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Relationships between sperm morphology and semen cation concentrations in red sokoto goats (*Capra aegagrus hircus)*

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The study evaluated the relationships between sperm morphology and semen cation concentrations in Red Sokoto bucks. A total of 31 Red Sokoto bucks were used for the study. Semen samples were collected from each animal on weekly basis for 52 weeks using an electro-ejaculator. Sperm morphological traits: detached mid-piece and tail (DMT), detached head (DH), mid-piece droplet (MPD), coiled and bent tail (CBT), and acrosomal abnormality (ACR) as well as semen cation parameters: sodium ion (Na^+), potassium ion (K^+) and calcium ion (Ca^{2+}) were respectively determined. Correlation analysis procedure (Pearson correlation) of SAS was used to assess the relationship between the measured characteristics. The results showed that correlations among the sperm morphological characteristics were generally low and not significant except the correlation between DH and DMT which was perfect ($P < 0.01$; $r = 1.0$). Semen cations correlated positively but non-significantly among themselves except the correlation between Na^+ and K^+ ($P < 0.05$; $r = 0.3$) which was significant. Relationship between semen cations and sperm morphological traits were generally negative and significant ($P < 0.05$; $r = -0.28$ to -0.40) except ACR which was positively and significantly correlated with Ca^{2+} ($P < 0.01$; $r = 0.37$). The study revealed that DH is highly associated with the DMT, while Na^+ concentration was an indicator of K^+ level in the semen, as positive and significant relationtions were observed between each pair. The negative and significant relationship between sperm morphological traits and semen cations, as observed in the present study suggest that the level of morphological defects of spermatozoa can be determined based on information on semen cations of the bucks.

Key words: Red Sokoto goats, sperm morphology, semen cations.

INTRODUCTION

The main criterion for keeping a buck at an insemination station is the production of buck ejaculates containing a high quantity of spermatozoa with high fertilization ability. The optimal production of semen of high biological value is influenced by numerous factors, including: breed (Kondracki et al., 2007; Smital et al., 2004), season of the

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year (Ciereszko et al., 2000; Wysokinska et al., 2005), age of the animal, and frequency of sperm collection (Deka et al., 2002). Examination of sperm morphology and determination of number of spermatozoa with morphological defects play a significant role in semen quality assessment, thus enabling the elimination of males with potentially low fertility prior to the preservation of their semen (Rodriguez-Martinez and Barth, 2006). Among the reproductive traits, quality semen plays a major role in determining the fertility and reproductive efficiency of any livestock production.

Abnormalities of the spermatozoa occur due to disorder of the seminiferous tubules, during ejaculation or in manipulation of the ejaculate including excessive agitation, over-heating to rapid cooling, mixture of water, urine or antiseptic in the semen (Hossain et al., 1990). The sperm head plays a significant role in the fertilization process. Experiments have revealed that the presence of 10% or more of any single type of head, mid-piece and tail defects and 20% or more of total abnormalities of spermatozoa is often coupled with reduced fertility in ruminant (Hancock, 1956). Semen volume, sperm motility, and sperm concentration have been reported to be negatively correlated with abnormal spermatozoa in Red Sokoto goats (Ambali et al., 2013). Reddy et al. (1975) also reported significant negative correlation between abnormal spermatozoa and conception rate.

Cation concentrations in the seminal plasma provide the congenial milieu for the survival of sperms (Kalita et al., 2006). The concentrations of different ions in seminal plasma also reflect the quality of semen and physiological status of reproductive accessory gland (Kalita et al., 2006). A large number of reports on the biochemical composition of cattle semen have been published (Rattan, 1990). But there is scarcity of parallel information about the semen of the Red Sokoto bucks maintained in the northern part of Nigeria. The objective of the study was therefore to determine the relationships between sperm morphology and semen cation concentrations in Red Sokoto bucks.

MATERIALS 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 at latitude 11° 09' 06' N and longitude 7° 38' 55' E, at an altitude of 706 m above sea level. It falls within the Northern-Guinea Savannah Zone with marked period of rainfall ranging from 1102 to 1904 mm. The mean maximum temperature varies from 26 to 35°C depending on the season. 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 are among the research animals owned and managed by Department of Animal Science, Ahmadu Bello University, Zaria. The bucks were reared under semi-intensive system. Supplemental feed (concentrates) was provided. Animals were subjected to dipping against ectoparasite as well as anti-helminthic drenching (deworming) and vaccination againt endemic diseases. Fresh drinking water was provided *ad libitum.* The experiment commenced when the bucks were 9 to 12 months of age and ended when they were 21 to 24 months.

Data collection

Semen collection and evaluation

Semen samples were collected from each animal on weekly basis for 52 weeks using an electro-ejaculator and were labeled accordingly. This was done in the morning hours throughout the duration of the experiment. Smear of each semen sample was prepared, air dried, labeled and kept for the determination of sperm morphology. A total of 1488 records were generated for each of the observed characteristics. Determination of sperm morphology and semen cations is given subsequently.

Sperm morphology

A smear of individual semen sample was prepared using eosin-nigrosin stain immediately after collection using the following procedures. A small drop of semen is placed on the edge of a clean slide and a ribbon of eosin-nigrosin stain is placed slightly closer to it. The corner of a second slide is dipped into the semen drop, and the resultant “hanging drop” of semen is mixed with the ribbon of stain. The second slide is then pulled across the first slide in a manner similar to the one used in creating a blood smear. The slide was dried, labeled and examined at 1000x with an oil-immersion lens. Fifty spermatozoa were examined from each sample. The total number of abnormal spermatozoa was counted and recorded. Types of abnormality observed were: detached mid-piece and tail, detached head, mid-piece droplet, coiled and bent tail, and acrosomal abnormality (acrosome membrane detached, acrosome outlines and acrosome cap defect). Acrosomal abnormalities were determined by using smears made from the raw semen and stained by Giemsa stain according to Watson (1975).

Semen cations

Cation analysis was performed at the chemical pathology laboratory in Pathological Department of Ahmadu Bello University Teaching Hospital, Shika, Zaria, with a Coleman 21 Flame Photometer. This instrument is calibrated with five standard stock solutions for concentration of ions as described by Cragle et al. (1958). The semen samples were centrifuged for separation of seminal plasma. Seminal plasma was then processed and different cations: Ca^{2+}, Na^{+} and K^{+} were estimated.

Statistical analysis

Correlation analysis procedure (Pearson correlation) of SAS (2002) was used to assess the relationship between the measured characteristics. The weekly data (1488 records) on sperm morphology and semen cation concentrations were used for estimating their relationships.

Table 1. Correlation coefficients (r) among sperm morphological traits in Red Sokoto bucks.

Correlation	MPD	DH	CBT	ACR
DMT	0.02	1.0**	-0.12	0.12
MPD	-	0.02	-0.05	0.03
DH	-	-	-0.12	0.12
CBT	-	-	-	-0.03

**P<0.01, MPD: Midpiece droplet; DMT: detached midpiece and tail; DH: detarched head; CBT: coiled and bent tail; ACR: acrosomal abnormality.

Table 2. Correlation coefficients (r) among semen cations in Red Sokoto bucks.

Correlation	Potassium ion	Calcium ion
Sodium ion	0.3*	0.23
Potassium ion	-	0.04

*P<0.05.

Table 3. Correlation coefficients (r) between sperm morphology and semen cations in Red Sokoto bucks.

Correlation	DMT	MPD	DH	CBT	ACR
Sodium ion	0.02	-0.28*	0.02	0.04	-0.01
Potassium ion	-0.40*	-0.38*	-0.40*	-0.36*	-0.31*
Calcium ion	-0.03	-0.30*	-0.31*	0.02	0.37*

*P<0.05, MPD: Midpiece droplet; DMT: detached midpiece and tail; DH: detarched head; CBT: coiled and bent tail; ACR: acrosomal abnormality.

RESULTS AND DISCUSSION

The result of the correlation analysis between semen morphological characteristics is presented in Table 1. The correlations amongst the semen morphological characteristics were generally low and not significant, except the correlation between DH and DMT which indicated perfect correlation (P<0.01; r =1.00). This signified that all the abnormal spermatozoa showing DMT also showed DH, thus increase or decrease in the number of DMT spermatozoa will lead to direct correlated response in the number of DH spermatozoa. This is consistent with Akpa et al. (2012) who also reported perfect correlation (r = 1.0) in Yankasa rams and Cevik et al. (2007) who reported r = 0.45 in bull, though lower but highly significant as the present study.

The result of the correlation analysis between semen cation concentrations is presented in Table 2. The correlation amongst the semen cations were generally positive but non-significant except the correlation between Na^+ and K^+ (r = 0.3; P<0.05) which was significant. The moderate, positive and significant correlation between Na^+ and K^+ confirmed the responsibility of the two ions in maintaining osmolarity and metabolic activities of the spermatozoa. This finding agrees with Akpa et al. (2012) who reported r = 0.37 in Yankasa rams and Quinn et al. (1965) who reported r=0.51 in rams, respectively. Nath (1988) also reported a positive and significant correlation between Na^+ and K^+ content in buffalo semen.

Table 3 shows the correlated relationship between sperm morphology and semen cation concentrations in Red Sokoto bucks. The results showed that the sperm morphological traits were negatively and significantly correlated with semen cations (P < 0.05; r = -0.28 to -0.40) except ACR which was positively and significantly correlated with Ca^{2+} (P < 0.05; r = 0.37). The positive correlation between Ca^{2+} and ACR signifies that an increase in the seminal concentration of Ca^{2+} will lead to corresponding increase in occurrence of acrosome defect in spermatozoa, thus stressing the role of Ca^{2+} in semen quality. Meseguer et al. (2004) have reported that Ca^{2+} concentrations in seminal plasma are good predictors of post-thaw semen quality. However, it has been reported that Ca^{2+} at all concentrations in the semen of rams is somewhat deleterious (Blackshaw, 1953).

Potassium ion was found to be negatively and significantly correlated with all the sperm morphological traits (P < 0.05; r = -0.31 to -0.40). This indicates that an increase in potassium ion in the seminal fluid will lead to

a corresponding decrease in the occurrence of sperm defect in the bucks. This is contrary to the report that K^+ is a natural metabolic inhibitor and that higher K^+ concentration in seminal plasma decreases sperm metabolism, thereby, decreasing sperm motility and contributing to sperm defects (Massányi et al., 2003). Zamiri and Khodaei, (2005) showed that low levels of Na^+ and K^+ ions were associated with high percentage of motile sperm. However, (Akpa et al., 2013) reported positive and significant correlation between seminal potassium ion and sperm motility in Red Sokoto goats.

Conclusions

The study revealed that DH is highly associated with the DMT, while Na^+ concentration was an indicator of K^+ level in the semen as positive and significant relationtions were recorded between each pair. The negative and significant relationship between sperm morphological traits and semen cations, as observed in the present study suggest that the level of morphological defects of spermatozoa can be determined based on information on concentration of semen cations of the bucks.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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