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Influence of Age, Body Weight and Season on Testicular and Epididymis Biometrics in Donkeys (*Equus asinus*)

Influencia de la Edad, el Peso Corporal y la Estación en la Biometría Testicular y el Epidídimo en Burros (*Equus asinus*)

S. Aissanou & A. Ayad

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SUMMARY: The objective of this present investigation was undertaken to study the testicular and epididymal biometrical characteristics in Algerian donkeys throughout the year according to age, body weight and seasonal changes. The study was conducted from February 2019 to January 2020. A total of 24 sexually mature donkeys (*Equus asinus*) were selected randomly. The testis and epididymis were collected after slaughter of donkeys and separated from the conjunctive and adherent tissues. The epididymis has been carefully removed at the testicular junction. In total, 10 biometric measures were selected and performed. Our results revealed that there are significant differences ($P<0.05$) between groups in most biometrics values. All biometric parameters varied throughout the year and were affected by the season. Significant differences of the GSI and SC values ($P<0.05$) were observed in different age groups and seasons. On the other hand, no significant differences were observed between the body weight categories of donkeys. The analysis of the correlation coefficients between the biometric values shows high positive correlations, ranged between 0.98 and 0.72 ($P<0.001$). There was a high positive correlation between age and all the parameters, ranged from 0.85 to 0.61 ($P<0.001$). However, there were low negative correlations between season and; testicular and epididymal biometrics. It is the first investigation that describes the male reproductive organs in donkeys of the Algerian race (*Equus asinus*), on the basis of biometric testicular and epididymal measurements. Our results showed that the essential differences were noted between some biometric parameters and the age, season and body weight of donkeys. In addition, the correlation coefficients were supported between biometric measurements and these factors. However, other approaches are necessary to undertake, such as histology of reproductive organs and hormone measurement, for a deeper understanding of the physiology of reproduction in donkeys.

KEY WORDS: Testis; Epidydimis; Biometry; Donkeys; *Equus asinus*.

INTRODUCTION

The common donkey (*Equus asinus*) represents an important component of Algerian livestock because it plays an important role in agricultural economy in particular as means of transport in semiarid regions and also the increasing use of these animals for milk production in some countries. According to Food and Agriculture Organization, the donkey population is continued to decline gradually (Starkey & Starkey, 2000), which constitutes a risk of extinction of the specie in Algeria. It is very necessary to have a perfect knowledge of seasonal physiological changes in order to optimize reproduction characteristics in donkey. This can contribute the increase of donkey populations, promote the species biodiversity and avoids the risk of its extinction.

In Algeria, the characterization of donkeys reproduction has never been conducted to determine the breeding season. Many studies have been carried out on morphometric analysis of the testes in numerous animals to predict sperm production, the storage potentials and fertilizing ability of the breeder male depending several factors such as age, photoperiodic and food quality (Ginther *et al*., 1987; Henry *et al*., 1987; Lemma & Deressa, 2009; Carluccio *et al*., 2013; Rua *et al*., 2017). Similarly, data on testicular size can be used to understand the testicular function and to provide a more knowledge of the different phases of spermatogenesis, and help to characterize puberty and sexual maturity (Nipken & Wrobel, 1997; de Assis-Neto *et al*., 2003; Moustafa *et al*., 2015).

Numerous quantitative investigations have been made in assessing testicular structure and function to describe the reproductive function in mammals (Silva *et al*., 2011; Peixoto *et al*., 2012; Kumar *et al*., 2014; Ajani *et al*., 2015; Oliveira *et al*., 2016; Gemeda & Workalemahu, 2017). Biometric analysis

Department of Pysico-Chemical Biology, Faculty of Nature and Life Sciences, Université de Bejaia, 06000, Bejaia, Algeria.

on some parameters, such as scrotal circumference (SC), testicular weight (TW), testicular length (TL) and testicular volume (TV) has also been performed in bucks (Ajao *et al*., 2014), rams (Ibrahim *et al*., 2012), bulls (Jain *et al*., 2008), and camel (Pasha *et al*., 2011a,b). It has been established that morphometric study of the testis, testicular measurement and the seasonal changes take place through year have been well documented for goats (Raji *et al*., 2008), rams (Divya *et al*., 2013), and bulls (Cardoso da Luz *et al*., 2013). Data generated from morphometric studies have been positively correlated with testicular circumference, weight and volume in beef bulls (Cartee *et al*., 1989). However, there are few reports in the literature concerning the testicular and epididymal biometrics analysis in donkeys (Morais *et al*., 1993; Carluccio *et al*., 2004; Lemma & Deressa). The present survey may improve on the available information on the testis changes of donkeys, especially Algeria local breed. The objective of this present investigation was undertaken to study the testicular and epididymal biometrical characteristics in Algerian donkeys throughout the year according to age, body weight and seasonal changes. The correlation between testicular and body morphometric measurements were also estimated.

MATERIAL AND METHOD

This research was approved by the Scientific Council of the Faculty of Nature and Life Sciences (Report of Faculty Scientific Council #05 dated October 30, 2018), University of Bejaia, Algeria. Concerning the ethical aspects, the experimental procedure was performed according to good veterinary practice under farm conditions.

Study area: The study was carried out in the Jijel province of Algeria (36° 47' N, 5° 45' E) on altitude of 20m and Mediterranean climate predominance. The province has four distinct seasons: winter (January to March), spring (April to June), summer (July to September) and autumn (October to December).The mean maximum summer temperature is ranged from 31.3 to 36.3 °C (August) and the mean minimum winter temperature is ranged from 6.6 to 7.7 °C (February) during the study period.

The study was conducted from February 2019 to January 2020. A total of 24 sexually mature donkeys (*Equus asinus*) were selected randomly from of Taza Animal Park (Jijel province). The ages of donkeys were determined from dentition analysis (Davézé & Raveneau, 2002). The age of the animals ranged between 3 and 20 years. Body condition scores (BCS) of donkeys were recorded before the animal slaughter (Pearson & Quassat, 1996). Scores were given by the same researcher based on a 1 (thin) to 5 (obese) scales. Animals were checked by a veterinarian and presented no signs of disease clinical especially in the testicular area. All donkeys were under condition of free stabling period. Three body measures were selected for morphometric characterization namely linear measures as withers height, body length and thoracic circumference.

Testicular and epididymal measurements. The testis and epididymis were collected after slaughter of donkeys and separated from the conjunctive and adherent tissues. The epididymis has been carefully removed at the testicular junction. In total, 10 biometric measures were selected and performed using a specially graduated measuring tape, viz. testicular length (TL), testicular width (TW), testicular height (TH), testicular weight (TWe), testicular volume (TV), cauda epididymal diameter(CED), epididymal weight (EWe), epididymal volume (EV) and scrotal circumference (SC). The gonadosomatic index (GSI, g/kg) was also estimated as the ratio of each testicular weight to body weight (Abba & Igbokwe, 2015).

The cauda epididymal diameter (CED) and scrotal circumference (SC) were measured using a Vernier caliper and graduated tape, respectively. Testicular and epididymal weights were obtained using a digital balance. The testicular volume (TV) was calculated using according to validated formula (Love *et al*., 1991): $TV = 4/3\ \pi\ (TL/2 \times TW/2 \times TH/2)$, $\pi = 3.14$. The epididymis volume (EV) was measured by the use of water displacement (Ali Abdullahi *et al*., 2012).

Statistical analysis. Data were analyzed using a mixed model for repeated measurements (Statview Software, Version 4.55) taking into account an autocorrelation between data obtained successively on the same animal. The data (± SD) were expressed as values of the testes and epididymal measurements (cm, cm^3 and g). The testes and epididymal measurements were analyzed using age (young: ≤5 years; adult: ≥5-≤10 years; aged: ≥11 years), weight animal, season (winter, spring, summer and autumn) and some body measurements (withers height, body length and thoracic circumference) as factors of variation. The one-way variance analysis (ANOVA) was used to evaluate the obtained data. The values were statistically different when the P-value was <0.05.

RESULTS

The overall mean (±SE) biometric characteristics of donkeys were shown in Table I. Mean values of age, body weight and body corporal score are 10.92 ± 0.75 years,

Table I. Descriptive data of corporal morphometrics, testicular and epididymal biometrics of donkey (*Equus asinus*) (n = 24).

Parameter	Mean	SE	Minimum	Maximum
Age (years)	10.92	0.75	3	20
Body condition score	2.98	0.14	2	4
Body weight (kg)	193.08	4.48	140	250
Withers height (cm)	111.58	0.9	101	130
Thoracic circumference (cm)	118.38	1.11	105	130
Body length (cm)	112.88	1.09	96	127
Testis width (cm)	4.92	0.13	3.1	6.5
Testis length (cm)	6.8	0.2	4	9.5
Testis height (cm)	3.79	0.12	1.7	5.2
Testis volume (cm^3)	73.42	5.53	13.51	149.2
Testis weight (g)	80.91	5.8	17.7	160
Cauda epididymal diameter (cm)	2.45	0.08	1.4	3.5
Epididymal volume (cm^3)	17.93	1.05	7.3	32.5
Epididymal weight (g)	17.96	1.05	7	33.1
Gonado-somatic index (g/kg)	0.82	0.07	0.19	1.5
Scrotal circumference (cm)	14.96	0.53	8	21.5

193.08 ± 4.48 kg and 2.98 ± 0.14, respectively. Mean values of morphological variables such as withers height, thoracic circumference and body length are 111.58 ± 0.9, 118.38 ± 1.11 and 112.88 ± 1.09, respectively.

Mean values of testicular and epididymal biometrics variables of donkeys (*Equus asinus*) for each age group, season and body weight categories are shown in Tables II, III and IV, respectively. Our results revealed that there are significant differences (P<0.05) between groups in most biometric values. Values of testicular height (TH), testicular weight (TWe), testicular volume (TV), epididymal weight (EWe) and epididymal volume (EV) were significant lower (P<0.05) in aged donkeys (≥12 years) compared to adult donkeys (≥6-≤12 years) and the young donkeys (≤5 years). Table III illustrates the seasonal variation of testicular and epididymal biometrics. All biometric parameters varied throughout the year and were affected by the season.

Table II. Values of testicular and epididymal biometrics in donkeys (*Equus asinus*) in different ages.

Morphometric measures	Young donkeys (≤5 years) (n=6) (Mean ± SD) (Min-Max)	Adult donkeys (≥6-≤12 years) (n=9) (Mean ± SD) (Min-Max)	Aged donkeys (≥12 years) (n=9) (Mean ± SD) (Min-Max)
Testicular length (cm)	5.08±0.2a (4.1-6.1)	7.1±0.2b (6-8.75)	7.71±0.28b (5.85-9.35)
Testicular width (cm)	3.71±0.15a (3.25-4.5)	5.24±0.16b (4.5-6.5)	5.43±0.13b (4.35-6)
Testicular height (cm)	2.7±0.16a (1.85-3.15)	3.89 ±0.09b (3.45-4.6)	4.49±0.15c (3.35-5.1)
Testicular weight (g)	29.49±3.47a (19.4-50.82)	86.37±6.37b (53.2-135.45)	112.64±6.57c (71.075-145.1)
Testicular volume (cm^3)	27.59±3.52a (14.69-44.58)	78.485±6.2b (50.115-126.84)	101.45±7.74c (44.67-141.07)
Cauda epididymal diameter (cm)	1.78±0.06a (1.5-2.05)	2.68±0.08b (2.25-3.35)	2.66±0.11b (2-3.15)
Epididymal weight (g)	10.11±0.75a (7.5-13.85)	18.2±1.65b (8.55-33.05)	23.547±0.79c (17.97-27.8)
Epididymal volume (cm^3)	9.64±0.76a (7.4-13.4)	18.5±1.51b (7.85-32.15)	23.44±1.01c (17.5-31.85)

a,b,cMeans with the different letters superscripts in each row of different ages are significantly different (P<0.05).

Table III. Values of testicular and epididymal biometrics in donkeys (*Equus asinus*) in different seasons.

Morphometric measures	Winter (n=7) (Mean ± SD) (Min-Max)	Spring (n=7) (Mean ± SD) (Min-Max)	Summer (n=5) (Mean ± SD) (Min-Max)	Autumn (n=5) (Mean ± SD) (Min-Max)
Testicular length (cm)	7.19 ± 0.35b (5.2-9.35)	6.14 ± 0.38a (4.1-8.1)	5.95 ± 0.24a (4.7-6.9)	8.02 ± 0.25b (6.9-8.85)
Testicular width (cm)	4.87 ± 0.23a (3.25-6)	4.63 ± 0.28a (3.3-6.5)	4.53 ± 0.23a (3.35-5.45)	5.78 ± 0.12b (5.45-6.4)
Testicular height (cm)	3.65 ± 0.25a (1.85-4.8)	3.55 ± 0.18a (2.7-4.6)	3.47 ± 0.25a (2.3-4.6)	4.66 ± 0.15b (4.05-5.1)
Testicular weight (g)	81.85 ± 10.10a (21.65-145.1)	66.92 ± 10.72a (20.7-135.45)	57.98 ± 8.8a (19.4-102.35)	122.09 ± 7.01b (83-135.5)
Testicular volume (cm^3)	73.6 ± 10.39a (14.69-141.1)	59.53 ± 9.8a (19.28-126.8)	52.5 ± 7.62a (19.04-90.6)	113.53 ± 6.08b (79.75-124.6)
Cauda epididymal diameter (cm)	2.19 ± 0.14a (8.25-27.8)	2.43 ± 0.15a (1.9-3.35)	2.33 ± 0.13a (1.7-2.8)	2.95 ± 0.07b (2.65-3.15)
Epididymal weight (g)	17.85 ± 1.92b (8.25-27.8)	19.3 ± 2.42b (8.38-33.05)	12.05 ± 1.29a (7.5-17.98)	22.15 ± 0.86b (17.93-24.95)
Epididymal volume (cm^3)	19.46 ± 2.37b (7.55-31.85)	18.46 ± 2.37b (7.4-32.15)	11.66 ± 1.24a (7.75-17.5)	21.32 ± 0.82b (17.3-24.05)

a,b,cMeans with the different letters superscripts in each row of different ages are significantly different (P<0.05).

Table IV. Values of testicular and epididymal biometrics in donkeys (*Equus asinus*) in different weight body.

Morphometric measures	Weight donkeys (140-180 kg) (n=9) (Mean ± SD) (Min-Max)	Weight donkeys (180- 220 Kg) (n=10) (Mean ± SD) (Min-Max)	Weight donkeys (220-250 kg) (n=5) (Mean ± SD) (Min-Max)
Testicular length (cm)	6.5±0.31a (4.5-9)	6.61±0.31a (4-9)	7.72±0.38b (5.7-9.5)
Testicular width (cm)	4.63±0.21a (3.2-5.7)	4.85±0.2a (3.1-6.5)	5.57±0.24b (4.2-6.5)
Testicular height (cm)	3.54±0.23a (1.7-5)	3.71±0.15a (2.5-5.5)	4.41±0.2b (3.1-5.1)
Testicular weight (g)	67.64±9.13a (17.7-138.5)	74.9±8.11a (19.5-145.5)	116.78 ±9.75b (65-160)
Testicular volume (cm^3)	62.66±8.36a (13.5-134.5)	67.93±7.88a 130.56-16.23	103.76±11.56b 149.2-41
Cauda epididymal diameter (cm)	2.41±0.13a (1.4-3.1)	2.28±0.1a (1.5-3.2)	2.84±0.15b (2.2-3.5)
Epididymal weight (g)	15.48±1.61a (7-27.4)	16.18±1.33a (8.35-26.9)	26.01±1.55b (19-33.1)
Epididymal volume (cm^3)	15.41±1.48a (7.5-26)	16.12±1.37a (7.3-26.2)	26.019±1.75b (18.4-32.5)

a,b,cMeans with the different letters superscripts in each row of different ages are significantly different (P<0.05).

Testicular weight (TWe), testicular length (TL), testicular width (TW), testicular volume (TV) and epididymal volume (EV) are very higher in winter and autumn compared to spring and summer seasons (P<0.05). Conversely, the caudal epididymal diameter and epididymal weight values were low (P> 0.05) in winter (2.19 ±0.14 cm and 17.85 ±1.92 g, respectively). In the current study, three groups of bodyweight donkeys were considered (Table IV). All biometrics parameters of the bodyweight donkeys ranged from 220 to 250 kg were also a significantly higher (P<0.05) compared to the weight donkeys 140-180 kg and 180-220 kg.

The gonadosomatic index and scrotal circumference expressed by age groups, seasons and body weight categories of donkeys (*Equus asinus*) are shown in Figure 1. Significant differences of the GSI and SC values (P<0.05) were observed

in different age groups. Also, the GSI and SC appeared to be increased by donkey's ages. GSI and SC values were significant high (P<0.05) in the autumn period compared to other seasons. On the other hand, no significant differences were observed between the body weight categories of donkeys.

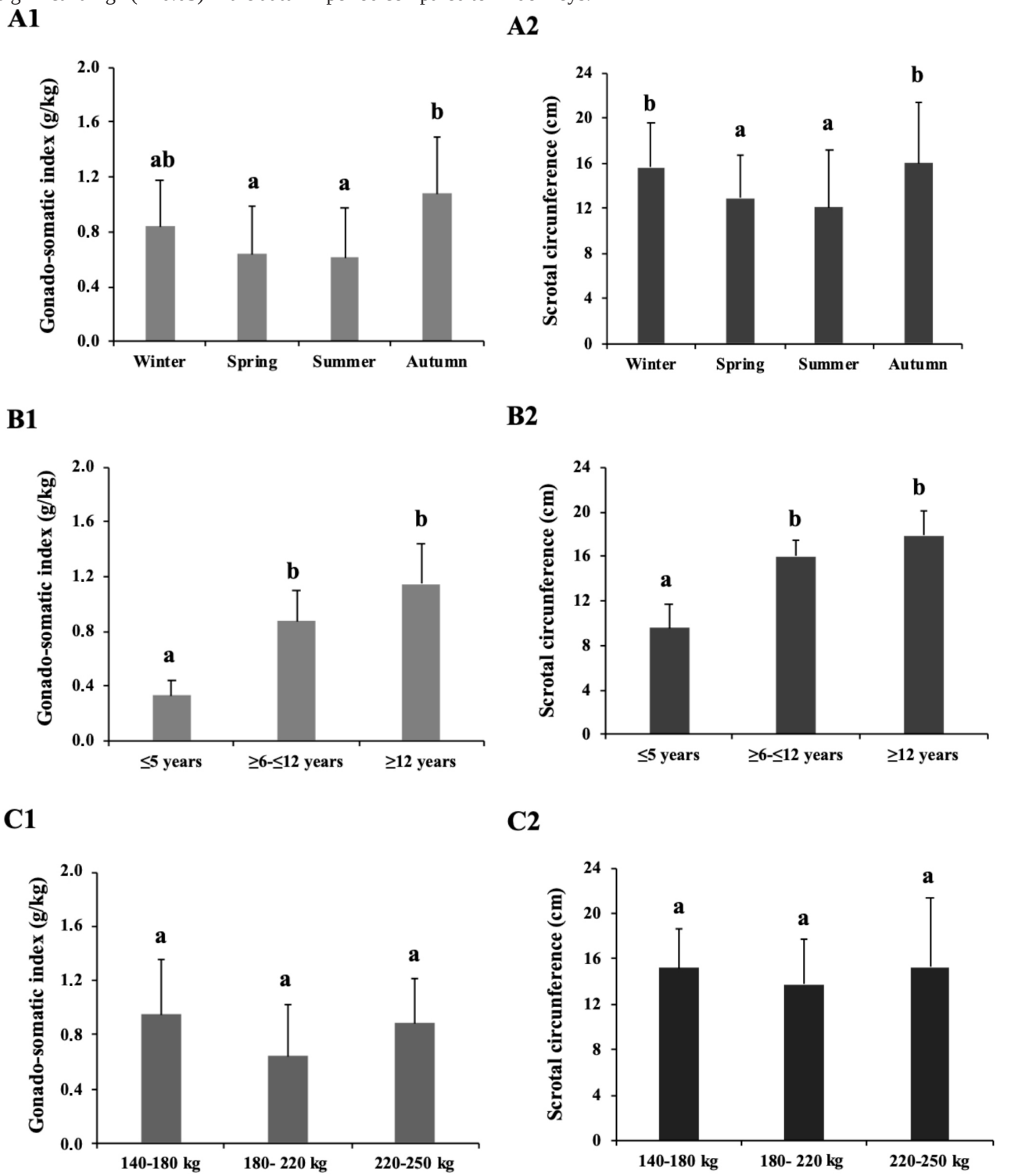

Fig. 1. Gonado-somatic index and scrotal circumference by age (A1, A2), seasons (B1, B2) weight body (C1, C2) in donkeys (*Equus asinus*), respectively. a,bMeans (±SD) with the same superscripts in each groups of different age, seasons and weight body are significantly different (P<0.05).

Testicular and epididymal biometrics correlation coefficients (r) are summarized in Table V. The analysis of the correlation coefficients between the biometric values shows high positive correlations, ranged between 0.98 and 0.72 (P<0.001). The correlation coefficients (r) among testicular and epididymal biometrics, morphologic variables, age, season and body weight are given in Table VI. There was a high positive correlation between age and all the parameters, ranged from 0.85 to 0.61 (P<0.001). However, there were low negative correlations between season and; testicular and epididymal biometrics. For the body weight, the correlations were more marked with EWe (r = 0.56) and EV (r = 0.55), moderately marked with TW; TWe; TH; TV and SC (0.41≥ r ≤0.49), and weakly marked with the rest of the biometrics parameters (P<0.05). Other low correlation values were recorded between the biometrics morphological parameters especially thoracic circumference.

Table V. Correlation coefficients (r) between testicular and epidydimal biometrics in donkeys (*Equus asinus*).

	TWe	EWe	CED	TH	TL	TW	TV	EV	GSI	SC
TWe	1									
EWe	0.83*	1								
CED	0.82*	0.72*	1							
TH	0.93*	0.73*	0.8*	1						
TL	0.95*	0.75*	0.74*	0.86*	1					
TW	0.93*	0.8*	0.82*	0.9*	0.91*	1				
TV	0.98*	0.79*	0.82*	0.93*	0.95*	0.94*	1			
EV	0.85*	0.94*	0.73*	0.75*	0.82*	0.81*	0.82*	1		
GSI	0.94*	0.74*	0.81*	0.9*	0.93*	0.91*	0.94*	0.76*	1	
SC	0.93*	0.75*	0.76*	0.89*	0.92*	0.91*	0.91*	0.8*	0.91*	1

Testicular length (Tl), testicular width (TW), testicular height (TH), testicular weight (TWe), testicular volume (TV), cauda epididymal diameter (CED), epididymal weight (EWe), epididymal volume (EV), Gonado-somatic index (GSI) and scrotal circumference (SC). *P<0.001.

Table VI. Correlation coefficients (r) between testicular and epidydimal biometrics and factor variation (age, season, weight body and body measurements) in donkeys (*Equus asinus*).

	Age	Season	Weight body	Withers height	Body length	Thoracic circumference
TL	0.73***	-0.35*	0.36*	0.26	0.42**	0.23
TW	0.70***	-0.18	0.43**	0.28*	0.42**	0.27
TH	0.78***	-0.05	0.41**	0.28*	0.42**	0.21
TWe	0.78***	-0.24	0.49***	0.38**	0.53***	0.3*
TV	0.74***	-0.23	0.43**	0.28*	0.45**	0.26
CED	0.61***	0.02	0.37**	0.33*	0.38**	0.2
EWe	0.71***	-0.24	0.56***	0.51***	0.58***	0.34*
EV	0.72***	-0.36*	0.55***	0.51***	0.61***	0.36*
SC	0.85***	-0.2	0.42*	0.34	0.51**	0.23
GSI	0.76***	-0.25	0.22	0.17	0.34	0.04

Testicular length (Tl), testicular width (TW), testicular height (TH), testicular weight (TWe), testicular volume (TV), cauda epididymal diameter (CED), epididymal weight (EWe), epididymal volume (EV), Gonado-somatic index (GSI) and scrotal circumference (SC). *P<0.05, **P<0.01, *** P<0.001

DISCUSSION

Testicular biometry is used as indicator of reproductive status and its characterization has been well documented in many mammals (Ibrahim *et al*.; Peixoto *et al*.; Murta *et al*., 2013). The reproductive status seems to be influenced by many factors throughout the year in seasonal breeding animals, particularly day length (Machado Júnior *et al*., 2011) and age (Jain *et al*.; Cardoso da Luz *et al*.). It is known that the quantitative methods are of great value in assessing testicular structure and function under various physiological and pathological conditions (Ekhoye *et al*., 2013; Omar *et al*., 2013).The knowledge of male reproductive function in donkeys starts with testicular and epididymal biometric description, as this is a very important means to understand the reproductive physiology of this

species and can help to predict an individual's breeding potential. To author's knowledge, this present study is the first biometrics investigation of the male reproductive organs in Algerian local breed donkeys, showing correlations between different factors (age, season and body weight) and testicular biometric parameters. However, there is limited information on a study that compared testicular and epididymal morphometric characteristic of donkey breeds.

The results of biometric survey revealed that the testicular volume (73.42 ± 5.53 cm^3) of donkeys was higher than Northeast breed of Brazilian donkeys aged from 5 to 7 years (48.44 ± 8.40 cm^3) (da Rocha *et al*., 2018). Conversely, several studies (Canisso *et al*., 2009; Omar *et al*.) have reported high values of testes volume in different breeds compared to our findings. The overall testis sizes of donkeys in the current study are lower compared to previously investigations from Brazil (Gastal *et al*., 1997) and Italy (Carluccio *et al*., 2004). GSI value found in Algerian local breed donkeys (0.82 ± 0.07) is very higher than in Pêga Donkeys (0.15) (Neves *et al*., 2014). However, GSI values were much higher than those reported for other domestic ruminants such as bulls 0.13 g/kg (Andreussi *et al*., 2014), goats 0.4 g/kg (Leal *et al*., 2004) and rams (Al-kawmani *et al*., 2014). Therefore, according to our age-related GSI results, it should be noted that the testes develop until the aged group of donkeys is attained. The differences between the average of many biometric measurements can be explained by breed difference, geographical locations, nutritional level, agro-climatic condition, and livestock management. Corporal morphometric traits (WH, TC, and BL) recorded in this study are very similar to those published recently in Algerian local breed donkeys (Ayad *et al*., 2019). The results of this study noticed that donkeys are small in size compared to the others mentioned in previously papers. This can be explained by the food quantity and quality and work intensity.

Our findings revealed that young, adults, and aged animals present a significantly difference ($P<0.05$) of testicular and epididymal biometrics parameters and this increases concomitantly with donkeys age. Similarly, the same observation was obtained concerning the body weight which there was a significant difference ($P<0.05$) between the values of some biometrics measurements according to the animal bodyweight categories. There was a significant difference ($P<0.05$) between the values of GSI and SC according to the donkey's age and their body weight categories. These findings corroborate with results obtained previously in Pêga breed donkeys (Canisso *et al*.) and other domestic animal species (Ajao *et al*.; Eljarah *et al*., 2017; Al-Sadoon *et al*., 2019). Likewise, El Wishy (1974) observed the same epididymal weight in donkeys with a body weight of 256.7 kg. Further, Lemma & Deressa recorded a high SC in Ethiopian donkeys ranged from 15.2 to 26.7 cm. These differences can be attributed to the BCS alterations of the donkeys considered in this study (2.98 vs. 3.41). However, it was determined that BCS and age can influence scrotal circumference (Lemma & Deressa). Many investigations have reported that the testicular size parameters increased with different age groups, this could indicate a normal structure of the spermatozoa and proved their high capacity for fertilization (Leal *et al*.; Abba & Igbokwe). This would be due to the fact that the physiological evolution according to animal age leads to a development of genital apparatus and morphological growth. Our results on changing of biometric parameters suggested that the activities of testis and epididymis appears to be active in donkeys aged (≥6 years) and weighted (≥220 kg) than others donkeys. Also, testicular growth is sustained in a period appropriate to the proliferation of seminiferous tubule epithelium associated with an increase in sperm production (Nipken & Wrobel).

In the literature, the testicular and epididymal biometrics values seem affected by the season. Previous investigations have demonstrated seasonal variations in reproductive activity throughout the year under natural photoperiod conditions in some animal species (Blottner & Jewgenow, 2007; Kumar *et al*., 2014). In the present work, biometric parameters have changed over the different seasons, higher values have been recorded for the short days length (winter and autumn) compared to the long days length (spring and summer) ($P<0.05$). Regarding to GSI and SC values of the donkeys, the results of this study also noticed that these values were significantly important during winter and autumn than during spring and summer. This could be explained by an increase in seminal tubule activity and sperm production (Carluccio *et al*., 2013). Indeed, in agreement with our observations, many investigations demonstrated that an increase in the physiological activity of the testes by biometric measurements of the testes during the different seasons in different animal species (Pasha *et al*., 2011a,b; Machado Júnior *et al*.; Martinez *et al*., 2012; Perumal *et al*., 2017). Our results controversies to those previously published, which demonstrated that Martina Franca's and Pêga breed male donkeys which did not show significant differences in testicular morphometric characteristics throughout the year (Kreuchauf, 1984; Gastal *et al*., 1996; Carluccio *et al*., 2013). This difference could be attributed to nutritional and photoperiodic environment, it is likely to be due to a genetic difference in sexual capacity of the breeds. Results of this current study suggest that the sexual behavior with intense libido could be exhibited during winter and autumn compared with spring and summer in Algerian local breed donkeys, which reinforces the concept that they are controlled by photoperiod.

Regarding correlation analysis (Table V), there were high significantly (P< 0.001) correlations between testicular and epididymal biometrics values, these provides information of the gonadal status of donkeys. This could predict that the structure of testes and epididymis of donkeys are normalness in the current investigation. These results corroborate with those reported in some domestic animals by numerous authors (Jain *et al*.; Pasha *et al*., 2011a,b; Ibrahim *et al*.; Ajao *et al*.; Al-Bulushi *et al*., 2019). In another study, Lemma & Deressa reported correlation coefficients of 0.43 (P<0.05) between SC and TWe in Ethiopian donkeys.

CONCLUSION

It is the first investigation that describes the male reproductive organs in donkeys of the Algerian local breed (*Equus asinus*), on the basis of biometric testicular and epididymal measurements. Our results showed that the essential differences were noted between some biometric parameters and the age, season and body weight of donkeys. In addition, the correlation coefficients were supported between biometric measurements and these factors. However, other approaches are necessary to undertake, such as histology of reproductive organs and hormone measurement, for a deeper understanding of the physiology of reproduction in donkeys.

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AISSANOU, S. & AYAD, A. Influencia de la edad, el peso corporal y la estación en la biometría testicular y el epidídimo en burros (*Equus asinus*). *Int. J. Morphol., 38(5)*:1434-1443, 2020.

RESUMEN: El objetivo de esta investigación fue estudiar las características biométricas testiculares y epididimarias en burros Argelinos durante todo el año de acuerdo con la edad, el peso corporal y los cambios estacionales. El estudio se realizó entre febrero de 2019 y enero de 2020. Se seleccionó al azar un total de 24 burros sexualmente maduros (*Equus asinus*). Los testículos y el epidídimo se recogieron después del sacrificio de los burros y se separaron de los tejidos conjuntivos y adherentes. El epidídimo se eliminó cuidadosamente en la unión testicular. En total, se seleccionaron y realizaron 10 medidas biométricas. Nuestros resultados revelaron que existen diferencias significativas (P <0,05) entre los grupos en la mayoría de los valores biométricos. Todos los parámetros biométricos variaron a lo largo del año y se vieron afectados por la temporada. Se observaron diferencias significativas de los valores de GSI y SC (P <0,05) en diferentes grupos de edad y estaciones. Por otra parte, no se observaron diferencias significativas entre las categorías de peso corporal de los burros. El análisis de los coeficientes de correlación entre los valores biométricos muestra altas correlaciones positivas, entre 0,98 y 0,72 (P <0,001). Hubo una alta correlación positiva entre la edad y todos los parámetros, que varió de 0,85 a 0,61 (P <0,001). Sin embargo, hubo bajas correlaciones negativas entre temporada y biometría testicular y epididimaria. Es la primera investigación que describe los órganos reproductores machos en burros de la raza Argelina (*Equus asinus*), sobre la base de mediciones biométricas testiculares y epididimarias. Nuestros resultados mostraron que se observaron las diferencias esenciales entre algunos parámetros biométricos y la edad, la estación y el peso corporal de los burros. Además, los coeficientes de correlación fueron compatibles entre las mediciones biométricas y estos factores. Sin embargo, son necesarios otros enfoques, como la histología de los órganos reproductivos y la medición de hormonas, para una mayor comprensión de la fisiología de la reproducción en burros.

PALABRAS CLAVE: Testículo; Epidídimo; Biometría; Burros; *Equus asinus*.

REFERENCES

Abba, Y. & Igbokwe, I. O. Testicular and related size evaluations in Nigerian Sahel goats with optimal cauda epididymal sperm reserve. *Vet. Med. Int. 2015*:357519, 2015.

Ajani, O. S.; Oyeyemi, M. O. & Moyinoluwa, O. J. Correlation between age, weight, scrotal circumference and the testicular and epididymal parameters of Red Sokoto bucks. *J. Vet. Med. Anim. Health, 7(5)*:159-63, 2015.

Ajao, E. O.; Akinyemi, M. O.; Ewuola E. O. & Osaiyuwu, O. H. Body measurement of Red Sokoto bucks in Nigeria and their relationship with testicular biometrics. *Iran. J. Appl. Anim. Sci., 4(4)*:761-7, 2014.

Al-Bulushi, S.; Manjunatha, B. M.; de Graaf, S. P. & Rickard, J. P. Reproductive seasonality of male dromedary camels. *Anim. Reprod. Sci., 202*:10-20, 2019.

Al-kawmani, A. A.; Alfuraiji, M. M.; Abou-Tarboush, F. M.; Alodan, M. A. & Abul Farah, M. Developmental changes in testicular interstitium in the Najdi Ram Lambs. *Saudi J. Biol. Sci., 21(2)*:133-7, 2014.

Al-Sadoon, A. A.; Al-yasery, A. J. & Al-Khagani, I. Y. Comparative morphological and anatomical study to development of testes and epididymis in males of arrabi and awassi sheep. *Plant Arch., 19(1)*:181-90, 2019.

Ali Abdullahi, I.; Al-Hassan Musa, H. & Jibril, A. Scrotal circumference and testicular morphometric characteristics of the camel (*Camelus dromedarius*) in the semi-arid environment of Northern Nigeria. *Int. J. Morphol., 30(4)*:1369-72, 2012.

Andreussi, P. A. T.; Costa, D. S.; Faria, F. J. C.; Fernandes, C. A. C.; Santos, M. D. & Silva, J. C. B. Testicular histomorphometric evaluation of Zebu bull breeds. *Braz. Arch. Biol. Technol., 57(6)*:900-7, 2014.

Ayad, A.; Aissanou, S.; Amis, K.; Latreche, A. & Iguer-Ouada, M. Morphological characteristics of donkeys (*Equus asinus*) in Kabylie area, Algeria. *Slovak J. Anim. Sci., 52(2)*:47-94, 2019.

Blottner, S. & Jewgenow, K. Moderate seasonality in testis function of domestic cat. *Reprod. Domest. Anim., 42(5)*:536-40, 2007.

Canisso, I. F.; Davies Morel, M. C. G. & McDonnell, S. Strategies for the management of donkey jacks in intensive breeding systems. *Equine Vet. Educ., 21(12)*:652-9, 2009.

Cardoso da Luz, P. A.; da Silva Santos, P. R.; Andrighetto, C.; Jorge, A. M. & de Assis Neto, A. C. The correlation between age, body weight and testicular parameters in Murrah buffalo bulls raised in Brazil. *J. Reprod. Dev., 59(1)*:14-7, 2013.

Carluccio, A.; Panzani, S.; Contri, A.; Bronzo, V.; Robbe, D. & Veronesi, M. C. Influence of season on testicular morphometry and semen characteristics in Martina Franca jackasses. *Theriogenology, 79(3)*:502-7, 2013.

Carluccio, A.; Villani, M.; Contri, A.; Tosi, U. & Battocchio, M. Studio preliminare su alcune caratteristiche seminali e morfometriche testicolari dello stallone asinino di Martina Franca. *Ippologia, 15(4)*:23-6, 2004.

Cartee, R. E.; Gray, B. W.; Powe, T. A.; Hudson, R. S. & Whitesides, J. Preliminary implications of B-mode ultrasonography of the testicles of beef bulls with normal breeding soundness examinations. *Theriogenology, 31(6)*:1149-57, 1989.

da Rocha, J. M.; Ferreira-Silva, J. C.; Neto, H. F. V.; Moura, M. T.; Ferreira, H. N.; Silva Junior, V. A.; Manso Filho, H. C. & Oliveira, M. A. L. Immunocastration in donkeys: clinical and physiological aspects. *Pferdeheilkunde Equine Med., 34*:12-6, 2018.

Davézé, J. & Raveneau, A. *Le Livre de l'Âne*. Paris, Rustica, 2002.

de Assis-Neto, A. C.; de Carvalho, M. A. M.; de Melo, M. I. V.; Miglino, M. A.; de Oliveira, M. F.; de Almeida, M. M.; Papa, P. C. & Kfoury Júnior, J. R. Aspectos biométricos do desenvolvimento testicular e corporal em cutias (*Dasyprocta aguti*) criadas em cativeiros. *Braz. J. Vet. Res. Anim. Sci., 40 Suppl. 2*:154-60, 2003.

Divya, V.; Kumar, V. G.; Nandi, S.; Ramchandra, S. G. & Surin, W. R. Scrotal-testicular biometry, sperm quality and quantity in rams (*Ovis aries*). *Asian Pac. J. Reprod., 2(4)*:301-3, 2013.

Ekhoye, E. I.; Nwangwa, E. K. & Aloamaka, C. P. Changes in some testicular biometric parameters and testicular function in cadmium chloride administered Wistar rats. *J. Adv. Med. Med. Res., 3(4)*:2031-41, 2013.

Eljarah, A.; Alhaider, A. K.; Jawasreh, K.; Ismail, Z. B.; Alhalah, A. & El-Bahr, S. M. Investigation of scrotal circumference, testicular dimensions and semen characteristics of the vulnerable Arabian oryx (*Oryx leucoryx*): an approach supports the future use of artificial insemination. *Ital. J. Anim. Sci., 16(3)*:484-9, 2017.

ElWishy, A. B. Testicular and epididymal sperm reserves in the ass (*Equus asinus*) and stallion (*Equus caballus*). *Z. Tierzuecht. Zuechtungsbiol., 91(4)*:334-44, 1974.

Gastal, M. O.; Henry, M.; Beker, A. R & Gastal, E. L. Effect of ejaculation frequency and season on donkey jack semen. *Theriogenology, 47(3)*:627-38, 1997.

Gastal, M. O.; Henry, M.; Beker, A. R.; Gastal, E. L. & Gonçalves, A. Sexual behavior of donkey jacks: Influence of ejaculatory frequency and season. *Theriogenology, 46(4)*:593-603, 1996.

Gemeda, A. E. & Workalemahu, K. Body Weight and scrotal-testicular biometry in three indigenous breeds of bucks in arid and semiarid agroecologies, Ethiopia. *J. Vet. Med., 2017*:5276106, 2017.

Ginther, O. J.; Scraba, S. T. & Bergfelt, D. R. Reproductive seasonality of the jenney. *Theriogenology, 27(4)*:587-92, 1987.

Henry, M.; Figueiredo, A. E.; Palhares, M. S. & Coryn, M. Clinical and endocrine aspects of the oestrous cycle in donkeys (*Equus asinus*). *J. Reprod. Fertil. Suppl., 35*:297-303, 1987.

Ibrahim, A. A.; Aliyu, J.; Ashiru, R. M. & Jamilu, M. Biometric study of the reproductive organs of three breeds of sheep in Nigeria. *Int. J. Morphol., 30(4)*:1597-603, 2012.

Jain, R.; Mohanty, T. K. & Pankaj, P. K. Study of relationship of age, testicular biometry and semen characteristics in bulls of Sahiwal and Friesian crosses. *J. Dairy. Foods Home Sci., 27(3-4)*:175-80, 2008.

Kreuchauf, A. Reproductive physiology in the jackass. *Anim. Res. Dev., 20*:51-78, 1984.

Kumar, R.; Pramod, R. K.; Kumar, P. R.; Negi, M.; Singh, S. P.; Singh, R. & Mitra, A. Testicular biometry and seasonal variations in semen parameters of Black Bengal goats. *Indian J. Anim. Sci., 84(6)*:635-9, 2014.

Leal, M. C.; Becker-Silva, S. C.; Chiarini-Garcia, H. & França, L. R. Sertoli cell efficiency and daily perm production in goats (*Capra hircus*). *Anim. Reprod., 1(1)*:122-8, 2004.

Lemma, A. & Deressa, B. Study on reproductive activity and evaluation of breeding soundness of jacks (*Equus asinus*) in and around Debre Zeit, Ethiopia. *Livest. Res. Rural Dev., 21(8)*:126, 2009.

Love, C. C.; Garcia, M. C.; Riera, F. R. & Kenney, R. M. Evaluation of measures taken by ultrasonography and calipers to estimate testicular volume and predict daily sperm output in the stallion. *J. Reprod. Fertil. Suppl., 44*:99-105, 1991.

Machado Júnior, A. A. N.; Assis Neto, A. C.; Ambrósio, C. E.; Leiser, R.; Lima, G. S.; Oliveira, L. S. & Carvalho, M. A. M. Goat scrotal-testicular biometry: Influence of the season on scrotal bipartition. *Pesq. Vet. Bras., 31(12)*:1116-9, 2011.

Martinez, J. M. P.; Domínguez, B.; Barrientos, M. P.; Canseco, R. S.; Ortega, E. & Lamothe, C. Biometry and testicular growth influenced nutrition on prepubertal pelibuey lambs. *Online J. Anim. Feed Res., 2(3)*:314-21, 2012.

Morais, R. N.; Mucciolo, R. G. & Vianna, W. G. Biologia reprodutiva de jumentos. I. Biometria testicular e comportamento sexual durante a colheita de sêmen. *Braz. J. Vet. Res. Anim. Sci., 30(1)*:47-50, 1993.

Moustafa, M. N. K.; Sayed, R.; Zayed, A. E. & Abd El-Hafeez, H. H. Morphological and morphometric study of the development of seminiferous epithelium of donkey (*Equus asinus*) from birth to maturity. *J. Cytol. Histol., 6(6)*:1000370, 2015.

Neves, E. M.; Costa, G. M. J. & França, L. R. Sertoli cell and spermatogenic efficiencies in Pêga Donkey (*Equus asinus*). *Anim. Reprod., 11(4)*:517-25, 2014.

Nipken, C. & Wrobel, K. H. A quantitative morphological study of age-related changes in the donkey testis in the period between puberty and senium. *Andrologia, 29(3)*:149-61, 1997.

Oliveira, K. G.; Santos, R. R.; Leão, D. L.; Queiroz, H. L.; Paim, F. P.; Vianez-Júnior, J. L. D. G. & Domingues, S. F. S. Testicular biometry and semen characteristics in captive and wild squirrel monkey species (*Saimiri* sp.). *Theriogenology, 86(3)*:879-87.e4, 2016.

Omar, M. M. A.; Hassanein, K. M. A.; Abdel-Razek, A. R. K. & Hussein, H. A. Y. Unilateral orchidectomy in Donkey (*Equus asinus*): Evaluation of different surgical techniques, histological and morphological changes on remaining testis. *Vet. Res. Forum, 4(1)*:1-6, 2013.

Pasha, R. H.; Qureshi, A. S.; Lodhi, L. A. & Jamil, H. Biometric and ultrasonographic evaluation of the testis of one-humped camel (*Camelus dromedarius*). *Pak. Vet. J., 31(2)*:129-33, 2011a.

Pasha, R. H.; Qureshi, A. S.; Lodhi, L. A.; Jamil, H.; Masood, A.; Hamid, S.; Iqbal, J. M.; Kamran, Z. & Khamas, W. A. Seasonal changes in the anatomy of testis of one-humped camel (*Camelus dromedarius*). *J. Camel Pract. Res., 18(1)*:145-53, 2011b.

Pearson, R. A. & Ouassat, M. Estimation of the liveweight and body condition of working donkeys in Morocco. *Vet. Rec., 138(10)*:229-33, 1996.

Peixoto, G. C. X.; Silva, M. A.; Castelo, T. S.; Silva, A. M.; Bezerra, J. A. B.; Souza, A. L. P.; Oliveira, M. F. & Silva, A. R. Individual variation related to testicular biometry and semen characteristics in collared peccaries *(Tayassu Tajacu* Linnaeus, 1758). *Anim. Reprod. Sci., 134(3-4)*:191-6, 2012.

Perumal, P.; Savino, N.; Sangma, C. T. R.; Chang, S.; Sangtam, T. Z. T.; Khan, M. H.; Singh, G.; Kumar, B.; Yadav, D. & Srivastava, N. Effect of season and age on scrotal circumference, testicular parameters and endocrinological profiles in Mithun bulls. *Theriogenology, 98*:23-9, 2017.

Raji, A. O.; Igwebuike, J. U. & Aliyu, J. Testicular biometry and its relationship with body weight of indigenous goats in a semi arid region of Nigeria. *A. R. P. N. J. Agric. Biol. Sci., 3(4)*:6-9, 2008.

Rua, M. A. S.; Quirino, C. R.; Veja, W. H. O.; Bartholazzi Junior, A.; Bastos, R.; Matos, L. F. & David, C. M. G. Biometric testicular and serum testosterone concentration of Brazilian Ponies stallions. *Rev. Bras. Saúde Prod. Anim., 18(1)*:204-10, 2017.

Silva, M. R.; Pedrosa, V. B.; Silva, J. C. B.; Eler, J. P.; Guimarães, J. D. & Albuquerque, L. G. Testicular traits as selection criteria for young Nellore bulls. *J. Anim. Sci., 89(7)*:2061-7, 2011.

Starkey, P. & Starkey, M. *Regional and World Trends in Donkey Populations.* In: Fielding, D. & Starkey, P. (Eds.). Donkeys, People and Development. Wageningen, Animal Traction Network for Eastern and Southern Africa (ATNESA), 2000. pp.10-21.

Corresponding author:
Prof. Dr. Abdelhanine Ayad
Department of Pysico-Chemical Biology
Faculty of Nature and Life Sciences
Université de Bejaia, 06000
Bejaia
ALGERIA

Email: hanine06@gmail.com

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