46
EL	11.05±0.13^{b}	12.19±0.15^{a}	12.39±0.18^{a}	11.96±0.23^{a}	11.80±0.09	12.10±0.12^{a}	11.39±0.13^{b}	11.80±0.09
TL	8.82±0.13^{c}	10.14±0.16^{a}	9.46±0.18^{b}	10.17±0.29^{a}	9.50±0.09	9.60±0.13	9.37±0.12	9.50±0.09
HoL	4.51±0.36^{c}	7.42±0.30^{b}	8.51±0.34^{ab}	9.13±0.46^{a}	6.76±0.22	7.56±0.28^{a}	5.68±0.32^{b}	6.76±0.22
NC	25.97±0.39^{b}	28.86±0.37^{a}	29.75±0.42^{a}	28.57±0.65^{a}	27.97±0.24	28.69±0.32^{a}	27.02±0.34^{b}	27.97±0.24

BWT = body weight, HW = height at wither, RH = rump height, BL = body length, PG = paunch girth, HG = heart girth, EL = ear length, HoL = horn length, NC = neck circumference

Total variance accounted for by PC1 and PC2 at ages 1 to 4 years are presented in Table 3. The variations (%) were 58.716 and 10.082 for 1 year, 40.682 and 13.151 for 2 years, 28.805 and 18.497 for 3 years, 35.247 and 16.633 for 4 years of age, respectively. However, the cumulative variations for years 1 to 4 were; 68.798%, 3.833%, 47.301% and 51.880 respectively. For age 1, HW, RH, BL, PG, HG, HoL and NC loaded highest in PC1 while EL and TL loaded by the PC2. In year 2, PG and HG loaded for PC1 while BL, El and TL loaded for PC2. HW, RH, BL, EL and HoL were the variables that loaded for PC1 in year 3 while PG, HG and NC loaded for PC2 in year 3. In year 4, RH, PG, HG and NC loaded for PC1 while HW and TL loaded highest in PC2. The results showed that PG and HG loaded high in PC1 in all the ages considered, these are variables for body shape and depth. This report is similar with the results obtained by Osinowo *et al*. (1989) who reported that HG gave best estimate for predicting body weight of Red Sokoto goats at 1-2 years of age. The relevance of principal component analysis was evident in the reduction of large number of explanatory variables into components that are non-correlated which can be used to give a better description of body size and shape of animals. Other researchers, such as; Kurnianto *et al.* (2013); Okpeku *et al.* (2011); Yakubu *et al.* (2011); Yakubu (2013), have also applied Principal Component factor analysis in the reduction of large number of explanatory variables into components that gave a better description of size and shape. The Principal Components obtained could be useful in evaluating the present goats' populations for selection programme.

Table 3: Eigenvalues, total variance, factor and factor loadings in West African Dwarf goat based on age (years)

Traits	1 year			2 years			3 years			4 years		
	PC1	**PC2**	Com.	**PC1**	**PC2**	Com.	**PC1**	**PC2**	Com.	**PC1**	**PC2**	Com.
HW	**0.668**	0.558	0.757	0.463	0.479	0.443	**0.831**	0.064	0.695	0.248	**0.748**	0.621
RH	**0.701**	0.519	0.760	0.498	0.277	0.325	**0.657**	-0.064	0.436	**0.644**	0.251	0.478
BL	**0.741**	0.497	0.797	0.460	**0.600**	0.571	**0.647**	0.252	0.483	0.591	0.423	0.528
PG	**0.841**	0.275	0.783	**0.761**	0.226	0.631	0.034	**0.791**	0.627	**0.826**	-0.094	0.692
HG	**0.793**	0.348	0.749	**0.704**	0.303	0.587	0.049	**0.750**	0.565	**0.743**	0.102	0.562
EL	0.157	**0.822**	0.701	0.193	**0.680**	0.500	**0.636**	-0.009	0.405	0.320	0.255	0.167
TL	0.166	**0.642**	0.439	-0.090	**0.837**	0.709	0.373	-0.229	0.192	-0.213	**0.839**	0.749
HoL	**0.652**	0.200	0.465	0.385	0.592	0.499	**0.616**	0.217	0.426	0.562	0.147	0.338
NC	**0.860**	-0.004	0.740	0.756	-0.092	0.580	0.050	**0.653**	0.429	**0.713**	-0.163	0.535
Eigenvalues	5.284	0.907		3.661	1.184		2.592	1.665		3.172	1.497	
% variance	58.716	10.082		40.682	13.151		28.805	18.497		35.247	16.633	

HW = height at wither, RH = rump height, BL = body length, PG = paunch girth, HG = heart girth, EL = ear length, HoL = horn length, NC = neck circumference, Com. = Communality

Table 4 shows the Eigenvalues and total variations shared with the factor loadings of morphological traits of West African Dwarf goats based on sex. The results showed that 56.501% of total variance was accounted for by PC1 and 10.804% by PC2, with cumulative of 67.305% of the total variances in the female goats, where PC1 retained the loadings for HW, RH, BL, PG, HG, HoL and NC, while the PC2 retained high loadings for TL. In the male goats, proportion of total variance were 55.475 and 11.524 for PC1 and PC2 respectively. PC1 had loadings for BL, PG, HG, HoL and NC and PC2 had loadings for HW, RH, EL and TL. The consistency of high loading for PG and HG may be termed body shape and depth. The Principal Components obtained could be useful in evaluating the present goats' populations for selection programme

Table 4: Eigenvalues, total variance, factor and factor loadings in West African Dwarf goat based on sex

Traits	Female			Male		
	PC1	PC2	Com.	PC1	PC2	Com.
HW	**0.694**	0.477	0.709	0.484	**0.704**	0.729
RH	**0.660**	0.440	0.630	0.525	**0.669**	0.724
BL	**0.733**	0.476	0.764	**0.610**	0.593	0.724
PG	**0.801**	0.153	0.666	**0.779**	0.358	0.735
HG	**0.827**	0.236	0.739	**0.755**	0.398	0.728
EL	0.410	0.540	0.459	0.010	**0.844**	0.713
TL	0.005	**0.893**	0.798	0.240	**0.648**	0.477
HoL	**0.622**	0.480	0.617	**0.614**	0.321	0.480
NC	**0.822**	-0.007	0.676	**0.848**	-0.031	0.719
Eigenvalues	5.085	0.972		4.993	1.037	
Variances (%)	56.501	10.804		55.475	11.524	

HW = height at wither, RH = rump height, BL = body length, PG = paunch girth, HG = heart girth, EL = ear length, HoL = horn length, NC = neck circumference, Com. = Communality

CONCLUSIONS AND RECOMMENDATIONS

This study revealed sexual dimorphism among the goat population with female (does) goats having higher values in the traits measured except tail length. Paunch girth and heart girth were variables that loaded high in PC1 across the ages (1 – 4 years) and sexes (does and bucks). The resultant factor score coefficients could be used to predict body weight more accurately than the original correlated variables. Results of the present investigation could assist farmers and genetic improvement specialists when conducting management, selection and preservation programs in Nigerian West African Dwarf goats.

REFERENCES

Adebambo, A.O., Adebambo, O., Williams, J. L., Blott, S. and Urquart, B. (2011). Genetic distance between two popular Nigerian goat breeds used for milk production. *Livestock Research for Rural Development*, 23 (*26).*

Akpa, G. N., Duru, S. and Amos T. T. (1998). Influence of strain and sex on estimation of within-age-group body weight of Nigerian Maradi goats from their linear body measurements. *Tropical Agriculture (Trinidad)*, 75: 462-467.

Akpa, G. N., Ambali, A. L. and Suleiman, I. O. (2014). Body Conformation, Testicular and Semen Characteristics as Influenced by Age, Hair Type and Body Condition of Red Sokoto Goat. *New York Science Journal,* 6 (7). 44 – 58.

Apori, S.O., Osei, D.Y., Rhule, S.W.A., Doku, C. and Oppong-Anane, K. (2011). Livestock marketing in the coastal savannah zone of Ghana. Proceedings of the 17th *Biennial Conference of the Ghana Society of Animal Production*, 20th - 23rd July, 2011, University of Ghana, Legon. 43-45.

Aziz, M. M. A. and Al-Hur, F. S. (2013). Differentiation between three Saudi goat types using size-free canonical discriminant analysis. *Emir Journal of Food and Agriculture*, 25(9):723–735.

Chiejina, S. N., Behnke, J. M and Fakae, B. B. (2015). Haemonchotolerance in West African Dwarf goats: contribution to sustainable, anthelmintics-free helminth control in traditionally managed Nigerian dwarf goats. *Parasite*, 22: 7.

Dereje, T., Berhanu, B. and Aynalem, H. (2013). Morphological Characterization of Indigenous Hararghe Highland Goat Breed in their Native Environment, West Hararghe, Ethiopia. *American-Eurasian Journal of Scientific Research*, 8 (2): 72-79.

Devendra, C. and Burns, M. (1983). Goat Production in the Tropics. 2nd ed. Farham Royal, *Commonwealth Agricultural Bureau*, 1-60.

Distancesto.com (2019). https://www.distancesto.com/coordinates/ng.

Fajemilehin, O.K.S. and Salako, A.E. (2008). Body measurement characteristics of the West African Dwarf (WAD) Goat in deciduous forest zone of Southwestern Nigeria. *African Journal of Biotechnology*, 7 (14): 2521-2526.

FAOSTAT. (2018). http:// http://www.fao.org/faostat/en/#data/QA

FAO. (2012). Phenotypic characterization of animal genetic resources. *FAO Animal Production and Health Guidelines*, No.11. Rome, Italy.

Frandson, R. D. and Elmer, H. W. (1981). Anatomy of the male Reproductive system. In: Frandson RD (ed). Anatomy and Physiology of farm Animals 3rd edition, Lea and Febiger, Philadephia. pp 430-442.

Jimcy, J., Raghavan, K.C. and Sujatha, K.S. (2011). Diversity of local goats in Kerala, India, based on morpho-biometric traits. *Livestock Research for Rural Development*, 23(5).

Karacaoren, B. and Kadarmideen, H.N. (2008). Principal component and clustering analysis of functional traits in Swiss dairy cattle. *Turkish Journal of Veterinary and Animal Sciences,* 32: 163–171.

Kosgey, I.S. and Okeyo, A.M. (2007). Genetic improvement of small ruminants in low-input smallholder production systems: Technical and infrastructural issues. *Small Ruminant Research,* 70(1):76-88.

Kurnianto, E., Sutopo, S., Purbowati, E., Setiatin, E.T., Samsudewa, D. and Permatasari, T. (2013). Multivariate analysis of morphological traits of local goats in Central Java, Indonesia. *Iranian Journal of Applied Animal Science,* 3 (2): 361-367.

Macciotta, N.P.P. and Gaspa, G. (2009). Use of principal component and factor analysis to reduce the number of independent variables in the prediction of genomic breeding values. *Italian Journal of Animal Science, 8 (Supplement 2*): 105–107.

Ngere, L.O.; Adu, I.F. and Okubanjo, I.O. (1984). The indigenous goats of Nigeria. *Animal Genetics Research and Information,* 3: 1-9.

Ojo, O.A. (2014). Genetic Diversity of Nigerian Indigenous Goat Breeds Using Microsatellite Markers. Ph.D Thesis. Ahmadu Bello University, Zaria, Nigeria. 153pp.

Okpeku, M., Yakubu, A., Peters, S.O., Ozoje, M.O., IkeobiI, C.O.N., Adebambo, O.A. and Imumorin, I.G. (2011). Application of multivariate principal component analysis to morphological characterization of indigenous goats in Southern Nigeria. *Acta Agriculturae Scandinavica,* 98(2):101–109.

Olutogun, O., Abdullahi, A.R., Raji, A.O., Adetoro, P.A. and Adetemi, A. (2003). Body conformation characteristics of White Fulani and Gudali (Zebu) cattle breeds of Nigeria. In: Proceedings of the 28th *Annual Conference of the Nigerian Society for Animal Production*, 28: 114- 117.

Osinowo, O.A., Olorunju, S.A.S., Otchere, E.O. and Arigi, L.A. (1989). Development of a weight band for Yankasa sheep and Red Sokoto goats. Paper presented at the 14th *Annual Conference of the Nigeria Society for Animal Production* held at Makurdi, 2-6 April. Benue state.

Pesmen, G. and Yardimci, M. (2008). Estimating the live weight using somebody measurements in Saanen goats. *Archiva Zootech.* 11(4): 30-40.

Pinto, L.F.B., Dacker, I.U., Demelo, C.M.R., Ledur, M.C. and Coutinho, L.L. (2006). Principal components analysis applied to performance and carcass traits in the chicken. *Animal Research,* 55: 419–425.

Revidatti, M.A., Prieto, P.N., De La Rosa, S., Ribeiro, M.N. and Capellari, yA. (2007). Cabras criollas de la región norte Argentina. Estudio de variables e índices zoométricos. *Archivos de Zootecnia,* 56: 479–482.

Rotimi, E.A., Egahi, J.O. and Adeoye, A.A. (2015). Effects of sex and location on body weight and morphometric traits in West African Dwarf (WAD) goats in Ushongo Local Government Area of Benue state, Nigeria. *FUDMA Journal of Agriculture and Agricultural Technology,* 1(1): 56-60.

Rotimi, E.A., Momoh, O.M and Egahi, J.O. (2018). Evaluation of some qualitative traits in Sahelian goats in Katsina state, Nigeria. *FUDMA Journal of Agriculture and Agricultural Technology,* 4(2): 207-211

Solomon, A. and Kassahun, A. (2009). Estimation of weight and age of sheep and goats. Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP). *Technical Bulletin* No. 23. 14pp.

SPSS. (2011). Statistical Package for the Social Sciences. User's Guide: Statistics, Version 15.0. Institute, Inc., Cary, NC, USA.

Truxillo, C. (2003). Multivariate Statistical Methods: Practical Research Applications Course Notes. Cary, NC: SAS Institute.

Yakubu, A. (2013). Principal component analysis of the conformation traits of Yankasa sheep. *Biotechnology in Animal Husbandry,* 29 (1): 65-74.

Yakubu, A. and Ayoade, J.A. (2009). Application of principal component factor analysis in quantifying size and morphological indices of domestic rabbits. *International Journal of Morphology,* 27: 1013-1017.

Yakubu, A., Salako, A.E. and Imumorin, I.G. (2011). Comparative multivariate analysis of biometric traits of West African Dwarf and Red Sokoto goats. *Tropical Animal Health and Production,* 43:561–566.