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Genetic parameters for growth traits of the Moroccan Timahdit breed of sheep

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Abstract

Data from 522 lambs of the Timahdit breed representing 13 sires were used to estimate genetic parameters. Traits analyzed were weights at birth (BW), 30 days (W30), 70 days (W70) and 90 days (W90), average daily gains from 10 to 30 days (ADG10–30), 30–70 days (ADG30–70) and 30–90 days (ADG30–90). REML estimates of variance and covariance components were obtained assuming animal models that included the fixed effects of sex, age of dam and the combined effect of year and types of birth or rearing, and the animal random effects for the direct and the maternal genetic effects. Genetic correlations were estimated with the same fixed effects and only additive direct genetic effects. Results showed that an important direct additive and maternal genetic effects were observed. Estimates of the direct heritability and maternal heritability were respectively 0.18, 0.59 (BW); 0.31, 0.34 (W30); 0.50, 0.24 (W90); 0.42, 0.08 (ADG10–30), and 0.31, 0.22 (ADG30–90). Estimates of additive direct-maternal correlations were important and ranged from -0.94 to -1.0 for live weights, and from -0.70 and -1.0 for daily gains. The estimates of genetic and phenotypic correlations were high and showed no genetic antagonisms among the growth traits. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Sheep; Timahdit; Heritability; Genetic correlation; Growth; Morocco

1. Introduction

Lamb weights and daily gains are important components of market lamb production. In Morocco, the Timahdit breed is the most important native breed in number (about 17% of the total ewe population) and in distribution. This local breed is well adapted to a wide range of pastoral and mixed farming environments, but has moderate lamb growth. Tijani and Boujenane

(1993) reported paternal half-sib heritabilities for growth traits in Timahdit breed. In their study, some estimates of heritability and genetic correlations were not computable due to negative variance components. However, there is no reports of genetic parameters for traits in Timahdit breed, calculated using animal model methodology and accounted for maternal genetic effect. Studies of various sheep breeds shown that both direct and maternal genetic influences are of importance for lamb growth and that estimation of the additive direct-maternal correlations are important (Burfenig and Kress, 1993; Maria et al., 1993; Tosh and Kemp, 1994).

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The objective of this study was to estimate additive direct and maternal genetic influences and genetic correlations of lamb weights and daily gains from birth to weaning in Timahdit breed.

2. Materials and methods

2.1. Animals and management

Data were collected from 1992 to 1997 at the National Institute and Agricultural Research experimental station 'El Koudia' located 30 km South of Rabat. Records on 522 lambs progeny of 255 ewes and 13 sires were used to estimate genetic parameters. The lambs had complete records for all traits from birth to weaning. Ewes were raised in an annual breeding cycle starting in July. Young ewes were exposed to rams at an average age of 1.5 years and were randomly mated. No culling was performed among the dams except for infertility, old age, and health problems. During lambing and suckling periods, ewes grazed on green pasture. Otherwise, they grazed on dry pasture and cereal crop residues. During the mating period of about 45 days and for 5 to 10 days after lambing ewes were kept indoors, and received a ration composed of cereals (barley, triticale), molasses, sun-flower meal, straw, hay, minerals and vitamins. Ewes were supplemented, depending upon available concentrate, pasture conditions and ewes requirements. Lambs were kept indoors during the day and had free access to hay and to a commercial creep feed that contained about 16% of crude protein, 0.8 forage units, minerals and vitamins. An annual program of vaccination, deworming and dipping was carried out for all animals. Lambs were weighed individually every 20 days, until weaning at around 90–100 days of age. Lambs birth weight (BW), age-standardized weights at 30 days (W30), 70 days (W70) and 90 days (W90) of age and average daily gains from 10 to 30 days (ADG10–30), 30 to 70 days (ADG30–70) and 30 to 90 days (ADG30–90) were analyzed.

2.2. Statistical analysis

Firstly, fixed linear models were applied to the data using Proc GLM in SAS (1989). Fixed model included effects for year-type of birth or rearing (1992 single,

1992 twin, ..., 1997 single, 1997 twin), sex (male, female), and dam age at lambing (≤ 1.5 , 1.5–2.5, 2.5–3.5, 3.5–4.5, > 4.5 years). Preliminary analyses were used to assess all first order interactions among fixed effects. These interactions were shown to account for only a small proportion of the total variation and were not significant ($p > 0.05$) for all seven traits. Final fixed models for BW, W30 and ADG10–30 included fixed effects due to the year-type of birth (12 levels), sex of lambs, and dam age. Final fixed models for W70, W90, ADG30–70 and ADG30–90 included the same fixed effects, except that year-type of birth effect was replaced by year-type of rearing (12 levels). To estimate the genetic parameters, the same fixed effects were included in mixed model together with the random animal effects for the additive direct effect and the maternal genetic effect, and residual effect.

Estimates of (co)variance components were obtained using the software MTDFREML (Boldman et al., 1993). Direct and maternal heritabilities were initially estimated using single-trait analyses. Then, genetic and phenotypic correlations between all traits were estimated using two-trait analyses which accounts for only one random genetic effect, direct genetic effect, in the model. The starting values for additive genetic and residual variances in the bivariate analyses were those estimated under univariate analyses. A minimum of two cold restarts were performed to check for global maxima. A variance of 10^{-8} of simplex function values was chosen as the convergence criterion. Standard errors of genetic correlations were calculated using the approximate formula given by Falconer and Mackay (1996).

3. Results and discussion

3.1. Environmental effects

Average weights and daily gains, standard deviations, and the proportion of variation explained by the models (R^2) are given in Table 1. The analyses of variance showed that the fixed models explained 38 to 56% of the phenotypic variances in all traits, and that effects of year-type of birth, year-type of rearing, and the sex of lambs were important environmental sources of variation for all growth traits ($p < 0.001$).

Table 1

Mean, standard deviations, proportion of total variance explained by each model (R^2 , %) and test of significance (F) for weights and gains of Timahdit lambs^a

	df	Birth weight (kg)	Weight at 30 days (kg)	ADG 10–30 (g)	Weight at 70 days (kg)	Weight at 90 days (kg)	ADG 30–70 (g)	ADG 30–90 (g)
Mean		3.72	9.51	183	17.09	20.37	190	181
Standard deviation		0.53	1.49	47	2.22	2.68	39	34
R^2 of the model (%)		47	51	38	56	52	51	53
Significance of effects in the model								
Sex	1	***	***	***	***	***	***	***
Ewe age	4	***	***	***	ns	ns	ns	ns
Year-birth type	11	***	***	***				
Year-rearing type	11				***	***	***	***

^a ns: $p>0.05$; *** $p<0.001$; ADG: average daily gain; df: degrees of freedom.

The dam age was only significant for traits before 30 days of age (Table 1). These effects of environment are in agreement with those reported and discussed in other studies on growth traits in Timahdit (Tijani and Boujenane, 1993), D'man (Boujenane and Kerfal, 1990), Beniguil (Boujenane and Mharchi, 1992), and Barbarine (Djemali et al., 1994) breeds. Consequently, growth records should be adjusted for these environmental effects in subsequent analyses.

3.2. Heritabilities

In general, both direct additive (h_d^2) and maternal (h_m^2) heritabilities were medium to high (Table 2), except h_m^2 for ADG10–30 which was low. The low h_d^2 estimates for BW fall within the range of values reported in the literature: Boujenane and Mharchi (1992) in Beniguil lambs (0.15), Djemali et al. (1994) in Barbarine lambs (0.26), and Boujenane and Kerfal (1990) in D'man lambs (0.34). Direct heritability estimates for W30, W70, and W90 were larger than those observed by those authors and by Khaldi and Boichard (1989). Boujenane and Kerfal (1990) found similar estimate for W90 in D'man lambs (0.52). In the Timahdit breed, Tijani and Boujenane (1993) observed much lower estimates of 0.02 (BW) and 0.06 (W90). These discrepancies between our estimates of h_d^2 and those of Tijani and Boujenane (1993), could be due to differences in animals, models fitted, and computational methods. These authors, used data from a Timahdit flock raised in medium Atlas area of Morocco, used a paternal half sib model, and the computational method was different.

Maternal h_m^2 estimates for live weights (Table 2) suggest that additive maternal effects are important. There is a lack of information about additive maternal effect estimates in the Moroccan sheep breeds. In sheep, Burfening and Kress (1993) found important h_m^2 , ranging from 0.30 to 0.65, depending on the model applied, for BW in Rambouillet, Targee and Columbian breeds. Poivey et al. (1994) reported medium h_m^2 estimate of 0.30 for W30 in Ile de France lambs. Our estimates of h_m^2 were higher than those observed by Khaldi and Boichard (1989) for Barbarine lambs, whose estimates of h_m^2 were 0.02 (BW), 0.04 (W30), and 0.03 (W90), and than those reported for BW and W90 of 0.22 and 0.01 in Romanov lambs (Maria et al., 1993), of 0.22 and 0.19 in Hampshire, of 0.31 and 0.09 in Polled Dorset, and of 0.13 and 0.02 in Romanov lambs (Tosh and Kemp, 1994). The high estimates of maternal effects in our study were probably due to neglecting the permanent environment maternal effect in the model, which requires repeated records on individual dams in the data. Saatci et al. (1999) observed that models ignoring a maternal permanent environment effects tend to have larger estimates of h_m^2 .

The results for live weights show a trend for increasing direct additive and possibly for decreasing additive maternal influences from birth to 90 days of age. Other studies showed the same tendency (Maria et al., 1993; Burfening and Kress, 1993; Tosh and Kemp, 1994).

For average daily gains, the h_d^2 estimates were 0.42 (ADG10–30), 0.36 (ADG30–70), and 0.31 (ADG30–90), similar to those observed by Djemali et al. (1994)

Table 2

Heritability direct-genetic correlation^a, genetic $\pm$ se^b, and phenotypic correlations^c between growth traits in Timahdit lambs^d

Growth traits	Birth weight	Weight at 30 days	Weight at 70 days	Weight at 90 days	ADG 10–30 days	ADG 30–70 days	ADG 30–90 days
Birth weight	0.18 <i>0.59</i> (–1.0)	0.63 $\pm$ 0.32	0.59 $\pm$ 0.33	0.49 $\pm$ 0.36	0.00 $\pm$ 0.44	0.54 $\pm$ 0.38	0.35 $\pm$ 0.43
Weight at 30 days	0.55	0.31 <i>0.34</i> (–0.97)	0.95 $\pm$ 0.16	0.92 $\pm$ 0.18	0.61 $\pm$ 0.33	0.78 $\pm$ 0.28	0.73 $\pm$ 0.30
Weight at 70 days	0.47	0.81	0.54 <i>0.38</i> (–1.0)	0.78 $\pm$ 0.24	0.56 $\pm$ 0.34	0.94 $\pm$ 0.17	0.76 $\pm$ 0.28
Weight at 90 days	0.40	0.81	0.90	0.50 <i>0.24</i> (0.94)	0.67 $\pm$ 0.34	0.91 $\pm$ 0.20	0.93 $\pm$ 0.18
Average daily gain 10–30 days	0.12	0.55	0.81	0.57	0.42 <i>0.08</i> (–0.70)	0.69 $\pm$ 0.32	0.63 $\pm$ 0.35
Average daily gain 30–70 days	0.22	0.76	0.83	0.73	0.35	0.36 <i>0.15</i> (–0.99)	0.90 $\pm$ 0.23
Average daily gain 30–90 days	0.17	0.34	0.73	0.85	0.37	0.79	0.31 <i>0.22</i> (–1.0)

^a Values given in bold, h_d^2 ; Values given in italic, h_m^2 ; Values given in brackets, r_{dm} .^b Values given above the diagonal.^c Values given below the diagonal.^d ADG=Average daily gain; h_d^2 =Direct genetic heritability; h_m^2 =Maternal genetic heritability; (r_{dm})=Direct-maternal genetic correlation.

of 0.24 (ADG30–70) and 0.31 (ADG30–90) in Barbarine lambs. Lower than the estimate of 0.56 observed for ADG30–90 by Boujenane and Kerfal (1990) in D'man lambs. But, higher than those reported for other breeds: Khaldi and Boichard (1989) for Barbarine, Tijani and Boujenane (1993) for Timahdit, and Boujenane and Mharchi (1992) for Beniguil lambs.

The estimate of h_m^2 was low for ADG10–30 (0.08). Whereas estimates for ADG30–90 and ADG30–90 were medium (0.15 and 0.22). High estimates of 0.29 (ADG10–30) and 0.27 (ADG30–90) were reported by Poivey et al. (1994) for Ile de France lambs. Our h_m^2 estimates for ADG30–90 were higher than those observed by Khaldi and Boichard, (1989) and Maria et al. (1993), who reported low estimates of maternal heritability ranged from 0.01 to 0.06 for growth traits in Barbarine and Romanov sheep. Maternal heritability decreases with age, which confirm the finding of Notter and Hough (1997), Yazidi et al. (1997), who

observed that maternal effects are substantial in young animals but diminish with age.

Estimated genetic correlations (r_{dm}) between direct additive and additive maternal effects were unreasonably negative and high for live weights ranging from –0.94 to –1.0 and for daily gains ranged from –0.70 to –1.0. The unrealistically high estimates of r_{dm} , could be due to the small size data and to the structure of this data set (i.e., the number of generations for which animals were measured both directly and as dams was limited). However, these estimates were obtained after rerunning the program with different starting values and with two or three cold restarts, and they still converged to the same estimates. Negative estimates for direct-maternal covariance for early growth traits are numerous in the literature for sheep. Maria et al. (1993) reported strong negative covariance (r_{dm}) between direct and maternal additive effects for lamb live weights of –0.99 (BW), –0.98 (W30), and –0.97 (W90). Poivey et al. (1994) also

reported high negative estimates of r_{dm} ranging from -0.61 to -0.70 for growth traits to weaning in Ile de France lambs. Other authors (Khaldi and Boichard, 1989; Burfening and Kress, 1993; Tosh and Kemp, 1994) found important covariances between additive direct and additive maternal effects for live weights traits, ranging from -0.74 to -0.18 . For Tosh and Kemp (1994) the antagonism between direct genetic effect and maternal genetic might be due to natural selection for an intermediate optimum. For Notter and Hough (1997), in the presence of such estimates, estimates of additive direct and (or) maternal variances may be large and can be accepted only if users also accept and incorporate the additive maternal covariance into any resulting applications. However, Yazidi et al. (1997) observed positive direct-maternal additive correlations for BW and weaning weight of approximately 0.18 and 0.50, respectively, suggesting that selection for increase body weight of the lamb will also improve the maternal ability of the ewe.

3.3. Genetic and phenotypic correlations

Genetic correlations between growth traits of Timahdit lambs were positive and of medium to high magnitude for the majority of traits, except with the BW (Table 2). The corresponding phenotypic correlations were medium to low. The largest relationships were found between chronologically adjacent weights. This tendency decreased as the interval between two weighing increased. In general, genetic correlations listed in Table 2 fall in the range of estimates of 0.18 and 0.71 reported between BW and other growth traits in previous studies (Boujenane and Mharchi, 1992; Djemali et al., 1994). The highest genetic correlations between body weights were observed between W30 and W70 and between W30 and W90. Furthermore, the highest genetic correlations between ADGs were between ADG30–70 and ADG30–90. Between W70, W90, ADG30–70 and ADG30–90 traits, the genetic and phenotypic correlation estimates were high and exceeded 0.63 and 0.73, respectively. In the literature, the values of genetic correlations ranged from 0.59 to 0.92 between W30 and ADG10–30, from 0.67 to 0.88 between W70 and ADG30–70 or ADG30–90, and from 0.79 to 0.98 between W90 and ADG30–90 (Boujenane and Kerfal,

1990; Boujenane and Mharchi, 1992; Djemali et al., 1994). Our estimates of phenotypic correlations were all positive, and in general showed the same trend as for genetic correlations. The estimates of genetic and phenotypic correlations obtained in this study are in contrast with those for growth traits in Timahdit breed observed by Tijani and Boujenane (1993).

4. Conclusions

This study showed important effects of some environmental factors on growth traits, which should be accounted for in genetic evaluations. The high direct and maternal heritability estimates obtained in this study indicated that it would be possible to improve growth traits through genetic selection at all ages. The estimates of genetic and phenotypic correlations were high and showed no genetic antagonisms among the growth traits. However, estimates of additive direct-maternal correlations were high and negative but the accuracy of such estimates is low due to the small data set in the present study.

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