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Estimation of genetic parameters and genetic gains for reproductive traits and body weight of D'man ewes

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ABSTRACT

The current study consisted of genetic analysis for reproductive performance and body weight using from 2003 to 2863 records of 1018 D'man ewes born from 136 sires and 468 dams. Data were collected from 1988 till 2009 in the Errachidia Experimental Station (ESE) of the Institut National de la Recherche Agronomique. Conception rate (CR), litter size at birth (LSB), litter size at weaning (LSW), litter weight at birth (LWB), litter weight at weaning (LWW), gestation length (GL) and ewe's body weight (EBW) averaged 94.4%, 2.38 lambs, 2.03 lambs, 6.23 kg, 39.6 kg, 149.9 days and 44.8 kg, respectively. The analysis of variance showed that LWB and EBW were influenced by age of ewe, parity and period of lambing. Also, period of lambing had significant effects on all studied traits. However, age of the ewe did not affect LSB and LWW. Genetic parameters and genetic trends for reproductive traits and EBW, estimated through REML and BLUP procedures using a repeatability animal model including additive genetic and permanent environment effects, in addition to fixed effects, resulted in heritability estimates of 0.09, 0.11, 0.10, 0.10, 0, 0.22 and 0.44 and repeatability estimates of 0.19, 0.13, 0.16, 0.10, 0, 0.26 and 0.62 for LSB, LSW, LWB, LWW, CR, GL and EBW, respectively. Genetic correlations among traits ranged from −0.21 and 0.93 and phenotypic correlations varied from −0.07 to 0.82. Estimated annual genetic progress was very small; 0.0009 lambs for LSB and −0.0078 kg for EBW. The study concluded that the actual genetic parameter estimates could be used in a breeding program to improve the productivity of D'man ewes and to make significant genetic progress.

1. Introduction

The D'man with 617,000 sheep is raised in the oases in South of Morocco. It is known for its exceptional reproductive performance: high prolificacy (200%), early puberty (6 months), long sexual season (from May to February), but it has a low growth rate (140 g/day). D'man fleece is characteristically entirely black although some animals are brown, white or various combinations of two or all three colours. Both sexes are polled (Boujenane, 2005, 2006). Because of its high prolificacy, the D'man breed is used in terminal crossbreeding to increase the number of lambs weaned. Genetic improvement of growth rate and reproductive traits is important to increase sheep productivity (Dickerson, 1978). However, it seems that improvement of reproductive traits has more economic impact than improvement of growth rate (Wang and Dickerson, 1991). Safari et al. (2005) showed that designing efficient selection and breeding strategies for genetic improvement and appropriate genetic evaluation of local breeds requires accurate estimates of genetic parameters. Several reports have estimated the genetic parameters for litter size at

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birth in sheep (Rao and Notter, 2000; Hagger, 2002; Ekiz et al., 2005), but only few literatures have reported estimates of genetic parameters for other reproductive traits. Concerning the D'man breed, Boujenane et al. (1991) estimated genetic parameters for litter traits based on paternal half-sib method. However, it is necessary to re-estimate variance components by the REML method that combines information from all related animals.

The objectives of the present study were to analyse reproductive traits and body weight of D'man ewes in order to examine the effects of environmental factors and to estimate genetic and phenotypic parameters to improve the efficiency of genetic selection.

2. Material and methods

2.1. Site of study

The study was conducted in the research station at Errachidia, belonging to the Institut National de la Recherche Agronomique, located in south-east of Morocco (40°39′S, 62°54′W). The climate is arid. The maximum temperature recorded is about 50 °C in summer, while the temperature can drop to −4 °C in winter. The mean annual rainfall is 200 mm, mainly occurring during November–March period.

2.2. Flock management

The flock of about 80 breeding ewes was maintained under an accelerated reproduction system of three lambings in 2 years. Ewes were mated following a controlled breeding, with lambing either in spring (March–May), summer (June–August) or autumn (October–December) season. At each mating season, ewes were allocated at random to a mating group. A single sire mating system was practiced with a ratio of 20–25 ewes per ram for a service period covering two oestrous cycles. At each joining season, at least 3 rams were used for mating. Each sire was generally used during two joining periods, and discarded once a male offspring was available for replacement. Ewes are generally culled at 7 years of age. But if they fail to wean lambs during two successive lambings, or show any health problem or exhibit extreme physical defects, they are culled before this age. Ewe lambs retained for breeding were selected on the basis of their birth type, health status and body conformation. They were first mated at about 12 months of age. Ram lamb selection was primarily based upon weaning weight among lambs born and reared as multiples.

The animals are indoors during all year, no grazing being allowed. They were housed according to their age, sex, physiological status and health status and maintained under intensive feeding system. Depending on the number of suckled lambs and lactation stage, lactating ewes were provided with 1–3 kg of alfalfa and 0.8–1.2 kg concentrate containing wheat bran, barley, sugar beet pulp, date residue and vitamin and mineral mix. Pregnant and non-pregnant ewes received less feed. Animals were fed twice daily with two equal amounts. Moreover, water and mineralised salt blocks were supplied *ad libitum* to animals in the flock at all time. Suckling lambs were creep fed starting from the second month of age. They were provided with a mixture containing alfalfa hay, barley, sun flower meal and mineral and vitamin mix. After weaning, lambs were placed in separate sex groups and were offered about 500 g/day of the same feed for the first 2 months after weaning. Male lambs were not castrated.

Adult animals were vaccinated against enterotoxaemia and treated against internal and external parasites. Lambs were vaccinated against enterotoxaemia at 1 month of age, with a booster 1 month later. They were also treated against internal parasites at 90 days.

2.3. Data recording and traits studied

After lambing, the ewe and its newly born lambs were separated from the rest of the flock and placed in an individual pen for a period of 2–3 days. Shortly after birth, lambs' navel cord was disinfected with an iodine solution. Newborn lambs were identified individually by an ear tag, and dam number, birth date, sex, birth weight and type of birth were recorded within 18 h of birth, and ewes' udders were inspected to assess the milk yield. Few days after parturition, ewes and their lambs were moved to a mixing pen with 15–20 other ewes and their lambs. Lambs remained with their dam until weaning at about 90 days of age. Excess lambs from multiple births were artificially reared, as were lambs that could not be reared by their own dam. Lambs were weighed at birth and every 3 weeks until weaning. All lamb deaths between birth and weaning were also recorded.

Conception rate (CR) of 1 or 0 was assigned to ewes that lambed or did not lamb, respectively. Litter size at birth (LSB) was the number of lambs born alive or dead per ewe lambing. Litter size at 90 days (LSW) was the number of lambs present at 90 days per ewe lambing. Litter weight at birth (LWB) was the sum of birth weights of lambs born for each ewe lambing. Litter weight at 90 days (LWW) was the sum of weights at 90 days of all lambs weaned per ewe lambing. Before calculating litter weight at birth and at 90 days, individual lamb weight at birth and at 90 days was adjusted for differences due to sex of lamb by adding to females' weights 0.18 kg and 3.3 kg, respectively. Gestation length (GL) was limited to ewes that lambed after 142 days and before 156 days of pregnancy. Ewe's body weight (EBW) represents the ewes' liveweight recorded at mating.

2.4. Statistical analyses

Data analysed were recorded from 1988 to 2009. Ewes' age at lambing averaged 32.8 months (varying from 18 to 113 months) and parity averaged 2.97 (varying from 1 to 13). The number of records varied from each variable studied to the other, with a minimum of 2003 records for LWB and a maximum of 2863 records for CR. All records were obtained from 1018 ewes born from 136 sires and 468 dams.

CR is a binary random variable, LSB and LSW have discrete numerical observations, and other studied traits have continuous expression. REML method using the MIXED procedure (SAS, 1996) was used to examine the effects of environmental factors on reproductive traits and body weight of ewes to fit in animal models for estimating the phenotypic and genetic parameters. The mixed model used included random effect of ewe and fixed effects of age at lambing (6 levels: age $\leq$ 1.5, 1.5 < age $\leq$ 2, 2 < age $\leq$ 2.5, 2.5 < age $\leq$ 3, 3 < age $\leq$ 3.5 and age > 3.5 years), parity (6 levels: 1, 2, . . ., 6 or greater), period of lambing (33 levels: autumn-1988, . . ., autumn-2009), which is a combination of season of lambing (autumn, spring and summer) and year of lambing (1988–2009). First order interactions between effects were not tested and hence were assumed to be negligible.

Heritability and repeatability for reproductive traits and ewe's body weight were estimated from variance components obtained for each trait separately with derivative-free REML procedure using the MTDFREML program (Boldman et al., 1995). The basic single trait repeatability model in matrix notation was:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{Wpe} + \mathbf{e}$$

where $\mathbf{y}$ is a vector of observations, $\mathbf{b}$ is a vector of fixed effects with incidence matrix $\mathbf{X}$, $\mathbf{a} \sim N(0, \mathbf{A}\sigma_a^2)$ is a vector of random animal effects with incidence matrix $\mathbf{Z}$, $\mathbf{pe} \sim N(0, \mathbf{I_c}\sigma_{pe}^2)$ is a vector of random permanent environmental effects with incidence matrix $\mathbf{W}$, and $\mathbf{e} \sim N(0, \mathbf{I_n}\sigma_e^2)$ is a vector of random residual effects. σ_a^2 is the additive genetic variance, σ_{pe}^2 is the permanent environmental variance, σ_e^2 is the residual variance, $\mathbf{A}$ is the additive genetic relationship matrix, and $\mathbf{I_c}$ and $\mathbf{I_n}$ are identity matrices of order equal to the number of ewes and the number of records, respectively. Convergence of the derivative-free iterative process was considered reached when the variance of simplex values (−2 log-likelihood) was less than 10^{-8}. To ensure a global maximum, each analysis was restarted with previous converged values until the estimated value of the −2 log-likelihood function did not differ in its first three decimal places. Solutions for fixed and random effects were from the last round of iteration in which the global maximum was achieved.

Similar derivative-free REML procedures were used for bivariate analyses to estimate correlations between traits. The model used was similar to that of univariate analyses. Estimates from single-trait analyses were used as starting values for bivariate analyses. Convergence was first obtained when the simplex variance was less than 10^{-3} and then when the simplex variance was less than 10^{-8}.

BLUP procedure was used in order to estimate genetic trends. The annual genetic progress for each studied trait was estimated as the regression coefficient of ewes' additive genetic values on their birth year.