Sexual development in Tazegzawt male lambs: body, testicular and penile growth before pre-puberty

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In sheep, measurement of body growth and testicular parameters and observations of state penile development can be useful tools to select the best breeders. The aim of this work was to study the testicular growth development in Tazegzawt lambs and the relationship with age and body growth parameters. Ten Tazegzawt ram lambs, born in the spring, comprising four from single births and six from multiple births, raised and managed under natural temperature and light were used to study the testicular development (scrotal circumference, testis diameter, testis length, tail of the epididymal diameter and estimation of testis volume) and the association with the development of body growth.

The results showed that the mean live weight in male Tazegzawt lambs was 5.0 kg at birth and 39.7 kg at 25 weeks of age. The highest average daily gain (293 g/d) was observed during the first months after birth.The increase of testicular size and penile state development were more closely associated with body weight than with age. The period from 9 - 25 weeks of age was characterised by rapid sexual development on the basis of testes and penile development. Tazegzawt lambs attained the pre-pubertal stage when the body weight exceeded 28 kg.

Significant correlations ($P \leq 0.001$) were found between testicular (scrotal circumference, diameter, length and volume of testis and epididymal tail diameter) and body (live weight and thoracic perimeter) measurements. Thoracic perimeter, scrotal circumference, testicular diameter and testicular length were more related to lambs weight than to chronological age.

Keywords: Sheep, body and testis growth, penile development, correlations, pre-pubertal

Body weight is often the most common informative measure of animal performance and it has been found to be very effective in assessing reproductive efficiency. The knowledge of testicular development by biometric measurements at early ages is very useful in selection of breeding males. According to Toe et al. (2000), measures of testicular size have received considerable attention as a possible selection criterion for improving fertility in sheep, and how these events proceed throughout pre-pubertal development determines the future reproductive capability of the adult male. Testicular size can be measured accurately in the live animal (Notter et al. 1981) and it may be useful as a selection criterion for improvement of reproductive ability. Testicular growth and development are closely related to body size (Osinowo et al. 1981) and are of some influence on sperm output (Amann 1970). Ramm and Stockley (2010) found that increasing age and body weight correlated positively with testicular sizes of lambs. Courot (1962) cited that gonadal development in the young male is more closely related to live weight than to age as the initiation of spermatogenic activity is more closely correlated to a certain state of physical development than to age (Toure and Meyer 1990). Therefore, it is important to closely monitor the phase of pre-puberty in order to be able to predict future fertility and to diagnose any reproductive complications (Giffin et al. 2014). Moulla et al. (2018) found that Tazegzawt male sheep reached puberty at a mean age of 33 ± 4.9 weeks with mean body weight of 43.1 ± 5.5 kg. The first semen was recovered from 30% of lambs at 29 weeks of age and by 45 weeks of age 100% of lambs were producing semen.

The purpose of this investigation was to assess pre-pubertal sexual development in Tazegzawt male lambs by measuring body and

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testicular parameters and state of penile development and also to establish the relationship between testicular parameters and body growth parameters.

Tazegzawt is an ovine breed located in mountain areas in the northern region of Algeria (precisely in Kabylia). This sheep breed is genetically distinct from other local sheep breeds (Gaouar et al. 2017) and has the following phenotypic characteristic; blue-blackish tasks on the muzzle, the edges of the eyes and earlobes (El Bouyahiaoui et al. 2015). Tazegzawt breed produce mainly red meat, while the milk production is used entirely for the lambs. According to El Bouyahiaoui et al. (2015), Tazegzawt breed have a good reproductive and growth performance (84% fertility, 150% prolificity, 127% fecundity, live weight at birth 4.7 ± 0.9 kg, at 30 days 21.6 ± 3.0 kg and at 90 days 25.8 ± 3.7 kg) and an acceptable level of wool productivity.

Currently, this breed which remained unknown for a long time is endangered because the number of herds is low and often the crosses are uncontrolled. There have been studies on the breed (El Bouyahiaoui et al. 2015; Moulla et al. 2018; El Bouyahiaoui et al.; 2019) but these studies did not investigate sexual development.

Materials and methods

The study was conducted at the experimental station at Oued Ghir, in Bejaia district, of the National Agronomic Research Institute of Algeria during the period February to September 2014. This station is located in western region of Algeria and has a Mediterranean climate with mean annual temperatures ranging from 12.9 to 22.1°C and average annual rainfall of 767 mm. The altitude, longitude and latitude are 66 m, 4° 58' E and 36° 42' N respectively.

Among 14 Tazegzawt ram lambs born in spring, four died soon after birth, hence ten were used in this study; four of these were from single births and six from multiple births. The lambs were weaned at 25 weeks of age with an average body weight of 39.7 kg, they were all raised under the same natural and nutrition conditions. During the first months after birth, the lambs were fed exclusively milk, then they received hay of oat vetch, commercial concentrate (containing 50% barley, 10% corn, 37.5% wheat bran and 2.5% mineral vitamin compound) and the animals were allowed to graze on spontaneous vegetation rangelands. Water and mineral blocks (containing vitamin A, D_3, E, magnesium, manganese, iron, zinc, cobalt, iodine and selenium) were provided *ad libitum*. All animals were vaccined against contagious diseases and received internal antiparasitic treatment (distomatosis, strongylosis, scabies). The measurement parameters were simultaneously recorded for each lamb.

Body development

Live weight was measured at birth and at 10 days of age, then live weight and thoracic perimeter were measured regularly at 2-week intervals from 9 – 25 weeks of age. Average daily gains of birth - 10 days, birth - 9 weeks, 9 – 13 weeks, 13 – 17 weeks and 17 – 25 weeks were all calculated. A load cell with a span of 50 kg and a scaling accuracy of 100 g was used to measure live weights.

Testicular development

Measurements of testicular growth started at 9 weeks and then every 2 weeks until 25 weeks of age. These measurements were testicular diameter, testicular length, scrotal circumference and epididymal tail diameter of each testis. A flexible meter tape measured thoracic perimeter and scrotal circumference and a sliding caliper measured the diameter and length of testis and the diameter of the tail of the epididym after forcing each testis against the scrotum.The testes volume was calculated according to the formula reported by Godfrey et al. (1998):

Volume = 0.0396 x average testis length x $(\text{scrotal circumference})^2$

Penile development

The degree of separation of penile adhesions with preputial mucosae was assessed at three stages as defined by Pretorious and Marincowitz (1968) and by Madani et al. (1989).

Stage 1. Infantile stage: the penis is thin and completely adherent to preputial mucosae.

Stage 2. Separation stage: the penis becomes visible; the separation of adhesions is initiated.

Stage 3. Pre-pubertal stage: the penis is completely separated from the prepuce and is fully exposed through the preputial orifice.

Data analysis

The data obtained were analysed using StatView 4.02 software (Abacus Concepts, Berkeley, CA, USA) for calculating means, standard deviations, minimums, maximums and coefficients of variation as well as the correlation matrix of the studied parameters. Growth curves were fitted by linear and non-linear models to determine the models that best characterised the growth of lambs.

Results

Body growth

Live weights at birth and different ages

The mean live weight and standard deviation of Tazegzawt ram lambs at birth was 5.0 ± 1.0 kg; the mean live weight at birth of single born lambs was higher than that of multiple births (5.6 ± 0.6 kg vs 4.5 ± 1.0 kg)

At 10 days, 9, 13, 17 and 25 weeks, the mean weights and standard deviations of the lambs were 7.5 ± 1.1, 22.8 ± 4.0, 27.2 ± 5.1, 32.8 ± 6.4 and 39.7 ± 7.0 kg respectively. The rates of growth were faster during the first 2 months with a significant difference between single and multiple birth types. The lambs born single tended to be larger, but the difference was not statistically significant ($P > 0.05$) except at birth and at 10 days (Figures 1 and 2).

The average difference in weight between single and multiple birth types was 3.67 kg at 9 weeks, 4.25 kg at 13 weeks, 4.42 kg at 17 weeks and 2.38 kg at 25 weeks of age.

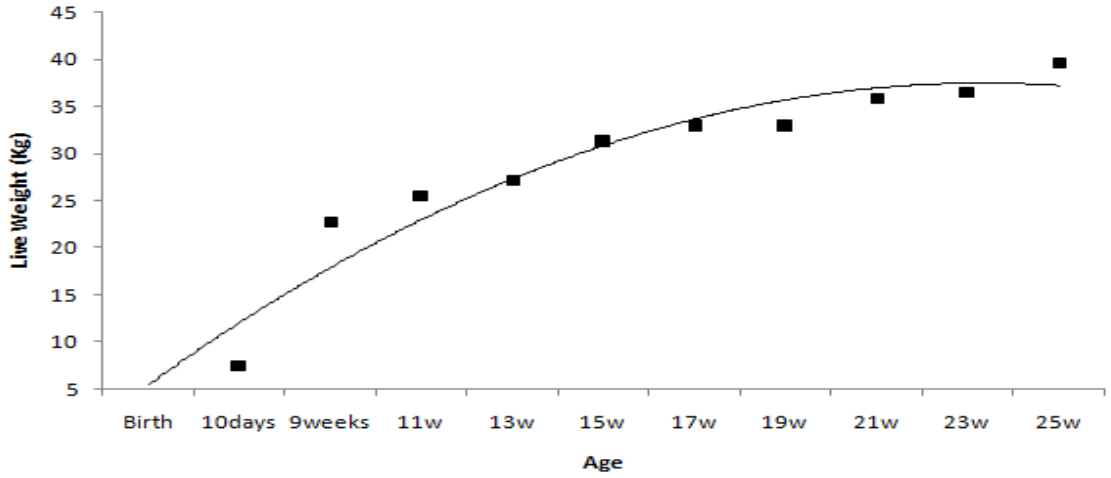

Figure 1: Relationship of live weight and age in Tazegzawt ram lambs from birth to 25 weeks (w) of age

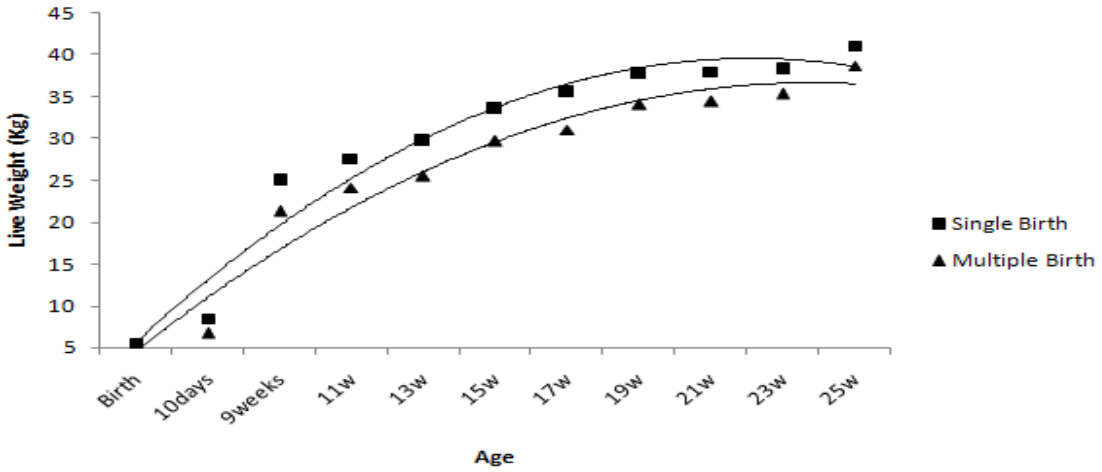

Figure 2: Relationship of live weight and age according to type of birth in Tazegzawt ram lambs from birth to 25 weeks of age.

Average daily gain

The highest average daily gain was observed between birth and 9 weeks age (293 ± 63 g/d), this decreased with age to reach 114 ± 34 g/d between 17 – 25 weeks. Average daily gain was higher in lambs born single than in lambs others born multiple up to 13 weeks; between 17 – 25 weeks multiple birth animals had higher average daily gains.

Growth of thoracic perimeter

The rate of growth of thoracic perimeter was 1.1 mm/d from 9 – 25 weeks of age in both single and mutiple birth animals. Thoracic perimeter increased from 66.1 ± 2.9 at 9 weeks of age to 77.3 ± 5.2 cm at 25 weeks of age (Figure 3).

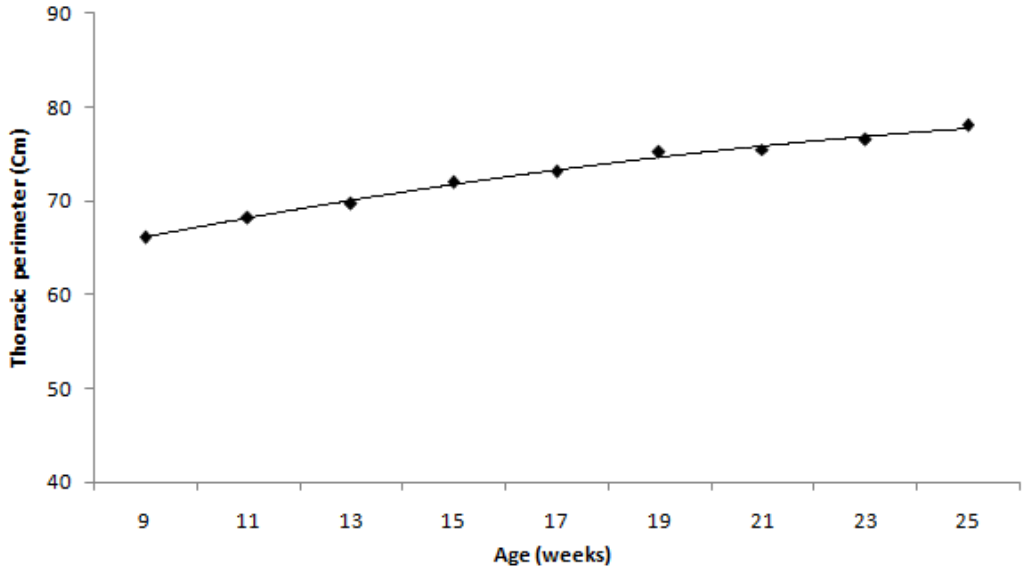

Figure 3 : Relationship of thoracic perimeter and age in Tazegzawt ram lambs from 9 – 25 weeks of age

Testicular growth

Table 1 summarises the development of live weight and of testes during the study. There was a gradual and linear increase in the testicular measurements from 9 – 25 weeks age with no differences between the right and left testes ($P > 0.05$). The results indicated a clear relationship between age and live weight and the testicular parameters of Tazegzawt lambs. The increase in testicular dimensions was relatively constant, but testis volume showed a rapid increase from 17 weeks of age.

State of penis development until 25 weeks of age

Observations up to 25 weeks of age indicated penile development from Stage 1 infantile, to Stage 2 partial separation of the penis from the preputial mucosa. Stage 2 commenced in eight of the ten lambs at 23 weeks of age and in the other two lambs at 25 weeks of age. Body weight, thoracic perimeter and scrotal circumference of the lambs in Stage 1 of penile development (30.1 ± 7.0 kg; 71.4 ± 4.9 cm; 14.2 ± 2.5 cm) were significatly lower than the corresponding values observed in lambs at Stage 2 of penile development (36.8 ± 5.0 kg ; 76.7 ± 4.4 cm ; 18.1 ± 4.7 cm) (Table 2).

Correlation analysis

Correlation coefficients are shown in Table 3. The various measurements of the testis were correlated highly with each other and also with body weight, thoracic perimeter and age ($P \leq 0.001$). Testicular measurements had higher correlations with body weight and thoracic perimeter than with age. The scrotal circumference correlated highly with testicular diameter, testicular length and epididymal tail diameter ($P \leq 0.001$).

Table 1: Live weight and testicular morphometry in Tazegzawt ram lambs from 9 to 25 weeks of age

	Testicular dimensions					
Age (week)	**Scrotal circumference (cm)**	**Testis diameter (cm)**	**Testis length (cm)**	**Epididymal tail diameter (cm)**	**Testis volume (cm^3)**	**Live weight (kg)**
9	12.5 ± 1.4	1.7 ± 0.3	4.8 ± 0.7	1.3 ± 0.2	30.3 ± 10.2	22.8
11	13.2 ± 1.7	1.8 ± 0.3	5.1 ± 0.7	1.4 ± 0.3	36.2 ± 13.5	25.5
13	13.5 ± 1.8	2.0 ± 0.3	5.5 ± 0.8	1.5 ± 0.2	41.6 ± 16.4	27.2
15	14.2 ± 2.0	2.3 ± 0.4	6.0 ± 0.9	1.5 ± 0.2	49.8 ± 19.7	31.2
17	14.9 ± 2.4	2.5 ± 0.6	6.6 ± 0.9	1.6 ± 0.3	60.8 ± 26.4	32.8
19	15.9 ± 3.6	2.7 ± 0.7	7.3 ± 1.4	1.7 ± 0.3	81.2 ± 53.3	32.8
21	17.0 ± 4.2	3.0 ± 0.8	7.9 ± 1.7	1.8 ± 0.3	101.3 ± 75.3	35.9
23	18.8 ± 4.9	3.2 ± 0.8	8.0 ± 1.7	1.9 ± 0.3	130.9 ± 93.2	36.5
25	19.8 ± 5.3	3.5 ± 0.9	8.5 ± 1.8	1.9 ± 0.3	153.4 ± 107.0	39.7

Values are represented as mean ± SD

Table 2: Penile stage development, body and testicular characteristics in Tazegzawt ram lambs

Stage of penile development	Number of observations	Parameter	Mean ± SD	Minimum	Maximum	CV (%)
1	72	Age (week)	15.2 ± 4.2	9	23	27
		LW (kg)	30.1 ± 7.0	17.0	45.0	23
		TP (cm)	71.4 ± 4.9	62.3	83.5	7
		SC (cm)	14.2 ± 2.5	10.0	23.0	18
2	18	Age (week)	23.4 ± 0.9	23	25	4
		LW (kg)	36.8 ± 5.0	28.0	46.5	16
		TP (cm)	76.7 ± 4.4	70.5	84.4	6
		SC (cm)	18.1 ± 4.7	13.4	25.5	26

Values are represented as mean ± SD

Stage 1: infantile stage, the penis is thin and completely adherent to preputial mucosae; Stage 2: separation of penile adhesions with preputial mucosae commenced and penis glans becomes visible; LW: live weight; TP: thoracic perimeter; SC: scrotal circumference

Table 3: Correlation coefficients between testicular morphometry, body measurements and age in Tazegzawt ram lambs from 9 to 25 weeks of age

	Age	LW	TP	SC	TD	TL	ETD	TV
Age	1							
LW	0.68	1						
TP	0.68	0.95	1					
SC	0.56	0.81	0.83	1				
TD	0.70	0.83	0.85	0.95	1			
TL	0.73	0.81	0.83	0.92	0.97	1		
ETD	0.61	0.76	0.78	0.86	0.91	0.92	1	
TV	0.75	0.73	0.76	0.97	0.92	0.91	0.82	1

LW: live weight; TP: thoracic perimeter; SC: scrotal circumference; TD: testicular diameter; TL: testicular length;

ETD: epididymal tail diameter; TV: testicular volume

Discussion

Despite its endangered status, Tazegzawt is one of the important sheep breeds in the mountainous area of Kabylia (Algeria) and is well adapted to the local conditions. In this study, we aimed to describe sexual development in males during the prepubertal phase including body development, testis growth and the state of penile development.

The results showed that the mean live birth weight of Tazegzawt ram lambs was 5.0 kg. Previous values reported for local breeds include 4.8 kg in same breed (El Bouyahiaoui et al. 2019), 4.5 kg in Ouled Djellal (Boussena et al. 2013) and 4.3 kg in Rembi (Benchohra et al. 2014). Values for other breeds include 4.3 kg in Awassi from Jordan (Kridli et al. 2006) and 4.5 kg in Blackbelly from Mexico (Herrera-Alarcón et al. 2007). Akpa et al. (2006) reported the low birth weight of 2.2 kg for Yankasa ram lambs of Nigeria. Live weight at birth in single born lambs was greater than that in multiple born lambs. This same result

was reported by other authors (Bonfoh et al. 1994; Boussena et al. 2013).

Body growth curves obtained in this study are similar to those observed by Salhab et al. (2001) in Awassi lambs and Boussena et al. (2013) in Ouled Djellal lambs. Furthermore the body weight at 10 days old of Tazegzawt lambs (7.5 kg) was similar to the result reported by El Bouyahiaoui et al. (2019) in the same breed. The average body weights of the Tazegzawt males at 9, 13, 17 and 25 weeks were 22.8 ± 4.0, 27.2 ± 5.1, 32.9 ± 6.4 and 39.7 ± 7.0 kg, respectively. These values are higher than those from the Ouled Djellal breed (Boussenaet al. 2013; Belkhiri et al. 2017) and from the Rembi breed (Benchohra et al. 2014). In Tazegzawt, El Bouyahiaoui et al. (2019) recorded a similar weight at 90 days, 13 weeks (27 kg) and a somewhat lower weight at 180 days, 25 weeks (37.7 kg). The weights of Tazegzawt lambs recorded are higher than those of the Kivircik ram lambs from Turkey as cited by Elmaz et al. (2007).

The maximum rate of growth was recorded during the first 2 months after birth (293 ± 63 g/d) and than decreased with age to 114 ± 34 g/d at 17 – 25 weeks. The high average daily gain during the 2 months after birth could be due to the good milk yield of the mothers.The slowdown of the average daily gain as lambs progressed in age is similar to the results reported by Bedhia et al. (2000).

Testis and scrotal development in this study were similar to the results reported by Boussena et al. (2013) and Belkhiri et al. (2017) in Ouled Djellal lambs, Belibasaki and Kouimtzis (2000) in Friesland, Chios, Karagouniki and Serres lambs, Salhab et al. (2001) in Awassi lambs, Emsen (2005) in Awassi and Red Karaman lambs and Elmaz et al. (2007) in Kiviricik lambs. A rapid and gradual increase of testicular size from 9 weeks (60 days) to 25 weeks (180 days) was more closely associated with body weight than with age and was also observed by Koyuncu and Ozis Altincekic (2013) in three sheep breeds. At this period of testicular growth, Tazegzawt ram lambs were in the stage of rapid sexual development as determined by the increase in testicular size; Hocherau-de Reviers et al. (1995) reported similar rapid development in both the length of seminiferous tubules and intertubular tissue.

The values of testicular measurements obtained in this study were comparable to those of the Kiviricik (Koyuncu et al. 2005), Awassi (Bilgin et al. 2004) and Ouled Djellal breeds (Belkhiri et al. 2017). El-Alamy et al. (2001) reported some differences related to the effects of breed and Ulker et al. (2005) reported differences caused by the different environments in which lambs were raised.

In the infantile stage of penile development (Stage 1) and in the stage of partial separation (Stage 2), the body weights recorded (30.1 ± 7.0 and 36.8 ± 5.0 kg respectively) were higher than those reported by Madani et al. (1989) in the Libyan Fat-Tailed ram lambs (28.7 ± 6.2 and 33.0 ± 2.4 kg respectively). In this study complete penile separation was observed pre-pubertal stage (Stage 3) with a body weight exceeding 28 kg.

The thoracic perimeter was more correlated with the live weight than with age, this result is consistent with Bahhar (1998). It is therefore possible to estimate the body weight from the measurement of the thoracic perimeter. The positive correlations reported in this study agree with the findings of Foster et al. (1989), Koyuncu et al. (2000), Salhab et al. (2001), Koyuncu et al. (2005) and Koyuncu and Ozis Altincekic (2013).

Conclusion

The results of this study concerning sexual development in Tazegzawt lambs showed that testicular measurements and penile development state were strongly correlated with body weight and can be used as criteria for selection at an early age. To increase herd fertility, as well as production and reproductive performance, it is useful to choose animals with well-developed testicles and satisfying

body growth. These results need to be extended by studying sexual behavior, determining testosterone levels and analysing spermatogenic activity.

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