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Genetic evaluation and genetic trend of growth traits of Zandi sheep in semi-arid Iran using random regression models

M. Bohlouli, H. Mohammadi*, S. Alijani

Department of Animal Science, College of Agriculture, University of Tabriz, Tabriz, Iran

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ABSTRACT

A number of 5573 body weight records of 1523 lambs from 164 sires and 875 dams were used to estimate additive genetic, direct and maternal permanent environmental effects on growth from 1 to 300 days of age. The data were collected during the period 1993–2007 from the rearing and breeding station of Zandi sheep in Tehran, Iran and analyzed fitting the random regression (RR) models. Fixed effects in models included age of dam, sex of lamb, type of birth and year of birth. The independent variables were Legendre polynomials of age at weighing and orders of fit from 2 to 5 were considered. The assumptions about the distribution of the residual variance were compared. The variances increased along the trajectory from 0.02 to 25.86, 0.21 to 5.46 and 0.09 to 3.90 for direct additive genetic, direct and maternal permanent environmental effect, respectively. The direct heritability ranged from 0.06 at 1 days of age to 0.52 at 300 days of age. The genetic changes of birth weight from 1991 to 2007 appear to be flat. For the other selected weight (150-d and 300-d weights), plots of genetic trends following similar increasing patterns. The Zandi sheep growth was adequately modeled using RR models despite the limited data. This study has demonstrated the possibility of application of RR models for routine genetic evaluation of Zandi sheep in Iran.

1. Introduction

Lamb and mutton are traditional sources of protein in Iran and the consumption levels are high in comparison with cattle and goats. The sheep population in Iran is mainly composed of fat-tailed carpet-wool native breeds. They are mostly adapted to the poor range conditions of the country. A high percentage of the sheep population is managed under a migratory system, utilizing the range as the major source of feed (Ghafouri Kesbi et al., 2008). The Zandi sheep is one of the most important Iranian native breeds known for its high grazing ability, adaptability to the harsh semi-arid conditions, and resistance to the common diseases in reared regions.

Currently random regression models are being applied in the analysis of longitudinal growth in cattle (Robert-Granié et al., 2002; Krejčová et al., 2007; Neser et al., 2012), sheep (Lewis and Brotherston, 2002; Ghafouri Kesbi et al., 2008; Abegaz et al., 2010; Kariuki et al., 2010; Wolc et al., 2011) and pig (Huisman et al., 2002) data. These models use polynomials in time to describe mean profiles with random coefficients to generate a correlation among the repeated observations on each individual (Robert-Granié et al., 2002). This approach has the advantage of studying change and increases statistical power. This is due to units serving as their own control and due to the possibility of estimating (co)variance components at any point on the trajectory of time. Additional advantages include the use of weight measurements without any need to correct for age and the reduction in the number of parameters to

* Corresponding author. Tel.: +98 912 758 45 72; fax: +98 261 224 67 52.
E-mail address: mohammadi37@tabrizu.ac.ir (H. Mohammadi).

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be estimated as compared to multivariate analysis. Lower approximate standard error estimates for parameters as compared to estimates from univariate analysis (Fischer et al., 2004) are also additional advantages of the random regression analysis.

In the tropics where large fluctuation in environmental variables, particularly in availability of feed, is common concurrent fluctuations in weight (growth) of animals is likely to occur. Under this condition the use of random regression analyses where the trait is the whole set of measurements along the trajectory may have an advantage in obtaining reliable estimates of parameters.

Previously univariate and bivariate analyses of data on birth, weaning, 6-month, 9-month and yearling weights have been done (Mohammadi et al., 2010). In this study different random regression models were applied in the analysis of weight data taken from birth to 300 days of age with the objective of identifying the appropriate model, obtaining more accurate estimates and estimates of genetic changes.

2. Materials and methods

2.1. Geographical location and herd management

The data used in this research were collected from the flock of Zandi sheep during the period 1993–2007 at the rearing and breeding station of Zandi sheep located in Khojir National Park between Tehran and Abali (1547 m above mean sea level and 35°45′ E and 51°40′ N with a moderate climate). The flock was established in 1991. The aim of the project was to establish a nucleus source to improve other flocks in the region. The starting animals were purchased from different sheep farms in the region. The flock is generally reared by following conventional industry practices. More details on the environment and flock management were described in a companion paper (Mohammadi et al., 2012).

2.2. Data

The data consisted of weight records from birth to 300 days of age. Animals that had three or four records within the specified age range were included in the analysis. A total of 5573 records of 1523 animals with a mean weight of 22.19 kg were eventually available. Animals with records were progeny of 164 sires and 875 dams and the pedigree included 2332 animals. The characteristics of data set are shown in Table 1.

Number of records and average weights for different ages are given in Fig. 1. Body weights increased evenly linear with increasing in age from 1 to 300 days of age so was the standard deviation. Therefore, the coefficient of variation remained at the relatively constant across ages.

Table 1
Characteristics of the data.

Number of records	5573
Means (kg)	22.187
SD (kg)	12.588
No. of animal with records	1523
No. of animal with 3 records	519
No. of animal with 4 records	1004
No. of animals in the analysis	2332
No. of sires	164
No. of dams	875
No. of sires with records and progeny in the data	61
No. of dams with records and progeny in the data	322

2.3. Statistical analysis

The choice of fixed effects to be considered was made after testing whether the effects were statistically significant with GLM procedure of SAS (2004). The statistical model included age of dam (2–7), sex of lamb (male and female), type of birth (single, twin and triples) and year of birth (1993–2007). All of the fixed effects were significant ($P < 0.01$) and included in the model. Weight as a function of age in days at weighing was included as a fixed regression of orthogonal polynomial. This fixed regression describes the average growth curve of all animals with records (Abegaz et al., 2010). Three sets of random regression coefficients were fitted to the data. These included direct genetic effect and direct and maternal permanent environmental effects. Random regression (RR) model fitted Legendre polynomials of age at recording (in days) as independent variables. The general model for the analysis was:

$$y_{ij} = F_{ij} + \sum_{k=0}^{5} \beta_k \phi_k(t_{ij}^*) + \sum_{k=0}^{k_\alpha - 1} \alpha_{ik} \phi_k(t_{ij}^*) + \sum_{k=0}^{k_\delta - 1} \delta_{ik} \phi_k(t_{ij}^*) + \sum_{k=0}^{k_\rho - 1} \rho_k \phi_k(t_{ij}^*) + \varepsilon_{ij}$$

where y_{ij}, is the jth record from ith animal at age t_{ij}^* that t_{ij}^*, is the standardized age of recording for y_{ij}, $-1 \le t \le 1$ for which Legendre polynomials are defined and $\phi_k(t_{ij}^*)$ is the corresponding kth Legendre polynomial; F_{ij} is fixed effects relating to y_{ij} (age of dam, sex of lamb, type of birth and year of birth). β_{kt} is the fixed regression on orthogonal polynomials of age; α_{ik}, δ_{ik} and ρ_{ik} are the kth order RR coefficients for the direct genetic, maternal and direct permanent environmental effects, respectively and $k_\alpha - 1$, $k_\delta - 1$ and $k\rho - 1$ are the corresponding order of fit for each effect.

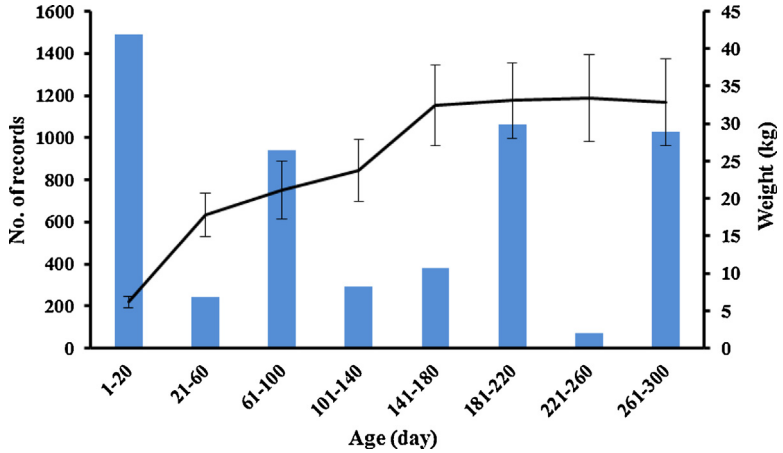

Fig. 1. Number of records and mean weights among age intervals.