



## Adoptable Formulae for Estimating Testicular Volumes Using Ultrasound Biometrics in Red Sokoto Goat Bucks

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### ARTICLE INFO

### ABSTRACT

#### Article history

Received: 07 Jan 2021

Accepted: 10 Mar 2021

Published: 30 Mar 2021

#### Keywords

Biometrics, Electronic caliper, Testicular volume, Bucks,

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The purpose of this study was to determine the adoptable formula for estimating testicular volume by ultrasound in the Red Sokoto Goat (RSG) bucks. Sixteen RSG bucks comprising of eight pubertal and eight post-pubertal bucks were used for this study. With the aid of the ultrasound electronic caliper, the bucks' testicular length, height and width were measured. These parameters were used to estimate Testicular Volumes (TV) using the Prolate Spheroid Formula (PSF), Prolate Ellipsoid Formula (PEF) and the Lambert Formula (LF). The TV obtained from these formulae were then compared with the true TV which was obtained using the Water Displacement Method (WDM). Results revealed that there were no significant differences in the TV estimated using the three formulae when compared with true TV for the post pubertal bucks. The TV estimated using PEF was significantly lower than the true TV estimated by WDM for the pubertal bucks ( $p < 0.05$ ). In conclusion, by ultrasound biometrics, PSF, PEF and LF were suitable for estimating TV for post pubertal RSG bucks, however, PEF was not suitable for pubertal RSG bucks.

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### Introduction

The Red Sokoto Goat (RSG) is an excellent source of protein in terms of meat and milk. It is one of the three major breeds of goats commonly reared in Nigeria. It is most populated in the Northern part of Nigeria (Akpa *et al.*, 2002; Maidu *et al.*, 2010). It is part of the small ruminants' population popularly referred to as the "cattle of the poor" because its rearing is peculiar to low income earners usually in the rural settings (Taiwo *et al.*, 2005; Adebayo and Chineke, 2011). Therefore, improving on RSG production will definitely go a long way in alleviating the challenges of protein deficiency particularly amongst the poor population as affordable protein and income will be readily available (Kues and Niemann, 2004; Anaeto *et al.*, 2010).

The RSG buck (typical of a male livestock) constitute about half of the reproductive capacity of the RSG farm and serves many does on the farm; at least at a ratio of 1:5 (Akpa *et al.*, 2010). Therefore, regular assessment of its reproductive capability is of utmost importance for

maximum production purposes. This is usually done using the Breeding Soundness Examination (BSE) protocol (Memon *et al.*, 2007; Ford *et al.*, 2009; Tibary *et al.*, 2018). In recent times, testicular ultrasound is being adopted into this protocol for male animals (Kollin *et al.*, 2006; Ali *et al.*, 2011; Carazo *et al.*, 2014; Saeed and Zaid, 2018). Also, this method has been used to take important testicular biometric parameters such as testicular volume - an index of spermatogenesis (Paltiel *et al.*, 2002; Sotos and Tokar, 2012; Raji *et al.*, 2016). However, there are no reports to this effect in the RSG buck. Therefore, this present study was carried out to determine the adoptable formula for estimating testicular volume by ultrasound in the RSG bucks for improved production purposes.

### Materials and Methods

#### Animals

Sixteen RSG bucks were acquired and divided into two groups comprising of group A – pubertal bucks ( $n = 8$ ) and group B – post pubertal bucks ( $n = 8$ ). These age

### Cite This Article

Raji, L.O., Osuagwuh, U.I., Amid, S.A., Mustapha, R.A. 2021. Adoptable Formulae for Estimating Testicular Volumes Using Ultrasound Biometrics in Red Sokoto Goat Bucks. *Journal of Bangladesh Agricultural University*, 19(1): 73–77. <https://doi.org/10.5455/JBAU.41471>

categories were determined by a preliminary study in which the bucks were electro-ejaculated and semen collected were analyzed. The RSG bucks that spermatozoa were observed in their ejaculate for the first time were categorized as pubertal bucks (six-month old bulks) while those that the semen characteristics were similar to those described in a study on West African Dwarf bucks (Raji and Ajala, 2015) for fully matured bucks were categorized as the post pubertal RSG bucks (two-year old bulks). The bucks were kept and stabilized at the goat unit of the Faculty of Veterinary Medicine, University of Ilorin, Ilorin, Kwara State, Nigeria.

#### Testicular ultrasound and biometrics

The mobile ultrasound machine (4Vet Mini made by Draminski) was used in this study. The bucks were properly restrained; the testes were thoroughly cleaned with cotton wool soaked in methylated alcohol before ultrasound gel was generously applied on them. The testes were not shaved because the hair on them were not significant enough to cause any obstruction to the sonogram. Testicular ultrasound was carried out on transverse and longitudinal planes on the right and left testes. The electronic caliper on the ultrasound machine was used to take important parameters such as testicular width, length, height and volume.

#### Testicular width

This was measured on the Transverse Plane as (TP) as the widest diameter between the lateral and the medial aspects of the testis (Figure 1).

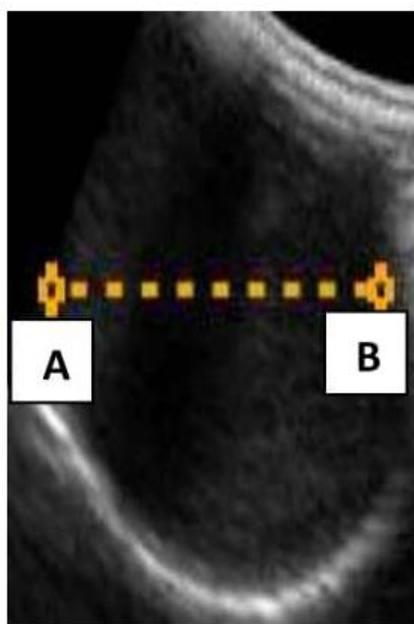


Figure 1. Sonogram showing the width of testis of red Sokoto goat buck (A-B) on transverse plane.

#### Testicular length

This was measured on the Longitudinal Plane (LP) as the distance between the most cranial part and most caudal part of the testis using the ultrasound electronic caliper (Figure 2).

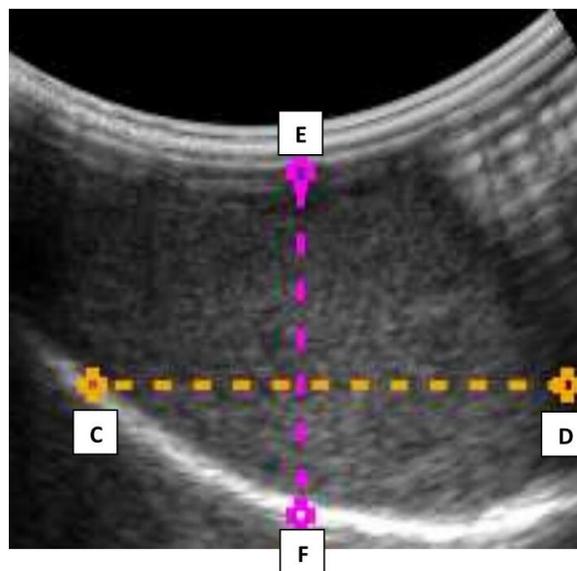


Figure 2. Sonogram showing the length (C-D) and height (E-F) of red sokoto buck testis (A-B) on longitudinal plane.

#### Testicular height

This was measured on the LP as the distance between the highest ventral points to the lowest dorsal points on the testis (Figure 2).

#### Testicular volume

Testicular Volume (TV) was then estimated from the Testicular Width (TW), Length (L) and Height (H) using the Prolate Ellipsoid Formula (PEF), Prolate Spheroid Formula (PSF) and Lambert Formula (LF) as described earlier (Sotos and Tokar, 2012; Raji *et al.*, (2016). The formulas are as follows:

The Prolate Ellipsoid Formula (PEF) =  $L \times H \times W \times 0.52 \text{ cm}^3$

The Prolate Spheroid Formula (PSF) =  $L \times W^2 \times 0.52 \text{ cm}^3$

The Lambert Formula (LF) =  $L \times H \times W \times 0.71 \text{ cm}^3$

The TV obtained by testicular ultrasound were then compared with the true testicular volumes obtained by the Water Displacement Method (WDM). The WDM was done as described earlier by Raji *et al.*, (2016). Briefly, the testes were harvested, separated from the epididymides and put in calibrated measuring cylinder filled with normal saline. The volume of normal saline the testis displaced, was taken as its volume, representing the true testicular volume.

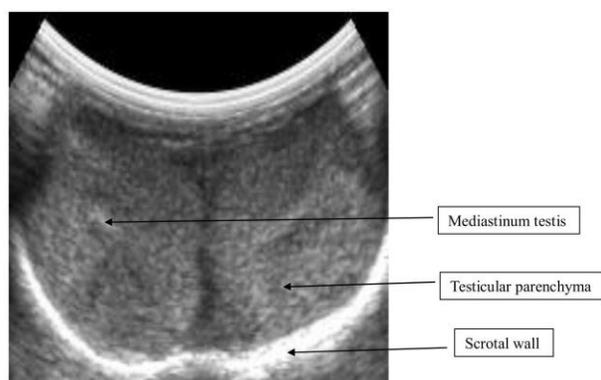


Figure 3. Sonogram of the testes of post pubertal red Sokoto buck showing the mediastinum testis, testicular parenchyma and scrotal wall.

### Statistics

Data obtained were expressed as means  $\pm$  standard deviation. One-way Analysis of Variance (ANOVA) followed by Dunnett's *post hoc* test and independent samples t-test were used to analyze the data. Values of  $p < 0.05$  were considered significant.

### Results

The results of testicular ultrasound biometrics for the pubertal and post pubertal RSG bucks were as presented on Tables (1-5). Table 1 and Table 2 show the testicular

volumes estimated using the WDM, PSF, PEF and LF for each of the right and left testes for the pubertal and post pubertal bucks respectively.

Table 3 shows the comparison of true testicular volumes of both testes for the pubertal bucks obtained using the WDM with the testicular volumes obtained using the PSF, PEF and LF. There were no significant differences in the TV estimated using the PSF ( $p = 0.00$ ) and LF ( $p = 0.01$ ) when compared with the true TV obtained using the WDM. The testicular volume estimated using the PEF was significantly lower ( $p = 0.08$ ) than those obtained using the WDM in the pubertal bucks.

Table 4 shows the results for the post pubertal RSG bucks true TV obtained using the WDM compared with the TV obtained using the PSF, PEF and LF. There were no significant differences in the TV estimated using PSF ( $p = 0.00$ ), PEF ( $p = 0.01$ ) and LF ( $p = 0.03$ ) methods when compared to that obtained using the WDM.

Table 5 shows a comparison of the TV estimated using the WDM, PSF, PEF and LF for pubertal and post pubertal bucks. The mean TV obtained using the WDM, PSF, PEF and LF were all significantly higher ( $p < 0.05$ ) in post pubertal bucks compared to those of the pubertal bucks.

Table 1: Estimation of testicular volumes of pubertal goat bucks (mean  $\pm$  SD) of the right and left testes by ultrasound using the prolate ellipsoid formula, prolate spheroid formula, Lambert formula and compared with true testicular volume estimated using the water displacement method.

Goats	RT-TV-WDM (cm <sup>3</sup> )	RT-TV-PSF (cm <sup>3</sup> )	RT-TV-LF (cm <sup>3</sup> )	RT-TV-PEF (cm <sup>3</sup> )	LT-TV-WDM (cm <sup>3</sup> )	LT-TV-PSF (cm <sup>3</sup> )	LT-TV-LF (cm <sup>3</sup> )	LT-TV-PEF (cm <sup>3</sup> )
1	40.1	39.5	44.3	29.4	39.4	40.3	43.9	30.1
2	39.0	38.3	42.7	29.2	39.6	39.1	41.8	28.7
3	36.1	35.6	40.7	30.0	37.0	36.5	39.6	29.6
4	42.3	41.9	47.0	34.4	41.2	40.7	46.5	35.2
Mean ( $\pm$ SD)	39.4 $\pm$ 2.6	38.8 $\pm$ 2.6	43.7 $\pm$ 2.7	30.8 $\pm$ 2.5	39.3 $\pm$ 1.7	39.2 $\pm$ 1.9	43.0 $\pm$ 2.9	30.9 $\pm$ 2.9

Keys: RT- Right Testes; LT- Left Testes; TV- Testicular Volume; WDM- water displacement method; PSF- Prolate Spheroid Formula; LF- Lambert Formula; Prolate Ellipsoid Formula; SD- Standard Deviation

Table 2. Estimation of testicular volumes of post pubertal goat bucks' (mean  $\pm$  SD) of the right and left testes estimated by ultrasound using the prolate ellipsoid formula, prolate spheroid formula, Lambert formula and compared with true testicular volume estimated using the water displacement method.

Goats	RT-TV-WDM (cm <sup>3</sup> )	RT-TV-PSF (cm <sup>3</sup> )	RT-TV-LF (cm <sup>3</sup> )	RT-TV-PEF (cm <sup>3</sup> )	LT-TV-WDM (cm <sup>3</sup> )	TV-PSF (cm <sup>3</sup> )	TV-LF (cm <sup>3</sup> )	TV-PEF (cm <sup>3</sup> )
1	83.9	86.1	87.6	64.3	83.0	87.2	86.9	65.7
2	87.8	90.2	96.4	70.6	86.9	89.5	95.1	71.5
3	75.3	75.8	87.4	64.0	76.4	76.3	88.6	63.4
4	88.1	89.5	111.3	81.5	89.3	90.4	110.8	80.2
Mean ( $\pm$ SD)	83.8 $\pm$ 6.0	85.4 $\pm$ 6.6	95.7 $\pm$ 11.2	70.1 $\pm$ 8.2	83.9 $\pm$ 5.6	85.9 $\pm$ 6.5	95.4 $\pm$ 10.9	70.2 $\pm$ 7.5

Keys: RT- Right Testes; LT- Left Testes; TV- Testicular Volume; WDM- water displacement method; PSF- Prolate Spheroid Formula; LF- Lambert Formula; Prolate Ellipsoid Formula; SD- Standard Deviation.

Table 3. Estimation testicular volumes of pubertal goat bucks' testicular volumes (means ± SD) of both testes by ultrasound using the prolate ellipsoid formula, prolate spheroid formula, Lambert formula and compared with true testicular volume estimated using the water displacement method.

Goats	TV-WDM (cm <sup>3</sup> )	TV-PSF (cm <sup>3</sup> )	TV-LF (cm <sup>3</sup> )	TV-PEF (cm <sup>3</sup> )
1	79.5	79.8	88.2	59.5
2	78.6	77.4	84.5	57.9
3	73.1	72.1	80.3	59.6
4	83.5	82.6	93.5	69.6
Mean (±SD)	78.7 ± 4.3* <sup>ad</sup>	78.0 ± 4.5	86.6 ± 5.6	61.6 ± 5.4* <sup>da</sup>

\*significant at  $p < 0.05$ ; TV- Testicular Volume; WDM- water displacement method; PSF- Prolate Spheroid Formula; LF- Lambert Formula; Prolate Ellipsoid Formula.

Table 4. Red Sokoto post pubertal goat bucks' testicular volumes of both testes estimated by ultrasound using the prolate ellipsoid formula, prolate spheroid formula, Lambert formula and compared with true testicular volume estimated using the water displacement method (expressed in mean ± standard deviation).

Goats	TV-WDM (cm <sup>3</sup> )	TV-PSF (cm <sup>3</sup> )	TV-LF (cm <sup>3</sup> )	TV-PEF (cm <sup>3</sup> )
1	166.9	173.3	174.5	130.0
2	174.7	179.7	191.5	142.1
3	151.7	152.1	176.0	127.4
4	177.4	179.9	222.1	161.7
Mean (±SD)	167.7 ± 11.5	171.3 ± 13.1	191.0 ± 22.1	140.3 ± 15.6

\*significant at  $p < 0.05$ ; TV- Testicular Volume; WDM- water displacement method; PSF- Prolate Spheroid Formula; LF- Lambert Formula; Prolate Ellipsoid Formula.

Table 5. Comparison of the testicular volumes estimated using the WDM, PSF, PEF and LF for pubertal and post pubertal Red Sokoto bucks

Goats	TV-WDM (cm <sup>3</sup> )	TV-PSF (cm <sup>3</sup> )	TV-LF (cm <sup>3</sup> )	TV-PEF (cm <sup>3</sup> )
Pubertal	78.7 ± 4.3* <sup>ab</sup>	78.0 ± 4.5* <sup>ab</sup>	86.6 ± 5.6* <sup>ab</sup>	61.6 ± 5.4* <sup>ab</sup>
Post pubertal	167.7 ± 11.5* <sup>ba</sup>	171.3 ± 13.1* <sup>ba</sup>	191.0 ± 22.1* <sup>ba</sup>	140.3 ± 15.6* <sup>ba</sup>

\*significant at  $p < 0.05$ ; TV- Testicular Volume; WDM- water displacement method; PSF- Prolate Spheroid Formula; LF- Lambert Formula; Prolate Ellipsoid Formula.

## Discussion

In this study, testicular ultrasound biometrics was carried out to determine the adoptable formula that could be used for estimating testicular volume of pubertal and post pubertal RSG bucks with the aim of improving on their BSE protocol. Results revealed that the TV estimated using PSF and LF were not significantly different from the true TV estimated using the WDM. However, the TV estimated using the PEF were significantly lower than the true TV obtained by the WDM. These suggest that the only two of the three formulae i.e. PSF and LF can be used for estimating testicular volume for the pubertal RSG bucks. We also observed that contrary to the pubertal RSG bucks, the three formulae i.e. PSF, LF and PEF were all suitable for estimating the TV by ultrasound for the post pubertal RSG bucks as their values were not significantly different from the true TV by WDM.

The findings of our present study are contrary to the report by Raji *et al.*, (2016) where they recommended the PEF as the most suitable formula for estimating testicular volume by ultrasound in post pubertal West African Dwarf (WAD) goat bucks which are a different breed of goats. Also, the values of TV for the post

pubertal RSG bucks in this study were higher than those reported earlier for fully matured WAD bucks (Raji *et al.*, 2016). These variations may be attributed to the fact that these goat bucks are of two different breeds even though of the same species. This also further shows that testicular ultrasound biometrics is necessary for other breeds of goats as the data for the BSE of WAD bucks cannot be used for RSG bucks because they vary in values; also in formula for obtaining the TV for the two different breeds of goats varies as earlier highlighted. This study revealed that the use of a non-invasive methods such as testicular ultrasound in taking important reproductive parameters will replace the invasive methods which usually requires the harvest of the testes thereby compromising the reproductive lives of such male animals ((Alper and Ibrahim, 2019; Fesseha, 2019).

This study also revealed that the testicular volumes of the RSG post pubertal bucks estimated by ultrasound using the PSF, PEF, LF and the WDM were significantly higher than those of the pubertal bucks. This suggests that the post pubertal bucks will potentially produce more semen than the pubertal bucks. Hence, better performances are expected from the post pubertal bucks to increase the farm population and ultimately, increase

protein supplies in terms of meat and milk. This further corroborates earlier reports that better results would be achieved to use post pubertal bucks that have reached their optimum breeding age in place of pubertal bucks which are often not fully ready for reproduction (Souza et al., 2011; and Raji and Ajala 2015).

## Conclusion

The present study highlighted the testicular ultrasound biometrics of pubertal and post pubertal RSG bucks with particular emphasis on testicular volume estimation. The PSF, LF and PEF (in this order of preference) are recommended for the estimation of testicular volume by ultrasound for the post pubertal RSG bucks while only the PSF and LF are recommended for the pubertal RSG bucks. The findings of this study will be valuable in improving on the clinical practice of testicular ultrasound and BSE of RSG bucks thereby leading to increase RSG production and animal protein supply. However, based on our observation in the present study, we want to suggest that more researches should be done in the area of testicular ultrasound biometrics in the various breeds and species of animals as there could be variations in breeds and species of animals. This is important because testicular volume is an invaluable reproductive parameter usually evaluated during the BSE of male animals. It is an index of spermatogenesis i.e the higher the testicular volume of a male livestock animal, the higher the probability of it increasing the population of the farm animals (Kollin et al., 2006; Pintus et al., 2015).

## Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

## Ethical approval

Ethical approval was sought and granted by the Ethical Committee, Faculty of Veterinary Medicine, University of Ilorin, Kwara state, Nigeria. The procedures and conduct of the research were scrutinized to conform with international standards for conducting research on small ruminants.

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