

# A morphological study on the testis in camels (*Camelus dromedarius*) in North-Western Nigeria

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Received 18th December 2024; Accepted 3rd February 2025

**ABSTRACT:** Dromedary camels can be easily recognized by their humps. They are renowned for their capacity to endure long periods without water. It is an animal species that has been scantily evaluated. The study assessed the morphometry of the camel testis in the North-Western region of Nigeria. The dataset consisted of twenty (20) testes from camel bulls ages 7 and 12 years. The data included body weight (BW), weight of the right testis (WRT), weight of the left testis (WLT), and the weight of both testes (WBT). The morphology and shape of the testes were white to greyish in colour and oval, respectively. An Ordinary Least Squares (OLS) regression model was used to predict the WBT based on age and BW. The model assessed the individual and combined influence of these predictors on testicular weight. The descriptive analysis showed that the body weight ranged from 362 to 562 kg, with a mean of 460.9 kilograms. The WBT ranged from 133 to 151 g, with a mean of 141.5 g. A regression model identified BW as a significant predictor of the weight of both testes. The coefficient for BW was 0.0538 ( $p=0.007$ ), indicating that for every 1 kg increase in body weight, the weight of both testes increased by approximately 0.054 g. However, age was not a statistically significant predictor ( $p=0.988$ ), likely due to its strong association with body weight. The model explained 35.6% of the variance in WBT ( $R^2=0.356$ ) suggesting that other factors might also contribute to testicular weight variability.

**Keywords:** Camel, hump, testis, Nigeria.

## INTRODUCTION

Camels are pastoral animals located in the Asiatic-afro regions, easily identified by the humps on their backs (Nelson *et al.*, 2015). They are known for their ability to stay for extended periods with no water (Kaufmann, 2005). It is considered a poorly researched species, particularly the Dromedary and Bactrian species (Beheiry, 2016; Majama *et al.*, 2023). They form an integral part of the livelihoods of many communities in arid regions, where their ability to thrive in harsh environments is invaluable

serving as vital sources of transportation and food (Keskes *et al.*, 2013; Asimwe *et al.*, 2020). Reproductive efficiency in male camels is crucial for optimizing breeding programs and ensuring healthy herd populations (Rateb *et al.*, 2020). Despite their importance, there is limited research on camel reproductive biology, especially compared to other livestock. Factors such as seasonality, hormonal regulation and environmental stressors have been reported to have a significant influence on reproductive performance

in male camels. Understanding these dynamics can enhance breeding strategies, improve fertility rates, and reduce the risks of genetic disorders (Gherissi *et al.*, 2020).

Recent studies have focused on testicular development, sperm quality, and the impact of management practices on reproductive outcomes (Monaco and Lacalandra, 2020; Manjunatha *et al.*, 2022; Ullah *et al.*, 2023). By increasing the research into male camel testis especially due to the unique reproductive biology of camels, along with understanding the intricacies of camel testicular function and spermatogenesis, these can provide insights into their breeding practices and improve overall herd management (Rashad *et al.*, 2024). Examining these aspects, can aid the development of more effective breeding programs and contribute to the sustainability of camel populations, ultimately benefiting the communities that rely on them.

However, due to low external input, traditional livestock management, unstable production conditions and low genetic potential of native camel populations, its reproductive efficiency under extremely dry conditions is said to be low (Skidmore, 2005). Factors, including nomadism and remote pastures, create an inaccurate breeding statement about camel herds in Nigerian pastoral conditions. The high mobility of camel herds in large pastoral areas (80% of the country's surface) and the absence of a specific and reliable identification and traceability system pose the biggest obstacles to measuring herd fertility stats and annual numerical productivity (Hoffmann, 2002). The illiteracy of pastoralists and uncooperative breeders, frequently makes it difficult to gather information and to record major events for both herds and individual animals in a herd notebook or other similar documentation (Abo El-Maaty *et al.*, 2019). Other factors that may impact the fertility of the herd include the high frequency of genital abnormalities and early embryonic deaths, the short male breeding season, bull infertility, and low libido which are not adequately evaluated (Gherissi *et al.*, 2020).

However, the Progeny History surveying technique can and has been used to obtain long-term data from large animal populations at a reasonable time and cost (Keskes *et al.*, 2013). This data may offer detailed information about reproduction for the species. Considering the patterns of drought and recovery that follow droughts in pastoral systems (Kaufmann, 2005), especially considering the climate changes due to global warming, the breeding seasons which are rainy/hot seasons have also been noted to be shortened due to these changes.

A good dromedary bull at the height of the breeding season has been reported to be able to successfully mate three females per day or 50 to 70 females per breeding season (Deen, 2013; Swelum *et al.*, 2018). This is the male-to-female ratio during the rutting/breeding season. However, a common cause of herd infertility is excessive breeding with too many females within a short rutting season. One male for every 20 to 25 females is the

recommended ratio, and more than one male for every 60 females should be the threshold (Gherissi *et al.*, 2020), however, this recommendation is often ignored. Livestock reproduction is influenced by the genetic potential of the breed and species, the caretaker's management, and the production environment. The Afro-Asian dryland belt serves as home to a decent number of camel herds. These regions generally have unfavourable conditions, such as high temperatures, limited water supplies, and scarcity of feed, which most likely contribute to the low reproductive performance of camels. Seasonal breeders intentionally breed during a particular period of the year to guarantee that their progeny is born when the surroundings are more favourable for survival (Gherissi *et al.*, 2020; Babar and Ashraf, 2023). While the start and length of the breeding season may vary depending on the region, in dromedary camels, this commonly corresponds with shorter photoperiod days, the seasonal variation in this species' reproductive activity. Numerous other variables, such as changes in the surrounding temperature, and the availability and calibre of feed, alter the impact of photoperiods on rutting (Manjunatha *et al.*, 2022). Seasonal variations in the testis, accessory sex glands, libido, testosterone levels, and characteristics of the semen have also been documented in male camels in Asian and North African studies (Khan *et al.*, 2003; Khalphallah *et al.*, 2024). In addition, male camels have been observed not to exhibit any sexual behaviour towards a female camel in oestrus for mating during the non-breeding season (Purohit *et al.*, 2022).

Hitherto, there have been no published reports on the species and its reproduction for this region. The present study is a report on recent examinations of the testis, a reproductive parameter of the male camel population, that were kept under pastoral management for the study area. Highlighting the potential implications for veterinary science, conservation, and agricultural productivity for the dromedary camel.

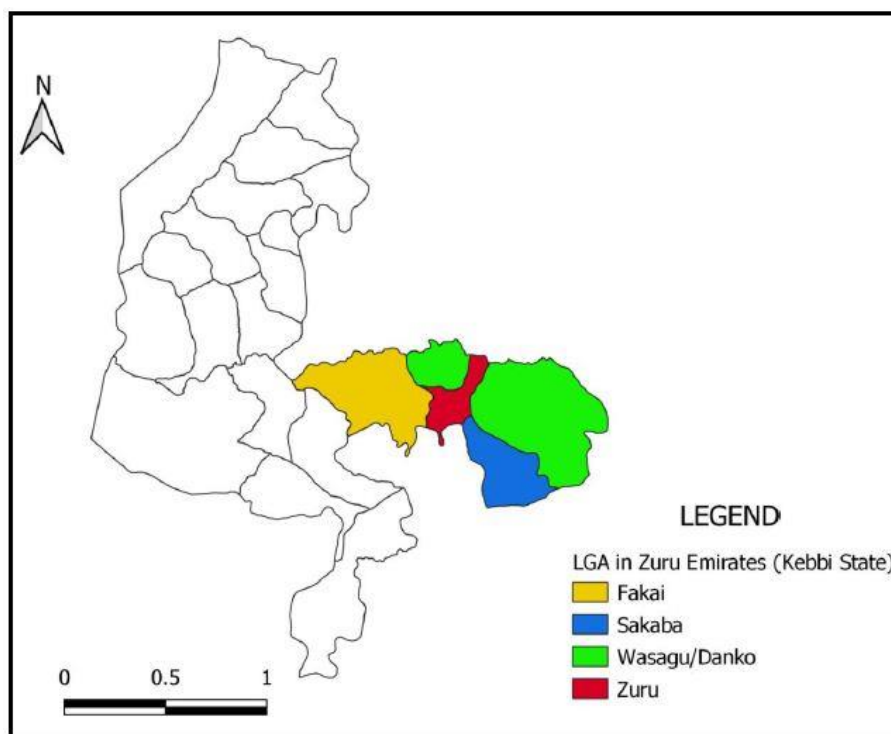
## METHODOLOGY

### Study area

A collection of tissue samples was obtained from herds in the arid region of Zuru, Kebbi State (North-West Nigeria), located at latitude 33°5' and longitude 6°11', with an average annual temperature of 27°C, and mean annual precipitation of 80 mm) (Figure 1).

### Animals used for study

Reproductive parameters of male Dromedary Camel (DC) were collected after an initial survey of herds in the study area conducted between February to August 2024. Camel



**Figure 1.** Map of Kebbi State, showing the four Local Government Areas under Zuru Emirate (Mohammed *et al.*, 2024; Ukwuani-Kwaja *et al.*, 2024).

herds from the pastoral semi-nomadic and marked for slaughter over a 3-week period in September 2024 were included in the study. The data including the age of the animal (estimated using dentition), the weight of each testis, combined weight, size measurements and histological assays were collected.

### Gross morphology

The weight of the camels was estimated according to the previously described method (Kuria *et al.*, 2007). The age of the camels was estimated using rostral dentition as previously described (Yahaya *et al.*, 2011, Khazaeel *et al.*, 2022). Similarly, the testes were carefully dissected after slaughter, and various physical parameters such as weight, length, and width were measured on both the left and right testes (Saini *et al.*, 2022). Weight was taken using an electrical digital weight balance (High precision scale SF-400, Jiangxi, China), and Length and Breadth were measured by vernier callipers (12.5 cm Vernier Callipers, Ambala, India).

### Statistical analysis

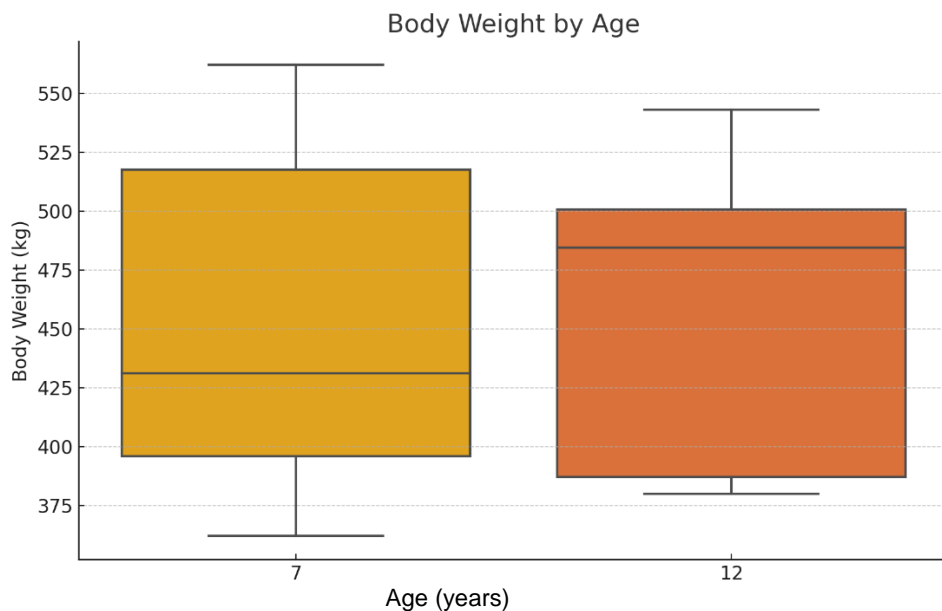
The morphometric data generated was analyzed using R

Project for Statistical Computing 4. 1. 2. Version, and it was considered significant if ( $p < 0.05$ ). Results were reported using narration and graphical representation.

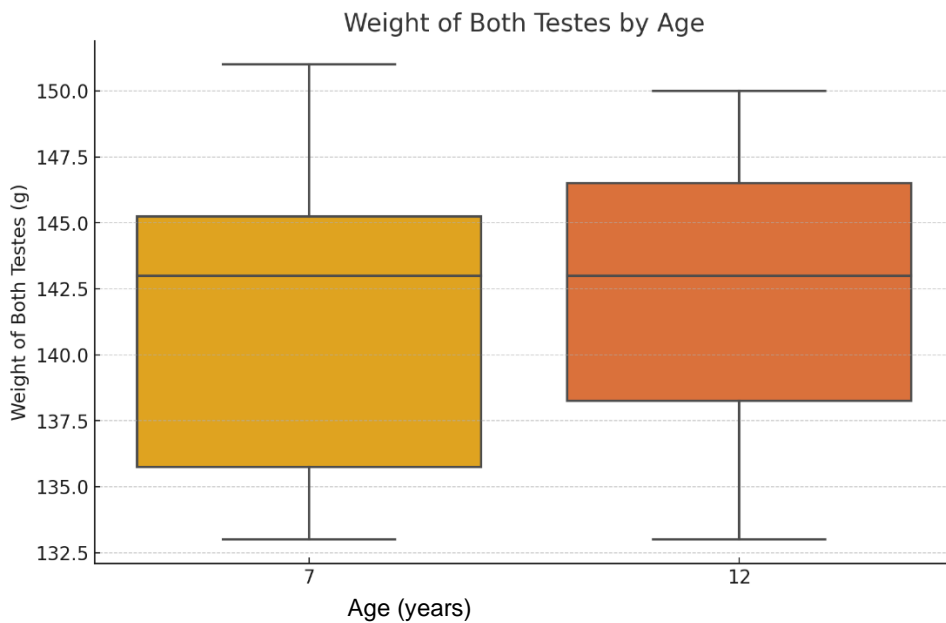
## RESULTS

This study analyzed the relationship between body weight, testicular dimensions, and age in male camels. The dataset consisted of twenty (20) observations with variables including age (7 or 12 years) and body weight (BW). The testicles included in this study were oval and small and ranged from white to greyish in colour (Figure 5).

The dataset was grouped by age, and mean values for each variable were compared. Boxplots were used to visualize the distribution of body and testicular weights between the two age groups. Animals aged 12 years had a slightly higher mean body weight (478.7 kg) compared to those aged 7 years (447.5 kg). Similarly, the mean weight of both testis (WBT) was higher in the 12-year group (144.5 g) than in the 7-year group (139.4 g). However, boxplot visualizations showed overlapping distributions, suggesting variability within each group (Figure 2). Other measures taken included the weight of the right testis (WRT), the weight of the left testis (WLT), and the weight of both testis (WBT). The 12-year-old group had a higher



**Figure 2.** Box plot graph of the body weight of male camels ages 7- and 12-years.



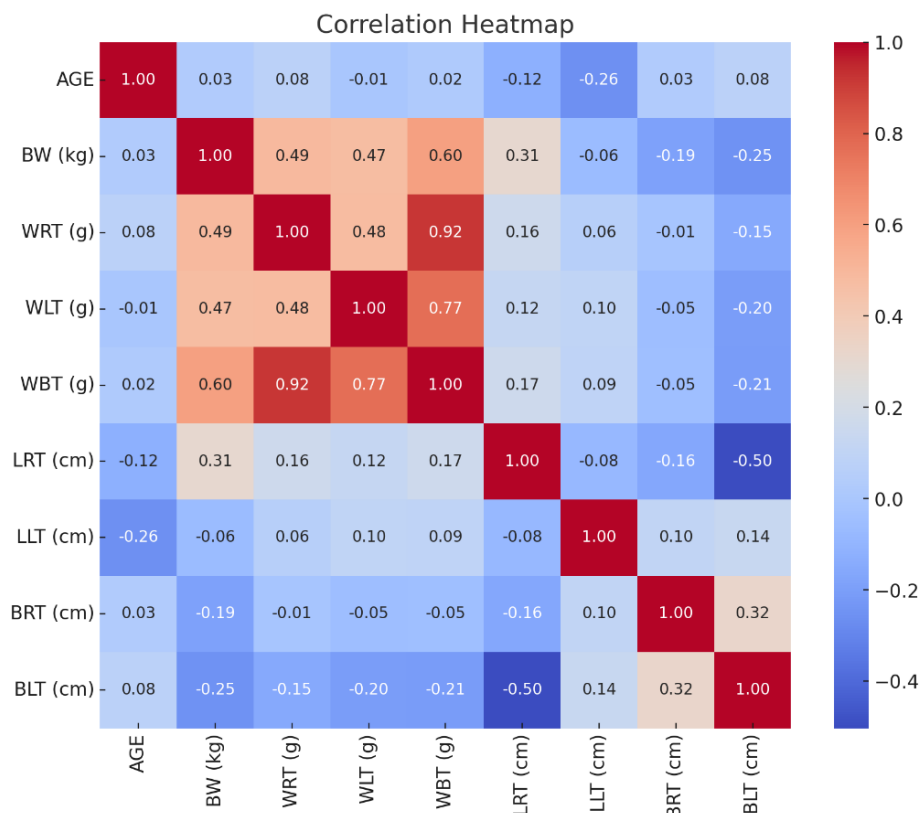
**Figure 3.** Box plots illustrate the distribution of the weight of both testes combined for the same two age groups.

mean weight of both testis (144.5 g) than the 7-year-old group (139.4 g). The overlapping boxplots indicate the variability in the weight of testis within each age group (Figure 3).

The dimensions of the testis included the length of the right testis (LRT), length of the left testis (LLT), breadth of the right testis (BRT), and breadth of the left testis (BLT).

The analysis involved summary statistics, such as means, medians, standard deviations, and ranges, which were calculated for all variables to provide an overview of the data's distribution.

An Ordinary Least Squares (OLS) regression model was constructed to predict the weight of both testis (WBT) based on age and body weight (BW) to identify relationships



**Figure 4.** A correlation matrix heatmap, demonstrating the relationship between variables with signature color red indicating a stronger association and signature blue, a weaker association. **Keys:** BW: Body weight, WRT: Weight of the right testis, WLT: Weight of the left testis, WBT: Weight of both testes, LLT: Length of left testicle, LRT: Length of right testicle, BLT: Breadth of left testicle, BRT: Breadth of right testicle.

among variables, which was further visualized using a correlation matrix heatmap (Figure 4). For instance, BW and WBT had a correlation coefficient of 0.60, indicating a moderate positive relationship. Testicular dimensions (LRT, LLT) showed weaker correlations with weight measurements, suggesting that testicular length might not be as closely related to body or testicular weight. A regression model identified body weight (BW) as a significant predictor of the weight of both testes. The coefficient for BW was 0.0538 ( $p=0.007$ ), indicating that for every 1 kg increase in body weight, the weight of both testes increased by approximately 0.054 g. However, age was not a statistically significant predictor ( $p=0.988$ ), likely due to its strong association with body weight. The model explained 35.6% of the variance in WBT ( $R^2=0.356$ ), suggesting that other factors might also contribute to testicular weight variability.

The descriptive analysis showed that body weight ranged from 362 to 562 kg, with a mean of 460.9 kg. The weight of both testes (WBT) ranged from 133 to 151 g, with a mean of 141.5 g. Testicular dimensions (LRT, LLT, BRT, BLT) exhibited relatively small variations, with average



**Figure 5.** Gross pictures of camel bull testis dissected out immediately after slaughter, showing the right (a) and the left (b) testis.

lengths of 8.1 cm (LRT) and 9.2 cm (LLT) and average breadths of 3.2 cm (BRT) and 2.5 cm (BLT).

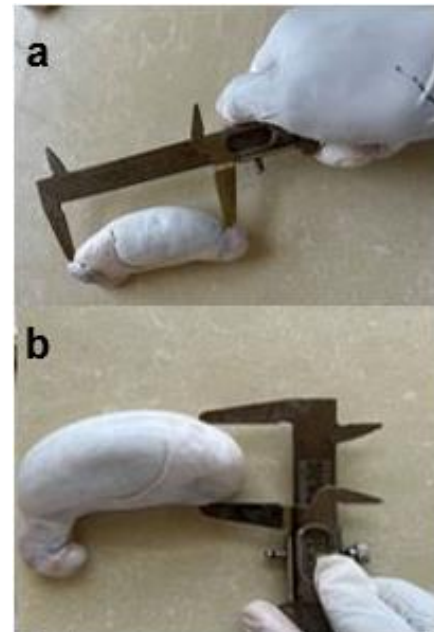
## DISCUSSION

In this study, an investigation into the locally available one-hump camel (*Camelus dromedarius*), a neglected species was conducted by exploring the testis, a major reproductive organ in males on a gross anatomical level, to observe whether the results may be indicative of the reproductive efficiency of these mammals for the assigned region. As an animal of economic and ecological importance, the study of its reproduction can aid in providing improved care and alleviating outcomes. The twenty (20) animals included in the study (Figure 2) were estimated to be 7 or 12 years of age using methods previously reported (Yahaya *et al.*, 2011, Khazaeel *et al.*, 2022). The ageing of a mammal is associated with the size of the testis with older males often possessing smaller sizes due to shrinkage and decreased function in comparison to younger males (Santiago *et al.*, 2018), although other mammalian species such as hamsters were observed to have no significant association between size of testis and age, a similar observation in the current study with no statistically significant difference between the age groups.

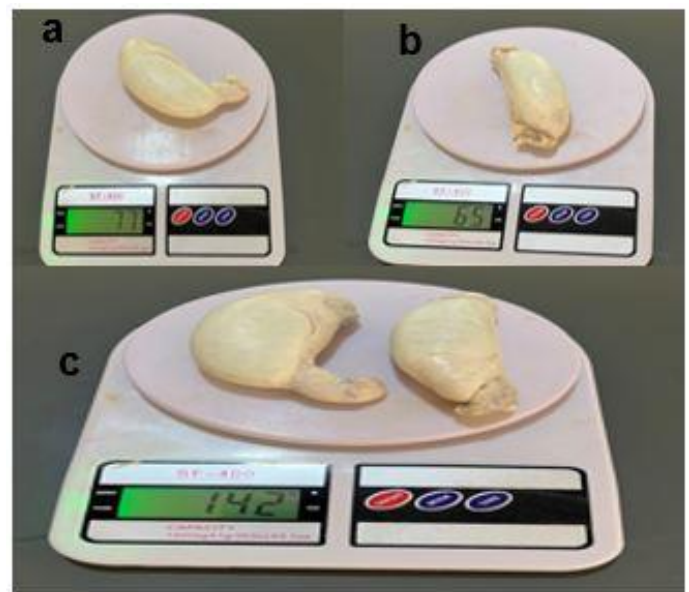
The 12-year group (mean weight 478.7kg) were seen to be slightly heavier than the 7-year group (mean weight 447.5 kg) but this was not significant with an overlap in the boxplots (Figure 2) which indicates the variability of weight within each age group. This we believe may be due to the nutrition received by the animals as these were from various herds or could be owed to underlying conditions which were not accounted for, as the progeny history testing technique (Kaufmann, 2005) was not employed. It is worth noting that the oldest age of animals within the study could be due to the common practice of ridding the herd of breeding males beyond this age, as reported in a Somalian study (Keskes *et al.*, 2013). The weight of an animal has been shown to influence testicular size and potential function (Handelsman, 2006).

The average weight of both testes was 141.85 g with a mean weight of 144.5 g in the 12-year group and 139.4 g in the 7-year group (Figures 3 and 7c), also with variability within the groups. Data on the weight of each testicle (left and right) were recorded, the right testicle was observed to be heavier albeit not significantly within each age group. However, several studies in camels and other mammals reported that the left testis is usually heavier and bigger than the right testis (Hafez and Hafez, 2001; Karimi *et al.*, 2019; Saini *et al.*, 2022), which is in contradiction with the present study. The overall weight of both testes plays an important role in the rate of fertility in males. This is because, the bigger the testis, the larger the sperm output associated with the capability to service two females per day (Elwishy, 1988; Al-Qarawi, 2005; Padalino *et al.*, 2015). The dimensions of both testicles including length and breadth were also taken (Figure 6).

From these morphometric measures, a correlation



**Figure 6.** Sample images of the measurement using 12.5 cm Vernier calipers, showing how the length of the testis (a) and breadth of the testis (b) were measured.



**Figure 7.** Images of weight measurement of camel testis, showing the right testis (a), left testis (b), and both testis (c) on the weighing scale.

matrix map was made to ascertain the possible statistical relationship between these variables for all animals within

the study (Figure 4). A strong positive correlation was found between body weight (BW), weight of the right testis (WRT), weight of the left testis (WLT), and the combined weight of both testes (WBT) indicating that as body weight increases, so does the weight of the testes. The correlation coefficient between body weight and the weight of both testes was 0.60, indicating a moderate positive correlation. Similarly, a previous study on the buffalo showed a positive correlation between body weight and testicular weight (Yassen and Mahmoud, 1972). In addition, Da Silva Santos *et al.* (2013) reported the biometric testicular parameters in which they analyzed scrotal circumference, testicular weight, testicular length, testicular width, testicular thickness and testicular circumference. Their data indicated a strong correlation between age and body weight, and additional significant relationships were identified between body weight, age and other testicular parameters. Thus, these parameters are suitable indicators when selecting bulls for breeding purposes.

Testicular length had weak correlations with the weight measurements, suggesting that length may not be as closely related to weight (Figure 4). Studies in sheep (Preston *et al.*, 2012) reported a positive correlation of testicular size with function, a conclusion that cannot be made for this study. An OLS regression model was done to predict the weight of both testes (WBT) based on age and body weight. The analysis found that body weight was a significant predictor of the weight of both testes, for each 1 kg increase in body weight, the weight of both testes increased by approximately 0.054 g, however, this cannot be conclusive evidence for optimal reproductive efficiency but can be a positive indicator. Age was not a statistically significant predictor in the model, potentially due to its strong association with body weight as 12-year group males were observed to be heavier than the 7-year group, which is often observed, with older animals regularly being heavier than younger ones. A study conducted on rams showed an association between the number of females in rutting season around a breeding male and an effect on testicular size as well as an effect of season on the size of the testes. As a ruminant mammal, a seasonal and herd composition effect might also have contributed to the testicular measurements observed in this study and may explain the variability within the groups.

## Conclusion

The current study reported on the morphological data for the testis of camels from the region as a preliminary investigation into the reproductive efficiency of the male to provide information for the species and potentially improve the reproductive outcomes for the research-neglected species. There was a correlation between the weight of an animal and its testicular weight whether combined or not, this suggests that the nutrition of the animals and its

consequent effect on the weight may impact testicular size and possibly testicular function and reproductive efficiency. The absence of information on potential confounding factors such as quality of care and its consequent impact on weight could not be ascertained for the present study. The inclusion of salient information such as feeding practices, type and quality of feed, and male-to-female ratio within the herd will aid research on reproductive outcomes. Longitudinal studies with concise records of previously mentioned factors would immensely improve knowledge of the reproductive efficiency of the species in the area.

## COMPETING INTERESTS

The authors have no competing interests to declare.

## ACKNOWLEDGMENT

The authors greatly appreciate the support of TETFUND Nigeria under grant number: TETF/DR&D/CE/UNI/ZURU/IBR/2024/VOL.1.

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