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Reproductive soundness in Uda rams: The role of horn and scrotal morphology

Muritada[1], I. O., Jayeola[1], O. E., Otu[1], B. O., Sikiru[2] A. B. and Egena[1*], S. S. A.
[1]*Department of Animal Production Technology, Federal University of Technology, Minna, 920001, Niger State, Nigeria.*
[2]*Department of Animal Science, Federal University of Agriculture, Zuru 872101, Kebbi State, Nigeria*

***Corresponding Author:** acheneje.egena@futminna.edu.ng,__**Phone Number**: +2348033117407*

Abstract

The study was conducted to determine the possible relationship between some morphological traits and reproductive soundness of 185 Uda rams from three different locations: Saki and Ago-Are (Oyo state), and Ilesha-Ibariba (Kwara state). Data was collected on horn length, horn circumference, and scrotal circumference using a flexible tape. The data was subjected to descriptive statistics, correlation, analysis of variance and regression analysis. The mean values obtained for horn length, horn circumference and scrotal circumference were 27.44, 16.40, and 29.24cm, respectively. Horn circumference had the highest coefficient of variation (51.22%), while scrotal circumference had the least (21.37%). Horn length correlated significantly and positively with horn and scrotal circumference (r = 0.514, P<0.001; r = 0.446, P<0.01, respectively). Horn circumference and scrotal circumference also showed positive and significant correlation (r = 0.238, P<0.05). The location of the farmers had an effect (P<0.001; 0.008) on horn length, horn circumference and scrotal circumference, respectively. The results also showed a positive relationship among horn length, horn circumference, and scrotal circumference of the Uda rams; rams with longer horns were found to have thicker horns and larger scrotal sizes (R^2 = 0.27 and 0.19), while the link between horn circumference and scrotal size was weaker (R^2 = 0.06). It was concluded that the horn morphometric traits evaluated in the study could serve as a simple physical sign of assessing the reproductive ability of Uda rams due to their positive correlation with scrotal circumference.

Key words: *Circumference, length, location, morphometry, Uda ram, relationship.*

Introduction

The livestock sector is one of the fundamental pillars of sub-Saharan African agricultural economies because it generates about 30–40% of the agricultural Gross Domestic Product (GDP) while providing support for more than 60% of rural livelihoods (Otte and Chilonda, 2002). Smallholder farmers and pastoralists have maintained control over the livestock sector in Nigeria where the 43 million sheep they keep have helped in providing a substantial part of the meat, milk and wool output (FAO, 2021). Among Nigerian indigenous breeds of sheep, the Uda which is a hardy, long-legged animal, is native to the Sahelian belt where it stands out not only for its adaptability to the arid climates, its resistance to endemic diseases like *Peste des Petits Ruminants* (PPR), but also its cultural significance to those keeping them. It is also found in southern Niger, central Chad, northern Cameroon, and western Sudan; it is classified as hair sheep breed, a meat breed with distinctive markings (the front half of the body is either black or brown, and the back half is white); the rams of the Uda are horned and the ewes are usually polled (Mason, 1996). Rams of the Uda breed with their massive spiral horns and substantial

body structure and face, have special value because they serve as sacrificial animals during cultural occasions; they also represent an important genetic resource (Blench, 1999).

The essential trait determining animal breeding success called reproductive soundness depends to a large extent on the genetic makeup, hormonal patterns, and environmental elements like nutrition and herd management practices (Martin *et al.*, 2004**;** Shorten *et al.,* 2021; Coate *et al.*, 2022**)**. Reproductive soundness is measured using a variety of methods: physical examination, reproductive organ examination, scrotal circumference measurement, semen quality evaluation, disease screening, and evaluation of libido and mating ability (Abuelo, 2025). Horn size together with scrotal circumference could establish themselves as essential phenotypic traits for monitoring reproductive performance in farm animals. The biological research community have for long, considered horns only as weapons that show genetic fitness and testosterone levels in ruminants (Bro-Jørgensen, 2007) as it function as a sexual feature that aid in fitness signalling. Horns have been linked to male virility and pastoralists choose breeding males based on their horn size (Dixon *et al.*, 2014). Also, dominance ranking linked to horn size in Bighorn sheep (*Ovis canadensis*) was reported by Hogg (1984). Studies by Geist (1966) had however, supposed that horn enlargement will lead to a reduction of reproductive organ development. Conversely, scrotal circumference (a non-invasive, easily measurable trait) is a well-established biomarker of testicular function, semen quality, and sperm production capacity; a size of 30cm or larger scrotal circumference has been reported to lead to enhanced sperm concentration, motility and conception rates in rams making this trait to be a possible foundation for contemporary ram selection programme (Evans and Maxwell, 1987).

Investigations on Dorper, Merino, and other sheep breeds show that, scrotal circumference is strongly linked to reproductive success (Duguma *et al.,* 2002; Ramao *et al.,* 2023). Similar studies on the Uda and other indigenous African sheep breeds are however, relatively scarce which results in an essential knowledge deficit in this area. While some information could be gleaned from research on Yankasa rams (Osinowo *et al.,* 1982; Osinowo *et al.,* 1988; Bello *et al.,* 2020), the results may not automatically apply to the Uda ram. Researchers have also studied external factors such as feed quality, parasitic load (Chiejina and Behnke, 2011), and heat stress (Marai *et al.,* 2007) effect on Uda rams. However, studies on how the relationship between certain intrinsic phenotypic characteristics (horn size and scrotal measurements) could help in the understanding of ram fertility is still inadequate. This deficiency in information has prevented breed-specific breeding strategies from being developed and thus, farmers have continued to use largely anecdotal methods that could miss optimal reproductive opportunities.

Even though works on the possible usage of horn morphometry to decide on the reproductive soundness of Uda rams is scarce, it is the thought of this authors that, it could be applied via an indirect route; that is, taking advantage of possible relationships with other traits that have been reported as yardstick for measuring reproductive ability in animals. This way, farmers may be able to easily predict the reproductive soundness of farm animals by a simple measure of the horns. Scrotal morphometry comes to mind, because of its reported positive correlation with fertility attributes including semen quantity and quality, hormonal levels, and breeding capacity of farm animals (Fourie *et*

al., 2004; Koyunku *et al.*, 2005; Camela *et al.*, 2018; Ramírez-Bautista *et al.*, 2023). Such connection and understanding of the magnitude of the relationship could play crucial roles in predicting reproductive fitness at the farm level. If this relationship is established, it is clear that more effective selection and breeding can be achieved due to its practicability and applicability. The study is therefore, aimed at clarifying the relationship between horn length, horn circumference, and scrotal circumference, and their possible effect on the reproductive fitness of Uda rams.

Materials and Methods

The study was conducted in three strategically selected locations within Nigeria, each representing a distinct agro-ecological zone and management systems. These are: Saki (8.6726° N, 3.3943° E) located in Oyo State. Saki is characterized by a tropical climate with an average annual rainfall of 1,200mm and temperature ranging from 25 to 35° C. The area is known for its mixed crop and animal farming system. Its relatively high rainfall supports year-round grazing, making it suitable for semi-intensive and intensive management systems. Ago-Are (8.5173° N, 3.4183° E) is also situated in Oyo State. It is a rural community with extensive pasture lands, making it suitable for both intensive and extensive livestock management systems. The area experiences a bimodal rainfall pattern, with peaks in June and September, providing ample forage during the wet season but, requiring supplementary feeding during the dry season. Ilesha-Ibariba (8.9144° N, 3.4246° E) is located in Kwara State, a part of Nigeria's Guinea savannah zone, with an average annual rainfall of 800 mm and temperatures reaching 40° C during the dry season. The area is predominantly pastoral, with Uda rams being raised under the traditional extensive system of management. The harsh climatic conditions and limited forage availability makes this location ideal for studying the resilience of Uda rams. These locations were chosen to ensure a fairly broad representation of Uda rams across different environmental and management contexts, enhancing the generalizability of the study's findings.

Data was collected from a total of 185 Uda rams purposively selected from the three study locations. Measurements were taken on the morphometric parameters of interest, namely: horn length, and horn and scrotal circumference; all were measured using a flexible measuring tape. Horn length was measured as the distance from the base of the horn to the tip of the horn, while horn and scrotal circumference were measured at the widest part of the horn and the scrotum, respectively. Data obtained from the morphometric traits were recorded in Microsoft Excel, and the means standard deviations and coefficient of variations were obtained. The data was further amplified via Monte Carlo simulation in Microsoft Excel making use of the means and standard deviations to a sample size of 2000 in order to obtain a larger representation. The effect of location of the study on the measured morphometric traits was evaluated using one-way analysis of variance. Pearson correlation analysis was used to evaluate the relationship between horn and scrotal traits, and predictive models were also generated; both using the SPSS statistical software. The predictive model was specified as follows:

$Y = \beta 0 + \beta 1X1 + \epsilon$

Where Y is the dependent variable, X1 is is the independent variable, $\beta 0$ is the intercept, $\beta 1$ is the regression coefficients, and ϵ is the error term.

Results

Table 1 shows the descriptive statistics of the morphometric traits. The

mean horn length was 27.44cm, horn circumference was 16.40cm, and scrotal circumference was 29.24cm, respectively. Horn circumference varied most with coefficient of variation of 51.22%. This was followed by horn length with coefficient of variation of 30.86%, while scrotal circumference varied the least with coefficient of variation of 21.37%.

Table 1: Descriptive statistics (mean, standard deviation, minimum and maximum values, coefficient of variation) of morphometric traits of Uda rams

Parameter	HL (cm)	HC (cm)	SC (cm)
Mean	27.44	16.40	29.24
Standard Deviation	8.47	4.26	6.25
Minimum	12.40	8.60	16.00
Maximum	45.00	29.30	41.00
CV (%)	30.86	51.22	21.37

CV = Coefficient of variation; HL = Horn length; HC = Horn circumference; SC = Scrotal circumference.

The effect of location on the horn length, horn circumference and scrotal circumference of Uda rams is presented in Table 2. The results showed clear differences in the traits across the locations. Rams from Ago-Are and Saki had longer ($p<0.001$) horns; Ago-Are rams also had the widest ($p<0.001$) horn (18.79cm), followed by those from Saki (16.04cm), while the least was observed for rams sampled in Ilesha-Ibariba (13.62cm). In terms of scrotal circumference, Ago-Are rams also recorded the highest ($p<0.001$) value (31.12cm), Ilesha-Ibariba rams had the intermediate value (29.98cm), and the least was recorded for rams from Saki (27.94cm).

Table 2: Horn length, horn circumference and scrotal circumference of Uda rams as affected by location

Parameter	HL (cm)	HC (cm)	SC (cm)
Saki	27.30^{a}	16.04^{b}	27.94^{b}
Ago-are	30.75^{a}	18.79^{a}	31.12^{a}
Ilesha	22.57^{b}	13.62^{c}	29.98^{ab}
Standard error	0.62	0.31	0.46
P-value	0.001	0.001	0.008

$^{abc:}$ Means along the same column with different superscripts are significantly different ($P<0.001$; 0.008); HL = Horn length HC = Horn circumference; SC = Scrotal circumference

The correlation coefficient between the measured morphometric traits is presented in Table 3. It ranged from r = 0.238 to r = 0.514. The correlation coefficients between the traits were highly significant ($P<0.01$). The highest correlation was observed between horn length and horn circumference (r = 0.514), while the least was observed between horn circumference and scrotal circumference (r = 0.238). The results of the association between horn length, horn circumference and scrotal circumference are shown in Table 4. Horn circumference was observed to be the best predictor of horn length (R^2 value of 0.27). The best predictor for horn and scrotal circumference was horn length (R^2 value of 0.27 and 0.19, respectively).

Table 3: Correlation between horn length, horn circumference and scrotal circumference of Uda rams

Parameter	HL	HC	SC
HL	-		
HC	0.514**	-	
SC	0.446**	0.238**	-

**(P<0.01); HL = Horn length; HC = Horn circumference; SC = Scrotal circumference.

Table 4: Predictive equation showing the association between the measured traits Uda rams

Parameter	Equation	SE	R^2	L.S
Horn length (cm)	10.66 + 1.02HC	2.13	0.27	***
	9.74 + 0.60SC	2.68	0.19	***
Horn circumference (cm)	9.29 + 0.26HL	0.91	0.27	***
	1.16 + 0.16SC	1.46	0.06	***
Scrotal circumference (cm)	20.24 + 0.33HL	1.40	0.19	***
	23.53 + 0.35HC	1.78	0.06	***

SE = Standard error; R^2 = Coefficient of determination; LS = Level of significance (P<0.001).

Discussion

The characterization of the Uda rams threw some light on the phenotypic traits studied. The values obtained for the traits (horn length and circumference, scrotal circumference) will form a reference baseline for the sampled Uda rams. The value obtained for scrotal circumference is greater than the 24.51cm reported for the same sheep breed in northern Benin republic by Benoit *et al*. (2016). The higher coefficient of variation of horn circumference reflects a marked phenotypic variance in this trait across the studied locations, and such variance has been reported to be a prerequisite to embarking on any selection and genetic improvement programme (Falconer and Mackay, 1996). The differences observed in the traits evaluated, implies the existence of a genetic and environmental influence on their expression in the Uda rams. This observed difference among the groups is supported by the findings of Aljameel *et al.* (2022) who while evaluating the body morphometry of Uda rams under different housing types and seasons in a semi-arid region of Nigeria reported that, location had an effect on the morphometry linked to nutritional, climatic, genetic, and management system variations. In the current study, Uda rams sampled at Ago-Are and Saki showed better horn and scrotal measurements, which could be explained either by their access to better nutrition and the local microclimate advantages. It could well be that, the presence of high-quality feed, extensive veterinary support, and the maintenance of genetic superiority were all working together to produce the results. Sejian *et al.* (2017) had also reported on the impacts of environmental stressors (ambient temperature, relative humidity and forage availability) on growth and reproductive characteristics of sheep and goats. The relatively low measurements observed for rams sampled at Ilesha-Ibariba could either be due to poor environmental conditions, or as a result of dilution of genes. On the whole, these findings support the idea that livestock productivity can best be enhanced by location-specific breeding and management guidelines (Notter, 2012).

Positive correlations were observed

between the length of horn, horn circumference and scrotal circumference implying that the traits are functionally related. Probable causes are related to co-genetic regulation, or co-environmental effects. Therefore, selection and improvement of any of the traits will impact positively on the other trait. The moderate phenotypic relationships between the traits could mean that, the indirect measurement of a male secondary sexual characteristics (such as horn morphometry in this case) could turn out to be an effective non-invasive measure of the reproductive soundness of the animal (Safari *et al.,* 2005). This is due to the positive and highly significant correlation observed between the horn traits and scrotal circumference. Also, studies have revealed that in rams, a positive correlation exist between horn and scrotal morphometry, and also with the age and body size of Yankasa rams (Akpa *et al.,* 2006). Sperm motility has also been associated with horn quality (Santiago-Moreno, 2007).

The predictive equations produced further revealed the existence of close correlation between horn length and horn circumference with R^2 value of 0.27. Additionally, HL also predicted the circumference of the scrotum. These results imply that proxies of the reproductive characteristics of Uda rams based on simple non-invasive measurements of horn length and horn circumference, could be used as reliable measures of reproductive soundness and this knowledge ultimately, could be applied to aid selection in low-input conditions. Akpa *et al.* (2006) had opined similarly that, the coefficient of determination relating ram age and body weight to scrotal size and horn development in their study, are indications that more of the variations in scrotal size and horn development could be attributed to their linear relationship with ram age; hence, both could be used as measures of sexual maturity. The relatively low coefficients of determination observed in the study however, are indications that possibly, some other factors (could be genetics, nutrition, health status, and others not explained) that could have contributed more to the phenotypic variations observed were not evaluated. On the basis of this, it is advisable that multiple traits be included in selection programmes and that, environmental effects should seriously be considered in such programmes. This way; genetic gain can be maximized leading to improvement in reproductive performance (Falconer and Mackay, 1996).

Conclusion

The findings revealed that:

i. Horn circumference having varied the most, suggests that it may be the most responsive to environmental and genetic influences among the parameters measured in the rams.
ii. A positive and significant correlation was observed between horn length, horn circumference and scrotal circumference.
iii. These relationships suggest that horn development may reflect aspects of the animal's reproductive potential and hormonal pathways influencing both horn growth and testicular development.
iv. Based on the combined analysis of all parameters, horn circumference emerged as the most adequate predictor of reproductive soundness in Uda rams, and can serve as a useful physical indicator for selecting Uda rams with superior reproductive potential.

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