Body Conformation, Testicular and Semen Characteristics as Influenced by Age, Hair Type and Body Condition of Red Sokoto Goat

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Abstract: The study was conducted to determine the influence of age, hair type and body condition score on body and testicular measurements, and semen characteristics using 31 Red Sokoto bucks. The ages of the bucks were categorized into four; 9-12, 13-16, 17-20 and 21-24 months. The hair types which were determined through touching and feeling were categorized according to the length and texture of the hairs as thus; short-smooth (SS) and long-curly (LC). The body condition was scored on a scale of 1 to 5 and then used to categorize the bucks into score 3 and 4. The linear body measurements {heart girth (HG), stature (ST), chest width (CW), withers height (WH), body depth (BD), body length (BL) and rump width (RW)} were measured in centimeters (cm) using flexible tape. The testicular measurements {testicular length (TL), testicular circumference (TC), were measured using flexible tape while testicular width (TW) and testicular weight (TWT) were estimated using the appropriate formulae}. The semen characteristics {semen volume, sperm motility, semen pH, sperm concentration and live and dead ratio were all determined accordingly). The study lasted for one year (July, 2011 – June, 2012). The results showed that the mean BW, HG, ST, CW, WH, BD, BL and RW were 15.02Kg, 59.9cm, 54.95cm, 8.37cm, 53.41cm, 32.86cm, 57.35cm and 17.03cm, respectively. Age and BCS significantly ($P<0.01$) influenced body weight, body conformation and testicular traits, but had a variable influence on semen characteristics. The BW, body conformation and testicular traits increased with increase in age of the bucks. Hair type had no influence on body weight, body conformation traits and semen characteristics but had influence ($P<0.01$) on some testicular traits. Bucks with BCS (4) were bigger in size (HG, ST, WH, BL,RW) and weighed more (BW) and had scrotum that are longer (TL), broader (TC), wider (TW) and heavier (TWT); hence producing more semen (SV) than those with BCS (3). The short-smooth haired bucks gave a better testicular dimension than the long-curly haired bucks. The results therefore, suggest that increase in age and body condition score may result into an increase in body and testicular size while hair type could be used as a predictor of testicular dimensions in Red Sokoto goat.
[Akpa G.N, Ambali A.L, Suleiman I.O. **Body Conformation, Testicular and Semen Characteristics as Influenced by Age, Hair Type and Body Condition of Red Sokoto Goat.** *N Y Sci J* 2013;6(7):44-58]. (ISSN: 1554-0200). http://www.sciencepub.net/newyork. 9

Keywords: Red Sokoto Goat; Semen; Age; Body conformation; Hair type; Body condition score

1. Introduction

Size and conformation are important characteristics in meat animals. Traditionally, animals are visually assessed, which is a subjective method of judgment (Abanikannda *et al*., 2002). In goat's body growth and development, objective means (linear body measurements) of describing and evaluating body size and conformation characteristics would overcome many of the problems associated with visual evaluation (Okpeku *et al*., 2011).

Body weight is an important economic trait in the selection of animals. The main purpose of animal breeding practices is to improve traits of economic value (Mendes *et al*., 2005). These traits have close association with explanatory variables such as age, breed and morphological characters. Body measurements have been used in animals to estimate body weight (Akpa *et al*., 2010; Adeyinka and Mohammed, 2006; Topal and Macit, 2004; Yakubu *et al*., 2005), especially in rural communities where scales are not readily available. Body size and shape measured objectively could improve selection for growth by enabling the breeder to recognize early maturing and late maturing animals of different sizes. Knowing the body weight of goats could also be exploited in adequate feeding and health care (treatment doses of antibiotics, anthelmintic, and so forth) (Slippers *et al*., 2000). However, it is not easily measured in the field. This is due to the time and energy expended while determining it; and the non-availability of weighing scales especially in the small scale farming sector. The chief method of weighing animals without scales is to regress body weight on a certain number of body characteristics, which can be measured readily (Thiruvenkandan, 2005; Yakubu *et al*., 2011).

In environments with high ambient temperatures and intense solar radiation, characteristics like coat pigment and hair type may play a vital role in productive adaptability. Importance of hair type had earlier been stressed for heat absorption and heat loss and thus, for adaptability of

animals. Animals with a wooly coat type have been shown to be less adaptable to hot climates (Peters *et al*., 1982), while findings have revealed that bucks showed lower reproductive activity during high ambient temperatures (Roca *et al*., 1992).

Sperm output has been shown to be positively associated with body weight in bucks (Mekasha *et al*., 2007). Delayed growth in body size and testicular mass obviously leads to reproductive wastage and economic loss. Increase of testicular size and body mass is influenced by several factors, including breed, age, nutrition and other environmental cues (Bielli *et al*., 2000; Karagiannidis *et al*., 2000; Mekasha *et al*., 2007). Large-sized breeds are heavier and have greater testicular measurements than small-sized breeds (Al-Ghalban *et al*., 2004). However, the extent to which the different breeds perform at various constant physiological stages deserves in-depth investigation. Even though body and testicular sizes of animals increase with age (Karagiannidis *et al*., 2000; Nsoso *et al*., 2004), the particular age at which domestic animals reach puberty is usually postponed until they attain a required body size.

Age had a pronounced effect, particularly on testis size. Old age arrives in bucks at different ages, depending on health, environment, and use. Most animals of 8 to 10 years of age appear to have adequate sperm numbers but an increase in abnormalities. The best prediction of how long a buck will live and produce good viable semen, while not 100% accurate, is to evaluate blood lines. This requires, of course, many individual observations within each group. With the onset of old age, there are bucks that have episodes of excellent semen production which lasts a period of weeks and then goes into another period of poor quality semen from which he may or may not recover. The reasons for these episodes are unknown and difficult to predict.

It has been demonstrated that the weight of testes at a constant age may be a useful indicator trait to select for increased reproductive efficiency (Harder *et al*., 1995). As there is likely to be considerable variation between breeds, a comprehensive study of body size and testicular function is strongly required. It has been reported that males strongly affect the reproductive efficiency of breeding herds, irrespective of whether they are used for natural breeding or artificial insemination (Chacon *et al*., 1999). By selecting males with larger testes at constant age, more does per superior sire could be inseminated, which might result in a greater efficiency of production.

Reproductive performance is a function of both doe and buck fertility. Therefore, all aspects related to semen evaluation are important in management practices, especially for AI in a breeding program. Scrotal circumference and semen characteristics were found to be different among different breeds and among individuals of the same breed (Kridli*et al*., 2005). Male fertility is an important factor in caprine reproduction since numerous does are generally bred to a single buck. Hence, evaluation of male fertility prior to breeding is of paramount importance to achieve breeding success. The potential fertility of breeding males can be evaluated in the field by assessment of mating ability; physical examination and a genital tract examination of both the external and internal genitalia (including a scrotal circumference measurement), and semen quality evaluation (Hoflack *et al*., 2006). These methods are useful for screening out sub-fertile males, although neither allows precise determination of the pregnancy rates that males actually achieve (Parkinson, 2004). Given the increasing socio-economic importance of goats and the increased requirements for proper goat husbandry, which demands the best breeding bucks for profitable production, a functional BSE system, which incorporates body conformation and testicular traits evaluation as well as semen characterization, is needed. Field assessments can be made of a buck's ability to mate, physical capability to mount, intromission achievement and ejaculation. Assessments can also be made of the quality of semen that the buck produces, which is, in turn, related to physical characteristics of its genitalia. Yet whilst it is relatively easy to assess such traits in the field, their value as predictors of bucks' fertility unfortunately remains the subject of considerable debate. The objective of this study was therefore to determine the influence of age, hair type and body condition scores on body weight, body conformation traits and testicular traits as well as semen characteristics in Red Sokoto bucks.

2. Material and Methods

Study Location

The study was conducted at the Experimental and Research Farm of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria. The area is situated between latitude 11^0 and 12^0N and altitude of 640m above sea level (Encarta Encyclopedia, 2009 PC version). The area falls within the Northern-Guinea Savannah Zone, having an average annual rainfall of 1100mm, which starts from late April or early May to mid-October. The peak rainy season is between June and September, followed by the harmattan period of cool and dry weather which last from October to January. This is then followed by hot-dry weather from February to April. The mean maximum temperature varies from 26^0C to 35^0C depending on the season, while the mean relative humidity during harmattan period and wet season are 21% and 27%, respectively.

Detailed description of Zaria was given elsewhere by Akpa *et al.* (2002).

Experimental Animals and their Management

A total of thirty-one Red Sokoto bucks were used for the study. The animals were under the management practices of the Department of Animal Science, Ahmadu Bello University, Zaria. The bucks were reared under semi-intensive system. The animals were released daily for grazing at 8.00am and another shift by 2.00 pm. Supplemental feed (concentrates) were provided. Animals received routine inspection and dipping (ectoparasite), as well as anti-helminthic drenching (deworming) and vaccination againt endemic diseases. Drinking water was provided *ad libitum.* The experiment commenced when the bucks were 9 – 12 months of age in July 2011 and terminated when they were 21 – 24 months, in June, 2012.

Data Collection and Traits Measurement

Body Weight measurement: The body weight of the bucks was measured in kilograms by following the procedure as described by Akpa *et al*. (1998). The weight of the observer was taken first, and then the body weight of each animal was taken by carrying the animal individually and standing on a weighing scale. The difference between this weight and that of the observer gives the weight of the animal. Weighing was done at the begining of the study and subsequently on monthly basis. A total of 372 records were generated for body weight.

Body Linear Measurement: Measurement of linear conformation traits were taken on the day of measurements in centimeters (cm) using flexible tape as described by Alphonsus *et al*. (2009) and Boisot *et al*. (2002). The measurements were taken at the onset and subsequently on monthly basis. A total of 372 records were generated for each of the body linear measurements. The traits are described as follow:

Heart Girth (HG): This is the circumference of the body at a point immediately behind the fore limbs and perpendicular to the body axis.

The Stature (ST): This was measured from the top of the spine in between the hips to the ground.

Chest Width (CW): This was measured from the inside the surface between the top of the front legs.

The Wither Height (WH): This is the highest point over the scapular vertically to the ground.

Body Depth (BD): This is the distance between the top of the spine and the bottom of the barrel at the last rib.

Body Length (BL): This was measured from the point of shoulder to the ischium.

Rump Width (RW): This is the distance between the most posterior points of pin bones.

Testicular Measurement:

These were done at the onset and subsequently on weekly basis before semen collection. A total of 1488 records were generated for each of the measurement. The measurement were as follows:

Testicular Length (TL): This was measured in centimeter with a flexible measuring tape as the distance along the caudal surface of the scrotum, from its point of attachment to the tip of the scrotum as described by Akpa *et al*. (2012) and Bratte *et al.* (1999)

Testicular Circumference (TC): This is the maximum dimension around the pendulous scrotum after pushing the testes firmly into the scrotum (Akpa *et al.*, 2006). It was measured in centimeters (cm)

Testicular Width (TW): This was taken as the division of Testicular Circumference by two.

Testicular Weight (TWT): This was determined using Bailey *et al.* (1996) formulae as given below;

$TWT = 0.5533 \times TL \times TW^2$

Where; TWT = Testicular weight
TL = Testicular length
TW = Testicular width

Semen Collection and Evaluation

Semen collection: Semen samples were collected from each animal at the onset and thereafter on weekly basis for 52 weeks using an electro-ejaculator and were labeled accordingly. This was done in the morning throughout the duration of the experiment. The sampled semen samples were evaluated immediately for colour, volume, motility and pH as describe by Zemjanis (1970).Smear of each semen sample was prepared; air dried, labeled and kept for further examination vis determination of sperm concentration using formaldehyde; determination of sperm morphology using oil immersion; and determination of live/dead ratio using eosin nigrosin. A total of 1488 records were generated for each of the observed characteristics**.**

Semen Concentration: The concentration of the spermatozoa was determined using the Red Blood Cell counting chamber of a haemocytometer that were crossed with microscopic grids containing 25 large squares with each containing sixteen smaller squares. The total number of smaller squares on the haemocytometer is 400. Sperm cells were counted diagonally from top left to the bottom right and from top right to the bottom left in five large squares or a total of 80 smaller squares (Rekwot *et al.*, 1997). Prior to counting, formaldehyde was used as a dilution reagent. A drop of semen was taken from each sample using automatic pipette and diluted with formaldehyde at 1:100. The haemocytometer was mounted into the microscope and an absorbable tube and O-no pette was used to pipette a drop of the solution into the haemocytometer chamber. The absorbable tube and the O-no pette were blown before pipette to avoid air bubbles in the O-no pette. After appropriate counting in the 5 large squares, the number obtained was

multiplied with 100 (dilution factor), 16 (the number of smaller squares in a larger square and the volume of the semen sample collected, multiplied by 10^6). The result obtained was recorded as the sperm cell concentration for the sample.

Live and Dead Ratio: The live and dead ratio was estimated by the preparation of a smear of individual semen sample using eosin-nigrosin stain immediately after collection. A drop of semen was diluted and placed on a clean glass slide using automatic pipette. A drop of the eosin-nigrosin solution was placed alongside the semen on the slide. A gentle circular turning of the slide was done to allow a uniform mixture of the two samples. A one-quarter of the part of another clean slide was placed on top of the first sample and the two slides were gradually and carefully drawn apart to prepare a thin smear on the first slide. This was allowed to dry and thereafter labeled. This was done for each sample and they were later mounted on the microscope for counting the live and dead sperm cells. The principle is that the dead sperm cells accept the stain and appear stained while the live sperm cells reject the stain and remain unstained. The procedure above was developed by Hancock (1951).

Determination of Factors

Age determination: The age of the animals were determined using the dentition estimation method by counting the number of permanent incisors that had erupted on the lower jaw of the mouth as described by Matika *et al*. (1992). This method puts the bucks at 9-12 months of age at the onset of the study. Measurements were made on these bucks at this age group, and subsequently until after 12 months. Thereafter, the ages of the bucks were categorized into 9-12, 13-16, 17-20 and 21-24 months.

Hair Type: The hair type of the animal was determined through a touch and a feel of the hair. Short-Smooth (SS) and Long-Curly (LC) which was based on length and texture of the hair were used to categorize the animal into groups.

Body Condition Score (BCS): The body condition score (1-5) were employed to score the bucks. The buck's backbone, loin and rump areas were palpated and examined and then scored. These areas do not have muscle tissue covering them, hence, combination of skin and fat deposit account for any cover that were felt around these areas. Amount of fat deposit was determined by the use of fingertip pressure which was exerted on the backbone, pin bone and hip bone respectively.

Score 1 (Very thin): Individual short ribs have a thin covering of flesh. Bones of the chine, loin and rump region are prominent. Hook and pin bones protrude sharply, with a very thin covering of flesh and deep depressions between bones. Bony structure protrude sharply and ligament prominent.

Score 2 (Thin): Individual short ribs can be felt but are not prominent. Each rib is sharp to touch but have a thicker covering of flesh. Short ribs do not have as distinct an over-hanging shelf effect. Individual bone is the chine, loin and rump regions are not visually distinct but easily distinguishable by touch. Hook and pin bones are prominent but the depression between them is less severe. Area below tail head and between pin bones is somewhat depressed but the bony structure has some covering of flesh.

Score 3 (Moderate): Short ribs can be felt by applying slight pressure. Altogether, short ribs appear smooth and the over-hanging effect is not so noticeable. The backbone appears as a rounded ridge, firm pressure is necessary to feel individual bones. Hook and pin bones are rounded and smooth. Area between pin bone and around tail head appears smooth without sign of fat deposit.

Score 4 (Fat): Individual short rib is distinguishable only by firm palpation. Short ribs appear flat or rounded, with no overhanging shelf effect. Ridge formed by backbone in chine region is rounded and smooth. Loin and rump region appear flat. Hooks are rounded and the space between them is flat. Area of tail head and pin bones is rounded with evidence of fat deposit.

Score 5 (Obese): Bony structures of backbone, short ribs and hook and pin bones are not apparent; subcutaneous fat deposit very evident. Tail head appears to be buried in fat tissue.

Statistical Analysis

Descriptive statistics were determined for each trait. The effect of age, hair type and body condition score on body and testicular measurement and semen characteristics were determined using General linear Model Procedure of SAS (2002). Significant differences in means were separated using Duncan's Multiple Range Test.

The model used is as follows:

$Y_{ijk} = \mu + A_i + H_j + C_k + E_{ijk}$

Where: Y_{ijk} = estimates of the given measurable characteristics

μ = over all mean

A_i = effect of *i*th age (i: 9-12, 13-16, 17-20 and 21-34)

H_j = effect of *j*th hair type (j: SS and LC)

C_k = effect of *k*th body condition score (*k* = 3, 4)

E_{ijk} = random error.

3. Results

The summary statistics for body and testicular measurement and semen characteristics are presented in **Table 1**. The results indicated that the mean body weight was 15.02±0.46Kg; Heart girth 59.95±0.45cm; Stature 54.95±0.82cm; Chest width 8.37±0.19cm; Withers height 53.41±0.58cm; Body depth 32.86±0.43cm; Body length 57.35±0.82cm; and Rump width 17.03±0.34cm. The Testicular length (cm), Testicular circumference (cm), Testicular width (cm) and Testicular weight (g) were 12.00±0.33, 17.38±0.26, 8.69±0.13, and 508.7±22.25, respectively. The semen volume (ml), motility (%), and semen pH were 0.42±0.05, 79.52±2.31, and 8.58±0.09, respectively while 701.13±70.55 and 0.82±0.12 were observed for Sperm concentration ($x10^6$) and Live & Dead ratio ($x10^6$), respectively.

The measurement of semen characteristics in the bucks, showed high variability which varied from 5.85 to 69.97. The most variable characteristics were semen volume and sperm concentration (Table1). Similar trend was observed in body conformation traits and testicular measurement, respectively.

The effect of age, hair type and body condition on body weight and all the body conformation traits are given on **Table 2**. Body weight and conformation traits were significantly (P<0.01) influenced by age. Age group 9 – 12 had the lowest while 17 – 20 had the highest which did not differ significantly from age group 13 – 16 and 21 – 24, respectively. There was non-significant effect (P>0.05) of hair type on body weight and all the body conformation traits. Body condition score had highly significant effect (P<0.01) on Body weight, Heart girth, Wither height, Body length and Rump width; and a significant effect (P<0.05) on Stature. However, Chest width and Body depth were not significantly (P>0.05) influenced by Body condition score. Animals with BCS (4) showed superiority over those of BCS (3).

Age effect on body weight showed that age group 9 – 21 had the lowest weight of 13.0kg than the rest with the highest weight coming from age group 17 – 20 (15.7kg) which was followed closely by age group 13 – 16 (15.5kg) and 21 – 24 (15.3kg) respectively (Table 2). The pattern for Heart girth and Body depth were similar to that of body weight. For age group 9 – 12, Wither height and Rump width were lower, while the age group 21 – 24 had the highest which was significantly similar to age group 13 – 16. Stature, Chest width and Body length were lower for age group 9 – 12. However, Stature was higher at age group 13 – 16 which did not differ significantly from age group 21 – 24; Body length was higher at age group 17 – 20 which was similar with age group 21 – 24; while Chest width was higher at age group 21 – 24 which did not differ statistically from age group
17 – 20. Only Chest width increased with age linearly while Rump width, Wither height and Stature took the Sigmund shape with age.

Table 1: Summary Statistics for Body and Testicular Measurements, and Semen Characteristics in Red Sokoto Bucks

Characteristics	N	Mean±Se	CV (%)	Min	Max
Body weight and Conformation					
Body weight (Kg)	372	15.02±0.46	17.01	10.00	20.00
Heart girth (cm)	372	59.95±0.45	4.22	55.00	65.00
Stature (cm)	372	54.95±0.82	8.35	40.60	63.50
Chest width (cm)	372	8.37±0.19	12.73	6.10	10.20
Withers height (cm)	372	53.41±0.58	6.08	45.70	57.40
Body depth (cm)	372	32.86±0.43	7.35	25.40	36.30
Body Length (cm)	372	57.35±0.82	7.92	50.80	70.50
Rump width (cm)	372	17.03±0.34	11.16	13.70	20.30
Testicular Measurement					
Testicular length (TL) (cm)	1488	12.00±0.33	15.33	8.60	16.50
Testicular circumference (TC) (cm)	1488	17.38±0.26	8.35	13.90	19.30
Testicular width (TW) (cm)	1488	8.69±0.13	8.35	6.95	9.65
Testicular weight (TWT) (g)	1488	508.7±22.25	24.35	272.60	749.03
Semen Characteristics					
Semen volume (ml)	1488	0.42±0.05	69.97	0.10	1.10
Semen motility (%)	1488	79.52±2.31	16.18	55.00	95.00
Semen pH	1488	8.58±0.09	5.85	8.00	9.00
Sperm Concentration ($x10^6$)	1488	701.13±70.55	56.02	209.00	1605.00
Live and Dead ratio ($x10^6$)	1488	0.82±0.12	11.97	0.60	1.00

The effect of body condition score on conformation traits indicated that BCS (4) was superior to BCS (3) for body weight and all the body conformation traits measured except for Chest width and Body depth where it had non-significant effect (P>0.05). No significant effect of hair type was observed.

Table 2: Effect of Age, Hair type and Body condition score on Body weight and Body conformation traits in Red Sokoto bucks

Factors	N	BW (Kg)	HG (cm)	ST (cm)	CW (cm)	WH (cm)	BD (cm)	BL (cm)	RW (cm)
Age (months)	372	**	**	**	**	**	**	**	**
9 – 12	93	13.0^{b}	58.0^{b}	47.2^{b}	7.3^{b}	47.4^{b}	29.9^{b}	51.2^{b}	14.1^{b}
13 – 16	93	15.5^{a}	60.4^{a}	57.1^{a}	8.3^{a}	54.8^{a}	33.3^{a}	58.0^{a}	17.4^{a}
17 – 20	93	15.7^{a}	60.7^{a}	55.9^{a}	9.1^{a}	54.4^{a}	35.8^{a}	63.6^{a}	16.8^{a}
21 – 24	93	15.3^{a}	60.3^{a}	56.4^{a}	9.6^{a}	55.2^{a}	33.0^{a}	58.7^{a}	19.5^{a}
SEM		0.44	0.44	0.47	0.14	0.24	0.34	0.56	0.16
Hair Type	372	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
Short-smooth	252	15.2	60.1	54.8	8.3	53.5	32.9	57.5	17.0
Long-curly	120	14.5	59.4	55.7	8.5	53.1	32.9	56.7	16.9
SEM		0.46	0.46	0.84	0.19	0.59	0.44	0.83	0.35
Body Condition Score	372	**	**	*	Ns	**	Ns	**	**
BCS (3)	144	12.4^{b}	57.4^{b}	52.7^{b}	8.2	52.1^{b}	32.7	55.6^{b}	16.0^{b}
BCS (4)	228	16.7^{a}	61.6^{a}	56.4^{a}	8.5	54.2^{a}	33.0	58.5^{a}	17.7^{a}
SEM		0.27	0.27	0.77	0.19	0.56	0.44	0.79	0.31

**= P<0.01; *=P<0.05; a,b,c means within the same column and factor with different superscripts differ significantly (P<0.05)

The effect of Age, Hair type and Body condition score on Testicular Measurement are presented on **Table 3**. The effect of age and body condition score were significant (P<0.01) on all the testicular measurements. Hair type significantly influence (P<0.01) testicular circumference (TC), testicular width (TW) and testicular weight (TWT), but had non-significant effect (P>0.05) on testicular length (TL). The effect of age on testicular measurement indicated that age group 21 – 24 performed best for all testicular traits measured. The performance was significantly (P<0.01) different from other age groups. However, performance of age group 17 – 20 was not significantly different with those in 13 – 16 but with those in 9 – 12 (P<0.01) for all traits measured. Hair type effect indicated that short-smooth bucks were significantly (P<0.01) superior to long-curly bucks. Body condition score in this study revealed that BCS (4) was significantly (P<0.01) superior in all the testicular measurement to BCS (3).

Table 3: Effect of Age, Hair type and Body condition score on Testicular measurement in Red Sokoto bucks

Factors	N	TL (cm)	TC (cm)	TW (cm)	TWT (g)
Age (months)	1488	**	**	**	**
9 – 12	372	10.9^{c}	15.7^{c}	7.9^{c}	372.3^{c}
13 – 16	372	12.2^{b}	17.4^{b}	8.7^{b}	513.1^{b}
17 – 20	372	11.3^{c}	18.1^{b}	9.1^{b}	513.6^{b}
21 – 24	372	13.2^{a}	18.9^{a}	9.5^{a}	654.6^{a}
SEM		0.32	0.20	0.10	17.00
Hair Type	1488	Ns	**	**	**
Short-smooth	1088	12.0	17.4^{a}	8.8^{a}	525.9^{a}
Long-curly	480	11.9	16.3^{b}	8.2^{b}	437.1^{b}
SEM		0.34	0.25	0.12	21.67
Body Condition Score	1488	**	**	**	**
BCS (3)	576	11.5^{b}	16.9^{b}	8.5^{b}	465.9^{b}
BCS (4)	912	12.3^{a}	17.6^{a}	8.8^{a}	535.7^{a}
SEM		0.33	0.26	0.13	21.73

**= P<0.01; a,b,c means within the same column and factor with different superscripts differ significantly (P<0.05)

Table 4 shows the effect of Age, Hair type and Body condition score on Semen characteristics. There was no significant effect of hair type on all the semen characteristics. However, semen volume and sperm concentration were significantly influenced (P<0.01) by age of buck. Age of buck on the other hand had no significant (P>0.05) effect on sperm motility, semen pH and Live and dead ratio, respectively. For semen volume, age group 21 – 24 months performed better (0.6ml) than the rest (0.2 – 0.5) while for sperm concentration, age group 13 – 16 months gave better (764.5) result than the rest groups (459.8 – 674.0). Body condition score had similar trend but only had significant influence (P<0.01) on semen volume and semen pH, while it had non-significant (P>0.05) influence on sperm motility, sperm concentration and live and dead ratio, respectively. Body condition score BCS (4) was superior in semen volume to BCS (3).

Table 4: Effect of Age, Hair type and Body condition score on Semen characteristics in Red Sokoto bucks

Factors	N	Semen Volume (ml)	Sperm Motility (%)	Semen pH	Sperm Concentration ($x10^6$)	Live & dead ratio ($x10^6$)
Age (months)	1488	**	Ns	Ns	**	Ns
9 – 12	372	0.2^b	80.0	8.8	459.8^b	0.8
13 – 16	372	0.2^b	80.3	8.5	764.5^a	0.9
17 – 20	372	0.5^a	80.0	8.7	674.0^a	0.9
21 – 24	372	0.6^a	76.0	8.4	662.4^a	0.8
SEM		0.05	2.42	0.09	72.27	0.02
Hair Type	1488	Ns	Ns	Ns	Ns	Ns
Short-smooth	1008	0.4	78.8	8.6	721.1	0.8
Long-curly	480	0.5	82.5	8.5	618.0	0.8
SEM		0.05	2.34	0.07	71.35	0.02
Body Condition Score	1488	**	Ns	**	Ns	Ns
BCS (3)	576	0.3^b	79.2	8.4^a	672.8	0.8
BCS (4)	912	0.5^a	79.7	8.8^b	719.0	0.8
SEM		0.05	2.32	0.08	71.63	0.02

**= P<0.01; a,b means within the same column and factor with different superscripts differ significantly (P<0.05)

4. Discussions

The mean BWT observed in this study (15.02±0.46kg) was consistent with 15.47±0.28kg reported by Otuma (2005) for WADxRSG cross bred buck from birth to 2 years and close to 16.41kg reported by Hassan and Ciroma (1992) for 1 – 2 year age group in Red Sokoto goats. Akpa *et al*. (1998) reported mean body weight in Red Sokoto goats at 7 – 12, 12 – 18 and 19 – 24 month of age to be 14.8±1.07, 17.3±0.93, 19.8±0.50 kg, respectively which are slightly higher than what was obtained in this study. Results obtained by Yakubu and Mohammed (2012); Okpeku *et al*. (2011) and Karua and Banda (1992) on Red Sokoto goat were higher than the one obtained in this study. Mean weight of 22.32kg obtained by Yakubu and Mohammed (2012); and 17.8±1.24kg by Karua and Banda (1992) in Red Sokoto bucks, respectively, were all higher than 15.02kg obtained in this study.

However, Adeyinka and Mohammed (2006) reported 10.02±0.73kg for Red Sokoto buck; Ebegbulem *et al*. (2011) reported 13.46±0.54Kg for WAD, while Bello and Adama (2012) reported 9.6Kg for Savanna brown bucks; these results are lower to those obtained in the present study at comparable age group. The discrepancies may due to breed and age differences. The results of the present study also collaborate with the report of Otoikhian *et al*. (2008) and 15.37kg mean body weight reported by Okpeku *et al*. (2011) on WAD goat.

Yakubu and Mohammed (2012) obtained high variability (19.5%) in body weight which is close to (17.01%) obtained in this study. The high variability in the body weight might not be unconnected with the environmental influences such as temperature and nutrition on this variable. This variation therefore, could serve as a basis for the genetic improvement of body weight. The mean HG, WH and BL of 81.7 ± 4.72 cm, 67.1 ± 4.03 cm and 69.5 ± 5.56 cm as reported by Okere *et al*., (2011) in Kiko bucks and 75.3 ± 4.87cm, 62.6 ± 2.88cm and 64.6 ± 6.2cm by Keith *et al*. (2009) in Boar bucks respectively, were all higher than the result of the present study. This may be due to differences in breed, climate or breeding goal.

The results on body length reported by Yakubu and Mohammed (2012) and Yakubu *et al*. (2010) as well as the results on rump width and body depth as reported by Yakubu *et al*. (2010) in Red Sokoto goat, agreed with the present results.

The strong influence of age on live body weight and linear body measurements in all the traits measured was depicted by the consistent increases in all the measurements as the animals advanced in age. This is expected since as the animal grows, size and shape are expected to increase with age. The observed values for linear traits in this study were slightly lower to those reported by Hassan and Chiroma (1992) and higher to those reported by Adeyinka and Mohammed (2006) in Red Sokoto goat. Among the four age groups, it was observed that body weight at age group 17 – 20 was the highest which was significantly higher than 9 – 12 age group, but similar to age group 13 – 16 and 21 – 24, respectively. This might be due to the expectation that higher age comes with higher body length and height until the peak is reached and then start to decline. It may also be due to physical condition of the animals and higher breeding activities as they mature. The result was similar to the report of Akpa *et al*. (1998) who observed body weight in Red Sokoto bucks at 1 – 6, 7 – 12, 13 – 18, 19 – 24, 25 – 30, and 31 –36, months of age to be 10.2±0.87, 14.8±1.07, 17.3±0.93, 19.8±0.50, 31.5±1.12 and 31.3±1.21kg, respectively; and that of Rahman (2007) who observed body weight of black Bengal bucks at 11.5 - 12.0, 14.0 - 16.0 and 17.5 - 19.0 months of age to be 16.62±0.12, 17.62±0.22 and 20.86±0.25 kg, respectively.

The results of the present study also collaborate with the reports of Alam (2006) and Herbert *et al*. (2003). However, Raji *et al*. (2008); and Adedeji and Gbadamosi (1999) reported higher body weight of 26kg and 25.53kg, respectively for Red Sokoto bucks at 2 years of age which are not consonant with 15.3kg observed in the present study at similar age group. Higher body weight had also been reported by Hamayun *et al*. (2006); and Fida *et al*. (2006) at comparable age group.

There was no wide variability in body measurements as the age of the animals increased, especially in live body weight. This is not in agreement with the earlier reports (Hamayun *et al*., 2006; Fajemilehin and Salako 2008) in goat; and Orheruata and Olutogun, (1994) in cattle who reported wide variations.

The effect of age on body linear measurement in Red Sokoto bucks was strong as there were consistent increases in all the traits as the animals aged. Akpa *et al*. (1998) had reported mean values for height at withers for Red Sokoto bucks at 7 – 12, 13 – 18, and 19 – 24 months of age to be 47.5±3.26, 53.3±1.49, and 53.5±1.87 (cm), respectively while Fida *et al*. (2006) reported 60.30, 68.25 and 72.14 (cm) at similar age group for Pakistani bucks. These results are not consistent with the result on height at withers obtained in this study. The same trend was observed in heart girth reported by Akpa *et al*. (1998) and Fida *et al*. (2006), respectively. Hamayu *et al*. (2006) reported the body length of buck at 4 –12, 18 – 13 and 19 – 24 months age groups to be 59.60±0.74, 64.38±1.39, and 69.42±0.29 (cm), respectively. This is close to 51.2, 58.0, and 63.6 (cm) obtained in this study at similar age groups. The same trend was also observed in Heart girth.

Rahman *et al*. (2008) reported 59.08±0.87 and 63.25±1.07 (cm) for HG; and 47.92±0.76 and 51.21±0.93 (cm) for HW at 9 and 15 months of age, respectively. These results are similar to the result of the present study at similar age group. However, the body length reported by Akpa *et al*. (1998) was slightly lower to the one obtained in the present study at similar age group. The observed linear body measurements in the present study also conformed to those reported by Moruppa and Ngere (1986) for Red Sokoto goats at similar age groups.

Bianca (1961) and Turner (1964) deemed hair type to be an indication of animal's physiological status, especially of its endocrine functions and efficiency of its energy metabolism. The results of the present study indicated a tendency towards such a relationship as inverse proportional relationship between hair type and body measurement was observed, indicating that performance is much determined by body weight and not by hair type (Peters *et al*., 1982). While hair characteristics may be of limited value in selection of meat goats to improve thermal adaptation, hair type can however play a role in avoiding ecto-parasitic infestation as long wooly or rough hair type has been reported to result into a lower body weight than a short coat (Peters *et al*., 1982).

Body condition score was observed to significantly affect body weight and all the conformation traits except chest width and body depth. This signified that bucks with good body weight and healthy body parts are expected to have a good body score and composition and vice versa. The correlation of the body condition scores with body weight has been reported by Sanson *et al*. (1993) to be high (r = 0.89) indicating that each unit increase in condition scores resulted in an increase of 5.1 kg in body weight. Hence, bucks with BCS (4) as observed in the present study were relatively bigger in size and weighed more than those with BCS (3). Results of Aumont *et al*., (1994) on Creole goats indicated that composition of muscle and adipose tissue was significantly influenced by body condition scoring. Ozoje and Mgbere (2002) also reported on the use of skeletal dimensions such as

heart girth and wither height as good indicators of live weight and condition score.

Testicular circumference is an indirect measurement of the testicular mass. It is a major component in breeding soundness assessment, mainly because it is easy and reliable, and provides an indication of size and growth (Chacon *et al*., 1999). Shamsuddin *et al.* (2000) reported that the mean testicular circumference of black Bengal buck at puberty ranged from 14.0 to 16.0 cm which is relatively lower to the ones obtained in this study. Raji *et al*. (2008) reported 23.17cm, while Adedeji and Gbadamosi (1999) reported 22.6cm for Red Sokoto bucks at 2 years of age. These are higher than that of the present study at similar age group. Higher results had also been reported by Keith *et al*. (2009) and Mekasha *et al*. (2008). However, similar to what is obtained in the present study was the results of Ugwu (2009) who reported 17.25 ± 0.76cm in WAD. The variability may be due to breed difference, contemporary group level, age, weight and height of bucks (Bourdon and Brinks, 1986).

The significant effect of age on the testicular measurements in Red Sokoto goats has been reported by other authors; Ogwuegbu *et al*. (1985); Shamsuddin *et al*. (2000); and Rahman, (2007). Age group 21 – 24 was observed to be superior in testicular circumference than other age groups. This might be due to differences in age, body weight and height of bucks. A large TC is associated with good seminal quality and a high daily sperm production in bucks (Mekasha *et al*., 2007). Changes in testicular circumference after reaching sexual maturity can occur in goats due to the influence of photoperiod, nutritional status and temperature (Coelho *et al*., 2006; Almeida *et al*., 2007; Delgadillo *et al*., 2007). However, even though SC increases with age, its growth increment is curvilinear with age in bucks compared to increases in BW (Bongso *et al*., 1982). Earlier studies have demonstrated that SC increases rapidly in young bulls, only gradually in mature bulls and can even decrease as bulls aged (Brito *et al*., 2002).

In the present study, the size of the testes varied at different age groups. The length and width of testes were also observed to increase with the advancement of age of animals which agreed with the findings of Gofur *et al*., (2007) and Islam (2001). Higher testicular weight in age group 21 – 24 might be due to their higher body weight and size. Raji *et al*., (2008) reported average testicular weight at 1.0, 2.0, and 3.0 years of age to be 55.00±2.87, 77.28±1.88 and 103.01±2.23 gm, respectively in Red Sokoto goats, while Kabiraj *et al.* (2011) reported 77.17, 126.58, and 131.53 gm, respectively at similar age group in black Bengal bucks. These results are much lower to the present result. This might be due to physical condition of the selected animals, agro-climatic condition, nutritional level, housing, disease control and other management procedure.

TW is highly related to sperm production, selection of bucks with larger testes would enable the insemination of more females in any AI programme (Coulter *et al*., 1975). Testicular weight has been shown to be sensitive to nutrition, and animals on a better dietary regime had heavier testes than those on a lower-quality dietary regime (Mekasha *et al*., 2007). Raji *et al.* (2008); and Adedeji and Gbadamosi (1999) reported testicular length of 13.6cm and 13.26cm at 2 years of age in Red Sokoto bucks, respectively. These are similar to 13.2cm obtained in this study at similar age group.

The significant effect of hair type on all testicular measurement except testicular length as observed in short-smooth haired bucks showing more superiority to long curly might be connected to adaptation. Short-smooth hair has advantage over long-curly as it provides a medium for convectional heat loss from the animal surface. This is supported by the assertion that hair structures have an important role to play in the adaptability of animals to different ecological zones (Banerji, 1984). It was observed that the scrotum of short haired bucks were relatively broader (TC) wider (TW) and heavier (TWT) than the long curly haired bucks.

In this study all the testicular measurement were significantly affected by body condition score which suggest that bucks with larger body size and good body score might possess larger testicular size which may invariable result into a good reproductive capability and improve the fertility of the animal (Akpa *et al.*, 2012). Appreciable and good body conformation as observed in bucks with BCS (4) than bucks with BCS (3) signified that bucks with BCS (4) may be expected to have a scrotum that are longer (TL), broader (TC), wider (TW) and heavier (TWT) than those with BCS (3).

The effect of age on semen characteristics was variable and was only observed in semen volume and sperm concentration. Higher semen volume in age group 21 – 24 might be due to expectation that old age comes with higher testicular size and hence higher sperm production. The semen volume obtained in the present study ranged from 0.2±0.05 to 0.6±0.05 ml with mean 0.42± 0.05 (Table 1 and 4) which agreed strongly with the findings of other researchers (Karim, 2008; Vilar *et al*., 1993; Singh *et al*., 1985). Kabiraj *et al.* (2011) reported 0.32±0.04 and 0.55±0.05ml at 0.5 – 1, and 1.5 – 2 years of age, respectively. This result is in consonance with the present study at similar age group. Furstoss *et al*., (2009) reported 0.48±0.10 ml of semen volume from Alpine bucks at 7 months of age which is slightly higher than the result of the present

study (0.2±0.05 ml at 9 – 12 month of age). These might be due to breed and nutritional differences, seasonal variation, collection methods and time of collection.

Das *et al*., (2006) reported semen volume which ranged from 0.16 to 0.51 ml in black Bengal buck, which is slightly lower to the values of the present study. Variation in semen volume reported by different workers might be due to differences in genetics, reproductive health status of bucks, age of bucks, frequency of collection, pooled volume, nutrition, season and management (Soderquist *et al*., 1992). Variations can also be due to skill of semen collector/attendant and temperature of AV.

The superiority of age group 13 – 16 in sperm concentration may be due to higher testicular size with higher spermatogenic activity in the animals of this age group (youthful age). According to Aguiar *et al*. (2006), such remarkable increase in the spermatogenic activity at the referred age results from the significant development of the seminiferous tubules and to the Sertoli cell differentiation. Findings on sperm concentration in this study are not in agreement with the findings of Karim (2008) who reported sperm concentration of between 2.75±0.28 and 3.24±0.37 billion/ml in black Bengal buck; and Khan (1999) who reported the average sperm concentration of 3777.93±142.76 million/ml, respectively. These are higher than the result of the present study.

Leon *et al*. (1991) and Sharma *et al*. (1991) reported that sperm concentration might vary according to variation in age, breed, collection frequency, feeding regime and climatic condition. According to Apu, (2007) and Afroz, (2005), the average sperm concentrations of buck semen were 2678.33±30.59 to 2913.33±46.23 and 2434.00±52.81 to 2853.00±90.12 million/ml, respectively. These are also higher than the present results. Das *et al*. (2006) and Mittal (1982) also reported higher values.

It is known that the morphological characteristics of spermatozoa are influenced by several factors including the genetic-make up, the physiological stage of the animal, nutrition, climatic factors and disease (Dowset and Knott, 1996; and Dana *et al*., 2000). Also, Greyling and Grobbelaar (1983) indicated that the percentage of live sperm yielded by the technique of the artificial vagina was significantly higher than those of semen collected by electro-ejaculator. These might be the reasons for lower sperm concentration as observed in the present study.

On the other hand, Javed *et al*. (2000) reported 1.00±0.50 $\times 10^6$/µl; while Raizada *et al*. (1988) and Terezinha *et al*. (1991) had reported sperm concentration of 2.90 and 1.33 ×106/µl) in buffalo bulls. These results are lower to the results of the present study. These variations may be attributed to breed and age differences. It can be observed in the present study that sperm concentration was higher in adult bucks than the young and old bucks. This may be attributed to pattern of reproductive advancement in bucks, particularly testicle size and thermo-regulatory mechanisms which are still developing in the young buck, but have reached maturity level in the adult buck. As bucks advance in age, testicular tissues may be broken down faster than being replaced (King, 1993). This may result in testicular degeneration, hence lesser semen production in the older bucks.

Body condition score only had effect on semen volume and semen pH. This suggests that buck with good and appreciable body condition may be expected to produce more semen per ejaculate. This is attributed to larger testicular size expected from bucks with good and appreciable body condition, hence the production of higher semen volume. Akpa *et al*. (2012) reported significant correlation between body condition score and testicular circumference as well as testicular weight. Live weight and body condition score are important variables influencing the reproductive capacity of domestic animals. Bucks with BCS (4) in the present study were relatively bigger with larger scrotum, hence the reason for increased volume of semen as observed in BCS (4) than what was observed in bucks with BCS (3).

The non-effect of hair type on semen characteristics in the present study may be explained by the fact that ambient temperature is considered as a secondary factor (after day length) affecting reproductive capacity in male small ruminants (Thimonier *et al*., 1986). Semen characteristic may be affected indirectly through temperature regulating capacity of hair around testicular traits in male animal. With animals on a good plane of nutrition as in the present study, all reproductive processes that are dependent on or related to male organ weights like sperm production and the efficiency of sperm production; sperm storage capacity and seminal characteristics would therefore be expected to be stable in the buck all year round.

Conclusions

- Age and body condition had strong influences on body weight and conformation traits with consistent improvement in the traits as the animal aged and body condition score increased from BCS 3 to BCS 4.
- Bucks with BCS 4 were relatively bigger in size (HG, ST, WH, BL, RW) and weighed more (BW) and had scrotum that were longer (TL), broader (TC), wider (TW) and heavier (TWT); hence produced more semen (SV) than those with BCS 3.

- Short-smooth haired bucks gave a better testicular dimension than the long-curly haired bucks.
- Semen characteristics in this study exhibited high variability which ranged from 5.85 to 69.97. The most variable characteristics were semen volume (69.97) and sperm concentration (56.02). Therefore, these two characteristics constitute major sources of variation for semen evaluation in Red Sokoto bucks.

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6/6/2013