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Characterization of testicular and epididymal parameters in Algerian Arabia bucks

N.A. Ouchene-Khelifi*, N. Ouchene, A. Dahmani

Institute of veterinary sciences, Saad Dahlab University Blida 1, Road of Soumaa, BP 270, Blida-09000, Algeria

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Abstract. *In goat production, the reproductive efficiency of bucks must be taken into account. Testicle size is the most appropriate parameter to directly improve the reproductive performance of females. In this study, body weight (BW), body condition score (BCS) and testicular and epididymal parameters of Arabia goats were studied. A total number of 200 bucks were randomly selected and classified into three age categories (6-12 months, 13-24 months and >2 years). BW, BCS, mean scrotal circumference, testicular volume, testicular diameter, testicular length, testicular weight, testicular density, epididymal weight, epididymal length, epididymal tail length, caput weight, corpus weight, caudal weight, Gonadosomatic Index, Epididymosomatic index and Epididymal-Testicular weight ratio were measured. A highly significant correlation was found between all parameters (p<0.05). The values of all parameters increased significantly with age, with the exception of the gonadosomatic and epididymosomatic indices, which decreased with age (p<0.05). These results provide data that can be used to anticipate an adequate ante-mortem sperm reserve based on testicular size in the preliminary selection of breeding males from the local sexually mature population.*

Keywords: body condition score, body weight, local breed, performance, reproduction

Abbreviations: BW- Body weight; BCS- Body condition score; SC- Scrotal circumference; TW- Testicular weight; EW- Epididymal weight; TL- Testicular length; EL- Epididymal length; TD- Testicular diameter; TV- Testicular volume; GSI- Gonadosomatic index; ESI- Epididymosomatic index; ETW- Epididymal-Testicular weight ratio.

Introduction

In Algeria, the local goat population, mainly present in difficult regions (mountains, forests, steppes and the Sahara) (Ouchene-Khelifi et al., 2015), uses poor food resources to produce meat (Madani et al., 2015). Its population is estimated at 4.9 million heads in 2018 (FAOSTAT, 2018). Among the four main local breeds (Arabia, Makatia, M'Zabyte and Kabyle dwarf), Arabia is the dominant breed (Ouchene-Khelifi et al., 2015, 2018a).

The increase in the amplitude of transhumance under the effect of the food deficit leads to significant mixing between goat populations and constitutes serious threats of extinction of certain genetic types. These threats occur in spite of goat genetic biodiversity in Algeria (Ouchene-Khelifi et al., 2018b). In goat production, the reproductive efficiency of the kid must be taken into consideration (Ajao et al., 2014). Indeed, the fertility of the male generally has a very great influence on the performance of the herd (Yoseph, 2004). Indirect selection recognizes that selection decisions can be based on parameters that are relatively easy to measure, expressed early in life and highly heritable. Among these selection criteria, testes size is the most appropriate parameter to directly improve reproductive performance of females (Bindon and Piper, 1976; Walkley and Smith, 1980; Schoeman et al., 1987). For this reason, the present study was designed and conducted to characterize testicular and epididymal morphobiometric measurements of Arabia bucks, in Algeria.

Material and methods

Study area and animals

This study was conducted, in the spring season of 2019, at the slaughterhouse in the Blida region, north-central Algeria. A total number of 200 Arabia bucks were randomly selected in this study. The breed was determined according to the morphometric characteristics described by Ouchene-Khelifi et al. (2015).

Three age categories were considered: 6-12 months (n=60), 13-24 months (n=80) and >24 months (n=60). The age of the bucks was estimated on the basis of dentition using the FAO (2012) breed descriptor guide and according to Wilson and Durkin (1984). All these bucks were healthy and confirmed to be free of any ante-mortem or postmortem abnormalities or disorders of the genitalia. In the living state, the testicles and scrotum were examined for size, symmetry and consistency. The genitalia of each animal were carefully examined for abnormalities. Males (total 22) with signs of clinical problems

*e-mail: khelifinaa@gmail.com

and reproductive organ abnormalities, such as severe scrotal lesions, orchids, epididymitis, unusual softness, asymmetry and immobility in the scrotum, were excluded from the study (Regassa et al., 2003).

Measured parameters

Body parameters of each animal were recorded such as: age, body condition score (BCS), live body weight (BW, kg) and scrotal circumference (SC, cm). The live body weight (BW, kg) of each buck was recorded before slaughter using a portable scale. SC was measured according to the method described by Goyal and Memon (2007) using a non-stretch tape measure. It was determined in 0.5 increments according to some studies, on a 5-point scale (ranging from 1 to 5 representing emaciated, poor, acceptable, fat or obese animals, respectively).

Immediately after slaughter, the gonads of each buck were identified, labeled and transported in a cooler to the laboratory for evaluation. All measurements were performed by the same person to minimize human error.

The epididymis was severed from the testicles with scissors before measurements were taken separately on the testicles and epididymis. Measurements of each pair of gonads were then averaged for each animal (Goyal and Memon, 2007; Jimenez-Severiano et al., 2010), namely: mean testicular weight (TW), g: measured using a sensitive electronic scale (to the nearest 0.001g) (Oyeyemi et al., 2012); epididymal weight (EW), g: measured using a sensitive electronic balance (to the nearest 0.001g); caput, corpus and caudal were identified on the basis of structures and anatomical locations were recorded separately (g) (Oyeyemi et al., 2012); testicular length (TL), cm: measured along the longitudinal axis of the testicle from the pole of the testicle to the other pole (Toe et al., 2000) using a caliper; epididymal length (EL), cm: measured along the epididymis using a caliper; testicular diameter (TD), cm: measured around the widest point, in an area equidistant from the testicular poles after pushing the testicles firmly into the scrotum (Ajao et al., 2014); testicular volume (TV), ml: measured using a water displacement technique according to Archimedes' principle (Toe et al., 2000; Oyeyemi et al., 2012; Ajao et al., 2014).

Mean testicular density calculated as follows: testicular density = weight of testes (g)/volume of testes (cc) (using the method described by Ibrahim et al. (2012). The gonadosomatic index (GSI, g/kg) has been estimated as the ratio of the weight of each testicle to the weight of the body (Abba and Igbokwe, 2015). The epididymosomatic index (ESI, g/kg) was also estimated as a ratio of each epididymal weight to body weight (Abba and Igbokwe, 2015). Epididymal-Testicular weight ratio (ETW, g/g): was estimated as a ratio of epididymal weight to testicular weight (Abba and Igbokwe, 2015).

Statistical analysis

Data were expressed as means ± SEM. The Pearson correlation test was used to study the correlation. For multi-variable comparisons, one-way ANOVA was conducted, followed by Tukey-Kramer testing using the program R software version 3.0.1(R Core Team2013). Differences were considered significant at $p<0.05$.

Results and discussion

The results of the body, testicular and epididymal parameters values according to age categories obtained are transcribed into Table 1. Discriminant correspondence analyses were conducted. The ability of these canonical functions to assign each individual goat to its group was calculated as the percentage of correct assignment of each group. Figure 1 allows visualizing the linear discriminant analysis and shows clear overlapping between the three age groups of animals.

Table 1. Body, testicular and epididymal parameters values according to age categories

Parameters	Age categories		
	6-12 months (n=60)	13-24 months (n=80)	> 24 months (n=60)
BCS	$1.90±0.24^{a}$	$1.97±0.16^{a}$	$2.19±0.32^{b*}$
BW, kg	$20.71±1.7^{a}$	$25.78±3.71^{b}$	$28.91±0.56^{c*}$
SC, cm	$20.83±1.59^{a}$	$23.66 ± 2.38^{b}$	$27.39±1.60^{c*}$
TL, cm	$6.96±0.78^{a}$	$7.13±0.76^{b}$	$8.12±0.74^{c*}$
EL, cm	$7.92±0.35^{a}$	$8.03±0.93^{b}$	$8.47±0.32^{c*}$
TD, cm	$4.29±0.40^{a}$	$4.72±0.73^{a}$	$6.36±0.60^{b*}$
TV, cm	$66.12±2.44^{a}$	$67.22±0.71^{b}$	$68.13±0.75^{c*}$
TW, cm	$57.61±2.43^{a}$	$69.61±1.81^{b}$	$73.97±0.70^{c*}$
Caput wt, cm	$2.57±0.30^{a}$	$2.47±0.30^{a}$	$2.91±0.56^{b}$
Corpus wt, cm	$0.80±0.09^{a}$	$0.80±0.09^{a}$	$0.84±0.06^{a}$
Caudal wt, cm	$1.69±0.18^{a}$	$2.30±0.24^{b}$	$2.31±0.11^{b}$
EW, cm	$5.06±0.54^{a}$	$5.57±0.48^{b}$	$6.06±0.60^{c*}$
TDs, cm	$0.87±0.04^{a}$	$1.04±0.03^{b}$	$1.09±0.02^{b}$
GSI	$2.79±0.17^{b}$	$2.75±0.34^{b}$	$2.58±0.25^{a}$
ESI	$0.25±0.03^{b}$	$0.22±0.03^{b}$	$0.21±0.03^{a}$
ETW	0.09±0.01	0.08±0.01	0.08±0.01

a,b,c Values that have not the same letter in the same line are different at $p<0.05$;
*These values are significantly higher than the other values in the same linear $p<0.05$.

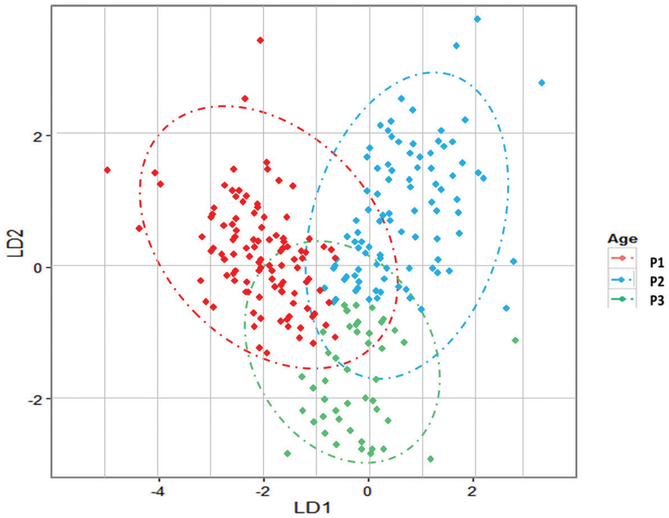

Figure 1. Canonical discriminant plot with 95 % confidence ellipses (in red, first age group; in light blue, second age group; in green, third age group)

In the three age categories, a highly significant positive correlation was found between all measured parameters (p<0.05). The values of all parameters increase significantly with age of bucks except for GSI and ESI which decreases with age (p<0.05). There is no significant difference (p>0.05) between the parameters of the right testicle when compared with the values of the left testicle.

Body, testicular and epididymal parameters are reliable indices for the assessment of semen production capacity and for the evaluation of the quality of animal husbandry. The BCS and BW values could be attributed to nutritional status (Mekasha et al., 2007; Agga et al., 2011). The examination of the reproductive quality of male domestic animals should take body condition into account, as spermatogenesis tends to be limited in body condition; thus, broodstock should be maintained in a moderate state (Parkinson, 2009).

In this study, the mean BCS for all the bucks was 2.01±0.24 (Table 2). This is in agreement with previous reports (Agga et al., 2011; Gemeda and Workalemahu, 2017) in Ethiopia.

Table 2. Descriptive statistics of live body parameters, testicular and epididymal values, n=200

Parameters	Mean	Standard Deviation	Min	Max
BCS	2.01	0.25	1.50	2.75
BW, kg	25.11	4.23	15.70	33.78
SC, cm	23.78	3.12	18.00	29.87
TL, cm	7.33	0.88	5.28	9.10
EL, cm	8.11	0.71	3.00	8.86
TD, cm	5.01	1.01	3.40	7.45
TV, cm	67.13	1.60	61.70	69.40
TW, cm	67.28	6.63	50.70	75.10
Caput wt, cm	2.61	0.42	2.00	3.94
Corpus wt, cm	0.81	0.08	0.60	0.91
Caudal wt, cm	2.13	0.34	1.38	3.00
EW, cm	5.55	0.64	4.13	7.32
TDs, cm	1.00	0.09	0.81	1.12
GSI	2.72	0.29	2.06	3.27
ESI	0.23	0.04	0.15	0.33

For BW, our mean value (25.11±2.60 kg) was in concordance with Sahi et al. (2019) in a study carried out in North East Algeria and exceeded the values recorded in other studies (Ajao et al., 2014; Abba and Igbokwe, 2015; Gemeda and Workalemahu, 2017).

The mean SC value recorded in the present study was 23.78±1.86 cm. This result is similar to the results reported by Raji et al. (2008) and Sahi et al. (2019) and exceeds those established in other studies (Raji et al., 2008; Agga et al., 2011; Oyeyemi et al., 2012; Ajao et al., 2014; Abba and Igbokwe, 2015; Gemeda and Workalemahu, 2017). These differences in values could be due to the effect of differences in nutritional management of males (Gemeda and Workalemahu, 2017). BW affects the SC value of domestic animals (Mickelsen et al., 1981; Mekasha et al., 2007). Large breeds have a higher SC compared to medium and small breeds of the same age (AlGhalban et al., 2004; Mekasha et al., 2008; Agga et al., 2011; Gemeda and Workalemahu, 2017). NseAbasi (2015) reported that for dairy breeds weighing more than 40 kg, a scrotal circumference of 25 cm or more is desired.

SC is an important indicator when observing animals and an essential part of assessing the robustness of the farm (Schoenian, 2012; Osasanya et al. 2014). It is also considered a reliable guide to the semen production capacity of the testis (Daudu, 1984; Raji et al., 2008; Ugwu, 2009). In our study, SC was highly correlated with TL and BW, which provide a good estimate for the prediction of post-mortem testicular and epididymal measurements (Agga et al., 2011).

TL mean value of Arabia Bucks was 7.33±0.76 cm, which is higher compared to the results recorded by Gemeda and Workalemahu (2017) in Ethiopia, Ajao et al. (2014) and Ajani et al. (2015) in Nigeria. However, higher values were reported by Sahi et al. (2019) in Algeria, Abba and Igbokwe (2015) in Nigeria, and Waheed et al. (2011) in Pakistan.

The mean value of TD reported was 5.01±0.58 cm. This is higher to previous reports (Agga et al., 2011; Ajao et al., 2014; Gemeda and Workalemahu, 2017) and comparable with Sahi et al. (2019) in Algeria. Our finding is lower compared to the results reported by others authors (Oyeyemi et al., 2012; Ajani et al., 2015). The discrepancies in values could be due to race differences, as differences in the size of testicular parameters have been reported between races (Goyal and Memon, 2007).

TV mean value established in this study (67.13±1.30) is close to the findings of Gemeda and Workalemahu (2017) and higher to the results of Ajao et al. (2014) and Agga et al. (2011). We found that the mean TW value was 67.28±1.30 g which is close to the findings of Gemeda and Workalemahu (2017) and Sahi et al. (2019) and higher when compared with other reports (Oyeyemi et al., 2012; Ajao et al., 2014, Ajani et al., 2015). According to Coulter et al. (1975), TW, in combination with other variables, can be used to select males based on testicular size at puberty as it is a reliable variable for estimating sperm production capacity (Ibrahim et al., 2012). Brito et al. (2004) reported that males with larger testicles tend to produce more sperm and produce females who reach puberty at an earlier age and ovulate more eggs during each estrus period (Söderquist and Hultén, 2006).

The mean EW is 5.55±0.54 g which is low compared to other reports (Oyeyemi et al., 2012; Ajao et al., 2014; Abba and Igbokwe, 2015; Gemeda and Workalemahu, 2017).

The EL and ETW mean values are lower compared to other findings (Ajani et al., 2015; Abba and Igbokwe, 2015). The ESI and GSI values are higher to other results (Abba and Igbokwe, 2015; Sahi et al., 2019).

Testis growth is sustained for a period appropriate to the proliferation of the epithelium of the seminiferous tubules associated with increased sperm production (Foc et al., 2014). The high GSI values that the testes developed correspond to the period of puberty (Wang et al., 2015). An increase in GSI is induced by an increase in gonad weight (Oyeyemi et al., 2012). This indicates a normal sperm structure and proves their high fertilisation capacity (Leal et al., 2004).

Differences in values could be due to differences between races. It has been reported that there are race differences in the size of testicular and epididymal parameters (Goyal and Memon, 2007). Indeed, the measurement of these parameters would be a reliable indicator of the semen production capacity of males and that these data could be used to improve male reproduction (Keith et al., 2009).

According to Akpa et al. (2013), all quantifiable physical parameters were directly related to sperm fertilisation capacity, which can be used as a measure of sperm quality. Semen production can be affected by the size of the reproductive organs and the physiological condition of the animal. Information on body measurements helps to improve the overall fertility of animals. In addition, the age, breed, season and nutritional status of the animal influence testicular measurements, which in turn influence the semen production capacity and the overall reproductive efficiency of small ruminants (Karagiannidis et al., 2000; Rege et al., 2000; Toe et al., 2000; Mekasha et al., 2007; Ugwu, 2009). A good measure of testicular weight, length and width would therefore be a reliable predictor of the sperm production capacity of males (Ugwu, 2009) and for the selection of breeding males (Keith et al., 2009).

The results of correlation between age and the body, testicular and epididymal parameters obtained are transcribed into Table 3. A very strong correlation was found between SC and age (r=0.82) and also between TDs and TW (r=0.98). Strong correlations exist also between age and TD, TL, TW, BW, EW and TDs with values of 0.78, 0.55, 0.74, 0.67, 0.51 and 0.7, respectively, and between BW and SC, TD (r=0.74 and 0.64, respectively). The weight of the animals increases with age. The same will be true for testicular measurements, as puberty does not stop testicular development, although the rate of increase may be reduced as the animals grow older (Mekasha et al., 2007).

Table 3. Correlation between age and the body, testicular and epididymal parameters

	Age	SC	TD	TL	EL	TV	TW	BW	EW	ESI	GSI	ETW	TDs	BCS
Age	1													
SC	0.82	1												
TD	0.78	0.72	1											
TL	0.55	0.47	0.43	1										
EL	0.35	0.26	0.33	0	1									
TV	0.43	0.44	0.39	0.5	0.1	1								
TW	0.74	0.74	0.62	0.39	0.22	0.51	1							
BW	0.67	0.74	0.64	0.32	0.27	0.42	0.75	1						
EW	0.51	0.48	0.38	0.23	-0.04	0.37	0.52	0.43	1					
ESI	-0.36	-0.47	-0.41	-0.22	-0.33	-0.24	-0.47	-0.75	0.26	1				
GSI	-0.36	-0.48	-0.43	-0.17	-0.21	-0.24	-0.26	-0.82	-0.2	0.71	1			
ETW	-0.16	-0.2	-0.17	-0.14	-0.26	-0.09	-0.4	-0.26	0.57	0.73	0.04	1		
TDs	0.7	0.71	0.58	0.3	0.22	0.32	0.98	0.73	0.48	-0.46	-0.23	-0.42	1	
BCS	0.49	0.41	0.24	0.44	0.29	0.26	0.37	0.3	0.12	-0.24	-0.12	-0.23	0.34	1

Conclusion

In the present study, we were able to highlight the essential values of testicular and epididymal measurements in Arabia bucks. This research indicates a strong association between testicular morphometric measurements, body weight and BCS. This also suggests that some of the body parameters and testicular/epididymal measurements are affected by buck age. This correlation tends to increase significantly with age. Moreover, the best indicator of the testicular and epididymal measurements may be the scrotal circumference which can be measured on live animals. We may conclude that testicular morpho-biometry, which is closely related to body weight, can allow predictions about the production of testicular sperm and is therefore important for evaluating the reproductive ability of males to be chosen, however it will also be appropriate to evaluate the content of sperm ejaculates to further insure the reproductive efficiency of the bucks. Therefore, it is proposed the age, weight and scrotal circumference of the animals to be used in the reproductive ability test.

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