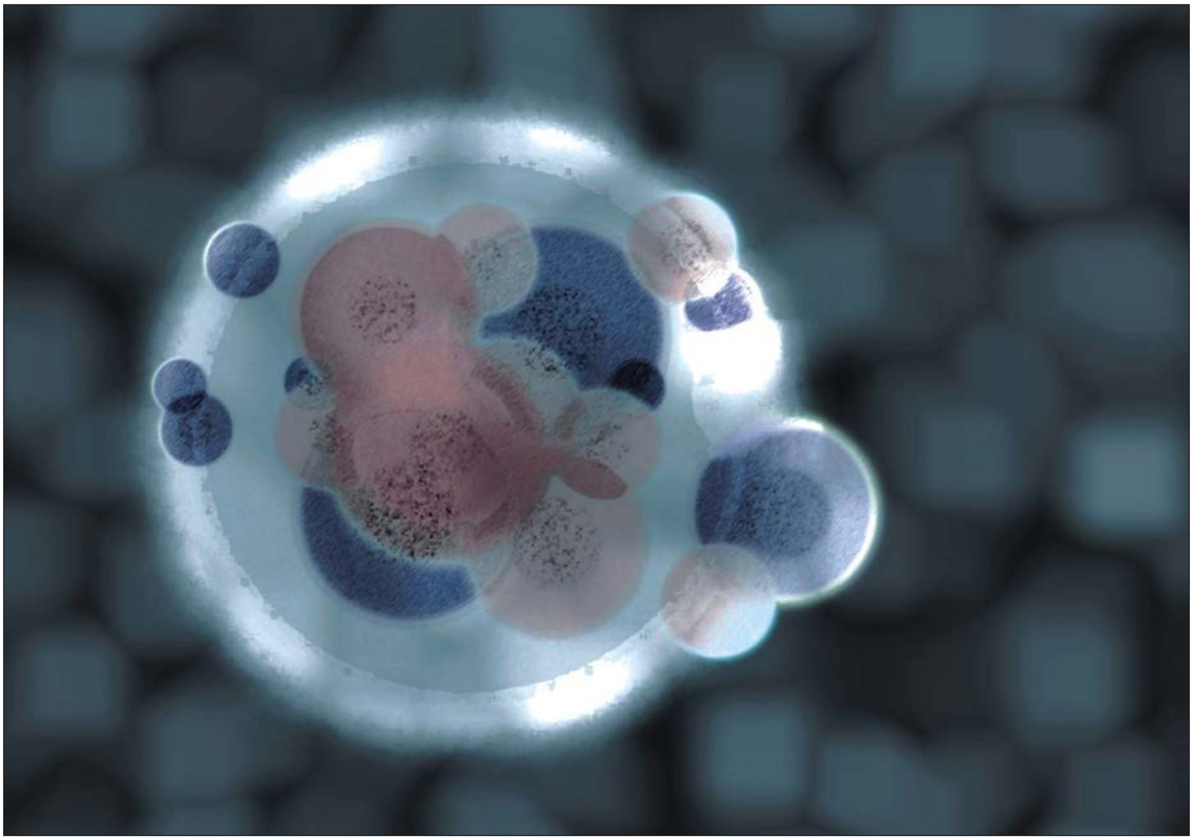

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Genetic and Phenotypic Characterization of the Tunisian Noire De Thibar Lambs on Their Growth Traits

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Abstract: Growth data recorded on 10244 Noire de Thibar lambs born along five years and raised in ten flocks in North-Western region of Tunisia were used to carry out this study. The analysis of variance has shown that herd, sex-type of birth and herd by date of birth interaction had highly significant effects on the lamb growth. Males born single were heavier and grew faster than the other sex-type of birth categories. However, twin or multiple males were less heavy than females born single. Age of dam had a significant effect only from birth to seventy days. The birth date, as well as the interaction among herd and sex-type of birth affected significantly all studied traits except the average daily gain between 70 and 90 days. Multiplicative adjustment coefficients were computed for sex-type of birth and age of dam factors. Heritability of each growth trait was estimated by an adjusted regression dam-offspring method. Genetic and phenotypic correlations between the traits were also estimated. Such parameters should be essential information for developing genetic evaluation tools and/or elaborating genetic improvement programs, especially, if we consider that the present selection practice remains empirically based on a biased average daily gain between 10 and 30 days.

Key words: Noire de thibar breed, growth traits, adjustment coefficients, heritability, genetic and phenotypic correlations, regression dam-daughter

INTRODUCTION

Noire de Thibar is a Tunisian composite breed with a meat production vocation. It is adapted to the intensive and semi-intensive management systems. Originally the breed has been created by a Netherlands monk called Novat who took part in a catholic mission of the Peres Blancs of St. Joseph de Thibar in the rainy North-western region of Tunisia. His work started in 1908 by reciprocal crossing of Merinos d'Arles from southern France with the Algerian Thin Tail breeds. This crossbreeding program and selection were undertaken with the aim of producing animals uniformly black in order to avoid an environmental constraint which is the presence of a bad-grass (*Hypericum perfoliatum* or *Hypericum crispum*) growing in association with cereal crops in Thibar region; hence the breed name. This plant contains a toxic substance generating a photosensitive anaphylactic reaction. In fact, white coat animals may develop skin reaction and sometimes go blind when they are exhibited to the sun rays. In 1924 only 5% of the elaborated stock had a white spot on the back of the head, or on the tip of the tail, or both. In 1945 the breed was officially recognized and a flock book opened under the name: Race ovine Noire de Thibar. Actually it represents about 3.5% of all Tunisian sheep livestock.

Typically, the Noire de Thibar breed has a uniform black coat, a cylindrical body form with a good conformation and a head slightly lengthened and polled. According to Mason (1967), a ram weight 80 to 90 kg at maturity and can reach between 0.65-0.70 m as height while ewe weights 50 to 60 kg and do not exceed a size of 0.60-0.65 m. Fleece cover almost all the body and its quality is medium to fine, it weights between 4-5 kg for rams and 2-3 kg for ewes. The breed prolificacy and fertility range between 130-134 and 68-88%, respectively (Djemali and Alhadrami, 1997). Gouhis (1989) concluded that the seasonal anoestrus is less deep in Noire de Thibar sheep than in any other breed exploited in Tunisia. This offers to breeders the opportunity to adapt their breeding programs with the best season.

In some flocks and since mid eighties, white fleeces appeared in some animals along with fertility problems due to an increasing degree of inbreeding. In order to

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reestablish the situation, Brown Swiss rams were imported from Switzerland and introduced in some flocks instead of adopting an appropriate strategy like this proposed by Rochambeau (1983). Portuguese Black Merino rams were recently imported and introduced in some flocks in order to create a new composite breed that is Sidi Tabet Cross. It is known that introducing new blood in a breed may cause many changes in its characteristics as growth curve (Katsaounis and Zygoyarnis, 1986; Thakur and Patnayak, 1987). Within 2007, a Noire de Thibar meat label is going to be created. Unfortunately, with the actual strategy of many breeders, the original Noire de Thibar blood is really going towards a total loss.

The Tunisian fat-tailed Barbarine breed remains the most representative of Tunisian sheep livestock since it expresses itself better in extensive system which is largely adopted in the country. During his life, a Barbarine animal may store about 5-8 kg of fat in his tail. For this reason mating must be assisted by the shepherd, making paternity control easier than for other thin-tail breeds for which only the maternal relationships are identified. Even though a national recording system does exist and cover most of the flocks, it is evident that unknown paternity was at the origin of the lack of genetic studies on the growth traits of the Noire de Thibar lambs comparatively to the Barbarine breed who benefits of a large pedigree database (Ben Hamouda, 1985; Khaldi *et al.*, 1987; Djemali *et al.*, 1994).

Since there is no previous characterization study of the original Noire de Thibar lambs growth, the aim of the present study is then to carry out a first one. This will consist on determining major factors affecting growth traits during the first three months of age, deriving adjustment factors for the identified non-genetic sources of variation and estimating genetic and phenotypic parameters. These would be useful information for breeders to develop and initiate a genetic improvement program proper to the original Noire de Thibar breed in order to maintain its genetic pool characteristics.

MATERIALS AND METHODS

An initial database of 10244 Noire de Thibar lambs growth records, collected in ten herds, grazing in North-Western region of Tunisia, during five years (From 1990 to 1994), were typed and saved on a hard-disk in order to be processed. The flocks were chosen on their breeding history since crossbreeding actions started after 1994. Hence, the studied herds were considered to be other blood's free. Lambs were born primarily in September (54.4%) and October (38.33%) of each year. Only 5.24% were born either in August (1.55%) or November (3.69%). This lambing period differ from this reported by Djemali *et al.* (1994) for the Barbarine breed. Proportions of lambs born single, twin, triplet and quadruple were 52.11, 47.34, 0.52 and 0.03%, respectively. Lambs were ear tagged at birth and, 21 days after the date of the first lambing, a sequential weighing process starts and continue to be carried out for each flock at five intervals of 21 days. However, a primary data analysis shows that only lambs born at the beginning of the weighing control have more chance to be weighed five or six times. For example, 41.45% of the lambs born in October profited of five weighings and only 3% of six weighings. For lambs born in September, these proportions were 57.88 and 17.72%, respectively; while 100% of lambs born in August have been weighed six times. With such weighing distribution, the growth traits corresponding to the third month of age would miss for a large proportion of lambs. The system of rearing is based on natural pasture along with concentrates used as supplement. Weights at 10 (W10), 30 (W30), 70 (W70) and 90 (W90) days of age were computed either by interpolation or by extrapolation on the weighing dates. Average daily gain between 10-30 days (ADG10-30), 30-70 days (ADG30-70) and 70-90 days (ADG70-90) were then deduced from the aforementioned weights. Only data included in the interval: mean±2 SD were considered in this study, this in order to avoid outliers effect that may result from errors made during weight control.

The least-squares techniques of the GLM procedure (SAS/STAT., 1998) were used to perform growth data analysis. The statistical model adopted to relate the observations with the independent variables was as follows:

$$Y_{ijklmn} = \mu + H_i + G_j(H_i) + A_k + S_l + D_m + HD_{im} + Hs_{il} + Ha_{ik} + AD_{km} + SD_{lm} + AS_{kl} + HDA_{imk} + HDS_{iml} + \epsilon_{ijklmn}$$

Where, Y_{ijklmn} is the lamb growth trait: W10, W30, W70 and W90 as well as ADG10-30, ADG30-70 and ADG7-90; μ is the overall mean; H_i the i^{th} herd (1 to 10); G_j is the j^{th} dam group (all dams born in the same year formed one genetic group); A_k is the k^{th} age of dam category (A = 2 years [15.23%]; B = 3 or 4 years [31.61%], C = 5 or 6 years [32.84%] and D = 7 and more years old [20.28%]); S_l is the l^{th} combined factor sex-type of birth (11 = male born single, 12 = male born multiple, 21 = female born single and 22 = female born multiple); D_m is the m^{th} date (month/year) of birth. The remaining components in the model were different interactions between the above factors that were considered fixed, except the random residual term which was assumed to fellow a N $(0, I\sigma_\epsilon^2)$ distribution.

Multiplicative adjustment factors for sex-type of birth and age of dam were calculated as described by Djemali *et al.* (1994). However, in the present research, significant interactions were also considered in computing the correction coefficients. The method was initially proposed by Schaeffer (1983), it consists on computing a set of Least-squares Mean (LSM) differences from a given level of the factor. The solution option of the GLM procedure was used to get the type III estimable functions of the linear model normal equations. The multiplicative adjustment factors were then derived from these LSM as reported by Djemali *et al.* (1994), but they were furthermore adjusted for interactions' effects. To estimate heritability (h^2) and since only maternal relationships were identified, we were constrained to apply the mother-daughter regression method (Falconer, 1981). Heritability was estimated as 2-times the regression coefficient of dams' observations adjusted for sex-type of birth and age of dam on their "daughters" performances adjusted for the same factors. Daughter word was put between quotation marks to indicate that male lambs were also considered as females since the adjustment operation bring all sex-type of birth categories to the level of a typical female born single and out of a 2 years old dam.

In spite of their extrinsic nature, we have computed and applied the adjustment coefficients for herd and month-year of birth in order to eliminate their possible effect on the regression slope. About 714 pairwise relations were identified in the original data and only 511 for the traits W70 and ADG30-70. Because of a less representative size, neither W90 nor ADG70-90 would be considered at this study. The Standard Error (SE) of estimate was computed as 2-times the regression coefficient SE's. Genetic correlations among growth traits were estimated by an average cross-covariances (dam-daughter) between two different corrected traits. The standard error of the estimate was obtained by:

$$SE\left(\hat{r}_g(x,y)\right) = \left(1-\hat{r}_g^2(x,y)\right)\sqrt{\frac{SE(h_x^2)\,SE(h_y^2)}{2\,h_x^2\,h_y^2}}$$

where, x and y designate two distinct traits and $\hat{r}$ the estimated correlation.

Phenotypic correlations were obtained by using the Ch'ang and Rea (1970) expression, with a standard error equal to:

$$SE\left(\hat{r}_p(x,y)\right) = \frac{1-\left(\hat{r}_p(x,y)\right)^2}{\sqrt{q}}$$

q: is the degree of freedom.

RESULTS AND DISCUSSION

Growth traits: A Noire de Thibar lamb born and raised under the conditions of the North-Western region of Tunisia weighs 5.12, 8.14, 14.32 and 17.40 kg at 10, 30, 70 and 90 days, respectively (Table 1). It grows daily by 150.97, 154.50 and 143.61 g between 10-30, 30-70 and 70-90 days, respectively. These performances are relatively low for a breed grazing in a region where feed resources are in abundance. This appears more evident when we compare them to those reported by Ben Hamouda (1985), Khaldi *et al.* (1987) and Djemali *et al.* (1994) for an experimental flock of the Barbarine breed growing in less favorable conditions (Central region of the country). However, in term of meat production, the tendency may reverse since Barbarine lambs store fat in their tails (what can represent as much as 8-10% of their live weight). After 30 days and in contrast with the former breed, the Noire de Thibar lambs grow faster. This would reflect the European origin of the breed. So, after 70 days the growth tends to be slower, this may be either attributed to the coldest and rainy season in the year (December-January) or to the feeding level or both. A real review of the breeding system is then recommended.

Sources of variation: The obtained results of growth traits variation analysis were shown in Table 2. They were in concordance with more recent literature (Gbangboche *et al.*, 2006). The Herd factor, as well as the herd by year-month of birth interaction have highly significant effects on all studied traits ($p<0.001$). This reflects the breeding system nature that could not be considered intensive. Let us recall that the Noire de Thibar breed was initially created to be adapted with such system not with an extensive one. This practice would certainly occult its true genetic potential of growing. The combined factor sex-type of birth was also a highly significant source of variation of all considered traits. This agrees with what is generally reported in almost all of the literature (Martin *et al.*, 1980; Ben Hamouda, 1985; Khaldi *et al.*, 1987; Boujenane and Kerfal, 1990; Djemali *et al.*, 1994; Gbangboche *et al.*, 2006). Age of dam had a decreasing significant effect only from birth to seventy days. For the Barbarine breed, this effect remains highly significant until 90 days (Djemali *et al.*, 1994). This result reflects an earlier weaning practice in almost all of the Noire de Thibar flocks. The birth date, as well as the herd by sex-type of birth interaction affected signicatively all studied traits except the average daily gain between 70 and 90 days. The first effect confirms, once again, what we previously concluded on the nature of breeding system, while the second reflects rather a difference in the

Table 1: Distribution parameters of weight and gain traits in Noire de Thibar lambs

	Weights (hg)				Average daily gains (g day^{-1})		
	W10	W30	W70	W90	10-30	30-70	70-90
Number of lambs	9419.00	9416.00	8182.00	4749.00	9414.00	8180.00	4742.00
Mean	51.22	81.43	143.22	174.04	150.97	154.50	143.61
SE of the mean	0.12	0.19	0.34	0.54	0.54	0.51	0.74
SD	12.20	18.75	31.27	37.07	52.25	46.02	51.38
CV	23.81	23.03	21.84	21.30	34.61	29.79	37.78
Min.	22.57	39.29	70.20	86.40	10.95	38.09	14.29
Max.	84.90	130.29	224.73	268.64	283.21	273.14	283.33

Table 2: Significance test (F) for factors affecting growth traits variation in Noire de Thibar lambs

	Weights					Average daily gains		
Sources of variation	Df ◇	W10	W30	W70	W90	10-30	30-70	70-90
Herd [A]	9	***	***	***	***	***	***	***
Genetic group (Herd) [B]	90	ns	*	*	**	**	**	ns
Sex-type of birth [C]	3	***	***	***	***	***	***	***
Age of dam [D]	3	***	***	**	0.068	**	*	ns
Year-month of birth [E]	9	***	***	***	***	***	***	0.056
Interactions								
[A] X [E]	81	***	***	***	***	***	***	***
[A] X [C]	27	***	***	***	***	***	***	0.066
[A] X [D]	27	ns	ns	ns	ns	ns	ns	0.08
[C] X [E]	27	ns	ns	ns	ns	ns	ns	ns
[D] X [E]	27	ns	ns	ns	ns	ns	ns	ns
[C] X [D]	9	ns	ns	ns	ns	ns	ns	ns
[A] X [C] X [E]	141	***	*	*	ns	***	*	ns
[A] X [D] X [E]	111	ns	ns	ns	*	***	ns	0.065
Corrected total df		9418	9415	8181	4748	9413	8179	4741
R^2 (%)		44.00	47.10	49.40	51.14	44.62	57.50	54.86

***p<0.001, **p<0.01, *p<0.05, ns: not significant. ◇ Corresponds to the W10 trait

general state of milk productivity between herds (Hammond, 1961). The latter criterion may be itself related to the feeding management (Blackwell and Henderson, 1955). The triple interaction herd by sex-type of birth by year-month of birth was also a significant source of variation for all growth traits considered before 70 days.

Sex-type of birth: The least squares mean differences between sex-type of birth groups were reported in Table 3. Generally in the literature, we noticed a tendency to test sex and type of birth effects separately, this leads to conclude that males are and since birth, more productive than females (El Tawil *et al*., 1970; Hamada, 1976; Djemali *et al*., 1994; Mandal *et al*., 2003; Hassan and Makuza, 2005). The combination of these two factors allowed us to show that males born single were heavier and grew faster than all the other sex-type of birth categories (e.g., at 90 days, about 4 kg was noticed as difference between males born single and females born multiple and at the same age, the first group weighed 2.6 kg more than males born multiple). Until three months of age, males born multiple weighed less than females born single; a difference that reached about 1.4 kg at 30 days, but decreased latter to reach 0.89 kg at 90 days. However, after 70 days all the males grew indeed faster than females since their average daily gain exceeded those realized by females born either single or multiple. This highlights a superiority of the genetic potential of growing in male lambs that was hidden under a maternal effect, especially before weaning.

Age of dam: The effects of age of dam on growth traits are shown in Table 4. The two years old ewes produced lighter lambs. This result agree with these recently reported by Benyi *et al.* (2006). In contrast with what has been concluded for the Tunisian Barbarine breed (Ben Hamouda, 1985; Djemali *et al*., 1994), the least squares mean differences computed in this study did not allow us to distinguish an optimum age of culling. The only conclusion that we may deduce is that especially after 70 days, the age of dam factor had no effect on the lamb growth traits. Noire de Thibar ewes should be reformed consequently on the basis of an elaborated index reflecting their general vigour rather than on their age.

Adjustment factors: Adjustment factors for sex-type of birth and age of dam were computed as described before. These are presented (between brackets) in Table 3 and 4, respectively. Females born single and 2 years old ewes were chosen as adjustment basis. Application of these multiplicative factors will bring the performances of all

Table 3: Least-squares mean differences for the combined effect sex-type of birth on growth traits and their corresponding multiplicative adjustment factors (between brackets)

	Weights (hg)				Average daily gains (g day^{-1})		
Sex-type of birth	W10	W30	W70	W90	10-30	30-70	70-90
Male-single	1.78	2.96	6.57	16.75	6.72	10.84	26.21
	(0.97)	(0.97)	(0.96)	(0.91)	(0.96)	(0.93)	(0.84)
Male-multiple	-8.64	-13.75	-12.44	-8.93	-31.07	-6.09	14.47
	(1.19)	(1.19)	(1.09)	(1.05)	(1.25)	(1.04)	(0.90)
Female-single	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
Female-multiple	-10.16	-15.81	-23.13	-22.58	-39.14	-20.15	-5.54
	(1.23)	(1.23)	(1.19)	(1.15)	(1.33)	(1.15)	(1.04)

Table 4: Least-squares mean differences for age of dam on growth traits and their corresponding multiplicative adjustment factors (between brackets)

	Weights (hg)				Average daily gains (g day^{-1})		
Age of dam	W10	W30	W70	W90	10-30	30-70	70-90
2 years	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
3-4 years	2.84	6.29	13.85	18.34	10.32	4.71	7.32
	(0.94)	(0.93)	(0.91)	(0.90)	(0.94)	(0.97)	(0.95)
5-6 years	2.19	6.39	18.02	17.88	12.21	17.46	-3.86
	(0.96)	(0.92)	(0.88)	(0.91)	(0.92)	(0.90)	(10.03)
7 years and more	3.97	8.22	14.64	14.02	11.29	13.70	-11.50
	(0.92)	(0.91)	(0.90)	(0.92)	(0.93)	(0.92)	(1.08)

Table 5: Heritability (on diagonal) estimated for growth traits of Noire de Thibar lambs and genetic (above diagonal) and phenotypic (below diagonal) correlations among them

Traits	W10	W30	W70	ADG10-30	ADG30-70
W10	0.30±0.08	0.74±0.05	0.73±0.05	-0.13±0.12	0.38±0.08
W30	0.65±0.02	0.23±0.08	0.77±0.05	0.59±0.09	0.34±0.10
W70	0.58±0.03	0.77±0.02	0.28±0.09	0.16±0.14	0.89±0.02
ADG10-30	0.05±0.04	0.71±0.02	0.55±0.04	0.18±0.08	-0.06±0.13
ADG30-70	0.23±0.05	0.29±0.05	0.81±0.02	0.22±0.13	0.34±0.09

lambs to a common level of evaluation. The adjustment was carried out by multiplying each growth trait by its corresponding factors. Hence, any preliminary selection conducted on the adjusted live weights or average daily gains would approach breeders' decision to the probable genetic merit scale. After adjusting performances for the above factors, we have remade the analysis following the same model. This showed that the effects of both factors become no more significant and that their corresponding mean-squares have been reduced by 72.74 to 99.24% following traits.

Genetic parameters

Heritability: Heritability estimated for the growth traits considered until 70 days were shown in Table 5. These were 0.30±0.08, 0.23±0.08, 0.28±0.09, 0.18±0.08 and 0.34±0.09, for W10, W30, W70, ADG10-30 and ADG30-70, respectively. In general, the heritability estimates for the Noir de Thibar weight traits were medium to high, this shows that faster genetic improvement through selection on these traits is possible. This result agree with what Abegaz *et al.* (2002) reported for Horro sheep. The authors have also shown that both maternal and direct heritability may be considered. The W10 heritability was higher in Noire de Thibar sheep compared to the estimates reported for the Barbarine breed (0.21 by Ben Hamouda, 1985 and 0.14 by Djemali *et al.* (1994). The heritability of W30 trait was similar to this estimated by Boujenane and Kerfal (1990) for the Moroccan D'man breed and was slightly lower than the value cited by Ben Hamouda (1985) for the Tunisian Barbarine lambs. For the W70 trait, the estimated heritability was close to this determined by Djemali *et al.* (1994) for the Barbarine breed [0.27]. However, the general tendency of all estimates was in concordance with what Al-Shorepy (2001) reported for some composite breeds. The ADG30-70 heritability was almost twice this determined for the ADG10-30 trait. This result agrees with what Mavrogenis *et al.* (1980) concluded on the difference between pre-weaning and post-weaning growth heritabilities. Estimate of ADG10-30 heritability was close to those reported by Ben Hamouda, (1985) and Djemali *et al.* (1994) for the Barbarine lambs; whereas the ADG30-70 seemed to be more heritable in the Noire de Thibar breed. Similar results were obtained in other breeds (Norgerg *et al.*, 2005). Hence, the ADG30-70 trait should be used as a selection criterion to increase lambs growing instead of the ADG10-30 that is currently employed by breeders. Furthermore, Inyangala *et al.*

(1982) have previously concluded that heritability of weight gain per day increases until one year of age.

Genetic and phenotypic correlations: Genetic correlations among growth traits (Table 5) ranged from-0.13±0.12 for W10 and ADG10-30 to 0.89±0.02 for W70 and ADG30-70. Between weights, all estimates were positive and relatively high. These results agree with those found by Ben Hamouda (1985) and Djemali *et al.* (1994) for the Barbarine breed. In contrast with ADG30-70, the ADG10-30 trait appeared less genetically correlated with the other traits, except with W30 (0.59±0.09). The average daily gain during an interval of age was genetically more correlated with its upper limit weight than with its lower limit one. Similar results were reported for the Barbarine breed by (Ben Hamouda, 1985; Djemali *et al.*, 1994). A small negative genetic correlation was determined between daily growth achieved before and after one month of age (-0.06±0.13). The works of Ben Hamouda (1985), Khaldi *et al.* (1987) and Boujenane and Mharchi (1992) converged towards a same conclusion. This could be a helpful result for the breeders since it has been shown now that selecting the future breeding animals exclusively on their ADG10-30 (i.e., the actual practice) would not involve a genetic improvement of growing after one month and vice versa.

Estimated phenotypic correlations that are shown in the same table were all positive, varying from 0.05±0.04 for W10 and ADG10-30 to 0.81±0.02 for W70 and ADG30-70. Almost all of these estimates agree with those reported in literature for other breeds. One could notice that both average daily gains remained weakly correlated confirming, once again, that selection on the ADG10-30 would not induce a substantial correlated response of the ADG30-70 trait.

CONCLUSIONS

Unknown paternity as well as the bad quality of field records may explain the absence of previous studies dealing with the growth of the Noire de Thibar lambs. The lack of weighings has constituted indeed and along this study, a major constraint that widely limited our investigation. A more adapted strategy of weighing is then strongly recommended. However, it has been shown in the present work that there are non-genetic factors that significantly affect production. Adjusting records for sex-type of birth and age of dam would make them useful for management of within-flock breeding programs.

Considering the estimated genetic parameters, one could conclude that the Noire de Thibar lambs growth during the first seventy days might be improved by focusing the selection on the corrected ADG30-70 trait, regarding its heritability, as well as its correlations with the other growth traits and/or on the live weight W30 which was the more correlated trait with ADG10-30. Let us recall that the latter trait heritability was the smallest. To achieve such goal, a best linear predictor may be derived for a weighed global breeding value including the genetic merit of both traits.

The breeders of the authentic Noire de Thibar sheep have now the essential tools to elaborate their genetic improvement program and/or to start a breed safeguard strategy.

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