Testicular and epididymal sperm reserve evaluations in three Jordanian goat breeds

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ABSTRACT
The study aimed to determine the effect of goat breed (Shami, Mountain Black and Hybrid) on testicular and epididymal sperm reserves. The study was conducted at Mutah University Animal Farm, Jordan in March 2016. The study area lies between Latitude of 31°27’N, Longitude of 35°74’W, and an altitude of 960 m. Average temperature and relative humidity recorded during the study were 14.6°C and 59.0%, respectively. Hybrid had the highest (P = 0.04) right testis epididymal weight (6.36 ± 0.3 g), and the highest (P = 0.03) epididymosomatic index (0.60 ± 0.1 g/kg), and the widest (P = 0.02) testicular width (0.32 ± 0.03 cm/kg) relative to body weight. Epididymal sperm concentrations in the right testicular side were the highest (P = 0.04) in Hybrid (0.530 ± 15 × 109 sperm/ml) compared to Shami (0.386 ± 0.4 × 109 sperm/ml) and Mountain Black (0.322 ± 0.10 × 109 sperm/ml). Total testicular-epididymal sperm concentrations in both testes were the highest (P = 0.04) in Hybrid (0.810 ± 0.20 × 1010 sperm/ml) compared to Shami (0.764 ± 0.09 × 1010 sperm/ml) and Mountain Black (0.716 ± 0.12 × 109 sperm/ml). Furthermore, Hybrid had the highest (P = 0.05) epididymal body sperm concentrations (0.252 ± 0.05 × 109 sperm/ml) in both testes compared to Mountain Black and Shami. Taken together, the outcomes of this work highlighted the testicular and epididymal sperm traits in bucks of three breeds native to the semiarid region of Jordan. Hybrid displayed greater testicular traits than Shami and Mountain Black.

1. Introduction

Goats play an important role in the agricultural revolution and advance of human civilization (Zeder 2008; Dwyer 2009). Goats are favored over other livestock animals due to their tolerance to harsh climatic conditions, especially under semiarid conditions (i.e. Jordan) (Zaitoun et al. 2004; Al-Dawood 2015, 2017a, 2017b, 2017c), and high twining rate (Güney et al. 2006). In Jordan, there are 940 thousand goat heads in 2016 (Agricultural Statistical Book 2016), distributing among four native breeds; Shami, Mountain Black, Dhaiwi and Desert goats, in addition to their crossbreds between Shami and Mountain Black which is called ‘Hybrid’ (Zaitoun et al. 2005). The Mountain Black represents the main breed in the country with 95.7%, while Shami and Hybrid breeds represent only 1.63% and 2.64%, respectively (Agricultural Statistical Book 2016). Mountain Black goats have moderate prolificacy and milking ability but they are highly adapted to the arid and harsh environmental conditions (Taylor and Field 1998), while Shami goats have a high milking ability and prolificacy (Güney et al. 2006).

Semen characteristics such as ejaculate volume, colour, consistency, mass motility, forward motility and sperm concentrations are not enough for potentially satisfactory breeder bucks (Al-Ghalban et al. 2004; Al-Omari 2012), thus measurements of gonadal and extragonadal sperm reserves are of vital importance (Ritar et al. 1992; Bitto and Egbunike 2006), where sperm reserves are needed. Sperm reserves have been successfully obtained at necropsy in domestic animals such as bucks (Alade et al. 2009; Ugwu 2009; Abba and Igbokewe 2015), rams (Illyasu et al. 2014; Etim et al. 2015), and bulls (Togun 2009). In goat production, buck fertility influences herd performance and reproductive efficiency compared to the fertility of individual doe (McGowan 2004); thus, selection of highly fertile bucks is of vital importance to improve goat production (Chacón et al. 1999; Memon et al. 2007). However, in areas with low technical and laboratory support for semen evaluation, livestock farmers may need a reference range of testicular sizes and sperm reserves for reproductive efficiency. In addition, to improve goat production in Jordan, the reproductive efficiency and fertility of bucks require more attention. In view of these, parameters that are relevant to breeding soundness of buck should be assessed. We hypothesized that goat breed could influence the testicular and epididymal sperm reserves. Therefore, the current study aimed to determine the effect of goat breed (Shami, Mountain Black and Hybrid) on testicular and epididymal sperm reserves. It aimed also to determine the relative testicular and epididymal weight to body weight (BWt) in order to identify goat buck breeds with optimal sperm output from...
testicular and related size variables. Another potential objective which is crucial to successful goat production and welfare was to provide a comprehensive evaluation of goat bucks’ fertility in Jordan.

2. Materials and methods

2.1. Location, animals, housing and feeding

The study was conducted during early sexual maturation of bucks in March, 2016, 9th 2017. Geographically, the study area is located in the Southern part of Jordan between Latitude of 31°27’ and Longitude of 35°74’ with an altitude of 960 m above sea level. Apparently healthy goat bucks representing three breeds (Shami, Mountain Black and Hybrid) were used in this study. The animals were reared under an intensive farming system at the Animal Farm, Agricultural Research Station, Mutah University, Karak, Jordan. All procedures performed in the present trial involving animals were in accordance with the ethical standards of the Institutional Animal Care and Use Committee (IACUC) protocol at Mutah University, Jordan (No. AGR-82006). The IACUC protocol was developed in accordance with the international guidelines of using animals in scientific procedures. The goat bucks were kept in a shaded housing facility, such that the animals were protected from direct solar radiation during the whole day. The facility had an adequate space per animal and a closed ceiling, two walls sides fully closed, the backside wall had a window and the front side opened. All animals were fed ad libitum using similar standard ration (15% crude protein, and metabolizable energy of 2.4 Mcal/kg), and had free access to water. Ingredients’ composition of the standard ration consisted of 45.3% barley grain, 15.7% soybean meal, 13.6% cracked corn, 13.6% wheat bran, 10.0% wheat straw, 0.9% salt, 0.5% limestone, 0.2% dicalcium phosphate, 0.2% mineral and vitamin premix.

2.2. Experimental design and measurements

Fifteen goat bucks were selected to set up the experiments. The chosen bucks were allocated to three breed groups, five from each group: Shami (BWt: 52.6 ± 1.2 kg, age: 422.2 ± 2.0 days), Mountain Black (BWt: 44.1 ± 1.9 kg, age: 416.8 ± 1.4 days), and Hybrid (BWt: 47.0 ± 2.3 kg, age: 425.2 ± 6.3 days).

Table 1: Weight (mean ± SD) of head epididymal weight (g), body epididymal weight (g), tail epididymal weight (g) and epididymosomatic index (g/kg) of three breeds of goat bucks from Jordan (Shami, Mountain Black and Hybrid).

| Parameter | Shami | Mountain Black | Hybrid |
|-----------|-------|----------------|--------|
| R-HEWt    | 3.88 ± 0.5a | 3.52 ± 0.8a | 4.16 ± 0.6a |
| L-HEWt    | 4.52 ± 0.6a | 3.70 ± 0.7a | 4.13 ± 0.6a |
| R-BEWt    | 4.56 ± 0.5a | 4.20 ± 0.4a | 5.62 ± 0.6a |
| L-BEWt    | 4.52 ± 0.7a | 4.32 ± 0.4a | 5.38 ± 0.7a |
| R-TEWt    | 4.36 ± 0.4a | 4.63 ± 0.6a | 6.36 ± 0.3b |
| L-TEWt    | 4.51 ± 0.5a | 4.95 ± 0.4a | 5.34 ± 0.6a |
| ESI       | 0.47 ± 0.05a | 0.53 ± 0.08ab | 0.60 ± 0.1b |

Notes: R-HEWt: Right head epididymal weight, L-HEWt: Left head epididymal weight, R-BEWt: Right body epididymal weight, L-BEWt: Left body epididymal weight, R-TEWt: Right tail epididymal weight, L-TEWt: Left tail epididymal weight, ESI: Epididymosomatic index. Different small letters within the same row indicated significant differences among the three breeds of goat bucks at \( P < 0.05 \) (one-factor ANOVA).

All goat buck groups from the three breeds tested were slaughtered at a local slaughterhouse at the Agricultural Research Station, Mutah University. Investigated reproductive organs were directly collected after slaughtering, transported in an ice pack to the laboratory, and then stored in a refrigerator within 30 min until further analysis. The testes and their epididymides were separated by dissection and then weighed. Tunica albuginea of the testes, extraneous tissues and blood clots were excluded from analysis. Dimensions of left and right testes for all selected animals were measured using a flexible metric tape and recorded. The testicular dimensions (Right testicular length (R-TL), left testicular length (L-TL), right testicular width (R-TW) and left testicular width (L-TW)) were measured relative to Bwt (cm/kg) for all selected animals in the breeds of goat bucks. The gonadosomatic index (GSI, g/kg) was estimated as the ratio of each side of testicular weight (R-TWt and L-TWT) relative to Bwt for all selected breeds of goat bucks.

Epididymis was weighed (EWT), and then sectioned into three parts: head, body and tail, and they were separately weighed as right head epididymal weight (R-HEWt), left head epididymal weight (L-HEWt), right body epididymal weight (R-BEWt), left body epididymal weight (L-BEWt), right tail epididymal weight (R-TEWt) and left tail epididymal weight (L-TEWt). The epididymosomatic index (ESI, g/kg) was estimated as a ratio of each epididymal weight relative to BWT for all selected breeds of goat bucks.

The testicular parenchyma and epididymal parts were thoroughly minced in Petri-dishes by using scissors and scalpel, and then soaked in 10–20 ml of 0.9% NaCl solution. The homogenate of soaked tissues was filtered four times through double-washed muslin cloth. The finally filtrated fluid was examined for sperm concentration using a Neubauer Haemocytometer according to the procedure described by Jindal and Panda (1980). Sperm reserves were analysed for testicular sperm (TS), epididymal sperm (ES), and testicular-epididymal sperm (TES). Sperm reserves of the epididymal parts were also analysed as epididymal head sperm (EHS), epididymal body sperm (EBS) and epididymal tail sperm (ETS).

Meteorological parameters including the ambient temperature (Ta) and relative humidity (RH) were daily taken three times using a digital thermo-hygrometer from Rabeh Metrological Station at the study site at 9.00 am (morning), 1.00 pm (afternoon) and 5.00 pm (evening) throughout the trial period. The Ta and RH recorded during the study period at the trial site ranged between 9.4°C and 19.8°C (mean: 14.6°C) as well as 42.4% and 72.8% (mean: 59.0%), respectively.

2.3. Statistical analysis

The statistical analysis was performed using the Proc General Linear Model (GLM) (SPSS 19.0, SPSS Inc. Chicago, IL, USA) (SPSS 1997). The experiment was Complete Randomization Design (CRD). The data were analysed using one-factor analysis of variance (ANOVA) to detect the differences in the tested parameters. When significant differences were detected, means were separated using Least Significant Differences (LSD) test at 0.05 probability level (Abacus Concepts 1991). In addition, correlation analyses among the tested parameters were...
conducted using Spearman’s correlation method (Zar 1999). All data obtained were presented as mean ± standard deviations (SD).

3. Results

3.1. Effect of breed on epididymal weight and epididymosomatic index

The effect of breed of goat bucks on the weight of epididymal parts (R-HEWt, L-HEWt, R-BEWt, L-BEWt, R-TEWt and L-TEWt) and ESI is represented in Table 1. The weights of R-HEWt, L-HEWt, R-BEWt, L-BEWt and L-TEWt were not affected by breed of goat bucks. In contrast, Hybrid had the heaviest (P = 0.04) R-TEWt (6.36 ± 0.3 g) compared to Shami (4.56 ± 0.4 g) and Mountain Black (4.63 ± 0.6 g). In addition, ESI was the highest (P = 0.04) in Hybrid (0.60 ± 0.1 g/kg) compared to Mountain Black (0.53 ± 0.08 g/kg) and Shami (0.47 ± 0.05 g/kg).

3.2. Effect of breed on the testicular dimension and gonadosomatic index

The effect of breed of goat bucks on the testicular dimension (TL and TW) relative to BWt and GSI is shown in Table 2. There were no differences in the left testicular length (L-TL) relative to BWt among breeds, in which Mountain Black breed had the lengthiest (P = 0.04) testicular (0.26 ± 0.03 cm/kg) compared to Hybrid and Shami (0.23 ± 0.01 cm/kg for each). Hybrid and Mountain Black breeds had the widest (P = 0.02) R-TW and L-TW relative to BWt compared to Shami breed. The GSI for both testes was not differed among breeds with 3.55 ± 0.52, 3.65 ± 0.41 and 3.75 ± 0.52 g/kg for Shami, Mountain and Hybrid, respectively.

3.3. Effect of breed on epididymal and testicular sperms concentrations and reserves

The effect of breed on the concentrations of epididymal and testicular sperms (ES, TS and TES) as well as the sperm reserves in epididymal parts (EHS, EBS and ETS) is presented in Table 3. There were no differences among breeds in the concentrations of ES in all testes compared to Mountain Black (0.380 ± 0.10 × 10^9 sperm/ml) and Hybrid (1.27 ± 0.20 × 10^9 sperm/ml) breeds, respectively. Furthermore, Hybrid had the highest (P = 0.05) epididymal body sperm concentrations (0.252 ± 0.05 × 10^9 sperm/ml) in both testicular sides compared to Mountain Black (0.120 ± 0.04 × 10^9 sperm/ml) and Shami (0.146 ± 0.05 × 10^9 sperm/ml). The concentrations of EHS in the right and left testicular sides were not differed among breeds tested (Shami: 0.226 ± 0.08 × 10^9 sperm/ml; Mountain Black: 0.278 ± 0.06 × 10^9 sperm/ml and Hybrid: 0.151 ± 0.03 × 10^9 sperm/ml). Meanwhile, the ETS concentration in the right testicular side was the highest (P = 0.05) in Hybrid (0.420 ± 0.10 × 10^9 sperm/ml) compared to Mountain Black (0.210 ± 0.07 × 10^9 sperm/ml) and Shami (0.274 ± 0.05 × 10^9 sperm/ml).

3.4. Correlation analyses

The correlations were calculated for different testicular characteristics in all goat bucks tested (Table 4). There was a positive correlation between TWt and each of TW (r = 0.74–78; P < 0.01) and EWt (r = 0.60; P < 0.05). The R-TW was positively correlated with EWt (r = 0.74; P < 0.01) and R-ETS (r = 0.50; P < 0.05). In addition, there was a positive correlation between L-TW and EWt (r = 0.53; P < 0.05); EWt and each of R-EWt and L-EWt (r = 0.88–0.89; P < 0.01); and TS with R-ETS (r = 0.83; P < 0.01). Furthermore, ES was strongly and positively correlated with ETS (r = 0.84; P < 0.01).

4. Discussion

Taken together, the outcomes of this work support the hypothesis that goat breed could influence the testicular and epididymal sperm reserves. However, the current study indicated that the reproductive parameters in term of epididymal weight and testicular dimension have been shown to vary according to goat breed investigated. It is important to mention that among the selection criteria, testis size (TL and TW) is the most suitable parameter to indirectly improve the reproductive performance of goat females (Schoeman et al. 1987; Agga et al. 2011). Furthermore, testicular size is a reliable parameter of the status of reproductive growth, spermatogenesis, and seminal characteristics (Daudu 1984). Combined with other variables testicular weight can be used to select goat males for testicular size at puberty since it is a reliable variable for estimating the sperm production capacity but it varies depending on the breed. Generally, the left testicular weight was heavier and both dimensions (width and length) were larger than the right testicular one in all breeds tested, which is in agreement with the findings of Oyeyemi et al. (2012) for Sahel bucks aged 30–54 months, and Raji and Njidda (2014) for Red Sokoto bucks aged 5–10 months. The heavier and larger testes produce more spermatozoa than the smaller testes (Brito et al. 2004) due to the increase in seminiferous tubules size and proliferation of germ cells characterizing higher
spermatogonial activity (Melo et al. 2010). Gemeda and Workalemahu (2017) reported buck testes weight of 70 g and testes length of 4.97 cm. Testes weight of 98 and 92 g was reported in Red Sokoto and Borno White breeds, respectively, in a semi-arid region of Nigeria (Raji et al. 2008), while a weight value of 52 g was reported for Shale bucks (Oyeyemi et al. 2012). Red Sokoto bucks had a testicular weight of 84 g at age of 24–30 months (Daudu 1984). Differences found between the current study and the previous studies might be due to differences in breed, age, BWt and nutritional management of the bucks used (Goyal and Memon 2007; Raji et al. 2008). Nevertheless, previous reports indicated that testicular size positively correlated with sperm production in WAD and cashmere goats (Walkden-Brown et al. 1994; Ugwu 2009). Therefore, the testicular weight and related size parameters would be imperative in selecting a breed that is reproductively sound as proposed by Ott and Memon (1980).

In the current study, the observed ESI was 0.60, 0.53 and 0.47 g/kg for Hybrid, Mountain Black and Shami, respectively. These results are in partial agreement with the findings of (Abba and Igboke 2015) in Nigerian Sahel buck breed (0.51 g/kg), while Raji and Njidda (2014) reported higher ESI (1.7 g/kg) in Red Sokoto buck breed. The current results indicated that GSI values for both testes were 3.55, 3.65 and 3.75 g/kg for Shami, Mountain and Hybrid, respectively. A lower value of GSI was reported in Nigerian Sahel buck (3.15 g/kg) (Abba and Igboke 2015); while a higher value (7.5 g/kg) was reported in Red Sokoto buck (Raji and Njidda 2014). In the current study, the differences in the GSI and ESI indices may be due to crossbreeding between Mountain Black and Shami goat bucks, which might be negatively or positively influence their early sexual maturation and the variability among the native breeds in heat stress, light and nutrition responses. The lower ESI in Shami as compared to Hybrid indicated that Shami might have better tail sperm reserves.

In the present study, the concentrations of ES, TS and TES in the left and right testes were not affected by goat breed, except the concentration of ES in the right testicular side, which was

Table 3. Concentrations (mean ± SD) of epididymal sperm, testicular sperm, testicular-epididymal sperm, epididymal head sperm, epididymal body sperm and epididymal tail sperm of three breeds of goat bucks from Jordan (Shami, Mountain Black and Hybrid).

| Breed | Testicular side | ES | TS | TES |
|-------|----------------|----|----|------|
|       |                |    |    |      |
| Sashi | Right          | 0.386 ± 0.04a | 0.158 ± 0.06a | 0.490 ± 0.06a |
|       | Left           | 0.379 ± 0.07a | 0.136 ± 0.03a | 0.510 ± 0.04a |
|       | Both           | 0.764 ± 0.09a | 0.294 ± 0.05a | 1.000 ± 0.10a |
|       |                |    |    |      |
| Mountain Black | Right          | 0.322 ± 0.10a | 0.162 ± 0.02a | 0.470 ± 0.04a |
|       | Left           | 0.394 ± 0.08a | 0.244 ± 0.08a | 0.510 ± 0.05a |
|       | Both           | 0.716 ± 0.12a | 0.406 ± 0.10b | 0.980 ± 0.07a |
|       |                |    |    |      |
| Hybrid | Right          | 0.530 ± 0.15b | 0.148 ± 0.04a | 0.670 ± 0.12a |
|       | Left           | 0.419 ± 0.14a | 0.178 ± 0.09a | 0.600 ± 0.08a |
|       | Both           | 0.810 ± 0.20a | 0.326 ± 0.09a | 1.270 ± 0.20b |

Breed | Epididymal side | EHs | EBs | ETS |
|-------|----------------|-----|-----|-----|
|       |                |     |     |    |
| Sashi | Right          | 0.046 ± 0.01a | 0.064 ± 0.02a | 0.274 ± 0.05a |
|       | Left           | 0.070 ± 0.01a | 0.080 ± 0.03a | 0.226 ± 0.08a |
|       | Both           | 0.116 ± 0.05a | 0.146 ± 0.05a | 0.500 ± 0.11a |
|       |                |     |     |    |
| Mountain Black | Right          | 0.050 ± 0.01a | 0.056 ± 0.02a | 0.210 ± 0.07a |
|       | Left           | 0.052 ± 0.01a | 0.064 ± 0.04a | 0.279 ± 0.06a |
|       | Both           | 0.102 ± 0.03a | 0.120 ± 0.04a | 0.488 ± 0.13a |
|       |                |     |     |    |
| Hybrid | Right          | 0.058 ± 0.02a | 0.050 ± 0.02a | 0.420 ± 0.10b |
|       | Left           | 0.068 ± 0.02a | 0.202 ± 0.05b | 0.151 ± 0.03a |
|       | Both           | 0.126 ± 0.02a | 0.252 ± 0.05b | 0.571 ± 0.17a |

Notes: ES: Epididymal sperm, TS: Testicular sperm, TES: Testicular-epididymal sperm, EHs: Epididymal head sperm, EBs: Epididymal body sperm, ETS: Epididymal tail sperm. Different small letters within the same column indicated significant differences within the same epididymal/testicular side at P < 0.05 (one-factor ANOVA).

Table 4. Correlations' analyses among testicular characteristics in the goat bucks.

| Breed | ES | TS | TES |
|-------|----|----|-----|
|       |    |    |     |
| Shami | 0.74** | 0.78** | 0.60* |
|       | 0.70** | 0.70** | 0.32  |
|       | 0.15  | 0.27  | 0.12  |
|       | 0.32  | 0.34  | 0.20  |
|       | 0.17  |      |      |
| R-TW  | 0.78** | 0.60* | 0.70** |
|       | 0.47  | 0.30  | 0.28  |
|       | 0.19  | 0.30  | 0.28  |
|       | 0.09  | 0.26  | 0.49  |
|       | 0.10  |      |      |
| L-TW  | 0.80** | 0.74** | 0.85** |
|       | 0.36  | 0.33  | 0.33  |
|       | 0.38  | 0.36  | 0.33  |
|       | 0.33  | 0.33  | 0.33  |
|       | 0.08  | 0.31  | 0.31  |
|       | 0.18  | 0.40  | 0.40  |
|       | 0.07  |      |      |
| R-EWt | 0.73** | 0.89** | 0.88** |
|       | 0.02  | 0.16  | 0.24  |
|       | 0.24  | 0.03  | 0.28  |
|       | 0.39  | 0.09  | 0.26  |
|       | 0.49  |      |      |
|       | 0.10  |      |      |
| L-EWt | 0.73** | 0.89** | 0.88** |
|       | 0.09  | 0.23  | 0.23  |
|       | 0.29  | 0.02  | 0.23  |
|       | 0.42  |      |      |
|       | 0.06  |      |      |
| TS    | 0.82** | 0.83** | 0.84** |
|       | 0.83** | 0.84** | 0.84** |
|       | 0.83** | 0.84** | 0.84** |
|       | 0.18  |      |      |
| R-ES  | 0.35  | 0.57* | 0.98** |
|       | 0.8** | 0.40  | 0.56* |
|       | 0.65* | 0.59* | 0.59* |
| L-ES  | 0.8** | 0.40  | 0.56* |
|       | 0.65* | 0.59* | 0.59* |
| ETS   | 0.65* | 0.59* | 0.59* |
| R-ETS | -0.22 |      |      |
| L-ETS |      |      |      |

Notes: TWT: Testicular weight, R-TW: Right testicular width, L-TW: Left testicular width, EWt: Epididymis weight, R-EWt: Right epididymal weight, L-EWt: Left epididymal weight, TS: Testicular sperm, ES: Epididymal sperm, R-ES: Right epididymal sperm, L-ES: Left epididymal sperm, ETS: Epididymal tail sperm, R-ETS: Right epididymal tail sperm, L-ETS: Left epididymal tail sperm.

*Correlation is significant at the 0.05 probability level.
**Correlation is significant at the 0.01 probability level.
higher in Hybrid compared to Shami and Mountain Black. In addition, the total concentrations of TS and TES in both testicular sides were the highest in the Mountain Black and Hybrid, respectively. However, TS and ES values for Hybrid, Mountain Black and Shami breeds tested in the current study were much lower than in Sokoto Red buck in tropical environment ($1.99 \times 10^9$ sperm/ml and $5.1 \times 10^9$ sperm/ml, respectively) (Bitto and Agam 2012). This might be due to that the current goat bucks were not been exposed to any pheromones effect. In contrast, sperm reserve of the investigated breeds had slightly higher TS than Nigerian Sahel bucks ($0.23 \times 10^9$ sperm/ml), but lower ES ($1.3 \times 10^9$ sperm/ml) (Abba and Igbokwe 2015). This might be due to the effect of crossbreeding between Mountain Black and Shami on early sexual maturation and all of the studied bucks were completely isolated from female goats, and thus they were not likely to exhibit standard sexual performance in their first year (Price et al. 1998; Ungerfeld et al. 2013). The epididymis is a convoluted duct, consisted of head, body and tail. The tails are the widest lumen and possess most storage and maturation capacity (Jindal and Panda 1980). It appears that epididymidal tail is capable of more spermatids storage than head and body regions of the epididymis in the three studied breeds. Generally, the present study indicated that the concentrations of EHS in the right and left testicular sides were higher in Hybrid breed compared to Shami and Mountain Black bucks. In addition, Hybrid had significantly higher EBS and ETS concentrations compared to Mountain Black and Shami. These findings are in agreement with those found in Red Sokoto and Angora bucks (Ritar et al. 1992; Bitto and Agam 2012; Raji and Njidda 2014), in which there is a variation in the EHS, EBS and ETS among goat breeds investigated.

In domestic animals, testes size and sperm production are highly correlated which implies that the larger the testes, the greater the sperm production. In the current study, the BWt had no correlation with TS, ETS, TWt, TW and TL suggesting that BWt might not be a good estimator of sperm output in the bucks, which agrees with Queiroz and Cardoso (1987), who reported that sperm reserves of Brazilian hairy ram are not correlated with BWt. In contrast, BWt had a strong correlation with TWt in Afar breed indicating good association between BWt and TWt. Similar reports of BWt being significantly correlated with testicular weight were observed in goats (Abba and Igbokwe 2015). These high positive correlations between BWt and SC with testicular measurements suggest that either of these variables or their combinations could provide a good estimate for predicting testicular and epididymal traits. In the current study, there was a positive correlation between TWt and each of TW and EWt, as well as R-TW with EWt and R-ETS. In Nigerian Sahel Goats, ETS was correlated with EWt, TWt and TS (Abba and Igbokwe 2015). The fair correlations between R-TW and both R-ETS and L-ETS, and between L-TW and both R-ETS and L-ETS suggest that the ETS reserves depend on the TWt and TW. Furthermore, ES was positively correlated with ETS, which is in agreement with a study conducted on Nigerian Sahel goats (Abba and Igbokwe 2015). Testicular size was weakly correlated with testicular sperm production in the present study; in contrast, it was strongly correlated in the studies on Cashmere goat bucks (Walkden-Brown et al. 1994; and West African dwarf goats (Ugwu 2009). Testicular dimension parameters (TW and TL) were positively correlated with TWt, which is agreement with findings reported on Shami bucks (Al-Ghalban et al. 2004); Sahel bucks (Alade et al. 2009; Oyeyemi et al. 2012), and Red Sokoto bucks (Ajani et al. 2015). The absence of correlation between TS and ETS clarify that sperm count was not dependent on testicular sperm production and epididymal tail sperm reserves. The lower sperm reserves values of the native goat bucks also related to decline in both photoperiod and ambient temperature during the month of March, thus implying lower spermatogenesis (Bitto and Egbunike 2006).

5. Conclusion

Taken into consideration the fewer number of animals per breed used in this study, aiming to have the maximum information from minimum number of animals and to minimize the loss of animals, the outcomes of this work support the hypothesis that goat breed could influence the testicular and epididymal sperm reserves. In addition, this study highlighted testicular and epididymal sperm reserves’ traits in bucks of Hybrid, Shami and Mountain Black breeds native to the semiarid region of Jordan. Furthermore, Hybrid displayed greater testicular traits than Shami and Mountain Black. Finally, the current findings could be contributed to ongoing efforts to improve goat bucks fertility and thus contribute to the sustainability of goat production in Jordan.

Disclosure statement

No potential conflict of interest was reported by the authors.

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