Nigerian J. Anim. Sci. 2023, 25 (2): 41-48

Location and Season Interaction on Reproductive Phenotypic Traits and Blood Biochemical Profile of White Fulani Breeding Bulls under Smallholder Production System

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***Target Audience:** Researchers, Animal breeders, Animal Producers, Students and Policy Makers*

Abstract

On-field Animal Research at three locations within Southern Guinea Savannah Agroecological Zone of Niger State of Nigeria was implemented in dry and wet seasons. The experimental animals investigated are White Fulani bulls (n=1404) kept under smallholder production system. Body weights of bulls were determined using Shaeffer's formula; the scrotal circumference and testicular length were measured. Body Condition Score (BCS) of the bulls was determined and rated on a 5-point scale (BCS=1-5). Testicular biometric measurements were used to categorize bulls into high and low fertile bulls. Blood samples were collected from 24 bulls from each of the category of fertility status established. There was significant $p<0.05$ interactions effects of location and seasons on live weight, body condition scores, scrotal circumference and testis length of the bulls ($p<0.05$). Average live weight of the bulls was higher $p<0.05$ during the wet season compared with dry season, 426.78±5.67 kg during wet season compared with 397.10±6.20 kg during the dry season. Overall, there were significant $p<0.05$ contributions of both location and season to the reproductive phenotypic traits of the breeding bulls. There were higher $P<0.05$ concentrations of blood biochemical parameters during the wet season compared with the dry season. However, compared with other locations, the concentrations of blood glucose, luteinizing hormones, testosterone, and cholesterol were significantly $p<0.05$ higher for the breeding bulls in Mokwa compared with other locations. There was significant ($p<0.05$) contributions of both the location and season interactions on blood biochemical parameters of the breeding bulls including the blood glucose, blood urea nitrogen, luteinizing hormone, testosterone and cholesterol concentration of the bulls. Similarly, high fertile bulls have higher ($p<0.05$) concentrations of blood urea nitrogen, testosterone and cholesterol compared with the low fertile bulls.

***Key word:** Scrotal circumference; Hormone; Season; Fertility; Breeding bull; Small holder system*

Description of Problem

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 main source of animal protein and income to pastoralists and other stakeholders such as butchers (7). The Tropical environments are known for their harsh climatic condition characterized by a high ambient temperature which hinders optimal performance of animals (6; 5; 4). The present work aims to establish a

relationship between reproductive phenotypic traits including the live weight, body condition, scrotal circumference, testicle length of the White Fulani bulls and their fertility status. The reproductive performance has a high economic value in beef and dairy cattle, 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 (8). Hence, the need for research that can lead to the identification of bulls with excellent potential to drive cattle improvement programmes. Having viable bulls in the herd is very important especially with the current clamour for ranching where a highly fertile bull is necessary for the success of artificial insemination programmes thereby, boosting the developmental level of the livestock industry in Nigeria. Hence, the objectives of this paper were to determine the effect of location and season on body measurements of the breeding bulls under smallholder production system using age, body condition score and testicular morphometric parameters obtained at different seasons for categorizing the bulls into high and low fertility status. Also, the study aims to evaluate the effect of fertility status and season on haematological and serum biochemical parameters of the breeding bulls.

Materials and Method

The study implemented an On-field Animal Research (OFAR) at three different locations within the Southern Guinea Savannah Agroecological Zone of Nigeria. The locations are Mokwa, Minna, and Suleja which are all located within Niger State of Nigeria while the seasons are dry (October to March) and wet (April to September). The animals investigated are White Fulani bulls (n=1404) which are being kept under the smallholder production system. The age of the animals was determined using the bulls' dentition. The randomization of sampling was done using simple random technique where age and equal numbers of bulls were assessed per season; through which a total of 1404 bulls were assessed for all the locations for both seasons.

Animal body measurements: The body length of the bulls (L) was measured in inches using calibrated meter rule while the chest girth of the bulls (G) was measured in inches too using the same calibrated meter rule.

Body weight of animal: The body weight of each bull was determined using Shaeffer's formula (10), and the obtained result was converted from pounds to kilogramme. The formula used was

$$\text{Body weight (pounds)} = L \times G^2/300$$

Where: -

L – Body length (inches)

G- Chest girth (inches)

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.

Body Condition Score (BCS): This follows physical feeling of the tissue cover at the short ribs, the spine, the hooks, pins and each side of the tail head. The body condition of the bulls was scored and rated on a 5-point scale (BCS 1-5) (3).

The records of the testicular biometric measurements of each bull were used to categorize bulls into high and low fertile bulls1) 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 each of the category of fertility (low fertile and high fertile) 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 plastic 5ml syringe of 25cm gauge into well labeled sample bottles containing Ethylene Diamine Tetra-acetic Acid (EDTA) which was used as the anticoagulant (9). For the blood samples used for biochemical analysis, 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 collection and subsequent analysis.

Data obtained from the body measurement, and testicular traits were subjected to descriptive statistic and univariate analysis of variance to determine differences in the body measurements, testicular traits, and body condition scores of the bulls at $p< 0.05$ level of probability. The testis circumference values were subjected to a scale of measurement earlier described (1). The significant difference in the means was determined at $p<0.05$ degree of level of probability, while similar means was separated using Duncan test in the post-hoc tools of the software.(SPSS v. 16.0)

Results

Effect of location and season interactions on the phenotypic traits of reproduction in the bulls

There was significant interaction effects of location and season on live weight, body condition scores, scrotal circumference and testis length of the bulls under smallholder production system ($p<0.05$). However, there was no significant interaction effects of location and season on age of the breeding bulls ($p>0.05$). Similarly, while 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 ($p<0.05$) 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 interactive effect of location and season also contributed significantly to the scrotal circumference and testis length of the breeding bulls ($p<0.001$). In overall, there were significant ($p<0.05$) contributions of both location and season to the reproductive phenotypic traits of the bulls including the live weight, body condition scores, scrotal circumference, and the testis length of the breeding bulls (Table 1).

Effect of location and seasons interactions on serum biochemical profiles of the bulls

Apart from the phenotypic traits, there was also significant contributions of both the location and season interactions on blood biochemical parameters of the breeding bulls including the blood glucose, blood urea nitrogen, luteinizing hormone, testosterone and cholesterol concentration of the bulls ($p<0.05$). However, compared with other locations, the concentrations of blood glucose, luteinizing hormones, testosterone, and cholesterol were significantly higher for the breeding bulls in Mokwa compared with other locations (Table 2). Also, there were higher ($p<0.05$) concentrations of all the blood biochemical parameters during the wet season compared with concentration determined in the breeding bulls during the dry season except for the blood urea nitrogen and luteinizing hormones.

Table 1 Phenotypic traits of the White Fulani bulls based on locations, seasons, and their interactive effects

Parameters	Location			Season			p-value		
	Mokwa	Suleja	Minna	Dry	Wet	Mean	Location	Seasons	Interactions
Age (years)	4.04±0.04[b]	4.11±0.05[a]	4.26±0.06[a]	4.01±0.04	4.26±0.04	4.14±1.03	0.003	0.001	0.124
Live weight (kg)	402.98±7.28[b]	379.49±7.27[c]	453.35±7.28[a]	397.10±6.20	426.78±5.67	411.94±7.28	0.003	0.001	0.001
Body condition scores	3.22±0.03[b]	3.16±0.04[b]	3.51±0.04[a]	3.29±0.04	3.30±0.03	3.30±0.04	0.001	0.805	0.01
Scrotal circumference (cm)	27.38±0.18[a]	27.08±0.17[a]	25.97±0.18[b]	30.03±0.16	23.59±0.14	26.81±0.15	0.003	0.001	0.001
Testis length (cm)	26.03±0.20[b]	27.33±0.22[a]	23.80±0.21[c]	20.98±0.18	30.46±0.16	26.14±0.17	0.003	0.001	0.001

Table 2: Comparative Effect of Locations and Seasons on the blood expression of reproductive hormones, glucose, urea nitrogen and cholesterol of the bulls

	Blood glucose	Blood urea nitrogen	Luteinizing hormone	Testosterone hormone	Cholesterol concentration
Locations					
Mokwa	5.84±0.24[a]	36.65±0.49[a]	1.52±0.36	4.58±0.10[a]	3.68±0.06[a]
Suleja	3.98±0.23[b]	36.12±0.43[a]	0.48±0.20	1.20±0.15[b]	2.35±0.05[b]
Minna	2.84±0.29[c]	33.05±0.40[b]	0.82±0.30	1.43±0.10[b]	2.44±0.02[b]
Mean	4.22±0.25	35.27±0.44	0.94±0.29	2.41±0.12	2.82±0.04
Seasons					
Dry	3.16±0.16	34.72±0.38	1.06±0.26	0.83±0.12	2.03±0.06
Wet	5.27±0.19	35.16±0.40	0.85±0.20	3.98±0.10	3.61±0.04
Mean	4.22±0.18	34.94±0.39	0.96±0.23	2.81±0.11	2.82±0.05
Fertility status					
High fertile	4.13±0.16	33.81±0.35	0.90±0.26	0.90±0.26	2.56±0.06
Low fertile	4.30±0.19	36.07±0.38	1.03±0.27	1.05±0.10	3.08±0.04
Mean	4.22±0.18	34.94±0.37	0.97±0.27	0.98±0.18	2.82±0.05
p-values					
Locations	0.001	0.001	0.062	0.001	0.001
Seasons	0.001	0.381	0.773	0.001	0.001
Fertility status	0.55	0.001	0.569	0.001	0.001
Location-season interaction	0.001	0.001	0.012	0.001	0.001

There was significant ($p<0.05$) difference in the ages of the bulls used for breeding with respect to location or seasons when the study was carried out; this implies that all the livestock producers use bulls within the same age range for breeding purposes. Hence the use of the phenotypic traits of scrotal length and testis 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 the blood biochemical profiles of the high fertile or low fertile bulls. This showed there was significant effect of location and season interaction on concentrations of blood glucose, blood urea nitrogen, luteinizing hormone, testosterone, and cholesterol between high and low fertile bulls ($p<0.05$). Similarly, based on the fertility status of the bulls, the high fertile bulls have higher concentrations of blood urea nitrogen, testosterone and cholesterol compared with the low fertile bulls ($p<0.05$).

Discussion

The study provides important insights into the variation in these traits (weight, body condition, scrotal circumference and testicular length) among the study locations and seasons. Age is an essential trait that determines the reproductive performance of bulls (2). In this study, the average age of the bull was higher in Minna than in Mokwa and Suleja; and during the wet season, the average ages of the bulls were higher compared with the dry season. This observation agrees with the submissions of (12), which suggested that seasonal changes could have significant impact in growth of and development of cattle under smallholder operations because of their dependence on natural grassland (11). The observed trends could be due to improved nutrition during the wet season, which might have led to better growth of the bulls; and possibility of the cattle owners to introduce older new animals into the herds (12).

The scrotal circumference and testis length are important traits in determining the reproductive potential of bulls. This is because, the scrotal circumference has been described as a non-gonadal and linear type trait that be used to discriminate reproductive ability of breeding dairy bulls (13). In this study, there was a significant difference in scrotal circumference and testis length based on locations, seasons, and interactive effects of location and season. The highest scrotal circumference and testis length were observed during the dry season, which could be because of the effect of high temperatures on scrotal development and function. The implications of this observation can be linked to increase temperatures and heat tolerance capabilities of the White Fulani bulls. This is because cattle are sensitive to high ambient temperature, although, it can negatively impact the sperm production and testicular function (14). However, as a heat-tolerance adaptation trait during the dry season, the increase in scrotal circumference and testis size could be regarded as a compensatory response to regulate testicular temperature and maintain optimal sperm production in the bulls (15).

The results of this study provide insights into the variation in phenotypic traits of White Fulani bulls among different locations and seasons. The study examined the effect of fertility status of bulls on their blood biochemical profiles and found significant differences in some blood biochemical parameters. Specifically, Blood Urea Nitrogen (BUN) was higher in low fertile bulls during the rainy season, and the highest BUN was found in bulls investigated at Minna based on locations. Additionally, there was a significant increase in blood glucose of the bulls irrespective of their fertility status, based on the interactive effect

of the season and location. The elevated BUN levels may indicate an imbalance between protein intake and utilization, or increased protein breakdown which could imply that, low fertility bulls may have compromised nitrogen utilization or increased protein catabolism during the rainy season (16). This finding highlights the importance of considering the fertility status of bulls when assessing their nutritional needs and management practices (17).

Furthermore, the fact that BUN levels were influenced by the rainy season indicates a seasonal variation in nitrogen metabolism which could imply that environmental factors such as changes in forage quality, availability, or dietary composition during different seasons can affect the nitrogen balance in cattle (18). Therefore, an understanding of these seasonal variations in BUN can aid in developing appropriate feeding strategies and nutritional management plans for cattle to optimize their productivity and health (19). The concentration of bilirubin also varied depending on fertility status and season, with the lowest concentration observed in high fertile bulls during the rainy season. Bilirubin is a product of the breakdown of haemoglobin in red blood cells and is primarily excreted through bile. Elevated levels of bilirubin can indicate liver damage or dysfunction and the observed decrease in bilirubin concentration during the rainy season in high fertile bulls may be due to their better nutritional status, leading to improved liver function and metabolism (20). The concentration of cholesterol varied depending on fertility status and season, with the highest concentration observed in high fertile bulls during the rainy season. Cholesterol is a major component of cell membranes and plays an important role in hormone synthesis and metabolism. The observed increase in cholesterol concentration during the rainy season in high fertile bulls may be due to an increase in their metabolic activity and the synthesis of reproductive hormones.

The concentration of blood glucose varied depending on fertility status and season, with the highest concentration observed in low fertile bulls during the dry season. Glucose is the primary source of energy for the body and is regulated by insulin and other hormones. The observed increase in blood glucose concentration in low fertile bulls during the dry season may be due to their poorer nutritional status and a higher demand for energy due to increased metabolic activity. The concentration of circulating luteinizing hormone varied depending on fertility status and season, with the highest concentration observed in low fertile bulls during the dry season. Luteinizing Hormone (LH) is a reproductive hormone that plays a crucial role in the regulation of reproductive function (21). The observed increase in LH concentration in low fertile bulls during the dry season may be due to an increase in the demand for reproductive hormones, as low fertile bulls may have lower levels of reproductive hormones than high fertile bulls (22). In summary, the study found significant differences in various blood biochemical parameters in bulls based on fertility status, season, and study location. These findings suggest that these factors should be taken into account when evaluating the health and reproductive status of bulls. It is also important to note that the observed differences in blood biochemical parameters may be attributed to various environmental and nutritional factors, and further research is needed to elucidate these relationships.

Conclusion and Applications

1. Phenotypic traits such as scrotal circumference and testes length could

be used to select fertile White Fulani bull for reproductive purpose. The study also showed that these phenotypic traits are influenced by seasons as varying values for the traits were recorded during the two seasons. The study provides an insight into the variations in phenotypic traits of White Fulani bull at different seasons.

2. The outcome of the study also showed that all the serum biochemical profile falls within the normal range for healthy cattle, which according to Isaac, *et al*., 2013, that animal with good haematology and serum biochemical constituents may have improved reproductive performance.
3. The values for serum biochemical attributes studied in this work can be considered as baseline reference values for breeding Bos indicus bulls as a way to monitor their health status. 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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