Morphological characterization and evaluation of heat tolerance traits in Nigerian goat breeds

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Abstract

There are three main breeds of goat in Nigeria: The West African Dwarf (WAD), the Red Sokoto and the Sahel. Goats are renowned for their hardiness and can survive in most environments. The goats sampling was carried out from farms and markets across different states in Nigeria, according to the geographical distribution of the breeds published by Blench (1999). This experiment was carried out to analyse morphological variability among Nigerian goats. A total of 318 goats spread across the three Nigerian breeds were used in the following populations (57 Sahel, 187 Red Sokoto and 137 West African Dwarf). Data were collected on body weight, linear body measurements and heat tolerance traits and were subjected to analysis of variance using the fixed effects of breed, sex and location. Results showed that breed, sex and location significantly ($P < 0.05$) affected all the linear body measurements and heat tolerance traits. The Sahel breed had the highest values in most of the measured traits compared to the West African Dwarf and the Red Sokoto breeds of goat. It was observed that goats from the northern part of Nigeria were heavier than their southern counterparts, and this can be likened to their genetic makeup and the extent of its interaction with the environment. The results of the study confirmed the population structure of Nigerian goat breeds and showed that they possess enough diversity to enhance genetic improvement for higher survival and productivity.

Key words: Goat, Breed, Traits, Respiratory rate and Pulse rate

Introduction

The lifestyles of humans were drastically improved since the domestication of animals and plants. Domestication has enabled people to consolidate food resources which were the keys to civilization, making people more independent from environmental fluctuations (Vila *et al.*, 2005). Goats have been kept since ancient times for meat, hide and fibre production, control of bush encroachment, as well as for cultural and religious purposes in many countries (De Villiers *et al.*, 1999; Boyazoglu *et al.*, 2005). Today, different goat breeds inhabit diverse environments throughout the world with body weight ranging from 9 to 13 kg

for small tropical breed to 100kg for the European dairy breeds and the Boer goats (Mason, 1981).

In Nigeria, small ruminants are estimated to be a total of 56.6 million head, with goats out-numbering sheep by three to two, the estimated population of goats in Nigeria is put at 34.5 million (RIM, 1992). Majority of these animals are sedentary village livestock and their patterns of distribution mirror that of human settlements. There are three main breeds of goat in Nigeria: The West African Dwarf (WAD), the Sokoto Red and the Sahel. Goats are renowned for their hardiness and can survive in most environments. They adapt and utilize marginal forage and are therefore valuable

asset for subsistence farmers and a cheap source of animal protein for human at large especially in the sub-Saharan Africa. Morphometric parameters are used to evaluate the characteristics of animals that may vary due to the influence of breed evolution, environment and nutrition (Riva *et al.*, 2004). Morphological characteristics are growth related and could therefore be a good index of importance of a species for conservation. Heat tolerance is an important trait for deciding which genetic resource to use of farms in tropical regions; many traits can be measured to determine heat tolerance of a breed, therefore the need to examine the traits and their usefulness in characterizing Nigerian goat. They could also serve as reliable breed discriminants. Hot environment is an important stressor of any animal production in the tropical environment and could have deleterious effects on productive performance while determining the profitability of any animal production enterprise in the region. Measures of rectal temperature, pulse rate and respiratory rate are some of the important determinant of the adaptation of any species to the tropical environment. Heat is produced by metabolism within the body and could include maintenance, growth and other productive traits (Ilori *et al.*, 2012). Locally adapted species are endowed with a pool of irreplaceable genetic materials which must be conserved for the future. The purpose of this study is therefore to provide the baseline information for the conservation and improvement of our indigenous goat genetic resource by morphologically characterize and evaluate the heat tolerance trait in Nigerian goats.

Materials and metmethods

Study area

The goats sampling was carried out from farms and markets across different states in Nigeria, according to the geographical distribution of the breeds published by Blench (1999). Figure 1 shows the sites of sample collection across Nigeria. Nigeria is located in West Africa on the Gulf of Guinea and has a total area of 923,768km² making it the world's 32nd largest country. It shares 4047km border with other countries such as Republic of Benin (773km), Niger (1497km), Chad (87km), and Cameroon (1690km) and has a coastline of at least 853km.

Study population

The number of animals sampled involved 381 goats with the following representatives per breed (57 Sahel, 187 Red Sokoto and 137 West African Dwarf). The goats were sampled from University farms, (Nassarawa State University; Usman-Dan Fodio University, Sokoto; Ahmadu Bello University, Zaria; University of Maiduguri, Borno State; Kebbi State University, Kebbi and Abubakar Tafawa Balewa University, Bauchi). Colleges of Agriculture farms (College of Agriculture, Samaru, Zaria; Kebbi State College of Agriculture, Zuru; College of Agriculture, Bauchi and Veterinary Research Institute, Vom, Jos). Some are also sampled from rural households and private farms across the country. Animals were classified on the bases of breed, sex, and location.

Data collection

Data on body weight, linear body measurements and heat tolerance traits were collected as follows:

Body weight (BWT in Kg): This was taken with the aid of a hanging scale.

Height at withers (HAW in cm): The

Table 1: Sampling details of Nigerian goats used in this study.

Location	Code	Latitude	Longitude
Nassarawa	A	N08.38.790	E008.33.542
Nassarawa	B	N08.38.831	E008.33.504
Nassarawa	C	N08.33.511	E008.33.076
Jos	D	N010.01.399	E008.51.043
Bauchi	E	N010.17.044	E009.47.644
Maiduguri	F	N011.47.553	E013.12.482
Maiduguri	G	N011.51.574	E013.10.531
Kano	H	N011.58.590	E008.25.815
Zaria	I	N011.47.764	E008.38.728
Ipokia (Ogun)	J	N06.30.434	E002.43.124
Abeokuta	K	N06.27.951	E002.43.153
Abeokuta	L	N07.10.184	E003.21.093
Abeokuta	M	N07.08.408	E003.21.068
Kebbi	N	N11.30.951	E013.43.153
Zaria	O	N11.07.951	E008.38.283
Sokoto	P	N13.05	E5.23
Sokoto	Q	N13.25	E4.67
Sokoto	R	N12.62	E4.78
Sokoto	S	N11.4	E4.12

Fig. 1: Sites of sampling collection (A indicates sampling location). The sampling sites are designated A to S.

measurement was made with a special measuring stick made with two arms, one which was held vertical and the other at right angles to it, sliding firmly up and down to record height.

Heart Girth (HG in cm) or Chest circumference: Heart girth is a circumferential measure taken around the chest just behind the front legs and withers. A flexible meter rule was used to take the measurement.

Fore cannon bone length (FCBL in cm): This was taken as the length of the lower part of the leg extending from the hock to the fetlock in hoofed mammals.

Rump height (RH in cm): Rump height was taken as the distance from the surface of a platform to the rump using a measuring stick as described for height at withers.

Chest Depth (CD in cm): Chest depth was measured as the distance from the backbone at the shoulder to the brisket between the front legs. A meter rule was used in the measurement.

Body length (BDL in cm): Body length refers to the distance from the base of the ear to the base of the tail (where it joins the body). Extreme care was taken to ensure that the backbone was straight in both vertical and horizontal planes. A flexible aluminum meter rule was used to take the measurement.

Hip width/pin bone width (HW in cm): Hip width is the distance between the outer edges of the major hip bones on the right and left side. The hip bones are easily located and the distance between them easily measured with a pair of large, half round or oval-shaped calipers.

The data collected on heat tolerance traits were taken in the morning and evening at all locations during the early dry season (October to December):

Pulse rate (beats/minute): Pulse rate is the number of heart beats per minute. This was

taken with the aid of a stethoscope and a stop-watch.

Respiratory rate (breaths/minute): Also known as breathing frequency is the number of breaths taken within a set amount of time, typically 60 seconds. This was taken with the aid of a stop-watch.

Body temperature (°C): Body temperature is a measure of the body's ability to generate and get rid of heat. This was measured with the aid of a digital thermometer placed between the forelimb and the body of the animals.

Rectal temperature (°C): Rectal temperature was measured with the aid of a digital thermometer inserted in the rectum.

Statistical analyses

Data were subjected to analysis of variance using the fixed-model of SAS (2009) statistical software. The fixed effects of location, breed and sex on the quantitative traits were analyzed using analysis of variance (ANOVA). Mean and standard errors were computed for each body measurement. The general linear model (GLM) procedure of the same software package was used to analyze the data fitting breed, location and sex as main effects in the model. After the removal of non-significant interactions, the following model was employed:

$$Y_{ijk} = \mu + B_i + S_j + L_k + e_{ijk}$$

Where

Y_{ijk} = individual observation

μ = Population mean

B_i = Effect of the i^{th} breed ($i = 1, 2, 3$)

S_j = Effect of the j^{th} sex ($j = 1, 2$)

L_k = Effect of the k^{th} location ($k = 1, 2$)

e_{ijk} = Random residual error normally and independently distributed with zero mean and common variance.

Results

Table 2 shows the distribution of animals sampled relative to their breed, sex, age and

location. The total number of West African goats (WAD) sampled was 137 which represents 35.96 percent of the studied population, the Red Sokoto breed was 187 representing 49.08 percent while the Sahel breed was 57 representing 14.96 percent. The number of male to female goats sampled was 117 males and 264 females representing 30.71 percent and 69.29 percent respectively. The total number sampled based on their locations was 244 from the North and 137 from the South which represent 64.04 percent and 35.96 percent respectively. In terms of the age group, a total number of 73 (19.16%) animals were below 1 year of age, 94 (24.67%) were animals between the ages of 1 to 2 years, 126 (33.07%) for animals with the range of 2 to 3 years of age, 66 (17.32%) for 3 to 4 years of age while those older than 4 years of age were 22 representing 5.37 percent (Table 2).

The least squares means and the standard errors of mean for body weight, linear body measurement and the heat tolerance traits of sampled population as affected by breed is shown in Table 3. While the WAD was not

significantly ($P>0.05$) different from the Red Sokoto and Sahel breed for the height at wither, rump height and their pulse rate, significant ($P<0.05$) difference was observed for body weight, body length, heart girth and chest depth between the breed and the other Northern breeds. The three breeds differ significantly ($P<0.05$) from each other for body weight, hip width, fore cannon bone length and respiratory rate.

Respiratory rate was also significantly ($P<0.0001$) affected by breed. The fastest rate was observed among the WAD goat, followed by the Red Sokoto goat and then the Sahel goat with 58.73 ± 1.59 °C, 47.96 ± 1.26 °C and 36.21 ± 1.14 °C respectively.

The effect of breed had no significant ($P>0.05$) effect on the body temperature of the sampled goat breeds, likewise no significant ($P>0.05$) effect was found on the effect of breed on rectal temperature.

Table 4 shows the least square means and the standard errors of mean for body weight, linear body measurement and the heat tolerance traits in Nigerian goats as affected by sex.

Table 2: Numbers of animals sampled per breed, sex, age and location

Parameters	Frequency	Percentage
Breed		
WAD	137	35.96
Red Sokoto	187	49.08
Sahel	57	14.96
Sex		
Male	117	30.71
Female	264	69.29
Location		
North	244	64.04
South	137	35.96
Age (Years)		
<1	73	19.16
1-2	94	24.67
2-3	126	33.07
3-4	66	17.32
>4	22	5.37

Table 3: Quantitative and heat tolerance traits of Nigerian goats as affected by breed

Variable	Breed		
	WAD (137)	Red Sokoto (187)	Sahel (57)
Body weight(Kg)	16.16 ± 0.49 ^c	21.14 ± 0.57 ^b	22.78 ± 1.08 ^a
Body Length (cm)	66.90 ± 0.82 ^b	78.43 ± 0.83 ^a	80.46 ± 1.42 ^a
HAW (cm)	39.17 ± 0.55 ^b	42.42 ± 1.33 ^b	58.65 ± 0.86 ^a
Rump height (cm)	42.39 ± 0.57 ^b	44.77 ± 1.34 ^b	59.97 ± 1.00 ^a
Heart girth (cm)	56.21 ± 0.67 ^b	64.00 ± 0.66 ^a	63.87 ± 0.92 ^a
Chest depth (cm)	21.35 ± 0.24 ^b	25.53 ± 0.33 ^a	25.50 ± 0.55 ^a
Hip width (cm)	9.77 ± 0.15 ^c	11.15 ± 0.14 ^a	10.35 ± 0.21 ^b
FCBL (cm)	9.59 ± 0.09 ^c	12.12 ± 0.14 ^b	13.96 ± 0.24 ^a
Pulse rate (beats/minute)	125.65 ± 1.92 ^a	129.49 ± 2.37 ^a	111.07 ± 5.06 ^b
Resp. rate (breaths/minute)	58.73 ± 1.59 ^a	47.96 ± 1.26 ^b	36.21 ± 1.14 ^c
Body temp. (°C)	38.88 ± 0.10 ^{NS}	38.40 ± 0.08 ^{NS}	38.67 ± 0.12 ^{NS}
Rectal temp. (°C)	39.26 ± 0.06 ^{NS}	39.21 ± 0.07 ^{NS}	39.14 ± 0.10 ^{NS}

^{a,b,c} - Means within the same row with different superscripts differs significantly. NS = Non significant, HAW = Height at wither and FCBL = Fore cannon bone length.

Highly significant effect ($P < 0.05$) was found among the sexes, the females having higher values recorded in all the traits except height at wither, rump height and fore cannon bone length with values of 42.78cm, 45.39cm and 11.29cm respectively.

Sex also had a significant ($P < 0.05$) effect on chest depth. The female goats have longer depth (62.22cm) than their male counterpart (23.17cm). No significant ($P > 0.05$) effect of sex was found on the fore cannon bone length.

Sex also differed ($P < 0.05$) significantly on respiratory rates of the goats. Female goats had the highest respiratory rate followed by the male goats with 51.93 breaths/minute and 45.88 breaths/minute respectively.

Table 5 shows the least square means and the standard errors of mean for body weight, linear body measurements and the heat tolerance traits in Nigerian goats as affected by location. Separating the breeds according to the locations sampled, animals sampled from the north recorded higher significant ($P < 0.05$) body parameters and

Table 4: Quantitative and heat tolerance traits in Nigerian goats as affected by sex

Variable	Sex	
	Male (117)	Female (264)
Body weight (kg)	17.75 ± 0.73 ^b	20.41 ± 0.46 ^a
Body length (cm)	72.61 ± 1.18 ^b	75.47 ± 0.72 ^a
HAW (cm)	45.71 ± 1.41 ^a	42.78 ± 0.91 ^b
Rump Height (cm)	47.99 ± 1.45 ^{NS}	45.39 ± 0.90 ^{NS}
Height girth (cm)	58.79 ± 0.81 ^b	62.22 ± 0.56 ^a
Chest depth (cm)	23.17 ± 0.42 ^b	62.22 ± 0.26 ^a
Hip width (cm)	9.81 ± 0.51 ^b	10.85 ± 0.12 ^a
FCBL (cm)	11.94 ± 0.23 ^a	11.29 ± 0.13 ^b
Pulse rate (beats/minute)	110.79 ± 3.34 ^b	131.81 ± 1.58 ^a
Resp. Rate (breaths/minute)	45.88 ± 1.63 ^b	51.93 ± 1.14 ^a
Body temp. (°C)	38.68 ± 0.10 ^{NS}	38.59 ± 0.07 ^{NS}
Rectal temp. (°C)	39.20 ± 0.10 ^{NS}	39.23 ± 0.04 ^{NS}

^{a,b} - Means within the same row with different superscripts differs significantly. NS = Non significant, HAW = Height at wither and FCBL = Fore cannon bone length.

Table 5: Quantitative and heat tolerance traits in Nigerian goats as affected by location

Variable	Location	
	North	South
Body weight (kg)	21.94 ± 0.51 ^a	15.42 ± 0.41 ^b
Body length (cm)	78.24 ± 0.76 ^a	68.08 ± 0.82 ^b
HAW (cm)	44.37 ± 1.11 ^a	42.45 ± 0.82 ^b
Rump height (cm)	46.42 ± 1.12 ^a	45.78 ± 0.78 ^b
Height girth (cm)	63.92 ± 0.58 ^b	56.27 ± 0.58 ^b
Chest depth (cm)	25.37 ± 0.28 ^{NS}	21.61 ± 0.29 ^{NS}
Hip width (cm)	10.91 ± 0.12 ^{NS}	9.86 ± 0.13 ^{NS}
FCBL (cm)	12.51 ± 0.13 ^{NS}	10.30 ± 0.19 ^{NS}
Pulse rate (beats/minute)	132.81 ± 1.77 ^a	112.07 ± 2.71 ^b
Resp. Rate (breaths/ minute)	48.67 ± 1.15 ^b	52.57 ± 1.63 ^a
Body temp. (°C)	38.53 ± 0.07 ^{NS}	38.78 ± 0.10 ^{NS}
Rectal temp. (°C)	39.26 ± 0.04 ^{NS}	39.15 ± 0.09 ^{NS}

^{a,b} - Means within the same row with different superscripts differs significantly. NS = Non significant, HAW = Height at wither and FCBL = Fore cannon bone length.

pulse rate compared with those from the south with the values of 21.94 kg as against 15.42 kg for body weight; 78.24cm as against 68.08cm for body length; 44.37cm versus 42.45cm for height at wither; 46.42cm as against 45.78cm for rump height; 63.92cm versus 56.27cm for heart girth and 132.81 beats/minute as against 112.07 beats per minute for pulse rate while no significant effect ($P>0.05$) were recorded for chest depth, hip width, fore cannon bone length and rectal temperature.

On the heat tolerance traits, location had a significant ($P<0.0001$) effect on the pulse rate and the respiratory rate of the sampled goats. In terms of pulse rate, the goats from the northern part had the higher rate (132.81 beats/minute) than the goats from the southern part of the country (112.07 beats/minute). On respiratory rate, the lower value was found with the Northern goats (48.67 breaths/minute) while the southern goats have a respiratory rate of 52.57 breaths/minute. Both the body and rectal temperature were not significantly

different ($P>0.05$) among the sexes.

Correlation matrix showing the relationships among body weight, linear body measurements and heat tolerance traits are presented in Table 6.

The correlation matrix revealed that generally the correlations among some of the measured traits were strong and highly significant ($P<0.0001$).

Body weight was positively correlated with body length, height at withers, chest depth, rump height, heart girth, fore cannon bone length and hip width with values ranging from 0.130 to 0.746. Body weight was negatively correlated with rectal temperature but was highly significant ($P<0.0001$) while no significant ($P>0.05$) association was recorded on the pulse rate, respiratory rate and the body temperature. Heart girth was highly and positively correlated with chest depth, hip width and the fore cannon bone length. The heat tolerance traits was negatively correlated with the heart girth but significant ($P<0.001$) and positive correlation with the

rectal temperature, body temperature and respiratory rate ($P>0.001$).

Height at withers was positively and highly correlated ($P<0.0001$) with rump height, heart girth, chest depth and fore cannon bone length but not significantly ($P>0.05$) correlated with hip width. Height at withers was negatively correlated ($P<0.05$) with pulse rate, respiratory rate and rectal temperature.

Pulse rate was positive and significantly ($P<0.0001$) correlated with respiratory rate, rectal temperature and the body temperature. Though there was a significant correlation among the heat traits, the correlation values were low ranging from 0.185 to 0.236.

Discussion

Conservation and promotion of the sustainable use of the incredible diversity of animal genetic resource is important and on the increase, however, not all of this resource has been duly characterized. In all the sampled locations, there were more females than males. This reflects the structure of goat populations generally kept by farmers who are artistic breeders and who naturally and traditionally know that a constant flock size essentially depends on a large number of reproductively active females that must be kept for long periods of time (Katangole *et al.*, 1996). Fajemilehin and Salako (2008) reported similar observations where they sampled a total of about 160 females to 84 males and observed that farmers prefer to keep female goats to minimize cost of feeding and to increase production efficiency. Majority of these farmers retain only the vigorous males to father the next generation of kids while other ones are being sold off to raise money for themselves.

In terms of total number of goats sampled,

Red Sokoto goats had the highest distribution than all other goat breeds sampled for this experiment. This confirms the report of Ngere *et al.* (1979) which stated that Red Sokoto goats had wider distribution than the other breeds. This may be because the skin of this animal is valuable for leather production and thereby commands high price in the market compared to that of other breeds. Likewise this breed of goat is mainly red in colour and therefore may be able to adapt better and withstand the high ambient temperature of the northern part of the country. The differences in linear body measurement and body weights observed in this study was similarly confirmed by Ngere *et al.* (1979) and Mason (1951) in their breed comparisons which clearly demonstrated the distinction among the three breeds and in agreement with the report in some literature that the WAD goat was the smallest of the breed followed by the Red Sokoto and the Sahel goat.

Breed was found to significantly affect body weight and the linear body measurement. Generally, the body measurements for Sahel goats were found to be slightly higher than those for Red Sokoto and West African Dwarf goats. This finding is in agreement with the report of Makun *et al.* (2008). In their study they observed higher body weight for Sahel goats compared to the Red Sokoto goats across different ages. A similar trend as those recorded in this study with respect to the higher body weight and body measurements of Red Sokoto goats relative to West African Dwarf was also recorded by Yakubu *et al.* (2010). Yakubu *et al.* (2010) reported similar values for body weight, withers height, rump height, heart girth and chest depth for the West African Dwarf and Red Sokoto goats. Mohammed and Amin (1996) also found similar values as those

Table 5: Quantitative and heat tolerance traits in Nigerian goats as affected by location

Variable	Location	
	North	South
Body weight (kg)	21.94 ± 0.51 ^a	15.42 ± 0.41 ^b
Body length (cm)	78.24 ± 0.76 ^a	68.08 ± 0.82 ^b
HAW (cm)	44.37 ± 1.11 ^a	42.45 ± 0.82 ^b
Rump height (cm)	46.42 ± 1.12 ^a	45.78 ± 0.78 ^b
Height girth (cm)	63.92 ± 0.58 ^a	56.27 ± 0.58 ^b
Chest depth (cm)	25.37 ± 0.28 ^{NS}	21.61 ± 0.29 ^{NS}
Hip width (cm)	10.91 ± 0.12 ^{NS}	9.86 ± 0.13 ^{NS}
FCBL (cm)	12.51 ± 0.13 ^{NS}	10.30 ± 0.19 ^{NS}
Pulse rate (beats/minute)	132.81 ± 1.77 ^a	112.07 ± 2.71 ^b
Resp. Rate (breaths/ minute)	48.67 ± 1.15 ^b	52.57 ± 1.63 ^a
Body temp. (°C)	38.53 ± 0.07 ^{NS}	38.78 ± 0.10 ^{NS}
Rectal temp. (°C)	39.26 ± 0.04 ^{NS}	39.15 ± 0.09 ^{NS}

^{a,b} - Means within the same row with different superscripts differs significantly. NS = Non significant, HAW = Height at wither and FCBL = Fore cannon bone length.

pulse rate compared with those from the south with the values of 21.94 kg as against 15.42 kg for body weight; 78.24cm as against 68.08cm for body length; 44.37cm versus 42.45cm for height at wither; 46.42cm as against 45.78cm for rump height; 63.92cm versus 56.27cm for heart girth and 132.81 beats/minute as against 112.07 beats per minute for pulse rate while no significant effect ($P>0.05$) were recorded for chest depth, hip width, fore cannon bone length and rectal temperature. On the heat tolerance traits, location had a significant ($P<0.0001$) effect on the pulse rate and the respiratory rate of the sampled goats. In terms of pulse rate, the goats from the northern part had the higher rate (132.81 beats/minute) than the goats from the southern part of the country (112.07 beats/minute). On respiratory rate, the lower value was found with the Northern goats (48.67 breaths/minute) while the southern goats have a respiratory rate of 52.57 breaths/minute. Both the body and rectal temperature were not significantly

different ($P>0.05$) among the sexes.

Correlation matrix showing the relationships among body weight, linear body measurements and heat tolerance traits are presented in Table 6.

The correlation matrix revealed that generally the correlations among some of the measured traits were strong and highly significant ($P<0.0001$).

Body weight was positively correlated with body length, height at withers, chest depth, rump height, heart girth, fore cannon bone length and hip width with values ranging from 0.130 to 0.746. Body weight was negatively correlated with rectal temperature but was highly significant ($P<0.0001$) while no significant ($P>0.05$) association was recorded on the pulse rate, respiratory rate and the body temperature.

Heart girth was highly and positively correlated with chest depth, hip width and the fore cannon bone length. The heat tolerance traits was negatively correlated with the heart girth but significant ($P<0.001$) and positive correlation with the

Table 6: Pearson correlation matrix for all the Nigerian goats' parameters measured

Variable	BWT	BLT	HAW	RH	HG	CD	HW	FCBL	PR	RR	BT	RT
BWT	1.000											
BLT	0.652***	1.000										
HAW	0.170***	0.356***	1.000									
RH	0.130*	0.364***	0.956***	1.000								
HG	0.746***	0.730***	0.245***	0.246***	1.000							
CD	0.524***	0.595***	0.274***	0.269***	0.586***	1.000						
HW	0.603***	0.619***	0.097**	0.103*	0.670***	0.550***	1.000					
FCBL	0.434***	0.536***	0.299***	0.303***	0.436***	0.401***	0.350***	1.000				
PR	-0.022**	-0.172***	-0.107*	-0.133**	-0.087**	-0.016**	-0.079**	-0.274***	1.000			
RR	-0.077**	-0.163**	-0.241***	-0.218***	-0.108*	-0.145**	-0.058**	-3.372***	0.231***	1.000		
BT	-0.239**	-0.258***	-0.009**	-0.039*	-0.331***	-0.149**	-0.252***	-0.124**	0.185***	0.180***	1.000	
RT	-0.193***	-0.263***	-0.105*	-0.147**	-0.214***	-0.090**	-0.208***	-0.011**	0.236***	0.121**	0.530***	1.000

KEY: BWT: Body weight; BLT: Body length; HAW: Height at Withers; RH: Rump height; HG: Height girth; CD: Chest Depth; HW: Hip width; FCBL: Fore Cannon bone length; PR: Pulse rate; RR: Rectal temperature; BT: Body temperature; RT: Rectal temperature.

recorded in this study for withers height and body weight for the Sahel breed.

This study showed that sex was an important source of variation for most of the body dimensions studied, that is, the impact of sexual dimorphism in goats is prominent. The findings is in support of the results observed in Devendra and Burns (1983), Ifut *et al.* (1991), Akpa *et al.* (1998) and Tsegaye (2009). They reported significant influence of sex on body weight and linear traits in goats. The higher body weight and heart girth of female goats observed in this study is also in agreement with that of Fajemilehin and Salako (2008) who reported higher body weight of does. They also reported greater body length, heart girth, withers height and rump height of female animals than males. Yakubu *et al.* (2011) also observed longer fore cannon bones in male sheep relative to female sheep. The longer fore cannon bone of male goats observed in this study might contribute to their higher rump and withers height. Mohammed and Amin (1996), Akpa *et al.* (1998), Adeyinka and Mohammed (2006), Hamayun *et al.* (2006), Tsegaye (2009) and Semakula *et al.* (2010), however, reported higher body weight and body dimensions for male goats than female goats.

Geographic location comparisons of the sampled populations showed that the goats sampled from the northern part of the country are heavier than in the southern counterpart. However, all other measurement showed significant differences which suggest that these goats are morphologically distinct. These observations are concurrent with the reports of Moruppa and Ngere (1986) and Ngere *et al.* (1979; 1984) for Nigerian goats. This observation may be due to the adaptability of the breeds in their different geographical locations. For example the West African

Dwarf goats are majorly found in the southern forest part of the country, whereas Sahel and Red Sokoto breeds are predominantly in the northern dry part of the country. The study shows that breeds of goat in the desert, the Sahel and Red Sokoto has higher and longer body weight and linear body measurements compared to the WAD that is based in the humid tropical region. The longer leg in the desert breeds may be beneficial for long distance trekking in search of forage in the desert region and as well as to keep the reproductive organs of the animals away from direct contact from the heated ground and other dangerous items. Location also affected pulse and respiratory rate of the sampled goat. The result observed was expected since goats are very important animals because of their favourable characteristics and capacity to adjust to harsh environmental conditions. The results observed may be due to the differences in the ambient temperature of the two locations under study.

Results of this study suggest from the Pearson's correlation matrix, that the selection for improved body length, heart girth, chest depth, hip width, height at wither and rump height will also result in the improvement for body weight in Nigerian goats. Orheruata and Olutogun (1994) reported high and significant correlation between linear body measurement and body weight for cattle. Salako and Ngere (2002) made similar submission for sheep. Similar trends were reported for WAD and Red Sokoto goats (Moruppa and Ngere, 1986; Osinowo *et al.*, 1989).

Buvanendran *et al.* (1981) summarizes that frame size and absolute height were complementary and that the total size of the animal is a function of length, height and circumference measurements. In agreement to this, many researchers have

used correlations among body parameters to assess the mutual dependence and relationship among the parameters and possibly to implicate the genetic control of certain parts on the same genomic region. Such knowledge may be crucial to the constructive manipulation of measurable parts in an attempt to alter conformation as suggested by Salako (2006).

Conclusion

The results of this research showed that breed and sex significantly ($P<0.05$) affects body weight, linear body measurement and some heat tolerance traits (respiratory and pulse rate) in Nigerian goats. Also linear body measurements were found to have significant correlation with body weight. Location was found to significantly influenced the body traits and some of the heat tolerance traits measured in this study, quantitative traits studied in this experiment classified the Nigerian goats into small (WAD), medium (Red Sokoto) and large (Sahel) goats based on the body weight and measures of body dimension. Results of this experiment confirmed the population structure of indigenous Nigerian goat breeds and that the geographical region to which each of the breeds are adapted to have significant effect on the parameters measured.

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