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RELATIONSHIP BETWEEN SCROTAL CIRCUMFERENCE AND ANDROGEN CONCENTRATION AS A PREDICTOR OF WHITE FULANI BULL'S FERTILITY

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ABSTRACT: The study implemented On-field Animal Research (OFAR) at three different locations within the Southern Guinea Savannah Agro ecological Zone of Niger State Nigeria in two seasons (dry and wet seasons). The experiment was conducted in a completely randomized design using a multifactorial arrangement; the factors are location, season and fertility status. The locations are three levels including Mokwa, Minna and Suleja, while the seasons are two levels including the dry and wet seasons. The experimental animals investigated were White Fulani bulls (n=1131) which are being kept under smallholder production system. The age was determined using dentition, the body weight of each bull was determined using Shaeffer's formula and the scrotal circumference and testicular length were measured using a measuring tape. Testicular biometry was used to categorize bulls into high and low fertility bulls. Blood samples were collected from 24 bulls from each of the established fertility categories and for each of seasons (dry and wet seasons) for hormonal assay. Scrotal circumferences were significantly ($p<0.05$) higher in Mokwa (27.38 ± 0.18 cm) and during the wet season (30.03 ± 0.16 cm) compared to the dry season (23.59 ± 0.14 cm). There was significant influence of location, season and fertility status on testosterone concentration of the bulls ($p<0.05$). The level of testosterone was significantly ($p<0.05$) higher in bulls in Mokwa and during the wet season (3.98±4.65 ng/ml) compared to a lower level during the dry season (0.83±0.71 ng/ml). Testosterone hormonal concentration was higher in high fertile bulls (3.76±4.77 ng/ml) compared with low fertile bulls which had lower (1.06±0.87 ng/ml) testosterone level. Scrotal circumferences were significantly ($p<0.05$) higher in Mokwa (27.38 ± 0.18 cm) and during the wet season (30.03 ± 0.16 cm) compared to the dry season (23.59 ± 0.14 cm). Scrotal circumference was positively correlated ($r = 0.62$) with androgen concentration and could therefore be used as a field level fertility marker in selecting fertile White Fulani bulls for reproductive purpose. The study shows that scrotal circumference and androgen concentration can be used as a predictor of White Fulani fertility

Keyword: Scrotal circumference; Hormone; Season; Fertility; Breeding bull; Small holder system

INTRODUCTION

The White Fulani cattle form the majority of cattle breeds adapted to tropical and subtropical regions in West Africa. It is an indigenous breed of cattle widely distributed in the humid tropical regions of Africa and plays significant roles in meat and milk production, as well as draught purposes. The White Fulani cattle are important genetic resources contributing to human livelihood as a major source of animal protein and income to pastoralists (Oke *et al*., 2022). The bull is the individual within a beef or dairy herd that bears the greatest responsibility in overall herd fertility. It has been reported that early pregnancy wastage due to fertilization failure or embryogenesis failures are potentially of seminal origin (Tang *et al*., 2013). The detection of those individuals with high fertility within a group of bulls is fundamental for efficient beef herd management. Also, the accurate detection of those animals with lower fertility is key to avoid putting at risk the herd's full fertility potential. It is fundamental that the full potential of the herd fertility is achieved without being compromised by low fertility bulls (Barth, 2018).

Reproductive performance has a high economic value in beef cattle production, because fertility affects generation intervals, the intensity of selection pressure that can be applied to the population, and the number of products that can be sent to the market (Parkinson, 2004). The most commonly referred to and easily detected consequence of using sub-fertile bulls is the loss of pregnancies. However, delayed conception and extended calving season are further consequences of using sub-fertile bulls (Kastelic and Thundathil, 2017). Scrotal circumference is a potentially useful indicator of reproductive traits and has been used to compose selection

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indices for bulls to use in breeding purpose. These traits are easily measured and correlated with body weight and reproductive performance (Morris *et al*., 2000; Boligon *et al*., 2010). Measurement of scrotal circumference and testicular parameters is an essential part of breeding soundness evaluation of breeding bulls. Measurement of these parameters especially scrotal circumference has a great value on onset of puberty, total semen production, semen quality, pathological conditions of reproductive system, and the fertility or infertility status of breeding bulls (Ott, 1991). Moreover, testicular measurements have been utilized as the indicators for reproductive capabilities in the post pubertal period of bulls (Ahmad *et al*., 2010). Key hormones involved in sperm production include Gonadotropin-Releasing Hormone (GnRH), Follicle Stimulating Hormone (FSH), Luteinizing Hormone (LH) and testosterone; Testosterone is the major androgen essential for spermatogenesis and is mainly responsible for the maintenance of secondary sexual characteristics and libido and thus promotes sperm production in bulls (Hafez and Hafez, 2013). The male reproductive system must maintain the proper balance of these hormones. If the balance is threatened or altered, normal sperm production is then changed and infertility could become an issue (Gilbert *et al*., 2012). Hormonal imbalance can inhibit estrogen and androgen receptors, and negatively affect male fertility; even causing low sperm count (Gilbert *et al*., 2012). Luteinizing hormone also plays an important role in quality sperm production in spermatogenesis (Gilad *et al*., 1993). Therefore, establishing a relationship between testicular morphometry and androgen concentration by determining the bull's fertility status using testicular biometrics and hormonal concentration at various locations across seasons could have positive impacts on the productivity of indigenous cattle of Nigeria.

MATERIALS AND METHODS

The study implemented an On-field Animal Research (OFAR) at three different locations within the Southern Guinea Savannah Agroecological Zone of Nigeria. The experiment was conducted in a completely randomized design using a multifactorial arrangement; the factors are location, season and fertility status. The locations are three levels including Mokwa, Minna and Suleja, while the seasons are two levels including the dry and wet seasons. The animals investigated were White Fulani bulls (n=1113) kept under the smallholder production system. The age of the animals was determined using the bulls' dentition. The randomization of sample was done using the age and equal numbers of bulls were assessed per season; making a total of 1113 for all locations for both seasons.

Measurement of Body weight of animal: The body weight of each bull was determined using Shaeffer's formula as reported by (Wanchuk, 2018). The formula used was expressed as

Body weight (pounds) = $L \times G^2/300$
Where: -
L – Body length (inches)
G- Chest girth (inches)

The result obtained was converted from pounds to kilogramme using a factor of 2.21 to divide the obtained value.

Testicular traits measurement: The scrotal circumference was measured using a tape at the broadest part of the scrotum and the values were recorded in centimeters. The testicular length was measured with the use of flexible tape while the values were recorded in centimeters.

The records of the testicular biometric measurements of each bull were used to categorize bulls into high and low fertile bulls using the standard reference of the Australian Cattle Veterinarians 2013 (Andrew, 2013). According to this standard reference scale, bulls with testicular circumference less than 30 cm are categorized as low fertile bulls while bulls with testicular circumference higher than 30 cm are categorized as high fertile bulls. There was random selection of 12 bulls per category of fertility (low fertile and high fertile) for both dry and wet seasons as established by implementation of the fertility categorization**.** The categorization was used for sampling of 5ml blood sample from each of the selected bull through the jugular vein using a 5ml plastic syringe into well labeled sample bottles for hormonal assay, the collected blood samples were allowed to coagulate at room temperature since they were collected using a vacutainer which contained no anticoagulant. After coagulation, the samples were transported on ice to the laboratory where they were further processed for serum hormonal assay analysis.

Data analysis
Data obtained from the study were subjected to analysis of variance using the software SPSS v.16.0.to determine differences in the scrotal circumference measurements and hormonal concentrations of the bulls at p<

0.05 level of probability. The significant difference in the means was separated using Duncan test in the post-hoc tools of the software.

RESULTS and DISCUSSION

RESULTS

Effect of Location and Season on Scrotal Circumference of White Fulani Bulls

There was significant difference in the scrotal circumference of the bulls based on locations ($p<0.05$) and seasons ($p<0.05$). The scrotal circumferences of the bulls were 27.38±0.18 cm, 27.08±0.17 cm and 25.97±0.18 cm based on locations (Table 1). The scrotal circumference of the bulls were significantly ($p<0.05$) higher for Mokwa (27.38±0.18 cm) compared to Minna and Suleja. The average scrotal circumference of the bull was higher during the wet season (30.03±0.16 cm) as compared with the dry season (23.59±0.14 cm).

Table 1: Age and phenotypic parameters of White Fulani bulls

	Location			Seasons		p-values		
Parameters	Mokwa	Suleja	Minna	Dry	Wet	Location	Seasons	Interactions
Age (years)	4.04±0.04	4.11±0.05	4.26±0.06	4.01±0.04	4.26±0.04	0.300	0.100	0.124
Live weight (kg)	402.98±7.28^{b}	379.49±7.27^{c}	453.35±7.28^{a}	397.10±6.20^{b}	426.78±5.67^{a}	0.05	0.05	0.001
Scrotal circumference (cm)	27.38±0.18^{a}	27.08±0.17^{a}	25.97±0.18^{b}	23.59±0.14^{b}	30.03±0.16^{a}	0.05	0.05	0.001

Means with different alphabets within the same rows are significantly different for the measured parameters ($p<0.05$).

Effect of Location and Season on the Hormonal Concentration of White Fulani Bulls

The results of effect of location on the hormonal concentration of White Fulani bulls studied during both dry and wet seasons at the study locations is presented in Table 2a and 2 b. Mokwa showed significantly ($p<0.05$) higher concentration of testosterone hormone (4.58±0.15) compared with Suleja and Minna. The results of effect of season on the hormone concentration of White Fulani bulls studied during both dry and wet seasons at the study locations is presented in Figure 1. The results showed that testosterone hormone concentration is significantly ($p<0.05$) affected by the season when the study was conducted compared with luteinizing hormone which showed no significant difference ($p>0.05$). It is observed that the level of testosterone hormone during the wet season was higher (3.98±4.65) compared to a lower level during the dry season (0.83±0.71).

Table 2a: Effect of Location on circulating testosterone hormone concentrations of White Fulani bulls

	Testosterone hormone (ng/ml)	**Minimum**	**Maximum**
Location			
Mokwa	4.58±0.15^{a}	4.50	5.10
Suleja	1.21±0.15^{c}	0.38	0.98
Minna	1.44±0.15^{b}	1.44	2.04
Mean	2.41±0.09	-	-
P-value	0.05	-	-
Recommended value	0.6-2.7	-	-
Significant level	***	-	-

^{abc}means with different superscripts in the same column are significant different for the parameter ($p < 0.05$)

Table 2b: Effect of Location on circulating luteinizing hormone concentrations of White Fulani bulls

	Luteinizing hormone (IU/ml)	**Minimum**	**Maximum**
Location			
Mokwa	1.57±0.33	0.77	3.08
Suleja	0.49±0.32	0.14	1.16
Minna	0.82±0.32	0.29	1.59
Mean	0.96±0.19	-	-
P-value	0.06	-	-
Recommended value	0.8-2.0	-	-
Significant level	NS	-	-

^{abc}means with different superscripts in the same column are significant different for the parameter ($p < 0.05$)

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Effect of location and season interactions on the scrotal circumference of White Fulani bulls

There was significant ($p<0.05$) interaction effects of location and season on live weight and scrotal circumference of the bulls under smallholder production system. There was significant difference in the live weight of the bulls based on location and season ($p<0.05$); there was a significant interactive effect of location and season on the live weight of the breeding bulls ($p<0.001$). Meanwhile, the average live weight of the bulls was higher during the wet season compared with dry season, because the average live weight of the bulls was 426.78±5.67 kg during wet season compared with 397.10±6.20 kg, which was the average live weight of the bull during the dry season. The scrotal circumference of the bull was 27.38±0.18 cm, 27.08±0.17 and 25.97±0.18 based on locations (Table 1). The scrotal circumference of the bull was higher for Mokwa (27.38±0.18 cm) compared to Minna and Suleja. The average scrotal circumference of the bull was higher during the wet season (30.03±0.16 cm) as compared with the dry season (23.59±0.14 cm). The interactive effect of location and season also significantly ($p<0.001$) influenced the scrotal circumference of the breeding bulls ($p<0.001$).

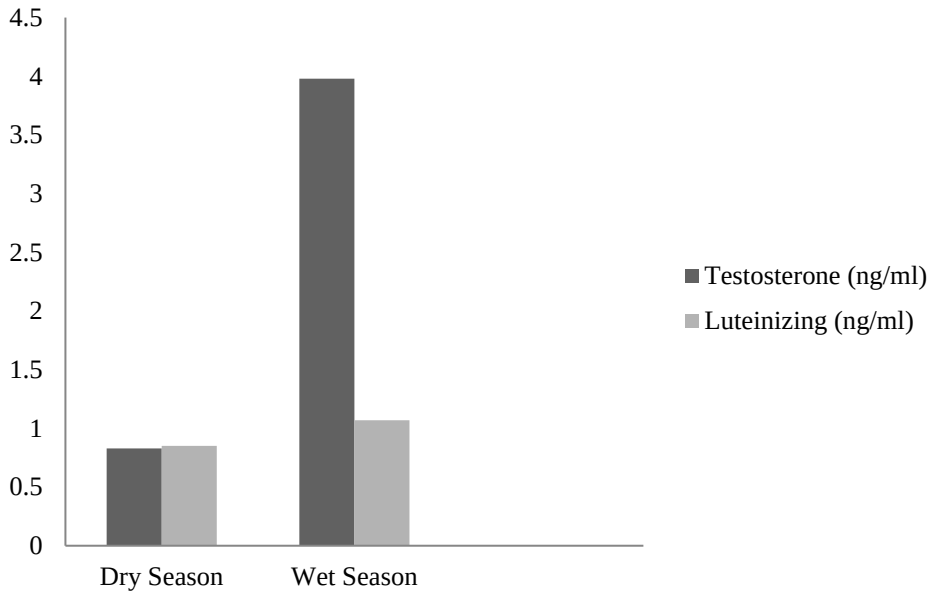

Figure 1. Effect of season on hormonal concentration of white Fulani bull

Effect of location, seasons and fertility status interactions on blood serum hormonal profiles of the bulls

There was significant ($p<0.05$) effect of location, season and fertility status interactions on blood serum hormones of the breeding bulls (luteinizing hormone and testosterone concentration) of the bulls. However, compared with other locations, the concentrations of blood luteinizing hormones and testosterone were significantly higher for the breeding bulls in Mokwa compared with other locations (Table 2a and 2b). Also, there were higher concentrations of the blood hormones during the wet season compared with concentration determined in the breeding bulls during the dry season except for luteinizing hormones. Mokwa showed significantly ($p<0.05$) higher concentration of testosterone (4.58±0.15) compared with Suleja and Minna. It is observed that testosterone was significantly higher than luteinizing hormone in all the study locations. The results showed that testosterone hormonal concentration is significantly ($p<0.05$) affected by the season when the study was conducted compared with luteinzing hormone which shows no significant difference ($p>0.05$). It is observed that the level of testosterone during the wet season was higher (3.98±4.65) compared to a lower level during the dry season (0.83±0.71) (Figure 1.). The results also showed testosterone concentration was significantly ($p<0.05$) affected by fertility status compared to luteinizing hormone whose level was not significantly ($p>0.05$) affected by the fertility status of the bull when the study was conducted. Testosterone concentration was higher (3.76±4.77) in high fertility bulls compared with low which had lower (1.06±0.87) level (Figure 2.).

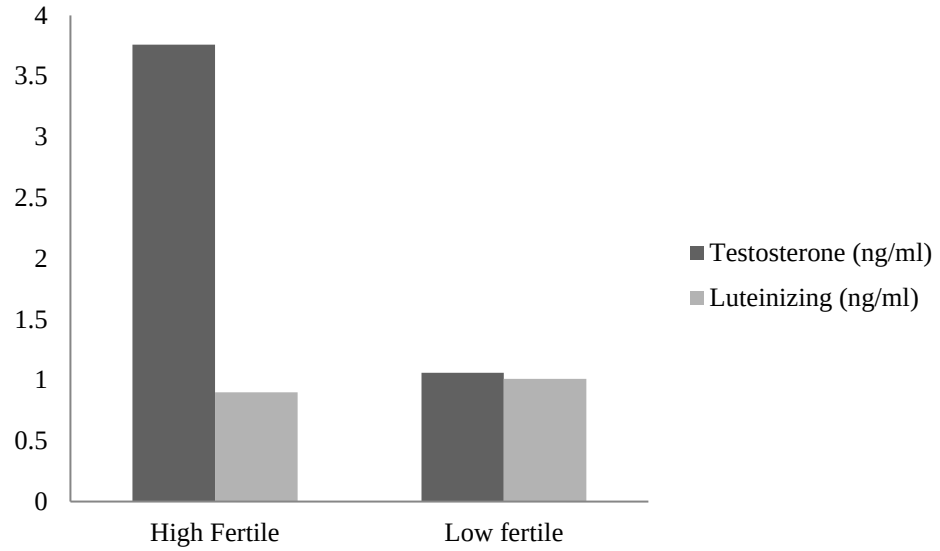

Figure 2. Effect of fertility status on hormonal concentration of white Fulani bull

DISCUSSION

Scrotal circumference and testis length are important traits in determining the reproductive potential of bulls. The scrotal circumference of a bull provides an important indication of its genetic merit for several important fertility traits (Mandal *et al*., 2022). In this study, there was a significant difference in scrotal circumference based on locations and seasons. The highest scrotal circumference and testis length were observed in Mokwa and Suleja, respectively; the highest scrotal circumference was also observed during the wet season and this is in agreement with the reports of Perumal *et al.* (2017), who observed significant effect of season on scrotal circumference in Mithun bulls with scrotal circumference being higher in spring and winter, and lowest in the summer. According to the American society of theriogenologists, a minimum scrotal circumference of 30 cm for bulls is considered as mature, regardless of the breed (Quezada-Casasola *et al.*, 2018). Increased scrotal circumference is associated with earlier age at puberty, increased semen production, improved semen quality, improved female fertility and earlier age at puberty in a bull's daughters (Mandal *et al*., 2022). The observed variations in the scrotal circumferences in the different locations could be attributed to the different temperature and rainfall pattern peculiar to each location despite been in the same Agroecological zone which could have resulted into differences in nutritional resources, management practices, and environmental factors during both seasons. The findings of this study could be useful in developing appropriate breeding and management strategies to improve the productivity and profitability of beef production systems using The observed variations in the scrotal circumferences in the different locations could be attributed to the different temperature and rainfall pattern peculiar to each location despite been in the same Agroecological zone which could have resulted into differences in nutritional resources, management practices, and environmental factors during both seasons.

The findings of this study could be useful in developing appropriate breeding and management strategies to improve the productivity and profitability of beef production systems using White Fulani bulls. The results revealed a significant difference in the scrotal circumferences based on season; bull's testes circumference was higher during the wet season compared with the dry season. The findings suggest that seasons have a significant impact on the scrotal circumference of White Fulani bulls. The White Fulani bulls in Mokwa had significantly higher concentration of testosterone compared to the other study locations; this is due to the fact that during the dry season higher number of high fertile bull was recorded as higher testosterone was found to be higher in high fertile bulls. Testosterone is directly related to fertility in males, as it guides reproductive development in fetal males, initiates puberty in adolescents, and ultimately produces reproductive capability through spermatogenesis and maintains libido in mature males (Mandal, 2014). This study was in agreement with Shatab *et al.* (2016) who recorded significantly higher testosterone concentration in their study of Endocrine Status of Serum Testosterone in breeding adult buffalo bulls. There is the need to understand the rhythmic changes and flow pattern of the endocrinological profiles to improve reproductive efficiency. The study revealed that testosterone hormone was significantly high during wet season as compared to dry season. The concentrations of testosterone observed in the study were higher than those reported in Holstein bull calves (0.49±0.66 ng/mL; Gholami *et al*., 2010), this is likely due to testosterone regulating testicular function, particularly Sertoli

cell function which also has a crucial role in the process of spermatogenesis (Griswold 2014). Recently, it has been proven that testosterone level is positively associated with sperm cell concentration and the proportion of motile spermatozoa in fertile bulls (Dasrul *et al*., 2020). The result is comparable with other reports in crossbred adult bulls (0.44 to 5.60 ng/mL; Kumar *et al*., 2006). The lower concentration of testosterone in the dry season is possibly as a result of its suppression by heat stress which could lead to decline in masculine sexual behaviour (Retana *et al*., 2014).

In this study testosterone concentration was significantly high in fertile White Fulani bulls compared to the low fertile bulls. The level of luteinizing hormone was not significant in both high and low fertile bulls. Chacur and Oba (2005), observed a positive correlation between serum testosterone concentration and fertility of bulls. They also found that animals with higher sperm motility showed, on average, also exhibit higher concentration of testosterone. Chacur and Oba (2005) observed a significant correlation between testosterone and semen characteristics and quality of semen showed high correlation with testosterone. From the results obtained in this study it was observed that low fertile White Fulani bulls had lower levels of the selected reproductive hormones than the high fertile bulls. In overall, there were significant contributions of both location and season to the reproductive phenotypic traits of the bulls including the live weight and scrotal circumference of the breeding bulls. In consonance with the scrotal circumference there was also significant contributions of both the location and season on blood serum hormones of the breeding bulls including the blood luteinizing hormone and testosterone concentration of the bulls. However, compared with other locations, the concentrations luteinizing hormone and testosterone hormone were significantly higher for the breeding bulls in Mokwa compared with other locations. Also, there were higher concentrations of all the androgens during the wet season compared with concentration determined in the breeding bulls during the dry season except for the luteinizing hormones. Hence the use of the phenotypic traits such as scrotal circumference to categorize the bulls into high and low fertile at each of the location for determining the possible interactive effect of location and season on hormonal concentrations of the high fertile or low fertile bulls. This showed there was significant effect of location and season interaction on concentrations of luteinizing and testosterone hormones between high and low fertile bulls. Similarly, based on the fertility status of the bulls, the high fertile bulls have higher concentrations of testosterone compared with the low fertile bulls.

CONCLUSION

Based on the findings from this study, phenotypic traits such as scrotal circumference, testes length and androgen concentrations including testosterone and luteinizing hormones could be used to select fertile White Fulani bull for reproductive purpose. Also, the values for blood serum hormones studied can be considered as baseline reference values for breeding *Bos indicus* bulls as a way to monitor their health status and reproductive capability. The level of androgen concentration can be affected by season and fertility in white Fulani bull due to the varying levels obtained in the two seasons and fertility status.

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