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Relationship between body weight, sexual secondary traits and epididymal semen quality in the Alpine goat.☆

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ABSTRACT

The aim of this study was to evaluate relationships among body weight, sexual secondary traits and epididymal semen quality in young bucks.

Body weight (BW), scrotal circumference (SC), horns diameter (HD), and horns length (HL) were recorded monthly on 54 young Alpine bucks, from the second to the eighth month of life. After slaughter, testicles weight (TW) and epididymal weight (EW) were recorded and epididymal sperm quality was evaluated. Epididymal sperm recovery was performed by using the retrograde flushing technique and sperm concentration, motility, viability and morphology were evaluated. Positive relationships between BW with TW ($P < 0.001$) and EW ($P < 0.05$), and SC with TW ($P < 0.05$) were observed. Some effects of secondary sexual traits on epididymal semen quality parameters were detected: BW and TW on sperm production (concentration, total number of sperm and number of semen doses) ($P < 0.05$), and SC on the presence of immature sperm ($P < 0.05$). In particular, it was shown that in goat species horns size is related to semen quality in terms of sperm production (concentration, total number of sperm and number of semen doses) and presence of normal sperm ($P < 0.05$). In conclusion, scrotal circumference and horns size could be used as parameters to select animals for breeding.

1. Introduction

Artificial insemination (AI) is increasingly used in dairy goats for reproductive management and, along with progeny testing, for genetic improvement (Furstoss et al., 2009). Associated to the use of AI, there is a growing interest to improve knowledge on the reproductive characteristics of these animals. The ideal method for evaluating fertility in males, other than the ability to produce offspring, is semen evaluation (Hafez, 1993). Optimal semen production is a prerequisite for the selection of bucks (Mekasha et al., 2007). In the goat body weight has been observed to be positively associated with semen quality and testicular growth (Mekasha et al., 2008); moreover testicular measurements have been shown to be a reliable measurement of the reproductive maturation status, spermatogenic capacity and seminal characteristics (Daudu, 1984), and have been used to predict sperm production and semen quality (Ritar et al., 1992). Then, delayed growth in body size and testicular mass is expected to lead to reproductive wastage and economic losses. In small-ruminants testicular size and body weight are influenced by several factors, including breed, age, nutrition, and photoperiodic changes (Karagiannidis et al., 2000). Horns are epidermal and bony appendages used by males of many ungulate species for intra-sexual competition during rut (Santiago-Moreno et al., 2007). In addition to their function in combat, horns are probably signals of male vigor for females' mate choice (Geist, 1966), and it has been suggested that males with most developed horns are naturally selected for reproduction (Santiago-Moreno et al., 2007). Horns growth appears to be modulated by testosterone and prolactin hormones (Santiago-Moreno et al., 2007). Furthermore, these hormones act directly to maintain secretory activity of male accessory sex glands (Ravautl et al., 1977), to control spermatogenesis (Regisford and Katz, 1993) together with LH and FSH (Courot and Ortavant, 1981) and consequently semen production. Considering that horns size is correlated with male dominance and fighting ability, and consequently lifetime reproductive success (Clutton-Brock et al., 1988), we can hypothesize that horns development may be associated to semen parameters. It is well known that in sheep, interactions between body and testis growth and sperm production are complex since early pre-pubertal ages and, in many aspects, are

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influenced by both the genetic background of animals and the environment (Langford et al., 1998; Belibasaki and Kouimtzis, 2000).

Information on these aspects, in particular concerning horns development related to semen quality, is scanty. The aim of this work was to investigate how differences in body weight, testicles and horns size, can be related to differences in sperm quality, by the assay of epididymal spermatozoa collected *post-mortem*.

2. Material and methods

2.1. In-vivo *evaluation*

Body weight (BW), scrotal circumference (SC), horns diameter (HD) and horns length (HL) were measured monthly, from the second to the eighth month of age, on 54 Alpine male goats bred for commercial purposes. BW was recorded in kg with an electronic portable scale, SC was measured in cm on the greatest scrotal diameter with a flexible tape, HD and HL were also measured in cm with a flexible tape. The animals were housed in two private farms located in Northern Italy. From birth (February–April 2010) to slaughter (October–November 2010) animals were kept on farm under natural light and fed with the same diet, grass hay and commercial mixture with 18% of crude protein. At the end of this period, the young bucks were slaughtered for commercial purpose at a local abattoir.

2.2. Post-mortem *parameters*

Testicles of bucks were collected after slaughtering and transported to the laboratory. Testicles with the respective epididymis and vas deferens attached, were isolated from scrotum and other tissues and weighted (TW) on average 3 h after slaughter. Then, cauda epididymis and ductus deferens, isolated from the rest of the epididymis, were weighed with a digital scale (EW). Spermatozoa were collected by using the retrograde flushing method (Turri et al., 2012) with a Tris-citric acid-fructose yolk extender (20% egg yolk). To avoid blood contamination of semen, superficial blood vessels were previously punctured with a needle and their contents wiped out. The content of each epididymis was evaluated for sperm concentration (10^9/ml), total number of spermatozoa (10^9), motility, viability, and sperm morphology, as described by Turri et al. (2014).

2.3. *Statistical analysis*

Statistical analysis was carried out using the SAS™ package v 9.4 (SAS Institute Inc., Cary, NC). The Nonlinear Model (PROC NLIN) procedure was used to fit a logistic model to BW, SC, HL and HD data in order to estimate these parameters at slaughter age (mean 8.8 months, SD 0.32, min. 7.57, max. 9.42), that occurred approximately one month after the last morphological evaluation (eBW = estimated body weight; eSC = estimated scrotal circumference; eHL = estimated horns length; eHD = estimated horns diameter). The General Linear Model (PROC GLM) procedure was used to analyse:

(a) the trend of BW, SC, HD, HL during growth; (b) the relationship between eBW, eSC, eHD, eHL, TW and EW; (c) the relationship between eBW, eSC, eHD, eHL, TW, EW with semen quality parameters. All models included farm as fixed effect and age at slaughter as covariate. Results are given as adjusted least squares means ± standarderror means (LSM ± SEM).

3. Results

Body weight increased from 14.59 ± 1.07 kg at 2 months of age to 28.56 ± 0.63 kg at 9 months of age. Scrotal circumference increased from 10.65 ± 0.71 cm at 2 months to 26.87 ± 0.41 cm at 9 months. Horns length varied from 6.13 ± 0.71 cm at 2 months to 23.53 ± 0.38 cm at 9 months, and the horns diameter increased from 7.47 ± 0.40 cm at 2 months to 15.40 ± 0.21 cm at 9 months. Growth curves of body weight, scrotal circumference and horns diameter slowed down from the 7th month of life.

Table 1
Relationship between *in-vivo* and *post-mortem* parameters.

Parameters	TW (g) Cov	*P* value	EW (g) Cov	*P* value
eBW (kg)	+1.88	***	+0.09	**
eSC (cm)	+1.83	*	NS	NS
eHL (cm)	NS	NS	NS	NS
eHD (cm)	NS	NS	NS	NS

Cov = covariates; eBW = estimated body weight; eSC = estimated scrotal circumference; eHL = estimated horns length; eHD = estimated horns diameter; TW = testicular weight; EW = epididymal weight.
***$P < 0.001$; **$P < 0.01$; *$P < 0.05$; NS = not significant.

Relationship between *in-vivo* and *post-mortem* parameters are presented in Table 1. A significant positive relation was present between eBW and both TW and EW. Moreover, a positive relation occurred between eSC and TW ($P < 0.05$), and among TW and EW (cov 9.53 g per g of epididymal weight, $P < 0.001$).

Further analysis have been performed considering each in vivo parameters (eBW, eSC, eHD, eHL) as dependent variable against the remaining *in-vivo* and *post-mortem* parameters. A significant positive relation was observed between eHL and eBW (covariate 0.27 cm per kg of body weight, $P < 0.05$) and between eHL and EW (covariate 0.98 cm per g of epididymal weight, $P < 0.05$) (Table 2).

Epididymal sperm was successfully collected from all bucks with the following characteristics: sperm concentration = 1.12 ± 0.58 × 109/ml; total number of spermatozoa = 2.73 ± 1.80 × 109; total motility = 75.27 ± 13.08%; viability = 72.53 ± 9.22%; normal sperm = 97.80 ± 2.63%; proximal droplets = 1.27 ± 3.90%.

Relations between *in-vivo* and *post-mortem* parameters with epididymal semen quality are shown in Table 3. The age of animals affected positively total number of spermatozoa and consequently the number of semen doses (covariate 2207.9 × 105 total number of sperm per months of age, $P < 0.05$; covariate 7.35 n. of semen doses months of age, $P < 0.05$; respectively), and negatively the percentage of proximal droplets (covariate −6.22% per months of age, $P < 0.01$). A significant positive relation was present between eBW and sperm production parameters: sperm concentration, total number of spermatozoa and consequently number of semen doses. These semen parameters were significantly affected also by eHL and TW. Horns length showed a positive relation with percentage of normal sperm. Percentage of proximal droplets had a negative relation with eSC. Total motility and viability did not show significant associations with *in-vivo* and *post-mortem* parameters.

4. Discussion

This study confirmed that horns length development in young Alpine bucks is positively associated to body weight, as demonstrated in literature for other secondary sexual traits like scrotal circumference and testicular weight. More interesting, it was demonstrated that horns length development was related to epididymal weight. In the ibex no relations were observed among horns and testicles size (Santiago-Moreno et al., 2007).

Scrotal circumference and testicular measurements are important components in breeding evaluation, useful to select superior animals for reproduction purposes. According to our data, a significant relation occured between body weight and testicular measurements (testicular and epididymal weight) and among scro-