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Genetic analysis of average daily gain in Baluchi sheep

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ABSTRACT

The objective of the present study was to estimate genetic parameters and genetic trends for average daily gain (growth rate) and to investigate the genetic effect of body weight at different ages (birth (BW), weaning (WW), 6 months (W6) and 9 months (W9)) on growth rate of Baluchi sheep. Data were collected at the Abbasabad Baluchi Sheep Breeding Station (flock 2) from 1983 to 2009. Traits were average daily gain from birth to weaning (ADGa), from weaning to 6 months of age (ADGb) and from weaning to 9 months of age (ADGc). (Co) variance components and genetic parameters were estimated by univariate and multivariate animal models using Restricted Maximum Likelihood (REML) procedure. Genetic improvements over analyze were calculated as the differences between the means of estimated breeding values at the beginning and at the end of analyze. Genetic trends were obtained by regressing the means of predicted breeding values on year of birth for each trait. Direct heritability estimates were, correspondingly, 0.03, 0.11 and 0.05 for ADGa, ADGb and ADGc. Estimate of maternal heritability (m^2) for ADGc was 0.11. Estimated value of maternal permanent environment variance as a proportion of phenotypic variance (c^2) was 0.14 for ADGa. Negative genetic correlations were observed for BW-ADGb and BW-ADGc. Direct additive genetic correlations between traits ranged from − 0.63 (BW-ADGc) to 0.91 (W9-ADGc). Phenotypic correlations ranged from − 0.49 (BW-ADGb) to 0.88 (WW-ADGa). Maternal permanent environmental correlations ranged between 0.13 (W9-ADGa) to 0.99 (WW-ADGa). Genetic improvements were 0.033 g, 0.36 g and 0.31 g for ADGa, ADGb and ADGc, respectively. Annual genetic gains (g/year) for ADGa, ADGb and ADGc, were 0.02, 0.03 and 0.04, respectively.

1. Introduction

In Iran, sheep is the most important source of protein and the tendency for lamb and mutton consumption is high in comparison with meat from beef cattle and goats. The Baluchi breed is the most frequent native breed of Iran. They are well adapted to the dry and hot climatic conditions with pasture of low quality in the eastern part of the country (Yazdi et al., 1997). Growth-related traits are main factors affecting efficiency in any meat-producing system. Achievable methods to improve meat production in sheep, are the production of more lambs per ewe thorough increasing ewe productivity, including lambing rate and frequency, and the increase in lamb growth performance which requires intensification of the growth potential and survival of lambs (Miraei-Ashtiani et al., 2007).

Genetic improvement by selection of superior animals based on their predicted breeding values is essential in livestock production and is required to be considered in breeding programs (Kosgey et al., 2006). In order to obtain genetic gain in growth traits, it is essential to estimate genetic parameters of direct and maternal elements that affect these traits, as well as to ascertain the role of each effect on the animal performance to make decisions in a selection program. The efficiency of a breeding program can be evaluated by scrutinizing the factual change in breeding values indicated as a proportion of expected theoretical change of the breeding value mean for the trait under selection (Jurado et al., 1994).

Numerous studies have confirmed that body weight and growth rate of lambs of different breeds notably are influenced by maternal as well as direct genetic effects (Yazdi et al., 1997; Abegaz et al., 2005; Bahreini Behzadi et al., 2007; Rashidi et al., 2008; Eskandarinasab et al., 2010, Mohammadi et al., 2013, Jalil-Sarghale et al., 2014, Aguirre et al., 2016). Most of these studies demonstrated that not accounting for maternal effects in genetic analysis of these traits, particularly for preweaning ones, resulted in upward biases in estimation of direct heritability.

The objective of this study was to estimate genetic parameters for average daily gain of Baluchi Sheep and to investigate the effects of body weights on these traits. We also evaluated the response of growth rate to a long term selection program started in 1983.

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2. Materials and methods

2.1. Data and management

Data and pedigree information of Baluchi sheep collected between 1983 and 2009 (26 years) were obtained from the second flock of the Abbasabad Baluchi Sheep Breeding Station (flock 2), Mashhad, Khorasan Razavi, Iran. Full details of the Origin and structure of the flocks are given in Yazdi et al. (1997). Selection was based on body weight, body conformation score and type of birth. Each ram (around 30 rams per year) randomly mated with 15 to 25 ewes and almost 50% of sires were kept for 2 to 3 mating seasons and rest were used once. Ewes were kept up to 7 parities (8 years of age). The annual rate of ewe replacement was 14%. The mating season commenced between late summer and early autumn and consisted at most three oestrous cycles (51 days). Lambing started in late January to late March. After lambing, the pertinent data about newborn such as sex, birth date, birth type, birth weight, sir ID and dam ID were recorded. Records of body weights for weaning (90 days, on average), 6 and 9 months of age were also registered. During spring and summer, flocks were kept on natural pastures and in autumn and winter animals were kept indoors and fed with a ration based on wheat and barley stubble. Supplementary feed was included during pregnancy and included a diet composed of wheat and barley straw, alfalfa hay, dry sugar beet pulp, and concentrate.

2.2. Traits considered

Average daily gain from birth to weaning (ADGa), from weaning to 6 months of age (ADGb) and from weaning to 9 months of age (ADGc) were studied. To calculate the average daily gain, pertinent gain was divided by the number of days in the period.

In order to account for the differences among animals in age at recording, weaning, 6-month and 9-month weights were adjusted to 90, 180 and 270 days of age, respectively.

2.3. Statistical analysis

The general linear model (GLM) procedure of the SAS Institute Inc. (2004) was used to identify fixed effects that had significant influence on traits. This was carried out on a model containing fixed effects of year of birth, age of dam, sex of lambs and type of birth. Six univariate linear animal models were fitted for each trait to estimate (co)variance components and corresponding genetic parameters. The models used were as follow:

Model 1: $Y = X\beta + Z_a a + e$

Model 2: $Y = X\beta + Z_a a + Z_c c + e$

Model 3: $Y = X\beta + Z_a a + Z_m m + e$ with $\mathrm{Cov}(a, m) = 0$

Model 4: $Y = X\beta + Z_a a + Z_m m + e$ with $\mathrm{Cov}(a, m) = A\sigma_{am}$

Model 5: $Y = X\beta + Z_a a + Z_m m + Z_c c + e$ with $\mathrm{Cov}(a, m) = 0$

Model 6: $Y = X\beta + Z_a a + Z_m m + Z_c c + e$ with $\mathrm{Cov}(a, m) = A\sigma_{am}$

where, y is the vector of observations, b is the vector of fixed effects, a and m are the vectors of random direct and maternal additive genetic effects, respectively, c is the vector of random permanent maternal environmental effects and e is the vector of residuals. X, Z_a, Z_m and Z_c are incidence matrices for β, a, m and c respectively. A is the relationship matrix, the expected value for y is Xβ; V[*a*], V[*m*], V[*c*] and V[*e*] are $\sigma^2{}_a$, $\sigma^2{}_m$, IND $\sigma^2{}_c$ and IN $\sigma^2{}_e$, respectively, where I is an identity matrix with orders of ND (number of dams) or N (number of records). Direct and maternal heritabilities (h^2 and m^2, respectively) and maternal permanent environmental effect (c^2) were estimated as σ^2a/σ^2p, σ^2m/σ^2p and σ^2c/σ^2p respectively, where σ^2a, σ^2m, σ^2c and σ^2p are estimates of direct genetic, maternal genetic, maternal permanent environment and phenotypic variances.

Data were analyzed with WOMBAT software package by AI-REML algorithm (Meyer, 2007). The most appropriate model for each trait was selected based on Akaike's Information Criterion (AIC; Akaike, 1974):

$$AIC_i = -2\log\cdot L_i + 2\cdot p\mathbf{i}$$

where log L_i represents the maximized log likelihood, and p**i** is the number of parameters obtained for each model. The model with lowest AIC is the appropriate model for that trait. Multivariate version of the univariate models were used to estimate covariances between traits. The models applied in multivariate analyses were those fitted for each of the underlying traits in the univariate analyses.

Genetic improvement for the interested traits over the end analyze was calculated as the differences between the means of estimated breeding values at the beginning and at the end of end of analyze. Genetic trends were calculated by regressing the means of predicted breeding values obtained from multivariate analysis on year of birth for each trait.

3. Results

Characteristics of the pedigree and data structure are summarized in Tables 1 and 2, respectively. As presented, the quality of data and pedigree structures seems enough to get accurate estimates of direct and maternal genetic parameters. The coefficient of variation for ADGa is less than that for the other traits, which is an indication of the smaller effect of environment on ADGa than on the other traits. Growth rate during pre-weaning period (213.83) was approximately 3 times greater than that obtained for weaning to 6 months of age (73.01) and 4 times greater than that observed for weaning to 9 months of age (54.81).

The least squares means and standard errors for average daily gains are presented in Table 3. Lamb gender, type of birth, and birth year had significant influences on all growth traits ($P < 0.01$). The effect of dam age at lambing was significant ($P < 0.01$) only for ADGa.

Estimates of AIC values for six models for each trait are listed in Table 4. The most appropriate model for ADGa, ADGb and ADGc was 2, 1 and 3, respectively.

Estimates of variance components and pertinent genetic parameters for the traits studied under the most suitable model are presented in Table 5. The estimates of direct heritability (h^2) for traits studied were low and ranged between 0.03 (ADGa) to 0.11 (ADGb). Estimates of maternal heritability (m^2) for ADGc was 0.11. Estimates of maternal permanent environment variance as a proportion of phenotypic variance (c^2) was 0.14 for ADGa.

Direct and maternal correlations between traits are given in Table 6. Direct additive genetic correlation between traits ranged from − 0.63 (BW-ADGc) to 0.91 (W9-ADGc). The maternal permanent environmental correlation estimate ranged between 0.13 (W9-ADGa) to 0.99 (WW-ADGa). The estimates of phenotypic correlations were generally

Table 1
Pedigree structure of Baluchi sheep.

Description	Number
Generations	16
Animals in the pedigree file	10,665
Animals with progeny	3531
Animals without progeny	7134
Non-base animals	9494
Non-base animals with known sire and dam	9033
Non-base animals only with known sire	7
Non-base animals only with known dam	451
Sires	385
Dams	3146
Grand sires	307
Grand dams	1582