

Testicular morphometry, gonadal and extra-gonadal sperm reserves of camel (*Camelus dromedarius*) during the hot dry season in the Sahelian region of Nigeria

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Abstract

Livestock farmers may need a reference range of testicular sizes and sperm reserves to ascertain the reproductive efficiency of a male. However, information on camel testicular morphometry and gonadal sperm reserve in semi-arid Nigeria is scanty. This study was designed to provide information on testicular morphometry and gonadal and extragonadal sperm reserves of camels in the Sahel region of Nigeria. Testes of 15 mature and healthy camels were obtained after slaughter from the Maiduguri central abattoir. Scrotal circumference was measured on the live animal to the nearest centimetre. Weights of each testis, epididymis and its distinct parts and tunica albuginae were obtained to the nearest milligram. The length and width of each testis and the length of the distinct parts of the epididymis were measured to the nearest millimetre. Gonadal and extra-gonadal sperm reserves were also estimated. All data were subjected to descriptive statistics, paired sample *t*-test and correlation analysis. Scrotal circumference ranged from 24.00 to 49.00cm with an average of 38.59 ± 2.41 cm. A high significant relationship ($r = 0.69$) between scrotal circumference and paired testis weight were observed. The left and right testes had similar sperm reserve. The sperm reserve of the left caput and caudal were however, higher ($p > 0.05$) than those of the right. The mean epididymal sperm reserve for caput, corpus and caudal were 84.857×10^6 , 268.71×10^6 and 542.79×10^6 , respectively. It was concluded that testicular morphometric characteristics have the potential to be used in predicting sperm production capacity in live camels' bulls.

Keywords: Epididymis, Scrotal circumference, sperm reserve, Testis

La Morphométrie testiculaire, réserves de sperme gonadal et extra-gonadal de chameau (*Camelus dromedarius*) pendant la saison chaude et sèche dans la région sahélienne du Nigeria



Résumé

Les éleveurs peuvent avoir besoin d'une gamme de référence de tailles testiculaires et de réserves de sperme pour vérifier l'efficacité reproductive d'un mâle. Cependant, l'information sur la morphométrie testiculaire de chameau et la réserve gonadale de sperme au Nigeria semi-aride est maigre. Cette étude a été conçue pour fournir des informations sur la morphométrie testiculaire et les réserves gonadales et extragonadales de spermatozoïdes de chameaux dans la région du Sahel au Nigeria. Des testicules de 15 chameaux matures et sains ont été obtenus auprès de l'abat de l'abattoir central de Maiduguri. La circonférence scrotale a été mesurée sur l'animal vivant jusqu'au centimètre le plus proche. Des poids de chaque testicule, épидидyme et ses parties distinctes et tunicaalbuginae ont été obtenus au milligramme le plus proche. La longueur et la largeur de chaque testicule et la longueur des parties distinctes de l'épididyme ont été mesurées au millimètre près. Les réserves de sperme gonadal et extra-gonadal ont également été estimées. Toutes les données ont fait l'objet de statistiques descriptives, d'un *t*-test apparié et d'une analyse de corrélation. La circonférence

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scrotale s'est étendue de 24.00 à 49.00cm avec une moyenne de 38.59 ± 2.41 cm. On a observé une relation significative élevée ($r = 0,69$) entre la circonférence scrotale et le poids apparié des testicules. Les testicules gauche et droit ont eu la réserve semblable de sperme. La réserve de sperme du caput gauche et du caudal étaient toutefois plus élevées ($p > 0,05$) que celles de la droite. La réserve épидидymale moyenne de sperme pour le caput, le corpus et le caudal étaient 84.857×106 , 268.71×106 et 542.79×106 , respectivement. Il a été conclu que les caractéristiques morphométriques testiculaires ont le potentiel d'être utilisées pour prédire la capacité de production de sperme chez les taureaux de chameaux vivants.

Mots-clés: Epididymis, circonférence scrotale, réserve de sperme, Testis

Introduction

Camels thrive in the harsh deserts of Africa and Asia; the species play very important roles in the livelihood of the indigenous people of these regions. In Nigeria, camels are found mainly in the semi-arid north (Jaji *et al.*, 2017) where they are used as pets and for transportation of people and goods, to supply hides and fibres for clothing, other textile articles, and meat and milk products (Gherissi *et al.*, 2017; Jaji *et al.*, 2017). The animals have been used and bred for several thousand years, but the efforts to understand their biology and diseases in greater depth has been only been done fairly recently. Since camels are still such important animals in Africa, the Middle East and Asia, there has been more interest and need to understand their reproductive physiology (Larson, 2010).

Effective reproduction is of great importance for increased and sustainable improvement of animal productivity and profitability. Morphometric analysis on the testes of any species is necessary for predicting not only sperm production but also of the storage potentials and fertilizing ability of the breeder male (Ibrahim *et al.*, 2012b). It has been reported in other species that there is a relationship between testicular morphometry and semen production and quality (Bath and Chaudhari, 2002; Bitto and Egbunike, 2006; Ugwu, 2009). There is also a consensus that information about gonadal and extra-gonadal sperm reserves appear to be important criteria for a thorough evaluation of male fertility (Obidi *et al.*,

2008; Omari *et al.*, 2018). Omari *et al.* (2018) furthermore, noted that in areas with low technical and laboratory support for semen evaluation, livestock farmers may need a reference range of testicular sizes and sperm reserves to ascertain the reproductive efficiency of a male. However, information on camel testicular morphometry and gonadal sperm reserve in semi-arid Nigeria is scanty. This study was therefore designed to provide information on testicular morphometry and gonadal and extragonadal sperm reserves of camels in the Sahel region of Nigeria.

Materials and methods

Testes of 15 mature and healthy camels were obtained after slaughter from the Maiduguri central abattoir. The processing of the samples was then done at the laboratory of the Department of Animal Science, University of Maiduguri, Borno state of Nigeria. Maiduguri in Borno state is located between latitude $11^{\circ}51'N$ and $13^{\circ}05'E$ and elevation of 345m above sea level. The city is situated in the Sahel savannah zone and is characterized by a short period of rainfall usually between June- September and a prolonged period of dry season (October to February) (Saleh *et al.*, 2015). Ambient temperature varies from $25^{\circ}C$ - $28^{\circ}C$ in December and rises to $40-45^{\circ}C$ around March to June. Sample collection was done between 5 – 6 am over one month (April-May). After collection, the testes were immediately covered in ice, taken to the laboratory and processed the same day. Scrotal circumference was measured on the

live animal. It was obtained using a piece of thread placed at the greatest diameter and measured on a rule. The testes were trimmed of all adhering tissue and fat. The epididymis and tunica albuginae were carefully removed. The epididymis was further cut into its three distinct parts; the Caput (Head), the Corpus (Body) and Cauda (tail). Weights of each testis, epididymis, and its distinct parts and tunica albuginae were obtained to the nearest milligram using an electronic scale (Metra®). The length and width of each testis and the length of the distinct parts of the epididymis were measured by using a digital Vanier calliper to the nearest millimetre.

The volumes of the testes were measured volumetrically using the Archimedes principles of water displacement in a measuring cylinder. Using measuring cylinder 100ml of water was measured and the testis was inserted into the water, and the volume of water displaced represented the volume of testis. The testis density was calculated from the testes weight and volume and expressed as:

$$\text{Testis density (g/cm}^3\text{)} = \frac{\text{testis weight (g)}}{\text{testis volume}}$$

In order to determine the gonadal and extra-gonadal sperm reserves, two grams of each sample was taken i.e. (left testes, right testes, left caput, right caput, left corpus, right corpus, left caudal and right caudal). Each sample was crushed using pestle and mortar and then homogenized in 60mL of normal saline with 5mL of antibiotics (penicillin). The homogenate volume after rinsing the mortar container with 60mL of normal saline and 5mL of antibiotic was added into the conical flask, the homogenate samples were allowed to stay overnight at a temperature of 5°C in the refrigerator so as to allow the sperm cells and spermatid to ooze out of the tissue. The homogenate was then filtered using double-layer cheesecloth to remove tissue debris.

Finally, the gonadal and extragonadal sperm concentrations were determined with a haematocytometer according to the method of the World Health Organization [WHO] (2010).

Daily sperm production was obtained from the testicular homogenates by dividing the Gonadal sperm reserves by a time divisor of 3.56 proposed by Amann *et al.* (1976) as cited by Ibrahim *et al.* (2012a).

Daily Sperm Production (millions) = Testicular sperm count

Time divisor (3.56)

All data were subjected to descriptive statistics, paired sample t-test, and correlation analysis using IBM SPSS 20.0 (SPSS, 2011).

Results and discussion

The descriptive statistics and paired sample T-Test of testicular morphometry of camel bulls in Maiduguri are shown in Tables 1 and 2. The scrotal circumference of camels in this study was similar to 30.9± 0.8cm reported by Stephen *et al.* (2019) for camel bulls in Maiduguri. This was however higher than the average mean of 23.73±1.43cm reported by Ibrahim *et al.* (2012b). The difference in scrotal circumference may be as a result of the age of the bull or season when the samples were collected although Ibrahim *et al.* (2012b) did not indicate this information in their work. Pasha *et al.* (2013) had earlier noted that season affects scrotal size of the camel. The paired testes weight in this study was similar to 189.40 - 226.20 g reported by Abdul-Raouf *et al.* (1995) for camels across all seasons. The weights observed in this study were to testicular weight range of 110.58 – 202.65g reported by Gherissi *et al.* (2016) for Sahraoui dromedary camel across all seasons. Abdul-Raouf *et al.* (1995) had earlier reported that season influences testicular weight. The average weights, length and width of the left and

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right testicles were similar to the reports of Hafez and Hafez (2001) and Ibrahim *et al.* (2012b). Testicular length and volume observed in this study were lower than those reported by Stephen *et al.* (2019) in the same location. The difference may be attributed to the season of sampling. They collected their data during harmattan (October to December) which corresponds to the rutting season (Abdussamad *et al.*, 2011) while the samples for this study were collected during the peak hot dry season (April to May). The left and right testicles had similar morphometry which confirms the report of Stephen *et al.* (2019) on

similarity of both left and right testicles of camel bulls in Maiduguri, Nigeria. The right, left and paired testis densities ranged from 1.04g to 1.73g/cm³, 0.98 to 1.90g/cm³ and 2.02 to 3.61g/cm³, respectively. This observation coincides with average density of 1.03±0.04g/cm³, 1.19±0.08g/cm³ and 1.10±0.04g/cm³ respectively for right, left and paired testis density reported by Ibrahim *et al.* (2012b) for camels in Kano, Nigeria. The observation in this study also confirmed the observation of Mahmoud (2006) that the right testicle was often slightly smaller than the left one (Bello and Umaru, 2013).

Table 1: Testicular morphometry of camel (*camelus dromedaries*) in semi-arid Nigeria

Parameter	Minimum	Maximum	Mean ± SEM
Scrotal circumference (cm)	24.00	49.00	38.59 ± 2.41
Right testis weight (g)	51.00	115.37	77.72 ± 5.22
Left testis weight (g)	48.00	137.00	79.95 ± 7.03
Paired testis weight (g)	99.00	246.00	157.05 ± 11.99
Right epididymis weight (g)	16.00	30.00	23.24 ± 1.18
Left epididymis weight (g)	13.00	31.00	24.47 ± 1.38
Paired epididymis weight (g)	30.00	60.00	47.94 ± 2.42
Right tunica albuginea (g)	13.00	43.90	25.85 ± 2.77
Left tunica albuginea (g)	9.00	44.20	26.42 ± 2.55
Paired tunica albuginea (g)	25.00	88.10	53.50 ± 5.13
Right caput weight (g)	4.00	11.00	7.68 ± 0.58
Left caput weight (g)	6.00	12.00	8.10 ± 0.55
Paired caput weight (g)	11.00	20.61	15.62 ± 0.90
Right corpus weight (g)	4.00	6.00	5.52 ± 0.23
Left corpus weight	4.00	10.00	5.43 ± 0.49
Paired corpus weight (g)	8.00	14.00	10.85 ± 0.49
Right caudal weight (g)	6.00	14.00	9.93 ± 0.75
Left caudal weight (g)	4.00	19.00	9.85 ± 1.17
Paired caudal weight (g)	7.00	32.00	19.41 ± 1.90
Right epididymal length (mm)	19.51	47.00	34.15 ± 2.02
Left epididymal length (mm)	22.00	47.00	35.86 ± 1.77
Paired epididymal length (mm)	25.00	46.25	35.01 ± 1.64
Right testis volume (ml)	45.00	95.00	63.64 ± 4.67
Left testis volume (ml)	40.00	119.00	66.77 ± 5.65
Paired testis volume (ml)	42.50	107.00	65.20 ± 5.04
Right testis length (mm)	63.04	95.07	78.65 ± 2.61
Left testis length (mm)	62.52	108.84	80.60 ± 3.06
Right caput length (mm)	3.50	7.50	4.45 ± 0.28
Left caput length (mm)	3.00	5.50	4.65 ± 0.91
Right corpus length (mm)	5.50	8.50	7.09 ± 0.27
Left corpus length (mm)	5.00	9.80	6.91 ± 0.37
Right caudal length (mm)	9.00	36.00	23.73 ± 1.97
Left caudal length (mm)	12.50	38.00	26.55 ± 1.69
Right testis width (mm)	33.00	51.82	42.05 ± 1.53
Left testis width (mm)	33.98	57.42	42.61 ± 1.80
Right testis density (g/cm ³)	1.04	1.73	1.24 ± 0.05
Left testis density (g/cm ³)	0.98	1.90	1.21 ± 0.07
Paired testis density (g/cm ³)	2.02	3.61	2.44 ± 0.11

The mean paired, right and left epididymal weights for camels in semi-arid Nigeria were 47.94±2.42g, 23.24± 1.18 g and 24.47±1.38 g, respectively. Weights of the right and left epididymides and their proportional parts were all similar. Overall weights of the caput, corpus and caudal parts of the epididymis corresponded to 33.19, 23.33 and 41.24% of the overall epididymal weight. This is similar to the observation made by Mahmud *et al.* (2015) who reported a higher value of caput weight in the one humped camel.

Table 2: Paired sample T-Test of testicular morphometry of camel in Maiduguri

Parameters	Right	Left	P-Value
Testis weight (g)	77.72 ± 5.22	79.95 ± 7.03	0.41
Testis length (mm)	78.65 ± 2.61	80.59 ± 3.06	0.27
Testis width (mm)	42.05 ± 1.53	42.16 ± 1.80	0.91
Testis volume (ml)	63.64 ± 4.67	66.77 ± 5.65	0.22
Epididymal weight (g)	23.24 ± 1.18	23.47 ± 1.38	0.14
Epididymal length (mm)	34.15 ± 2.02	35.86 ± 1.77	0.39
Epididymal Caput weight (g)	7.68 ± 0.58	8.10 ± 0.55	0.53
Epididymal Corpus weight (g)	5.51 ± 0.23	5.43 ± 0.49	0.88
Epididymal Caudal weight (g)	9.93 ± 0.75	9.85 ± 1.17	0.92
Epididymal Caput length (mm)	4.45 ± 0.28	4.65 ± 0.19	0.51
Epididymal Corpus length (mm)	7.09 ± 0.98	6.91 ± 1.34	0.69
Epididymal Caudal length (mm)	23.73 ± 1.97 ^b	26.54 ± 1.68 ^a	0.04*
Weight of Tunica albuginea (g)	25.85 ± 2.77	26.41 ± 2.55	0.70

The paired tunica albuginea weight ranged from 25.00g to 88.10g with an average 53.50±5.13g. This is contrary to what Ibrahim *et al.* (2012b) reported that the right and left tunica albuginea averaged 10.11±0.97g and 9.92±1.12g, and the paired tunica albuginea of the camel average 20.02 ±2.02g. The difference between the weights in this work and that of Ibrahim *et al.* (2012b) may be due to the age of the animals used or the season the observations were made. Table 3 shows the correlation of testicular parameters of camel bulls in the Sahelian region of Nigeria. A highly significant relationship between scrotal circumferences and paired testis weight were observed. According to Obande *et al.*

(2015) "testicular size or the amount of sperm-producing tissue is estimated through the use of scrotal circumference. This is because there is a high correlation between scrotal circumference and sperm output". Bitto and Ochogwu (2007) and Ibrahim *et al.* (2012b) had earlier reported a similar relationship between scrotal circumference and testis weight in the boar and camel, respectively. This positive relationship is an indication that testis circumference can be used to select for camel bulls with potentially greater chances of producing more sperm cells. There was a strong relationship (r = 0.90) between paired epididymal weight and paired caput weight.

Table 3: Correlations among morphological parameters of camel testes camel in semi – arid Nigeria

	1	2	3	4	5	6	7	8	9
1. Scrotal circumference (cm)	1								
2. Paired testis weight (g)	0.61*	1							
3. Paired epididymal (g)	0.07	0.01	1						
4. Paired caput weight (g)	0.11	-0.03	0.90**	1					
5. Paired corpus weight (g)	0.17	0.28	0.52	0.40	1				
6. Paired caudal weight (g)	-0.26	-0.33	0.62*	0.35	0.21	1			
7. Paired epididymal length (cm)	-0.52	-0.25	-0.10	-0.28	-0.08	0.29	1		
8. Paired testis volume (ml)	0.41	0.86**	0.12	0.78	0.45	-0.23	-0.07	1	
9. Paired density (g/cm ³)	0.34	0.26	-0.19	-0.23	-0.28	-0.11	-0.29	-0.26	1

*--- correlated at (P<0.05)

**--- correlated at (P<0.01)

Table 4 shows the descriptive statistics of testicular sperm reserve and daily sperm production while Table 5 shows Paired

sample T-Test of gonadal, extragonadal and daily sperm production of camels in semi-arid Nigeria. The mean sperm reserve for

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left testes, right testes and paired testes were similar with the means reported by Ibrahim *et al.* (2012a) in semi-arid Nigeria but lower than the means reported by Osman and EL-Azab (1974) for camels in Egypt and Sudan. The left and right testes had similar sperm reserves (Table 5). The sperm reserve of the left caput and caudal were however higher ($p>0.05$) than those of the right. The mean epididymal sperm reserves for caput, corpus and caudal were 84.857×10^6 , 268.71×10^6 and 542.79×10^6 respectively. Sperm reserve for the caudal epididymis was higher than the $281.90 \pm 20.40 \times 10^6$ reported by Abd and Ibrahim (2014) for sperm concentration in the caudal

epididymis of the camel during the hot season in Iraq. The distribution of the spermatozoa in the three segments of the epididymis in the present study agreed with the report of Ibrahim *et al.* (2012a) who noted that the caudal epididymis had about 62% of the total sperm reserve of the camel epididymis. This observation is also similar to what Ewuola (2013) reported in rabbits where the caudal epididymis had the higher sperm reserve. Comparing the left and right segments of the epididymis showed that mean sperm reserve in the left caput and caudal were higher ($p<0.05$) than those of the right. However, the mean reserve in the corpus was similar for both.

Table 4: Descriptive statistics of gonadal, extra-gonadal and daily sperm production ($\times 10^6$) of camels (*Dromedarius camelus*) in semi-arid Nigeria

Parameters	Range		Mean \pm SEM
	Minimum	Maximum	
SR Left testis	9.00	129.00	37.07 \pm 8.62
SR Right testis	3.00	81.00	31.07 \pm 5.45
SR Paired testis	15.00	171.00	68.14 \pm 11.71
SR Left caput	9.00	108.00	50.57 \pm 8.30
SR Right caput	3.00	594.00	57.43 \pm 41.51
SR paired caput	12.00	609.00	84.86 \pm 41.39
SR Left corpus	12.00	1356.00	192.00 \pm 93.40
SR Right corpus	12.00	720.00	103.71 \pm 48.77
SR paired corpus	24.00	2076.00	268.71 \pm 143.23
SR Left caudal	33.00	1386.00	359.36 \pm 115.82
SR Right caudal	30.00	873.00	191.14 \pm 59.91
SR paired caudal	12.00	2259.00	542.79 \pm 166.04
DSP Left testis	2.06	29.52	8.48 \pm 1.97
DSP Right testis	0.69	18.54	7.11 \pm 1.25
DSP paired	3.43	39.13	14.91 \pm 2.79

SR -Sperm reserve, DSP- Daily sperm production, SEM- Standard error of Mean

Table 5: Paired sample T-Test of gonadal, extra-gonadal and daily sperm production ($\times 10^6$) of camels in semi-arid Nigeria

Parameter	Mean \pm SEM		p-value
	Left	Right	
Sperm reserve testis	39.00 \pm 9.08	30.23 \pm 5.82	0.33NS
Sperm reserve caput	53.31 \pm 8.47	16.15 \pm 4.80	0.00*
Sperm reserve corpus	198.46 \pm 100.64	108.69 \pm 52.41	0.10NS
Sperm reserve caudal	370.85 \pm 124.48	178.39 \pm 63.22	0.05*
Daily Sperm production in testis	8.923 \pm 2.08	6.92 \pm 1.33	0.33NS

Table 6: Correlation among gonadal and extra gonadal sperm reserve

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. SR Left testis	1															
2. SR Right testis	0.35	1														
3. SR Paired testis	0.90**	0.72**	1													
4. SR Left caput	0.45	0.37	0.50	1												
5. SR Right caput	-0.20	0.19	-0.06	-0.35	1											
6. SR paired caput	-0.07	0.19	0.04	-0.27	0.98**	1										
7. SR Left corpus	-0.17	-0.34	-0.28	0.12	-0.09	-0.01	1									
8. SR Right corpus	-0.11	-0.23	-0.19	0.17	-0.12	-0.04	0.98**	1								
9. SR paired corpus	-0.16	-0.40	-0.30	0.08	-0.08	0.00	0.99**	0.97**	1							
10. SR Left caudal	-0.08	-0.38	-0.23	-0.09	-0.11	-0.03	0.81**	0.72**	0.80**	1						
11. SR Right caudal	-0.11	-0.20	-0.17	-0.033	0.21	0.29	0.91**	0.91**	0.92**	0.72**	1					
12. SR paired caudal	-0.08	-0.34	-0.22	-0.09	0.01	0.09	0.90**	0.83**	0.90**	0.97**	0.87**	1				
13. DSP Left testis	0.89**	0.30	0.79**	0.46	-0.20	-0.04	0.18	0.25	0.20	0.20	0.24	0.24	1			
14. DSP Right testis	0.30	0.97**	0.67**	0.37	0.19	0.21	-0.17	-0.05	-0.23	-0.24	-0.03	-0.18	0.35	1		
15. DSP paired	0.75**	0.68**	0.87**	0.50	-0.04	0.07	0.03	0.17	.02	-0.09	0.17	.00	0.85**	0.73**	1	
16. SC	0.24	-0.56*	-0.08	0.12	-0.39	-0.31	0.26	0.28	0.34	0.32	0.16	0.26	0.24	-0.56*	-0.08	1

DSP- Daily sperm production, SEM- Standard error of mean, SR- sperm reserve, SC- scrotal circumference,

**- Correlation is significant at 0.01 level ; *-Correlation is significant at 0.05 level

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The mean daily testicular sperm production (DSP) recorded in this study were higher than the values obtained by Ibrahim *et al.* (2012a). This difference may be due to environmental peculiarities, age, of the animal, testicular size, season, or even nutrition as the animal were purely reared on pastoral condition. Mean DSP were similar for both the left (8.923 ± 2.08) and right (6.92 ± 1.33) testicles.

A significantly high correlation was found between sperm reserve of right and left testes with paired testes and daily sperm production of paired testes. However, there was a significant negative correlation between daily sperm production of right testes with scrotal circumference ($r = -0.56$, $p < 0.05$), corpus sperm reserve and caudal sperm reserved, ($r = 0.90$, $p < 0.01$). The significant correlation observed between the testes and scrotal circumference, daily sperm production (DSP) corpus sperm reserve and caudal sperm reserve is in agreement with the observation of Bitto and Egbunike (2006) in the West Africa dwarf bucks.

Conclusion

The study showed that testicular morphometry and sperm reserve of camels in Sahelian Nigeria are comparable to that obtainable in camels of other regions of the world. It was also concluded that testicular morphometric characteristics have the potential to be used in predicting sperm production capacity in live camels' bulls.

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